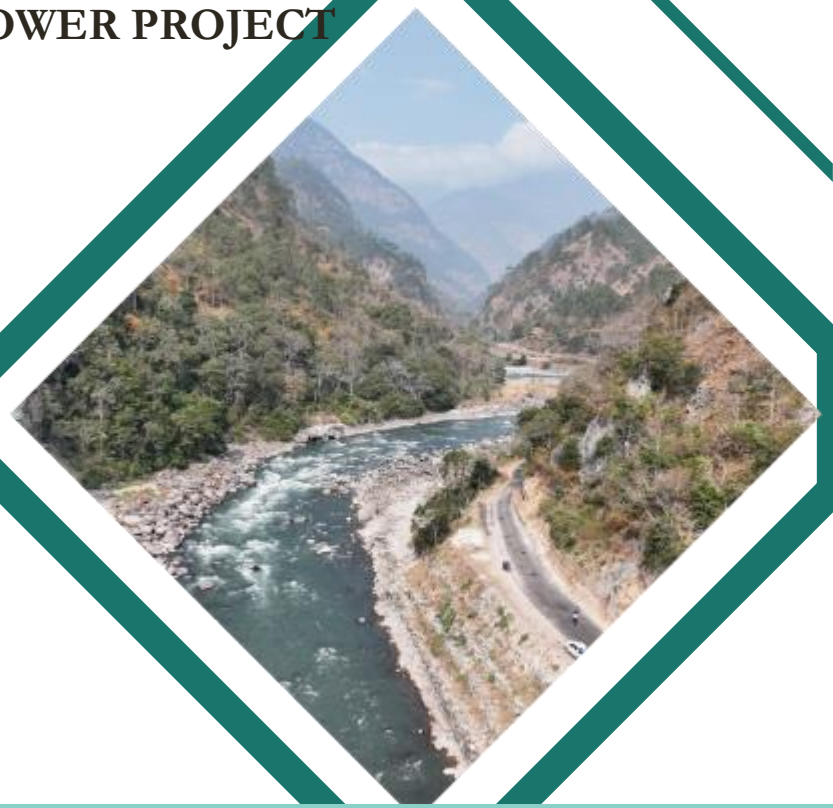
ENVIRONMENT & SOCIAL IMPACT ASSESSMENT (ESIA)

DRAFT

1125 MW DORJILUNG HYROPOWER PROJECT

MONGAR AND LHUENTSE

BHUTAN



MARCH 2025

DRUK GREEN POWER CORPORATION LIMITED (DGPC)

THIMPHU, BHUTAN

Disclaimer:

This Environmental and Social Impact Assessment (ESIA) for the Dorjilung Hydro-electrical Power Project[1] was prepared by the Druk Green Power Corporation Limited, Royal Government of Bhutan (RGoB), and follows Good International Industry Practices (GIIP) and the Bank's Environmental and Social Framework (ESF).

The review of this ESIA is a key part of the Bank's due diligence process and is currently ongoing. This ESIA may still contain gaps to fully address all pertinent E&S issues in the project. Any gaps in this ESIA will be filled through supplemental studies, assessments, and/or plans that will be completed in a reasonable timeframe to ensure compliance with the ESF.

For the benefit of potentially project affected people (PAP) and other interested stakeholders, and in alignment with the Bank's Policy on Access to Information this ESIA is being disclosed as soon as it became available. The disclosure of this ESIA, however, should not be considered as a final clearance of the ESIA by the World Bank.

[1] Synonymously called "Dorjilung Hydropower Project (DHPP)"

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

ACC	Anti-Corruption Commission
ADB	Asian Development Bank
AM	Avoidance measures
AoA	Area of Analysis (for CHA)
AoI	Area of Influence
BC	Biological corridor
BCTA	Bhutan Construction and Transport Authority
BLSS	Bhutan Living Standard Survey
BPC	Bhutan Power Corporation
CCAA	Competition & Consumer Affairs Authority
CCF	Construction Contractor Facilities
CIA	Cumulative Impact Assessment
CIC	Community Information Centre
CHA	Critical Habitat Assessment
CHQ	Critical Habitat Qualificative
CSO	Civil Society Organization
CSR	Corporate Social Responsibility
DGPC	Druk Green Power Corporation Limited
DHPS	Department of Hydropower and Power Systems
DLEC	Dzongkhag Land Exchange Committee
DLGDM	Department of Local Governance and Disaster Management
DMS	Detailed Measurement Survey
DoCDD	Department of Culture and Dzongkha Development
DoECC	Department of Environment and Climate Change
DoFPS	Department of Forest and Park Services
DoLAM	Department of Land Administration Management
DoST	Department of Surface Transport
DoW	Department of Water
DPCL	Druk Petroleum Corporation Limited
DPOB	Disabled People's Organization of Bhutan
DPR	Detailed Project Report
DV	Domestic Violence
E&S	Environmental and Social
ECCD	Early Childhood Care & Development
EIA	Environmental Impact Assessment
EM	Enhancement measures
EMP	Environmental Management Plan
EOO	Estimated Extent of Occurrence
ESCP	Environmental and Social Commitment Plan
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESS	Environmental and Social Standards
FGDs	Focused Group Discussions
GBCL	Green Bhutan Corporation Limited
GBV	Gender Based Violence
GC	Gewog Centre

GHG	Greenhouse Gases
GIIP	Good International Industry Practice(s)
GLOF	Glacial Lake Outburst Floods
GRC	Grievance Redress Committee
GRM	Grievance Redress Mechanism
HEP	Hydro-Electric Power
HH	Household
HIV	Human Immunodeficiency Virus
HPP	Hydro Power Plant/Project
HRT	Head Race Tunnel
IEE	Initial Environmental Examination
JMT	Joint Monitoring Team
KII	Key-Informant Interview
LALRP	Land Acquisition and Livelihood Restoration Plan
LFPR	Labour Force Participation Rate
LLRR	Land Lease Rules and Regulations
LMD	Land Management Division
LMP	Labour Management Procedures
LOO	Likelihood of Occurrence
MAL	Ministry of Agriculture and Livestock
MDS	Muck Disposal Site
MM	Monitoring measures
MoE	Ministry of Education
MoENR	Ministry of Energy and Natural Resources
MoESD	Ministry of Education and Skills Development
MoH	Ministry of Health
MoHA	Ministry of Home Affairs
MoICE	Ministry of Industry, Commerce, and Employment
MoIT	Ministry of Infrastructure and Transport
MoWHS	Ministry of Water, Hygiene and Sanitation
NBC	National Biodiversity Centre
NCWC	National Commission for Women and Children
NFE	Non-Formal Education Centres
NGEP	National Gender Equality Policy
NGO	Non-Governmental Organization
NLC(S)	National Land Commission (Secretariat)
NPAG	National Plan of Action for Gender
NRCRLF	National Research Centre for Riverine and Lake Fisheries
NSB	National Statistics Bureau
NSSC	National Soil Services Centre
OFM	Offsetting measures
PA	Protected area
PAPs	Project Affected Person
PAVA	Property Assessment and Valuation Agency
PCR	Physical Cultural Resources
PETL	Power Evacuation Transmission Line
PHC	Primary Healthcare Center
PHC	Primary Health Care
PHCB	Population and Housing Census of Bhutan

PM	Particle Matter
PMU	Project Management Unit
R&R	Rehabilitation and Resettlement
RBK	Riverine Bank of Kurichhu
RBP	Royal Bhutan Police
RES	Restoration measures
RGoB	Royal Government of Bhutan
RM	Reduction measures
RNR	Renewable Natural Resources
RP	Resettlement Plan
RSAHP	Rural Sanitation and Hygiene Programme
SGBV	Sexual and Gender Based Violence
SIA	Social Impact Assessment
SL	State Land
SNV	Stichting Nederlandse Vrijwilligers (Netherlands Development Organization)
TLLC	Thromde Land Committees
TM	Training measures
TSPM	Total Suspended Particles Matter
UNICEF	United Nations International Children's Emergency Fund
WB	World Bank

GLOSSARY

Word / Term	Meaning
Anim	Nun
Colony	Bhutanese term for construction camp
Chatrim	Act, statute
Chhuzhing	Land use term – land cultivated with irrigation (natural or artificial)
Chiwog	Administrative territorial unit (lowest level); can include several villages
Chorten	Stupa (temple)
Dasho	Honorific title for senior representatives
Drangpon	Judge
Dratshang	Monastic Body
Driglam namzha	Code of etiquette
Dzong	Large fortresses, may be used for administrative and religious purposes
Dzongkhag	Administrative territorial unit (equivalent to a district/region); such as Mongar and Lhuentse Dzongkhags in the Project area
Dzongda	Chief of a Dzongkhag; equivalent to a regional governor
Dzongkhag Tshogdu	District Council and highest decision-making body in the district
Gewog	Administrative territorial unit (block under a Dzongkhag); can include several Throms / Thromdes
Gewog Tshogde	Local Government Council at the Gewog level/Gewog Assembly
Goenpa	Monasteries
Gup	Elected Head of Gewog and Chairperson of Gewog Tshogde
Kamzhing	Land use term – land without irrigation (rainfed only)
Kidu	Benefits (social welfare) granted by the King or the Royal Government of Bhutan.
Ku Sung Thugten	ku -body, sung-expression of thought, thug-mind relics
Ku Sung Thugten Mendrel	Long life relic
Ladam	Customary practices which restrict access to sacred mountain passes during part of the year.
Lhakhang	Buddhist temple
Lhostamkha	Nepali-speakers
Lu	Lus are subterranean beings that live in sacred places
Mangmi	Elected representative of Gewog who serves as the Dy. Chairperson of Gewog Tshogde
Muck Disposal	Bhutanese term for spoil disposal area
Nye	Sacred pilgrimage sites/religious sites/imprints that are considered the abode of a spiritual being
Nu.	Ngultrum (Bhutanese currency; BTN is the official trigram)
Project Area	The area that the project will impact. This is further defined in the Project Area of Influence as direct, indirect and cumulative in Section 3.9
Rabdeys	Monastic bodies in dzongs other than Punakha and Thimphu.
Ridam	Customary practices restrict access to mountains, groves, lakes, etc. during part of the year.
Sharshopkha	Language spoken in eastern part of Bhutan.
Sokshing	A plot of land with rights for leaf litter production and collection.
Ten-sum	Three types of sacred treasures comprising of images, scriptures, and stupas.
Throm / Thromde	Administrative territorial unit (municipality - urban); such as Mongar, Lhuentse and Gyelpozhing in the Project area
Thram	Land title
Thromde Tshogde	Municipal Committee.
Thrompon	An elected representative and the Chairperson of the Thromde Tshogde; Municipal Administrator or Mayor.

Word / Term	Meaning
Thuemi	An elected representative to Local Government.
Tsogpa	Elected representative of a Chiwog and member to Gewog Tshogde; equivalent to a village head
Tsogdu	Governance system in Bhutan
Yenlag Thromde	The smallest form of Thromde, such as Autsho Yenlag Thromde. A Yenlag Thromde is one with a resident population of more than 1,500 irrespective of their census, where 50% or more of the population is dependent on non-primary activities and is less than 50 acres (20 ha).
Zomdu	Village/Community meeting
Note on units	For most of the ESIA, the metric system is being used. Surface is expressed in acres as requested by DGPC this is the commonly used unit in Bhutan.

EXECUTIVE SUMMARY

THE DORJILUNG HYDROPOWER PROJECT

Background

Bhutan has significant untapped hydropower generation potential. The Power System Master Plan 2040 estimates the overall hydropower potential at 36,900 MW. To date, the Royal Government of Bhutan (RGoB) has constructed projects with a total installed capacity of 2,450 MW, it issued National Guidelines for the Development of Hydropower Projects (2018) integrating environmental and social considerations to avoid or mitigate negative impacts.

In 2020, RGoB, through the Department of Hydropower and Power Systems (now Department of Energy) of the Ministry of Economic Affairs (now Ministry of Energy and Natural Resources) requested World Bank assistance to develop its human and institutional capacity by applying this renewed framework to develop specific projects. The 1,125 MW Dorjilung Hydropower Project (Dorjilung HPP, the Project) was selected as a priority development and the Detailed Project Report (DPR) including the Environmental and Social Impact Assessment (ESIA) of the project is being updated by Druk Green Power Corporation Limited (DGPC) through the consultancy services of Studio Pietrangeli, Italy (Technical Advisory Consultant) and Artelia, France (ESIA Consultant).

The Proponent

DGPC is an electricity utility company created in 2008 that operates and maintains the hydropower assets of Bhutan. Its Vision is to "Promote, develop and manage renewable energy projects, particularly hydropower, in an efficient, responsible and sustainable manner, and to maximise wealth and revenues to the Nation". With an installed capacity of 2209 MW, DGPC mission is to efficiently manage existing hydropower plants and accelerate hydropower development in Bhutan by developing new hydropower projects.

DGPC currently operates the following key hydropower plants: Basochhu (64 MW); Chhukha (336 MW); Kurichhu (60 MW); Mangdechhu (720 MW), Tala (1020 MW) and Nikachhu (118 MW), Dagachhu (126 MW) and rest isntalled capacity from embedded generations.

DGPC is committed to contribute towards fuelling the energy needs of Bhutan and the region by harnessing the energy in an environmentally and socially sustainable manner. DGPC supports social emancipation and community vitality through various initiatives of its own and in collaboration with other partners. DGPC recognises the importance of protection of catchments as it provides steady precipitation – a perennial source of water for the river system. Further, preservation of the catchments reduces soil erosion, which would otherwise decrease the life of underwater equipment of DGPC plants.

DGPC, in fulfilling its vision and mission, plays a major role in supporting the communities through its corporate social responsibility (CSR) initiatives. DGPC continues to improve the quality of life of the communities through long-term value creation for all stakeholders. This objective is for aligning DGPC's CSR with Bhutan's overarching development policy of "Gross National Happiness." Towards achieving this, DGPC continues to support community related religious, educational, social, and environmental activities that are in the greater interests of the Bhutanese public through donations and contributions.

The Project

The Dorjilung HPP is a proposed Run of River hydropower development of 1,125 MW on the Kurichhu River in Eastern Bhutan (Mongar and Lhuentse Dzongkhags). It involves the construction of a 139.5 m high concrete dam (85 m above riverbed) and the creation of a 44.17 Mm^3 reservoir. Water will be conveyed

through a 14.97 km long headrace tunnel on the right bank of the river, connecting to an underground powerhouse with 6 Francis units and short twin tailrace tunnels (360 m).

The conveyance of water through the tunnel will shortcut about 16 km of river stretch where the waterflow will be drastically reduced, one of the key impacts. The HPP scheme is planned to be operated in peaking mode, with an expected annual energy generation of 4504 GWh. The existing Kurichhu Hydropower Plant (KHP) reservoir finishes about 1 km downstream of Dorjilung HPP tailrace tunnel and will act as a large demodulation basin for Dorjilung HPP peaking operations.

The geological conditions are reported as suitable for the construction of the dam, Powerhouse, and Headrace Tunnel, with phyllitic schist providing a stable foundation on both banks and the use of durable quartzite for critical structures ensuring the integrity and long-term performance of the hydropower project.

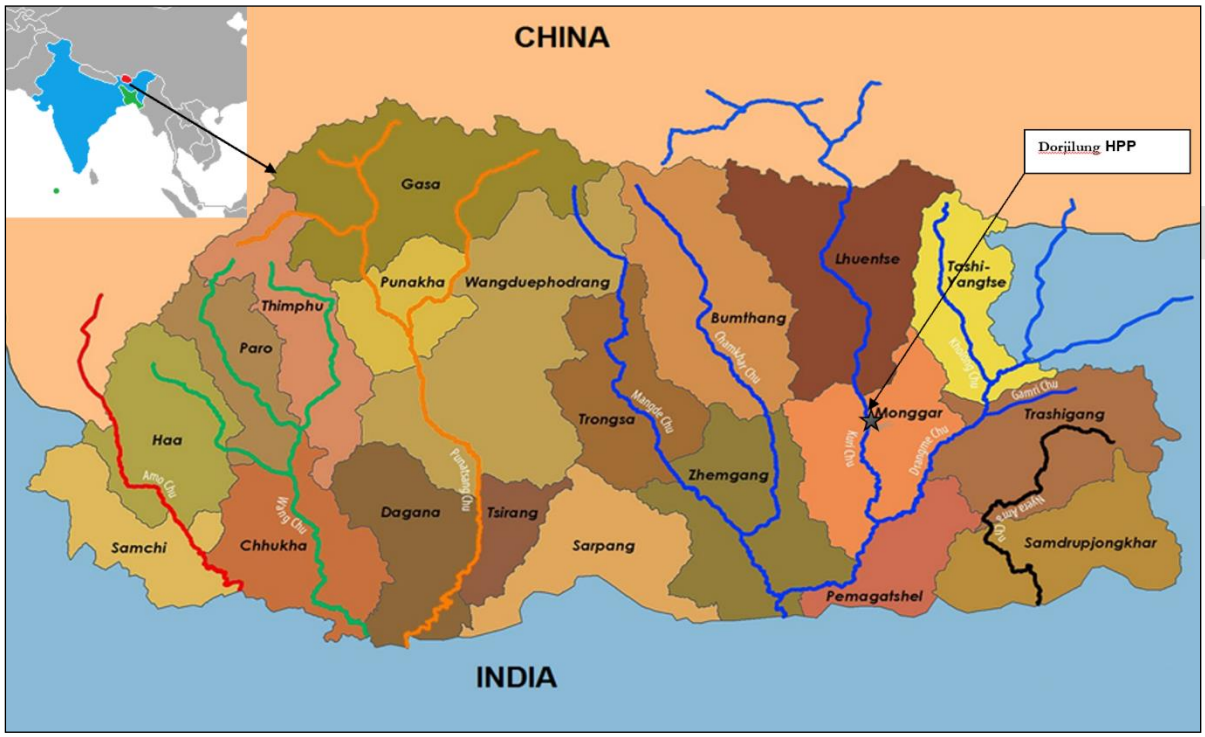


Figure 1: Location of Dorjilung HPP in Bhutan

Table 1: Dorjilung HPP synoptic table

ITEM	UNIT	DORJILUNG HPP
Design flood	m^3 /s	16,225
Check Flood	m^3 /s	20,123
Reservoir-gross storage	Million m^3	44.17
Reservoir-live storage	Million m^3	12.62
Reservoir area at FRL	ha	145.82
Full Reservoir Level (FRL)	m	EL. 850
Minimum Drawdown Level (MDDL)	m	EL. 840
Dam type	-	Concrete gravity (RCC and CVC)
Length of dam at top	m	241.0
Dam top	m	EL. 853.0
Maximum height of dam (above deepest foundation level)	m	139.5m of which 85m will be above the riverbed level
Spillway gates	-	6 gates(w) 9.0 m x (h) 15.10 m
Headrace tunnel	-	Single 14,974 m long concrete-lined with 11.0 m finished diameter
Surge Shaft	-	Single 135 m high restricted orifice with 4.1 m diameter
Pressure shaft	-	3 nos. 332.8 m long steel-lined of 5.5 m finished diameter
Powerhouse	-	Underground with dimensions 210.0(l) x 23.0(w) x 60.5 m(h)
Tailrace tunnel	-	2 nos., 350.0 m & 360.0 m long, horseshoe shaped with 8.0m m diameter
Normal tail water level	m	EL. 544.0
Dewatered reach between the dam and tailrace tunnel	km	About 16
Catchment area	km^2	8,782 (of which 5,813 km^2 is outside Bhutan)
Installed capacity	MW	6 vertical Francis units at 187.5 MW = 1,125 MW
Design discharge	m^3 /s	451
Gross head	m	300.45
Design Energy	GWh	4504
Firm power	MW	153
Construction Period	Months	60 months excluding 18 months of pre-construction activities

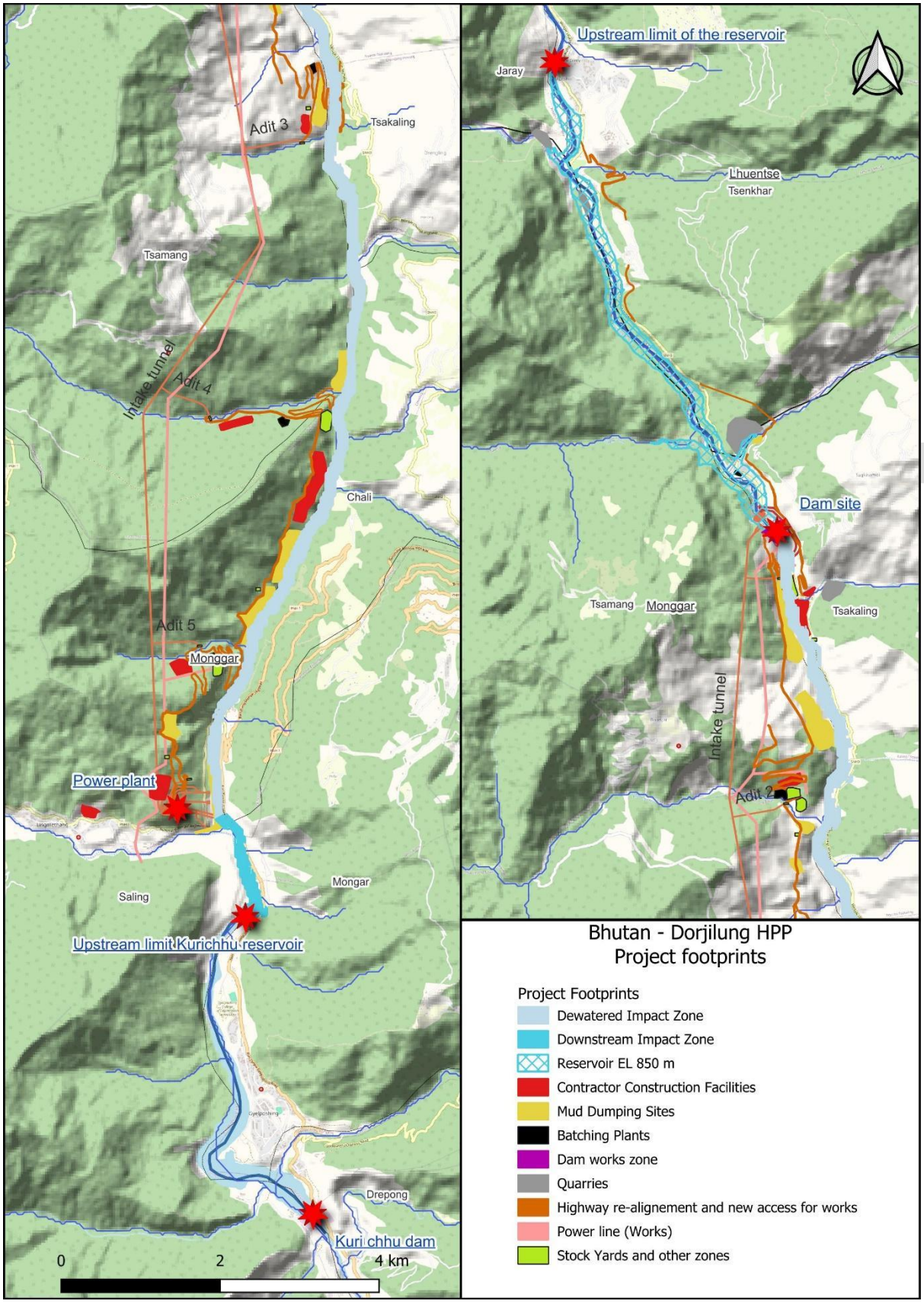


Figure 2: Detailed Layout of Dorjilung HPP

Project Areas of Influence

Three main Project Areas of Influence have been defined for the Project through an iterative process with consideration of the project components and operations, affected receivers and stakeholder engagement.

Table 2: Area of Influence

Area of Influence	Definition as per WB ESS1 Guidance note 23	Main description
Direct	- A direct impact is an impact which is caused by the project and occurs contemporaneously in the location of the project.	- This Direct AoI includes the direct footprint of the Project facilities (both temporary and permanent installations, including the submergence area as a result of the reservoir) and extends to a 5 km radius (land distance). - For terrestrial flora, the direct impact zone is generally limited to the footprint plus a buffer of 50 m to 100 m. - For Aquatic impacts the downstream extent of the AoI stops at the existing Kurichu HPP as it is considered that this reservoir will effectively act as a demodulation basin to the to the Dorjilung HPP peaking operations. The upstream extent of the AoI has been set at the Yungichu HPP (currently under construction about 30 km u/s of Dorjilung HPP). - For the socio-economic studies this includes 56 villages in 7 gewogs.
Indirect	- An indirect impact is an impact which is caused by the project and is later in time or farther removed in distance than a direct impact, but is still reasonably foreseeable, and will not include induced impacts.	- This Indirect AoI includes an additional buffer zone of 10 km (aerial distance) around the Direct AoI. In particular, this captures the broader Biodiversity Corridor #7 (some of it falls within the Direct AoI). - For aquatic biodiversity, in particular migratory species, the area of indirect influence may extend downstream and upstream in a watershed logic according to the migration patterns of the identified species and knowledge on their biology. The downstream extent of the AoI stops at the existing Kurichu HPP as it is considered that this reservoir will effectively act as a demodulation basin to the Dorjilung HPP peaking operations. The upstream extent of the AoI has been set at the Yungichu HPP (currently under construction about 30 km u/s of Dorjilung HPP). - For habitat, the area of influence of the project is also considered in an area of 5 km to 10 km around social influxes. - For mobile and threatened terrestrial fauna species or those with limited distribution, the area of influence may extend according to a logic of population dynamics, continuity of habitats, corridors or designated/proposed protected areas. - For the socio-economic aspects, the Mongar and Lhuentse districts were added.
Cumulative	- The cumulative impact of the project is the incremental impact of the project when added to impacts from other relevant past, present, and reasonably foreseeable developments.	- This Cumulative AoI includes the Kuri-Gongri HPP for the d/s boundary and the Yungichhu HPP for the u/s boundary. This also captures the ongoing Gyalsung Industrial Estate development at Lingmethang (which is also covered by the Direct AoI due its proximity to the Powerhouse). - This encompasses about 2 Districts. - See Section 11 of ESIA for further details.

Project Justification

Large-scale hydropower projects in Bhutan at the scale of the Dorjilung HPP have provided fiscal space and multiplier effects for the RGoB to invest in human and physical capital, allowing the country to significantly improve service delivery and educational and health outcomes. Hydropower projects drive economic growth through boosting general demand, both during the construction phase and when projects are commissioned.

Dorjilung HPP is proposed by RGoB as a project to serve both domestic demand and regional electricity trade, which will bring revenue to the government from multiple sources. The development and implementation of Dorjilung HPP will also provide job opportunities to local labour and professionals of both genders.

Dam Safety

The following **Dam Safety documentation**, as required under the World Bank ESS4, has been prepared and are included under Volume X of DPR update.

- Framework Instrumentation Plan.
- Construction Supervision and Quality Assurance Plan (ToR for consultancy service).
- Preliminary Operations & Maintenance Plan.
- Framework Emergency Preparedness Plan.

Project Alternatives

'No Project' Alternative

A 'no project' alternative would avoid significant negative impacts such as long-term change in the hydrology of the Kurichhu River, disruption/loss of habitat and biodiversity, and physical and economic displacement of communities. However, not developing the Dorjilung HPP will result in a significant gap for the national economic development of Bhutan. There is currently no alternative economic activity which could bring a similar amount of revenue and hard currency for the country.

The 'no project' alternative represents a significant risk for national development with negative flow-on effects to the country and the Bhutanese society.

Alternative Power Generation

Bhutan's installed electricity generation capacity stands at 2452.1 MW (2024) with the majority derived from hydropower (2450 MW). Diesel generators are the second largest source of electricity, contributing to about 9 MW. Electricity from renewables such as solar and wind contribute less than 1% combined. The theoretical potential for solar generation is estimated at 6,000 MW while the theoretical potential for wind power is estimated to be approximately at 761 MW. The mountainous terrain greatly reduces the potential for these renewable energies. While there is also potential to develop waste to energy, technology is not considered mature or robust enough for large scale development. Building and operating a hydroelectric facility rather than a thermal installation of similar capacity is more advantageous and less impactful in terms of both greenhouse gas emissions and air quality.

The Dorjilung HPP would have an ***emission factor of about 1.5 g CO_2eq/kWh*** *and* ***generate between 268 times and 672 times less CO_2eq over the lifetime of the plant than thermal generation*** *equivalent (natural gas, diesel or coal).*

Alternative Project Location and Equipment

The original development (2004 Master Plan) had a smaller installed capacity of about 400 MW with an intake on the left bank of the Kurichhu River and a short 1.6 km headrace tunnel. The (2011) prefeasibility

study considered alternatives for the dam and the powerhouse. One dam alternative (D-3) would have flooded the Autsho Township and D-2 was preferred over D-1 due to the occurrence of a landslide near the intake and poorer configuration of the spillway (for D-1). The preferred option was Alternative 2 with the D-2 dam location, and an underground powerhouse shifted downstream to Kurizam (PH-2) to maximise head. The DPR (2016) confirmed the current dam location (about 1 km upstream of Rewan) while the underground powerhouse site was shifted further downstream near the confluence of Kurichhu and Shongarchhu. The 'economic optimum' generation scenario would require Full Supply Level at 855 m asl but would also flood Autsho township and result in significant resettlement and economic displacement.

The Full Supply Level at 850 masl was selected (out of 9 scenarios) to minimise the land impacted by submergence and to avoid submergence of Autsho Township.

The updated (2024) DPR retains the same configuration for the hydropower scheme, but significant work was undertaken on the construction facilities with at least two alternatives considered for the: access roads, road bypass, muck disposal sites, construction contractor facilities and technical installations. One of the main changes was shifting many sites from the left bank to the right bank to reduce roads and travelling distances. Most preferred options result in reduced land clearing (totalling over 144 acres of avoided clearance), reduced impacts on private land and a decrease in potential impacts in terms of noise, air quality and traffic due to greater distance between these sites and inhabited areas. Decision was also made to house the national staff in the existing KHP premises and Autsho township thereby removing the need for the dam colony and the powerhouse colony. This is not considered a major issue in terms of labour influx or gender impacts as this concerns national workers directly hired and managed by DGPC. This reduces the land taken for the project by another 60 acres.

All up, over 200 acres of land clearing have been avoided through alternative selection.

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE PROJECT

The Environmental and Social Impact Assessment (ESIA) is a planning document providing decision-makers with the elements necessary to decide to initiate or stop the project.

The present ESIA report (2023-2024) provides a complete revision of the 2015 ESIA, is fully compliant with World Bank Environmental and Social Framework (ESF) obligations and with applicable requirements of the RGoB and is supported by several additional E&S documents.

Institutional and Legal Framework

This ESIA has been prepared to meet the World Bank Environmental and Social Standards. The recommendations in the ESIA are intended to ensure the Project meets Bhutan national obligations, World Bank Environmental and Social Standards, international treaties and conventions to which Bhutan is a party, and good international practice. A gap analysis of Bhutan national laws and regulations and the World Bank Environmental and Social Standards was prepared. Bhutan has a comprehensive legal framework governing E&S management which is aligned with most of the World Bank ESF principles. Bhutan has multiple regulatory tools and governance arrangements for E&S management, including on gender. One of the most notable exceptions is in relation to economic displacement, livelihood restoration and people using lands without a title. Bhutan is a signatory to several international conventions but is not a member of ILO.

Screening for the applicability of the ESS7 – Indigenous Peoples

A screening process aims at assessing if the ESS7 applies (according to paragraphs 8 and 9 of ESS7) was undertaken based on existing literature review, official documents, key informant interviews and results of focus-group discussions and household survey.

Bhutan's rich diversity, resulting from numerous waves of migrations, has fostered a tapestry of languages, traditions, and customs. This multicultural fabric, while distinct, does not align with the characteristics of "indigenous" as per ESS7. The ESIA research, incorporating socio-economic surveys, reveals no self-identification or reference to "indigenous" traits among groups like the Chhalipas and Kurmaedpas. Despite their unique dialects, these groups demonstrate considerable cultural, traditional, and customary congruence with the larger Sharchokpas group. Their assimilation into mainstream Bhutanese society, particularly in customs and traditions, and the absence of a unique connection to natural resources suggest a cultural and social integration that does not meet the ESS7 criteria for indigenous recognition.

The Dorjilung HPP, based on ESS7 screening, does not consider the Indigenous Peoples criteria applicable.

Public Consultation and Stakeholder Engagement

A Stakeholder Engagement Plan was prepared for the Project to ensure that appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible, and appropriate manner and format. The Stakeholder Engagement Plan was originally prepared based on the initial analysis of stakeholders from the DPR and existing ESIA. As a living document, it was updated and revised during the ESIA update. Stakeholder engagement will be a continuous process throughout the entire project cycle. The SEP also includes a plan for consultation and messages during the project implementation and operation phases. The SEP will continue to be updated and revised as and when required by DGPC as the Project progresses.

During the update of the ESIA numerous stakeholder consultation and/or engagement activities were carried out. This included key activities in the project area as well as additional meetings with Government departments/officials and organizations in person in Thimphu. Methods used included community consultations, formal meetings, one on one interviews, focus group discussions, consultation with individual households and site visits for verification and agreement. The main public consultation and stakeholder engagement activities included the following (as of March 2024):

- **13 public meetings with communities in the Project area**. This included focus group discussions (e.g. gender, business, seasonal calendar and general relation to the river and surroundings) and key informant interviews.
- **30 meetings with local government agencies, religious authorities, and businesses in the Project** area.
- A census of over 500 households in the Project area which also provided the opportunity to present and discuss the Project and potential concerns and questions from the community.
- **Direct engagement with 50 households directly affected by the Project** (loss of land and properties).
- **15 meetings with national government agencies** in Thimphu.

Outcomes of the consultations were summarised and considered in the ESIA. The main points included:

- **Overall support for the Project and eagerness to see the Project starts** (following 2016 consultations).
- **Concerns about pollution** (in particular **dust**), **blasting activities** and potential cracks to houses and religious buildings, water scarcity and **competition for water resources**, **insecurity** (for women and children), **robberies** (livestock and relics in temples), some **health** aspects and **inflation**.
- **Expectations** for local **business opportunities and employment** (with a view to have preferential hiring and contracting for local people and local business), **keeping the youths** in the area and having

more students for the local schools, some **local development** and **benefit sharing** including in terms of road widening, better access and having some Project facilities handed over (such as landfill).

PROJECT FOOTPRINT AND ASSOCIATED IMPACTS

Total Footprint Impacts

Table 3 documents the total Project footprint. The total footprint is 918.31 acres comprising 900.08 acres of State Reserved Forest (SRF) land and 18.89 acres of private land including institutional land.

Table 3: Total project footprint

Aspect	Key points	Est. impact amount (acres)
Reservoir	The submergence area extends 6.80 km	359.894
Dam works zone	For dam wall construction.	11.100
Portal	For tunnel access	1.782
New Access Roads	27.58 km of new access roads to various project components and work sites will be required to be constructed	96.044
Road realignment	5.4 km of public roads needing realignment due to project components	24.868
Muck disposal sites	12 MDS for access roads, HRT, Adits, Surge Shaft, Powerhouse	198.743
Non-residential buildings	1 temporary site office	4.706
Contractor Construction Facilities (CCFs)	9 CCFs are proposed to accommodate the contractor site offices, employee housing, labour camps, stores/warehouse, workshops, parking yards for equipment and fabrication yard	101.131
Aggregate Processing Plant (APP)	1 APP	1.745
Stockyards	Four stockyards will be used for material stockpiling.	21.456
Explosive Magazine	5 Explosive magazines	2.847
Batching Plants	5 batching plants	13.121
Quarries and borrow pits	2 quarry sites under assessment	26.900
Construction Power	Total length approximately 19.81km	58.74
Power Evacuation Transmission lines	The location extends south from Dorjilung HPP powerhouse to Durungri PS.	Unknown
	Total area (acres)	**918.31**[2]

[2] *This acreage is calculated after subtracting the area affected by two or more components to avoid double counting.*

Footprint impacts on natural habitat

Natural habitat losses and potential global risks on habitats in the project area

The total project footprint will mostly impact natural habitat (1497 acres; 96%) and to a much lower extent modified habitat (62 acres; 4%). Table 4 documents the total habitat area in the Area of Influence and the percentage of that habitat impacted by the Project (either by direct clearing or through dewatering). It also highlights the criticality and sensitivity of the impacted habitat and the potential global risk.

Table 4: Total project footprint

Habitats	Habitat in the AoI Area (in acres and % of AoI)	Habitat losses (1) Project footprint (100% loss) (2) Dowstream, dewatered and powerline sections (3) Total		Critical (criteria Ca and Cb)	Sensitivity	Potential global risk
		Acres	%			
River	1300 0.7%	**(1) 141.3** (2) 288.3 (3) 429.6	11% 22% 33%	Yes (Ca and Cb 3 Fish and 4 birds)	Yes High endemicity level	High
Chir pine forest	38,457 21%	**(1) 514.9** (2) 99.8 (3) 614.7	1.3% 0.3 1.6%	Yes (Ca 3 mammals and 4 birds	Medium Forest type widely distributed in Bhutan	High
Broadleaf forest	123,213 65%	**(1) 82.8** (2) 13.0 (3) 95.6	0.1% 0.0% 0.1%	Yes (Ca 3 mammals and 4 birds) Ca and Cb one plant	Medium Forest type widely distributed in Bhutan	High
Riparian Forest	889 0.5%	**(1) 83.8** (2) 243.9 (3) 327.7	9.4% 27.4% 37%	Yes (Ca 3 mammals and 4 birds	Medium Forest type widely distributed in Bhutan	High
Shrubs	6715 3.6%	**(1) 20.5** (2) 9.1 (3) 29.6	0.3% 0.1% 0.4%	May be use by mammals and birds including CHQ species but with less importance	Medium widely distributed and	Substantial
Agricultural land (Chhuzhing, Orchards and Kamzing)	8210 4.4%	**(1) 6.7** (2) 4.2 (3) 10.9	0.08% 0.05% 0.13%	No	No, modified habitat with some biodiversity value	Low

Impacts, mitigation and offset – natural habitat

The impact associated with project footprint on natural habitat cannot be avoided and reduced once the alternative is chosen. The residual impact on natural habitat is equal to the potential impact (**High**) and thus, to achieve the objective of no net loss, offsetting measure must be developed.

To achieve the objective of no net loss and in accordance with good practices and national regulations, a reforestation program must be put in place and undertaken. This program will be associated with a long term adaptative monitoring program validating the completion of the actions and the results in terms of natural habitat restoration.

Table 5: Objective of the afforestation program

Habitats	Riparian forest	Broadleaf forest	Chirpine forest	Shrub
Losses (Ha) (100% loss by footprint	83.8	82.6	514.9	20.5
Power line	0.9	10.7	65.4	Not considered
Dewatered section and downstream section	Not considered for offsetting/afforestation. Eflow mitigation measure will reduce enough the potential impact to consider that the residual impact will be negligible.			
Area of afforestation (Losses X2) (Ha)	171.2	186.6	1160.6	41
Note for habitat equivalence	The afforestation program should consider 16 km of riverine forest x 2 (river flooded by the reservoir) of Riparian Forest to be included in the Area of afforestation program			To be converted into Broadleaf or Chirpine forest

In addition to the project footprint, the dewatered section may have a significant impact on the surrounding environment. In a buffer zone of 50 m around the axis of the river, about 288 acres of river and tributaries would be affected as well as 248 acres of Riverine forest, 34 acres of Chir pine forest and 2 acres of Broadleaf forest. The reduced flows will have a wide range of impacts through modifications in air humidity, level of the alluvial aquifer, runoff on the slopes and sediment transport. The loss of these natural habitats is a **high** impact, the river and the riparian forest are sensitive habitats which have CH qualifying species and sensitive species.

Table 6: Potential natural habitat losses in the dewatered section

Natural Habitat losses in acres	Rivers	Riparian forest	Broadleaf	Chirpine	Shrubs	Total
Dewatered and downstream sections	287.9	243.0	2.3	34.5	4.1	571.8

The residual impact should be **Low** for the riverine broadleaf forest and Moderate for the river habitat.

Footprint impacts / land acquisition and livelihood restoration
Land and structures affected by the Project

The submergence created by the reservoir and the direct land requirements from the Project (considering all facilities including the power construction line) will result in a total of 53 Project Affected Households (PAHs) including two institutions and land lessee. The census of the 50 PAHs indicates approximately 157 Project Affected Persons (PAPs).

One two-storied traditional house belonging to one household including an attached kitchen, toilet, cowshed, water tank, poultry (unused) and two storage sheds are impacted by reservoir submergence and will require relocation. Additionally, reservoir submergence will also impact other infrastructures: an unused poultry farm including barbed fence on the left bank below Autsho town, barbed wire fence around an agricultural land below Autsho town, an automobile workshop (including four wooden sheds with Corrugated Galvanized Iron sheets, a concrete ramp for car wash, two wooden toilets and two servicing

channels) currently operated on a leased land of a private individual, and an Automatic Water Level Station located at old Autsho suspension bridge. Other infrastructures which include an unoccupied traditional house and barbed wire fence with wooden post and ruins of poultry farm (pillars and post) are identified to be temporarily affected by Contractor's Construction Facilities (CCF-2). A total of 342 fruit trees are identified to be impacted by the project.

The project will alter water flows and cause loss of aquatic habitats in the dewatered section. However, the practice of fishing is illegal in the river and very rare so there will be no or low impacts on fisheries.

The project will result in the direct submergence of about 3.72 km of the Highway of Mongar to Lhuentse near Autsho. The new Rewan to Autsho section of the Mongar-Lhuentse Highway will measure 6.15 km after realignment (vs. 6.80 km prior to the Project). It will include about 5.4 km of new road and a new tunnel of 750 m.

The Cultural Heritage Management Plan identifies 45 cultural heritage sites, of which a total of 23 sites are documented as important cultural heritage elements but no site will be directly impacted due to the project. There is one hot stone bath in the dewatered section likely to lose value as it will become disconnected from the river. Several intangible cultural heritage elements including religious practices, local festivals, local languages and dialects including knowledge of tradition arts and crafts are also identified. However, the project is not considered to have significant impacts on intangible cultural heritage.

Land Acquisition and Livelihood Restoration Plan

A Draft Land Acquisition and Livelihood Restoration Plan has been prepared based on the field surveys. This document outlines the eligibility and compensation matrix and the overall approach for Project Affected Households including in terms of consultation and grievance redress. The Project will ensure that all affected households are compensated adequately through the following process:

- Prior to the start of construction activities, DGPC along with the Dzongkhag Land Record Officers will determine the type of compensation and amount to be paid through consultation with affected households to agree on compensation.
- The Land Acquisition and Compensation summary and the approved Grievance Redress Mechanism will be made available to the community and will be disclosed publicly.
- Once agreements are reached with affected households, an agreement/Memorandum of Understanding on the purchase price or the compensation package will be prepared for signature between DGPC, Gewog and Affected households so that transactions can proceed.
- Activities to improve existing economic activities and developing alternative sources of income will be initiated by the Project.
- Once this has been agreed upon and approved by the Project it will be implemented. Activities expected to include preferential hiring and skills training, assistance for management of received financial compensation, support to develop existing economic activities and assistance for legalization of land.
- The implementation of the activities will be monitored and reported upon and any grievance arising during project implementation will be addressed through the Grievance Redress Mechanism.

The reconstruction of infrastructure such as the Highway of Mongar to Lhuentse and the feeder poles will be directly managed between DGPC and the relevant Government Agency (such as Bhutan Power Corporation).

PHYSICAL ENVIRONMENT CONDITIONS AND IMPACTS

Climate. The Project is located in the Humid Sub-tropical zone of Bhutan. Mean monthly air temperature varies from 31°C in August and 8°C in January with marked colder / hotter periods in winter and summer. Mean annual rainfall in the direct Project area varies between 840 mm (Autsho) and 900 mm (Monggar) while some part of the catchment receives up to 1700 mm in altitude.

Climate Change Risk Assessment. A climate change risk assessment was conducted separately from the ESIA using the IHA/WB guidelines. The projections indicate a wide range of clear warming trend for air temperature (up to +1.5°C by 2030 and up to + 4.5°C by 2050) while mean precipitations present more uncertainties with both increase and decrease projected (-10% to +30%). The climate is generally expected to be warmer and wetter in the Project area leading to earlier snowmelt and increase flows in the medium term followed by drying trends over the longer term. Energy generation from the Project is directly related to these trends with possible changes between -7% and +18% (for -10% and +20% precipitation / + 3°C vs. baseline). There is also a general increase of risk associated with Glacial Lake Outburst Flooding events.

Seismicity. Bhutan is situated in a highly seismically active region known for experiencing earthquakes of moderate to high intensity. Based on the records kept at the Department of Disaster Management (DoDM), MoHCA 2015, the specific project area has not encountered any significant earthquakes to date. The historical seismic activity in the region has not affected the project area, indicating a low to non-existent seismic sensitivity.

Geology, Soils and Topography. The study area falls under the Shumar Formation consisting of alternating layers of quartzite and phyllite/mica schist with some carbonate and gypsum bands. The formation is thicker in the Kurichhu valley, where it forms an anti-form and is affected by faulting and thrusting in the southern part of the area. The soil composition in the study area is dominated by sand and gravels, with minimum quantities of fine particles (silt and clay). Organic matter content of the soils is rather moderate to low. The topographical features of the region surrounding the project site are characterised by rising peaks and steep hills, stretching over an altitude range of 1,000 to 2,500 masl. Deforestation is not a major issue in the area, both slopes and catchment present a reasonable tree cover.

Hydrology. The controlled catchment of the Kurichhu River at dam site covers an area of 8,782 km^2. The area of the basin above 5,000 m elevation is 2,710 km^2 and the area between 768 m (dam location) and 5,000 m elevation is 6,072 km^2. About 66% of the catchment (5,813 km^2) lies in China. The length of the river from its sources to the dam site is about 218 km. The Mean Catchment Elevation of the Dorjilung controlled catchment is 4,350 masl. From its water sources to Dorjilung HPP, the Kurichhu flows with an average gradient of 21.15 m/km, which is a steep gradient. The mean annual flow at the dam site is 280 m^3/s with a mean maximum of 1350 m^3/s and a mean minimum of 60 m^3/s. The calculated Probable Maximum Flood (Design Flood) for Dorjilung HPP is 11,885 m^3/s. A 25–year return period flood (2,152 m^3/s) has been selected for the construction flood design event.

Natural Hazards. In addition to river flooding and Glacial Lake Outburst Flooding previously mentioned, the area is also prone to landslides and rockfalls due to the steep slopes and cliffs (several active areas in the Project area) and also to wildfire during winter (drier season).

Sediment. Sediments analysed from the Kurichhu river show sedimentary material mainly dominated by sand and gravel, with limited percentage of fine material. As a result, organic matter content is low, strongly reducing the organic pollution potential of the sediment. The yearly total suspended load varies from 3.18 MT to 18.37 MT; measured concentration of total suspended sediment varies from 0.35 to 6838 mg/l.

Water Quality. The whole catchment of the Kurichhu shows very low density of population and large forested area. Human activities are mainly agricultural, and no significant industrial activities are reported. The sources of pollution are thus very limited in the catchment, mainly domestic effluents from villages

and animal dejections from cattle and wild fauna. Based on the 60 water samples collected and analysed, water quality of the Kurichhu river in the Project area is of Class A quality, devoid of any significant pollution outside some organic contamination from human and animal origine. The results of analysis are compliant with NECS criteria applicable to Class A ambient water quality.

Air Quality. Based on direct sampling, the air quality of the Project area is excellent with the concentration of $PM_{2.5}$ in two sites slightly higher than the WHO guidelines but all other measurements much lower than WHO/NEC guidelines for NO_2, SO_2, CO and $PM_{2.5}$.

Noise. The recorded noise levels consistently remain below the National Environmental Commission's (Department of Environment and Climate Change, Ministry of Energy and Natural Resource) recommended guideline of 65 decibels (dB) and compliant with the World Bank Group General Environmental, Health and Safety Guidelines (55 dB for daytime noise level in residential areas). The noise levels in the Project area are generally low with no discernible threat to sensitive receivers.

Construction impacts on water, soil and air quality. The main impacts on water, soil and air quality from the Project are associated with construction activities such as accidental spills, leakage from fuel and hazardous materials leakage, increased erosion and sediment from excavation and earthworks. The mechanised works, open air blasting and heavy vehicle movements will create significant volume of dust, in particular during the drier part of the year (winter). Due to the small volume of the reservoir and a relatively short renewal time, no major impacts on water quality are expected during operation because of water stratification in the reservoir.

EFLOW

A High-Resolution Environmental Flow (EFlow) Assessment was carried out for the Project using the Building Block Methodology. This methodology is based on habitat simulations using is a fuzzy logic description that links the habitat preference of key species together with the habitat description. The Building Block Methodology included characterisation of the Physical, Biological and Human Environments followed by a workshop between the thematic experts, and a final summary of the results.

The EFlow objectives will be to (i) Maintain low water in the alluvial aquifer at sufficient depth with a minimum depth of 10 to 20 cm in rapids and pools (ii) Maintain flow peaks in the dry segment during the monsoon to conserve certain abiotic factors on the banks through significant and short flooding phases (iii) Take advantage of annual and exceptional flood events and sediment emptying phases to form these flood peaks in the short-circuited section. As an order of magnitude, 3 to 5 one-day flood peaks per monsoon with a peak flow of 80% of the river flood flow should make it possible to maintain the abiotic conditions of the banks (iv) The water intake for EFlow will the highest possible to avoid the dead volume of the reservoir, two meters below the minimum operating level should be considered during project detail phase.

The **EFlow concluded that in a dry season flow rate of 6 m^3/s should be maintained in the dewatered reach**, with sufficient variation to follow early monsoon freshes and the gradual decrease in the autumn, so as to reflect the natural pattern of the river and trigger biological changes. This base value of 6 m^3/s is determined from a 1-D hydraulic model. Beyond, this flow rate, the overall habitat value increases very slowly, because whilst the wetted area increases, the velocity and to a lesser extent depth become less suitable. This minimum flow will be supplemented by several tributaries located in the dewatered stretch and will depend on the rainfall and timing of the monsoon and, as a result, EFlow releases may not always be according to a predetermined monthly schedule.

The Kurichhu dam acts as an ideal demodulation dam and is located a short distance from the restitution. The short reach affected by hydropeaking is channelised laterally with riprap on the right bank and the road on left bank, reducing the effects of fish stranding. The presence of a right bank tributary immediately

downstream of the Dorjilung tailrace will, to some extent, help maintaining the flow outside of hydropeaking. In the hydropeaking reach, the focus should be on eliminating configurations such as draining pools that can trap fish.

BIOLOGICAL ENVIRONMENT CONDITIONS AND IMPACTS

Ecological Values / Terrestrial Habitat and Species

Impact on protected area. There is low risk of impact in addition of those already described in the project footprint. The main impacts on protected areas may result from the presence of workforce and labour influx leading to poaching and illegal collection of species, as well as an introduction of invasive species.

Impact on CHQ plants. There is no additional impact on the known station of *Hoya bhutanica* as it will be flooded by the reservoir (impacts already considered in the 'project footprint' section).

Specific impact on CHQ birds. Vultures and Pallas fish eagle have no nest in the project area that were identified through field surveys. The impact of noise, vibration and blasting on this species from clearing and filling reservoir activity will be low. For the Dark-rumped Swift, the nesting is limited to the cliff areas which are potentially in or close to the quarry sites.

Blasting and crushing may limit adequate habitat in a radius of 1 or 2 km around the blasting point depending on the sensibility of the species during breeding from March to May. The impact is considered as substantial due to its low probability but high intensity.

Specific impact on CHQ mammals. There are 3 mammals CHQ species, the Chinese Pangolin (*Manis pentadactyla*), Capped langur (*Trachypithecus pileatus tenebricus*) and the Tiger (*Panthera tigris*). The Chinese Pangolin and Tiger may be present on the project AoI but with a low probability. Direct impacts from works activities and physical environment alteration limited to the vicinity of the project are low. Indirect impacts resulting from the presence of workers and associated social influx may be high. Poaching is very low in Bhutan due to cultural factors, strong awareness and regulations. However, the presence of workforce during several years will increase the risk of creating a poaching.

Ecological Values / Aquatic Habitat and Species

Impact on CHQ fish. There are 3 CHQ fishes. *Creteuchiloglanis bumdelingensis*, *Parachiloglanis bhutanensis*, *Parachiloglanis dangmechuensis*, these 3 torrent catfish species are restricted range and found in tributary of the AoA but with no evidence of occurrence in the Kurichhu river. The strongest impact factor will be the risk of loss of hydraulic continuity and increased turbidity. The tributaries, in particular on the right bank, may be impacted by the access tracks crossings, by the earthworks and the spoil of the tunnel digging operations. Land clearing may also increase the water turbidity and impact the population of the 3 CHQ catfishes. The potential impact is considered as high.

Impact on natural aquatic environment

Construction activities associated with the Dorjilung HPP can have adverse effects on aquatic ecosystems, particularly on water quality. Land clearing, earthworks, temporary river diversion, cement manufacturing, and concrete pouring can degrade water quality (through reduced oxygen levels, hydrocarbons pollution and increased turbidity) and lead to fish mortality both at the project site and downstream. This can have significant consequences for many species living in the Kurichhu.

In the project area, a total of 11 fish species were identified, including those in the main Kurichhu River, its confluence, and tributaries. During the pre-monsoon season, 7 fish species were found in the mainstream Kurichhu River. These fish populations primarily consist of species like the torrent stone carp, Buduna, copper masher, Gadera, Khasi garra, snow trout, and Sucker throat catfish. The construction activities have the potential impact on these aquatic species, *Persicaria capitata,* semi-aquatic plant observed in the mainstream river and the riparian vegetation along the riverbanks. The relatively low fishing pressure and

limited dependence on fish by the local population may somewhat mitigate these effects. The significance of the potential impact is considered high.

Dorjilung HPP operation could pose certain risks to fish populations, including the potential for fish mortality. It's important to note that while these concerns exist, none of the fish species (with increased risks of mortality due to the turbines) in the area are currently classified as threatened according to the IUCN.

Conservation and Protected Areas

Phrumsengla National Park (also KBA). There is no direct impact on this National Park but 9% (83 km²) is inside the Area of Influence. Social influx may increase the pressure on natural environment. Direct impact on Corridor#7 may also induce changes in connectivity's. Potential impact is considered as low.

Biodiversity Corridor #7. The reservoir is located within Corridor 7. Changes in flow regimes may slightly impact the connectivity of some species, but the river in its current configuration already constitutes a significant barrier to connectivity. For some good swimming species, the low flow of the lake instead of the fast flow of the river, even if it is narrower, will be easier to cross. Further downstream, the shortcut segment will increase the connectivity between the two banks with numerous opportunities for crossing the river. The potential impact is considered as substantial for the Corridor #7 but only low (even positive) to moderate depending on the species.

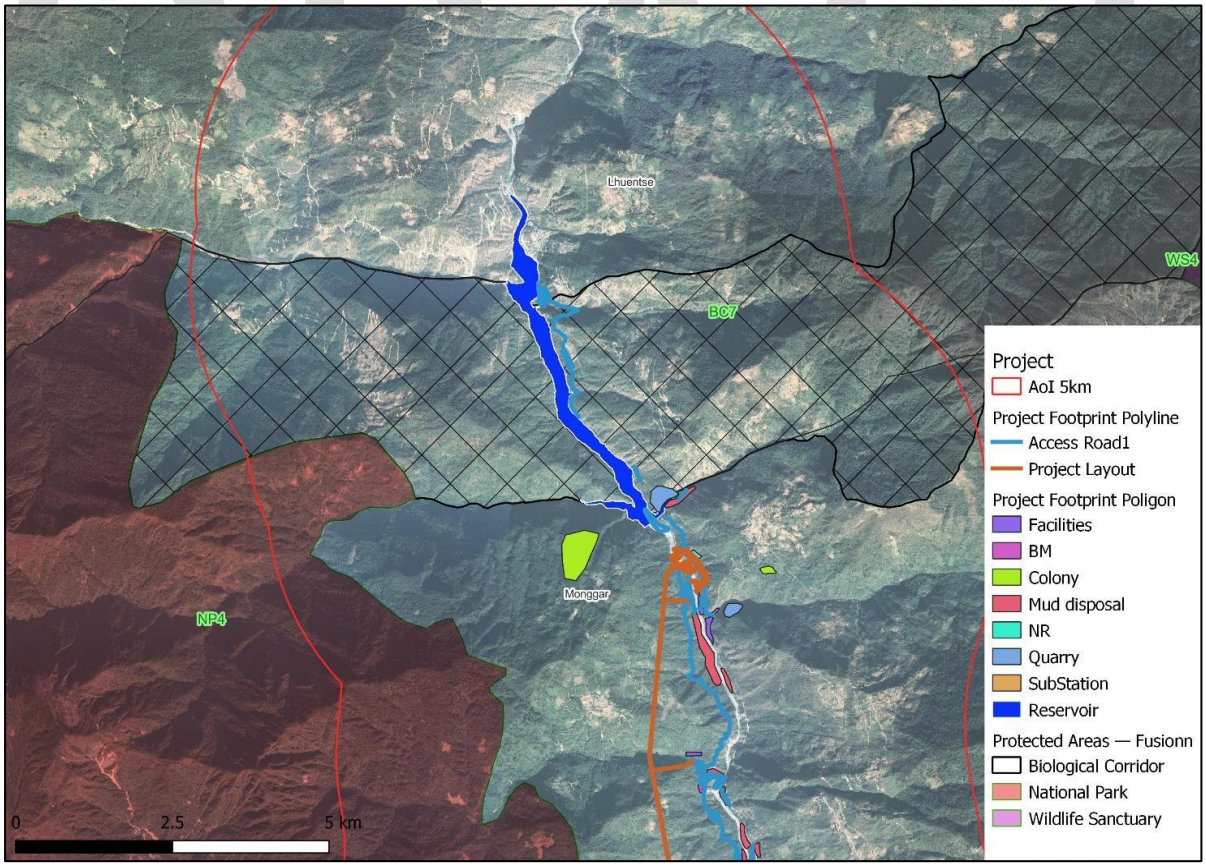


Figure 3: Biological Corridor # 7 in relation to the project components

KBA Pallas's Fish-eagle. Is impacted in its northern half by the dewatered segment and the powerhouse including restitution. The known nesting area is located closed to the lake of the Kurichhu dam. For this species, the most important feeding success occur in lake and wetland and with a lesser importance in river and stream. There is also a medium risk of modification of prey availability due to the dewatered segment and water level variations in the lake. It is also expected that the new lake upstream de project dam may

become a new feeding area as the most important feeding success occur in lake. Considering the feeding behaviour of this species there is a low risk of fishing success loss thank to its capacity to target various terrestrial and aquatic species in various aquatic habitats and the impact is considered as moderate.

HUMAN ENVIRONMENT AND IMPACTS

The project's area of influence comprises 2 Dzongkhags, 7 Gewogs, 42 Chiwogs, and 69 villages. According to the Bhutan Living Standards Survey (BLSS) 2022 estimates the districts of Lhuentse and Mongar are populated by 14,031 and 34,948 people respectively, with an average household size of about 4.4 people per household. Around two thirds of the population is rural and one third is considered urban.

Language disparities could lead to some challenges during Project implementation as some local communities do not use Dzongkha (the national language) fluently. This has been considered with Project's communication provided in multiple local dialects. About 38% of surveyed household members over 18 years old are non-literate (meaning they can neither read nor write) with more women (43%) than men (32%) being illiterate.

The local area generally shows relatively good level of socio-economic services. Some local schools are below capacity and would welcome new students, while others are overcrowded and struggling to cater for their existing students. The health services are insufficient in terms of human resources but the facilities are relatively good. A substantial majority (93%) of the participants reported no difficulties in accessing an adequate food supply (as opposed to the remaining 7% who encountered difficulties), reflecting a favourable food security situation within the communities. Most households surveyed are connected to the water supply system directly in their homes, or to their neighbours from whom they obtain water.

The entire study area is covered by the power grid, and all populations have access to it. During the survey, no report of any power cuts or network instability was made. Mobile phone coverage is 100% (also providing web access) in both districts.

The study area is predominantly agricultural. About 42% of interviewed households members are farmers, followed by 20% of civil servant and 15% working in a business (as owner or employee). Farming in the study area is mostly small-scale and traditional, focusing on self-consumption with some surplus for sale. Female participation is notably high in agriculture. Land ownership shows a higher percentage in rural areas, with a significant portion owned by women, indicating a possible matrilineal and matrilocal inheritance pattern in certain districts. All the Gewogs of the study area contain a high proportion of forest (from 75% to 95%), which is higher than the national level (71%). The cultivated land represents 1% in Lhuentse and 3% in Mongar.

Impacts associated with Construction Activities

Construction of large infrastructure projects is always associated with a range of impacts including:

- Increased risk of erosion and sediment load from excavation and earthworks.
- Construction traffic and earthworks leading to dust generation and other air quality impacts, high noise levels and impacts on water quality; potentially affecting local communities.
- Blasting and vibrations resulting in cracks and structural damages to roads, buildings, temples.
- Large amounts of waste (domestic, green and construction waste) and hazardous waste.
- Use of water and energy (fuel) with potential competition with the local communities for resources.
- Occupational health and safety risks and employment issues for workers.
- Community health and safety risks in relation to traffic, hazardous materials, live electrical equipment, open excavation, heavy machinery, etc.
- Camp management (including sanitary conditions and security management).

However, these impacts are routinely managed with existing and mature mitigation measures. While it will require detailed planning and careful implementation, these impacts should be managed to an acceptable level during the construction stage.

Labour Influx

The staff requirement for the peak construction period is estimated to be around 460 persons for the national staff (only national staff would be allowed to bring their families, including children). The Project is expected to recruit more than **6300 workers (mostly foreign labour) in addition to the 460-national staff**, spread over various project locations, with the maximum at the dam site and the powerhouse locations.

The main substantial impacts are:

- **Increased risks of communicable diseases**. Construction sites and international transit routes are associated with marked increase of transmittable diseases, in particular sexually transmitted infections.
- **Gender based harassment and violence**. Construction workers are predominantly younger males. Those who are away from home on the construction job are typically separated from their family and act outside of their normal sphere of social control. This can lead to inappropriate and criminal behaviour, such as sexual harassment of women and girls, exploitative sexual relations, and illicit sexual relations with minors from the local community.

A large influx of male labour may also lead to an increase in exploitative sexual relationships and human trafficking whereby women and girls are forced into sex work. Rapes involving foreign workers during the construction of the local highway near Lingmethang were reported during consultations.

Additional impacts associated with labour influx include loss of cultural heritage, disruption of cultural values, general insecurities and public unrest, increased poaching and illegal collection of natural resources, tension during demobilisation, long term settlement of workers creating tension and inflation on local prices.

Gender, Sexual Exploitation, Abuse, Harassment and Vulnerability

A **Gender, Sexual Exploitation, Abuse, Harassment and Vulnerability Action Plan** was prepared as the **Project is considered to present high risks of gender-based violence and sexual exploitation, abuse, and harassment**.

The plan provides an overview of the gender and vulnerability situation at national and local levels, identifies project-related impacts/risks and gender gaps, proposes specific actions to address gender gaps and vulnerability, enabling local women/youths and People with Disability to have a voice and a role in decision-making, and creating an environment in which women, youths and People with Disability can benefit from the Project, access employment opportunities, and develop their income-generating activities over the long term. It includes indicators to monitor progress and also identifies stakeholders, possible service providers and assess their capacity to support implementation and aid in grievance redressal. The plans also aim at improving the capacity of the Project to manage and monitor women and vulnerable groups issues and associated risks.

A sub-plan targets gender, sexual exploitation, abuse, harassment, and vulnerability risks for the project.

Cultural Heritage

A dedicated field survey identified 45 cultural heritage sites, of which 4 are less than half a kilometre away from the Project, 8 are between 0.5-1 km away, 9 are between 1-2 km, 21 are between 2-5 km and 4 are more than 5 km away. **A total of 23 sites were documented as important cultural heritage elements**

but no site will be directly impacted or destroyed because of the Project. There is one hot stone bath in the dewatered section likely to lose value as it will become disconnected from the river.

When exploring both tangible and intangible relationship of the community with the Kurichhu River, aside from hot bathing spots, no intrinsic religious or spiritual characteristics of the river itself were mentioned.

Several intangible cultural heritage elements were also identified as part of the surveys including religious practices, local festivals, local languages and dialects, as well as knowledge of tradition arts and crafts such as Thangka painting, pottery, weaving, mask making, calligraphy, metalworking, bamboo crafts. **The Project is not considered to have significant impacts on intangible cultural heritage.**

Socio-economic Opportunities

The project will **positively impact short-term employment by creating jobs** for the civil works and will mobilize up to 460 national workers and more than 6000 foreign workers. The individuals employed, and their household members, will benefit from increased income that is likely to increase their overall standard of living, access to healthcare and educational resources, and reduce their socio-economic vulnerability.

Social influx into local communities will create **opportunities for local suppliers** to meet the increased demand for various goods and services. This usually includes a range of opportunities such as **provision of food and materials but also opening of small shops and restaurants**. The **creation of guest houses** for Project workers has an impact on local communities, as this accommodation creates jobs for its construction, management and stewardship. The **leasing and renting of land** by the local communities for the Project facilities can enable local communities to increase and/or stabilize their income.

The **provision of basic services can also be maintained or increased by the social influx**, as workers, camp followers and their families will need those services (healthcare, education, transportation, etc). It is anticipated that the children of the national workers (460 workers expected at the peak of the construction period) will be enrolled in the schools in the project area, primarily at the dam site and the powerhouse but potentially also at other locations (e.g. secondary colonies). This should have a positive impact on school classification and level of resources (based on number of students). The construction phase, including the social influx of population, can bring Civil Society Organizations (CSOs) and Non-Governmental Organizations (NGOs) to develop their activities in the area and have a positive impact for local communities.

IMPACTS ON ECOSYSTEMIC SERVICES

Ecosystem services are the benefits or advantages that human (people, communities, businesses) derive from ecosystems such as provisioning services (food, drinking water, medicinal plants, building materials), regulating services (e.g. water and air quality or natural hazards mitigation), cultural services (spiritual, recreational…) and support services (e.g. genetic exchange pathways). Some impacts on ecosystem services are already captured in other sections of the document (e.g. loss of grazing areas and arable land).

The Project will have direct and indirect impacts on several ecosystem services (such as collection of wood and fibre wood, erosion control or water regulation) but the **impacts are considered minor and no additional mitigation measures are identified as necessary in response to impacts on ecosystem services**. The mitigation measures implemented for other impacts will be sufficient.

CUMULATIVE IMPACTS

The Cumulative Impact Assessment (CIA) for the Dorjilung Hydropower Project (HPP) has been prepared as an addendum to the original CIA for the Kuri-Gongri Basin (SWECO, 2018). This was prepared due to the need to specifically address the cumulative impacts associated with this project, which were not comprehensively covered in the original CIA. The initial CIA provided a broad assessment of the cumulative impacts of multiple hydropower projects within the Kuri-Gongri basin, but it lacked detailed,

project-specific data on the Dorjilung HPP. This addendum aims to bridge that gap by incorporating recent data and analysis for the environmental and impact assessment of Dorjilung HPP, ensuring a thorough evaluation of the Dorjilung HPP's potential cumulative impacts on the basin's environment and communities.

The Dorjilung HPP is a significant project within the Kuri-Gongri Basin, and its cumulative impacts need specific attention. This addendum allows for a detailed examination of these impacts, particularly in relation to other hydropower projects in the basin. It provides a focused assessment on how the Dorjilung HPP interacts with existing and planned projects, which is essential for understanding the full scope of environmental and social changes regarding conduction perspectives and river basin perspectives.

The cumulative impact assessment adopts two distinct perspectives: a **construction perspective** and a **river basin perspective**. From the construction viewpoint, it addresses the cumulative impacts of the Dorjilung Project with other large construction endeavours in the local area (six regional developments projects in the next 20 years were identified and confirmed in consultation with government officials). The river basin perspective delves into the broader impacts, specifically examining the cumulative effects of the Dorjilung Project and other hydropower initiatives within the Kuri-Gongri Basin. For the river basin perspective, the cumulative impact assessment strongly builds on the previous Kuri-Gongri Cumulative Impact Assessment Report (SWECO, June 2018).

For the Dorjilung Project, three VECs have been identified as experiencing beneficial cumulative impacts, while eight VECs assessed to face a range of slight to significant negative cumulative impacts. Mitigation measures are required at the project and regional level to effectively reduce the extent of cumulative impacts of hydropower development in the Kurichhu watershed. Table 7 summarizes the significance of cumulative impacts for each of the VEC and compares the Kuri Gongri Scenario 1 case to the Dorjilung Addendum case.

Table 7: Cumulative impacts to selected VECs

Selected VECs	Cumulative Impact Significance (CIA 2018)	Update (2024) with Dorjilung Construction perspectives
Forest Cover	Slight negative impact.	Slightly negative impact
Slope Stability	Slight negative impact	**Major Negative Impact**
Migratory Fish	Major negative impact	**Significant Negative Impact**
Scenery and Landscapes	Moderate negative impact	**Major Negative Impact**
Protected Areas	Major negative impact	**Moderate Negative impact**
Livelihood Opportunities	Positive impacts	Significant Positive impacts
Community Quality of Life	Significant negative impact	**Major Negative Impact**
Access to Markets and Services	Positive impacts	Positive impacts
Cultural Heritage	Moderate negative impact	Slight negative change
Downstream Public Safety	slight negative impacts	**Significant negative impact**
Economic Growth	Positive impact	**Major positive impact**
Domestic Electricity Supply Security	Positive impact	Not Assessed

The main recommendation for the management of cumulative impacts emphasizes the importance of developing a program for aquatic and fish species, which complements the mitigation plans for the Dorjilung HPP and contributes to a larger basin and state-wide strategy for managing aquatic habitats. This program would not only serve the needs of individual projects of Dorjilung but also contribute to a broader, coordinated effort at the regional level, enhancing the knowledge and conservation of longitudinal migratory species, lateral migratory species, and species with restricted range. To do so, the following key recommendations are suggested:

- An **Aquatic and Fish Management Plan** aims to address the conservation and monitoring of aquatic life, with a particular focus on migratory species. The goals of this plan are to improve the understanding of species behavior, population dynamics, and the effects of hydropower operations on aquatic ecosystems. This may include interventions to improve fish productivity such as installation of a hatchery or fish capture and release strategies.

- Additionally, a **Cascade Management Plan** is proposed to coordinate the operation of Kurichhu, Dorjilung, Kuri Gongri, Khomachhu and Yungachhu projects (HPPs) within the Kurichhu basin. This plan will focus on managing flood risks, optimizing sediment transport and flushing strategies, maintaining riverine health, and ensuring effective fish monitoring and ecological management to support biodiversity.

- Strategies for **River Connectivity** are crucial for maintaining or enhancing river connectivity, which is essential for migratory species. The goals include ensuring that species can complete their life cycles without significant disruption from hydropower operations. This will involve engaging in knowledge sharing with other hydropower projects and relevant agencies to build a comprehensive understanding of the regional ecosystem. The strategy includes developing shared databases, research initiatives, and capacity-building programs. Collaboration with environmental agencies and local communities is also recommended to develop and implement conservation programs, integrating various perspectives and expertise into management strategies for more effective and sustainable outcomes.

- The **Long-Term Management Plan for Restricted Range Catfish Species** includes several key objectives. Additional investigations are necessary to assess the distribution of restricted range catfish species in other watersheds to validate their status. Assessments of lateral movements are needed to understand the relationship between species and the main river downstream of the tributaries, ensuring all life cycles are completed and genetic diversity is preserved. Dedicated monitoring is required to track population levels in tributaries, ensuring that residual impacts remain insignificant to minor. A preservation strategy for upper watersheds must be defined, along with recommendations for hydropower projects to maintain lateral connectivity.

- To further support these efforts, a **Research Program** should be financed in collaboration with universities, the National Research Center for Riverine and Lake Fisheries (NRCRLF), the Department of Forest and Park Services (DOFPS), and the Department of Water (DoW). This program will aim to improve knowledge of restricted range catfish species. Additionally, a National Conservation Action Plan should be created, dedicated to these species and other similar species. Inventories and mapping of restricted range species in similar tributaries in Bhutan should be prioritized, especially in already protected areas. A national strategy for the conservation of these species should be developed, which includes designating additional upper watersheds for conservation, free from hydropower equipment and other activities that could impact these species and ensuring long-term management of these newly protected areas.

- The CIA identifies a two-step approach to managing cumulative impacts across the Kurichhu basin. The first is to employ project level mitigations for the Dorjilung HPP. The second is to develop a broader **Cumulative Impact Management Plan** across the Kurichhu basin involving the collaboration and cooperation of DGPC together with a range of government institutions.

- Finally, the Hydropower Master Plan 2040 should also address options for the **Preservation of One Or More Free-Flowing Rivers** without hydropower development on the river mainstem. Options for hydropower development on tributaries in coordination with solar power

development could provide further assurance of energy security while also promoting ecotourism and other opportunities.

By incorporating these additional measures and recommendations, the Dorjilung HPP can effectively mitigate its cumulative impacts, not only at the project level but in collaboration with other project developments and activities in the Kurichhu basin.

ENVIRONMENTAL AND SOCIAL MANAGEMENT (ESMP)

The role of the ESIA process is to identify potential impacts that may result from the implementation of the Project and to develop a set of mitigation measures that are technically appropriate, financially acceptable and concretely applicable in the context of the Project. The ESMP has a very different role. It is an **operational document** which aims to define the operational context for the implementation of the measures.

Building on the above principles, the ESMP covers all measures aimed at preserving the integrity of the physical, biological and human environment in the project area of influence. The ESMP:

- Aligns with ISO 14001 and compliance with applicable government regulations, international and industry standards.
- Ensures the prevention of negative impacts (direct and indirect) on the environment, on affected communities, on labour and in relation to health and safety.
- Ensures the prevention of risks, incidents through appropriate mitigation measures.
- Maintains information sharing among stakeholders.

A number of stand-alone documents have been prepared during the ESIA study, as required by the World Bank ESF which form, with the ESMP, part of the ESIA documentation:

- Biodiversity Management Plan (BMP).
- EFlow Management Plan (EFMP).
- Stakeholder Engagement Plan (SEP).
- Labour Management Procedures (LMP).
- Gender, Sexual Exploitation and Abuse (SEA)/Sexual Harassment (SH) and Vulnerability Action Plan (GSVAP).
- Cultural Heritage Management Plan (CHMP).
- Grievance Redress Mechanism (GRM).
- Land Acquisition and Livelihood Restoration Plan (LALRP).
- Local Development Plan (LDP).
- Addendum to Cumulative Impact Assessment.

The proposed organization for the ESMP responds to the contemplated arrangements for the delivery of the Project with three levels of organization for Environmental, Social, Health and Safety (ESHS) management. DGPC, through its Project Management Unit (PMU), will manage all E&S aspects including (i) general supervision of activities to be carried out prior, during and after construction of the project and (ii) coordination with other stakeholders including concerned Government Central and local Agencies, World Bank and other IFIs involved.

DGPC will be supported by an Owner's Engineer (if DGPC performs the Owner's Engineer function itself, all relevant tasks assigned to the Owner's Engineer also need to be transferred to DGPC PMU). The Construction Contractor is appointed by DGPC. At this stage of the Project development, the most probable organisation will be the recruitment of a Contractor which will provide engineering, procurement

and construction and deliver a completed project on a turn-key basis. The Contractor will manage bidding procedures, selection and management of all its subcontractors, including for ESHS. The ESMP documents in detail all key ESHS management procedures and activities:

- Communications.
- ESHS data management, documentation, and reporting.
- Grievance redress mechanism (see hereafter).
- ESHS supervision.
- ESHS non-compliance procedure.
- ESHS change management procedure.
- ESHS staffing, recruitment, and training.
- Senior management ESHS review, auditing, and document updates.
- ESMP program and budget.

E&S Roles and Responsibilities

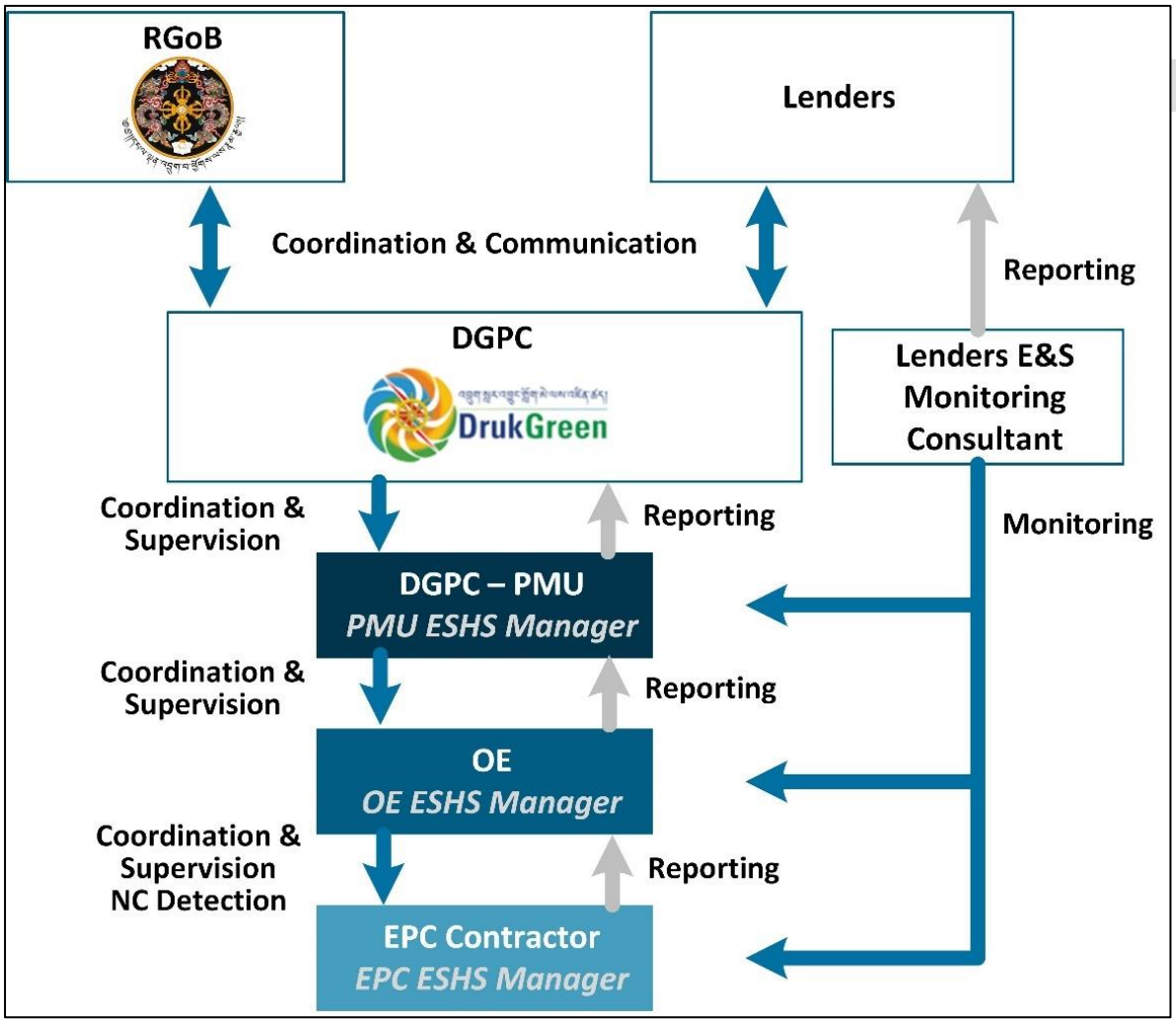


Figure 4: E&S Roles and Responsibilities

The ESMP proposes 3 complementary Action Programs that are adapted to the development phases of the Project (pre-construction and preparatory, construction and operations):

- The Preliminary Program of Action (PPA), which includes all the measures recommended during the early stage of the Project before the start of construction works. These measures concern the

organization and capacity building of the teams which will be responsible for ESHS management during construction and operation, as well as all the complementary studies and surveys identified during preparation of the ESIA and deemed necessary prior to construction works. It comprises 4 specific plans.

- The Program of Actions adapted to the Construction period (PAC), which defines the principles of organization and the environmental inspection procedures for the construction sites. This PAC also defines the overall contractors' obligations in relation to environmental and social management of the construction sites and colonies. It comprises 26 specific plans.
- The Program of Actions adapted to the Operation period (PAO), which defines the environmental quality controls applicable during the period of operation of the structures and necessary to monitor the environmental efficiency and performance of the corrective measures put in place. It comprises 10 specific plans.

GRIEVANCE REDRESS MECHANISM

The Project has several grievance redress mechanisms: an overall mechanism, a stand-alone mechanism for Projects' workers and a dedicated mechanism for gender harassment and violence. The grievance redressal mechanism is depicted in the figure below.

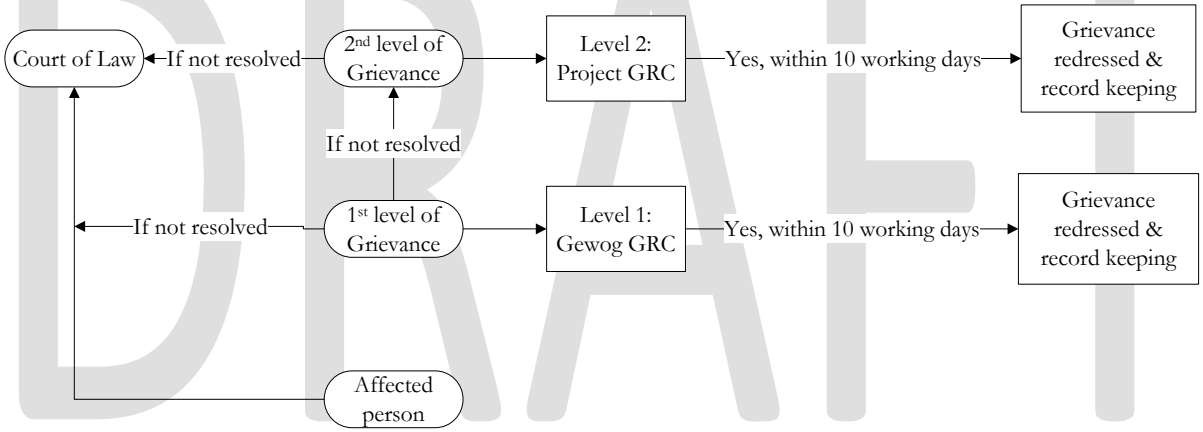


Figure 5: Two-tiered GRM of the Dorjilung Hydropower Project

CONCLUSIONS

The ESIA further confirms the proposed development at 850 m FSL as the optimum option for Dorjilung HPP development considering technical, economic, environmental, and social aspects. While the Project will result in some high impacts (including unavoidable loss of habitat and properties), the range of impacts remains relatively limited and acceptable, further considering the installed capacity (1125 MW) and the expected annual energy generation of 4,504 GWh.

From an E&S perspective, the main impacts are the loss of natural habitat and impact on critical species and the loss of land and properties for about 78 households including 2 institutions: with one household requiring resettlement. This is mostly the consequence of the project footprint and the creation of a 16 km dewatered section of river. While the project will bring some opportunities for local employment and economic development, there are also significant impacts associated with the large number (6300+) of construction workers mobilised during the main construction phase.

The proposed mitigation, management, and monitoring measures are sufficient to respond to key impacts from the Project while allowing its objective of increasing renewable generation in the region. The ESMP, LALRP and associated plans constitute a robust framework for adaptive management minimising adverse consequences on the physical, natural, and human environments.

A. DORJILUNG HPP – CONTEXT AND PROJECT

Introduction

Legal/institutional framework and performance standards

Project description

Project justification

Alternatives Analysis

1 INTRODUCTION

The Royal Government of Bhutan (RGoB) with support from the World Bank, issued National Guidelines for the Development and Construction of Hydropower in 2018 that incorporate Good International Industry Practices (GIIP) including on integrating Environmental and Social (E&S) considerations to avoid or mitigate negative impacts.

In 2020, the RGoB, through the Department of Hydropower and Power Systems (DHPS) of the Ministry of Economic Affairs (now known as the Department of Energy under the Ministry of Energy and Natural Resources), requested World Bank assistance to develop its human and institutional capacity by applying this renewed framework to develop specific projects. The proposed 1,125 MW Dorjilung Hydropower Project (Dorjilung HPP, the Project) was selected as a priority development and will be developed, implemented and operated by Druk Green Power Corporation Ltd. (DGPC).

ARTELIA (with Phuensum Consultancy Services (PCS) as its Bhutanese partner) was engaged in 2023 to revise the E&S documentation for the Project including the Environmental and Social Impact Assessment (ESIA) and associated reports to meet the requirements of World Bank Environmental and Social Framework (ESF) and applicable requirements of the RGoB. The revised E&S documentation will form part of the Dorjilung HPP Detailed Project Report (DPR, equivalent to a feasibility study).

In 2015, DGPC submitted the DPR of Dorjilung HPP. The study was carried out by DGPC in association with M/s Energy Infratech Private Limited, India. The DPR provided an environmental and social impact screening and a mitigation planning in compliance with the Asian Development Bank (ADB) and the Government of Bhutan requirements. The results were presented in DPR Volume VIII (Component 1: Environmental Impact Assessment, Component 2: Social Impact Assessment), Volume VIIIA (Environmental Management Plan) and Volume VIIIB (Resettlement Plan).

The present ESIA report (2023-2024) provides a complete revision of the 2015 ESIA, is fully compliant with World Bank ESF obligations and with applicable requirements of the RGoB and is supported by several additional E&S documents presented and discussed later in this report.

1.1 General Overview of the Project

The Dorjilung HPP is a proposed Run of River hydropower development of 1,125 MW on the Kurichhu River in Eastern Bhutan (Mongar and Lhuentse Dzongkhags). It involves the construction of a 139.50 m high concrete dam (85 m above riverbed) and the creation of a 44.17 million m^3 reservoir. Water will be conveyed through a 14.974 km long headrace tunnel (HRT) on the right bank of the river, connecting to an underground powerhouse with 6 Francis units and 2 nos. tailrace tunnels (TRT) (350.0 m and 360.0 m). The conveyance of water through the tunnel will shortcut about 16 km of river stretch where the waterflow will be drastically reduced, one of the key impacts. The HPP scheme is planned to be operated in peaking mode, with an expected annual energy generation of 4,504 GWh. The existing 60 MW Kurichhu Hydropower Plant (KHP) reservoir, which tail is located about 1 km downstream of Dorjilung HPP TRT, will act as a large demodulation basin for Dorjilung HPP.

The dam site is located at Rewan, at about 36 km upstream of KHP. The Powerhouse will be situated near Lingmethang (about 10 km upstream of KHP). The project construction should be completed within a period of 60 months (5 years), excluding 18 months pre-construction activities. The location of Dorjilung HPP in Bhutan is depicted in Figure 6 and the general arrangement of the project is presented in Figure 7.

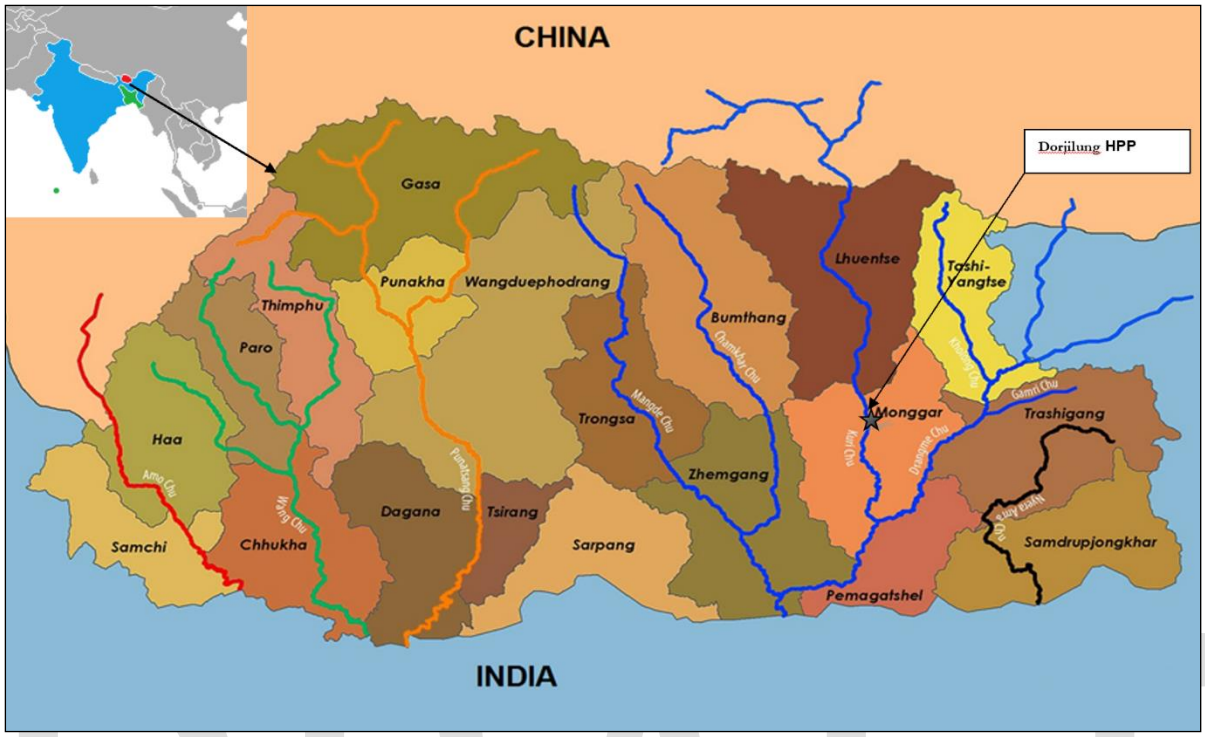


Figure 6: Location of Dorjilung HPP in Bhutan

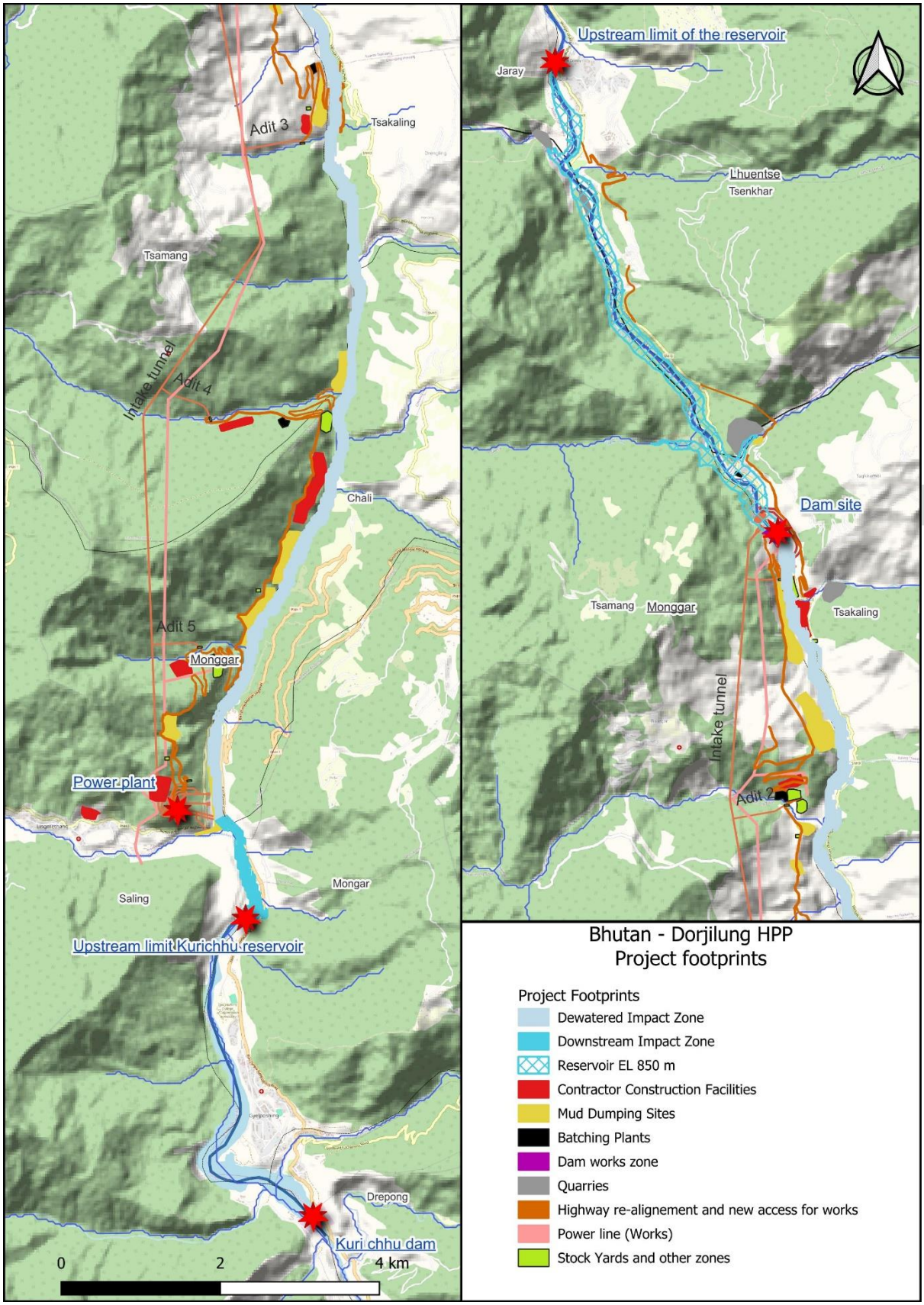


Figure 7: General arrangement of Dorjilung HPP

1.2 Project Proponent

1.2.1 Druk Green Power Corporation

Druk Green Power Corporation Limited (DGPC) is an electricity utility company that operates and maintains hydropower assets of Bhutan. It was established in January 2008 through the merger of the three hydropower corporations of Basochhu, Chhukha and Kurichhu. Tala was merged with DGPC in 2009 and Mangdechhu and Embedded Generation in 2022. Its Vision is to "Promote, develop and manage renewable energy projects, particularly hydropower, in an efficient, responsible and sustainable manner, and to maximise wealth and revenues to the Nation". With an installed capacity of 2,444 MW, the company's mission is to efficiently manage existing hydropower plants and accelerate hydropower development in Bhutan by developing new hydropower projects. As more projects were planned and developed and the electricity grid expanded to cover every nook and corner of the country, Bhutan embarked on restructuring the sector at the start of the 21st century through the adoption of a number of new policies and legislative interventions.

DGPC currently operates the following key hydropower plants:

- Kurichhu (60 MW)
- Basochhu (64 MW)
- Nikachhu (118 MW)
- Dagachhu (126 MW)
- Chhukha (336 MW)
- Mangdechhu (720 MW)
- Tala (1020 MW)

1.2.2 DGPC E&S Management

DGPC is committed to contribute towards fuelling the energy needs of Bhutan and the region by harnessing the energy in an environmentally and socially sustainable manner. DGPC supports social emancipation and community vitality through various initiatives of its own and also in collaboration with other partners. DGPC recognises the importance of protection of catchments as it provides steady precipitation – a perennial source of water for the river system. Further, preservation of the catchments reduces soil erosion, which would otherwise decrease the life of underwater equipment of DGPC plants.

1.2.3 DGPC Corporate and Social Responsibility

DGPC, in fulfilling its vision and mission, plays a major role in supporting the communities through its Corporate Social Responsibility (CSR) initiatives. DGPC continues to improve the quality of life of the communities through long-term value creation for all stakeholders. This objective is for aligning DGPC's CSR with Bhutan's overarching development policy of "Gross National Happiness." Towards achieving this, DGPC continues to support community related religious, educational, social, and environmental activities that are in the greater interests of the Bhutanese public through donations and contributions.

In addition, DGPC conducts *Baza Guru Dungdrup* and *Drupchhen* at Chhukha Zangdopelri, and *Mani Dungdrup* at Rinchentse lhakhang annually. Further, the disaster management teams at the hydropower plants provide rescue and support during accidents, fires and other emergencies along the Thimphu-Phuentsholing highway.

Facing COVID-19 pandemic, DGPC took necessary measures to limit the impact of the pandemic on its employees and businesses and ensure strict compliance to all safety and health protocols. In consultation with the shareholder Druk Holding Investment Limited (DHI), DGPC introduced timely and essential measures for the safety and wellbeing of its employees.

DGPC also contributed Nu. 550 million to DHI's efforts in providing support to the COVID-19 Relief Fund. An incinerator valued at Nu. 2.42 million was donated to the Ministry of Health to be used for incinerating Covid-19 related waste from the hospitals.

As an institutional partner of Women in Power Sector Professional Network in South Asia (WePOWER), DGPC nominated five female employees as counsellors to raise awareness on workplace on sexual harassment and promote safe working environment.

1.3 Context and organisation of the E&S Documentation

1.3.1 Context and Objectives of the ESIA

The Environmental and Social Impact Assessment (ESIA) (with accompanying complementary studies) is a planning document that provides decision-makers with the elements necessary to decide to initiate or discontinue the project. The state of the physical, biological and human environment at the start of the project is described in detail, the potential impacts are technically analysed, and the proposed mitigation measures are clearly justified.

1.3.2 Previous E&S Documentation for the Project

As mentioned in the introduction above, the following documentation is available from the previous Dorjilung HPP DPR:

- Environmental Impact Assessment (2015)
- Social Impact Assessment (2015)
- Environmental Management Plan (2015)
- Resettlement Plan (2015)

A Cumulative Impact Assessment (CIA) was prepared in 2018 for the Kuri-Gongri Basin by SWECO. For Dorjilung HPP, an addendum to CIA 2018 has been prepared and included under Volume VIIIC.

1.3.3 Proposed E&S documentation

The E&S Documentation has been organised as follow (see also Figure 8):

- Volume VIII ESIA: ESIA is structured in full compliance with the requirements of the World Bank (WB) ESS1 as detailed in the Guidance Note. To these general ESS1 requirements, some additional sections are incorporated as requested by the WB for this specific project, mainly as summaries of additional studies presented in stand-alone documents (see details below).
- Volume VIIIA ESMP: The document is structured in compliance with ESS1 Guidance note. It addresses measures to implement during pre-construction and preparatory, construction and operation periods. It details actions required for effective and efficient implementation of recommended measures.
- Volume VIIIB ESIA Appendices: This volume compiles all pertinent information from secondary or primary origin (field survey reports) in support of the ESIA main text.
- Volume VIIIC Supporting Documents: Other specific studies produced as stand-alone documents namely, EFlow Assessment (high resolution) and Eflow Management Plan (EFMP), Biodiversity Management Plan (BMP), Environmental and Social Commitment Plan (ESCP), Stakeholder Engagement Plan (SEP), E&S Borrower Capacity Assessment, Gender, GBV-SEA/SH and Vulnerability Action Plan (GSVAP), Land Acquisition and Livelihood Restoration Plan (LALRP), Cultural Heritage Management Plan (CHMP), Labour Management Procedures (LMP), Local Development Plan (LDP) and Addendum to Cumulative Impact Assessment.

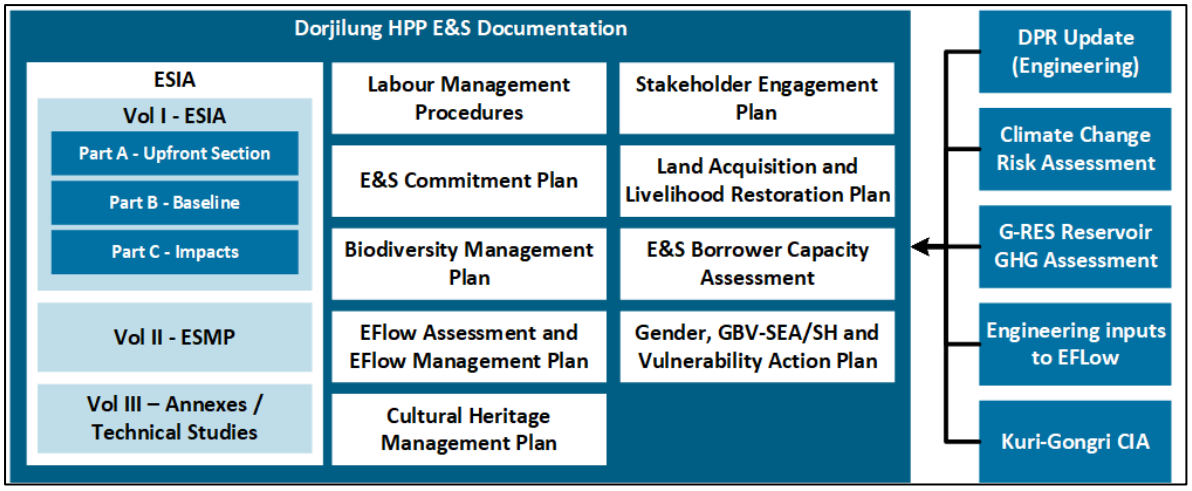


Figure 8: Overview of Dorjilung HPP E&S Documentation

1.3.3.1 Environmental and Social Commitment Plan

The Environmental and Social Commitment Plan (ESCP) is the binding document for DGPC in terms of E&S management. It documents at a strategic and macro level all the E&S commitments made by DGPC for the implementation of the Project. It effectively engages the responsibility of DGPC as a proponent. The ESCP was drafted by ARTELIA, but it will be finalized by DGPC in close coordination with the WB.

1.3.3.2 Borrower E&S Capacity Assessment

The Borrower E&S Capacity is undertaken as a stand-alone task by ARTELIA and DGPC. It is based on a process aimed at scoping and assessment of the required E&S capacity of the Borrower for effective and efficient management of the ESMP measures during implementation and operation of the Project:

- STEP 1: Identify key E&S tasks.
- STEP 2: Mapping the Institutions and other Stakeholders.
- STEP 3: Analyse institutional arrangements and linkages.
- STEP 4: Assess the capacity of individual institutions.
- STEP 5: Recommend actions to strengthen institutional capacity.
- STEP 6: Monitor capacity development indicators and adapt activities as needed.

It focused on ESS2, ESS4 and ESS10, as required by the Project.

1.3.3.3 Labour Management Procedures

The LMP have been developed to manage labour arrangements and labour risks during the implementation of the Project. Labour management procedures are in line with national requirements as well as the objectives of the WB's ESF, specifically objectives of ESS 2: Labour and Working Conditions (ESS2) and also the International Labour Organization (ILO) standards. This plan outlines the key measures and strategies to promote fair and safe labour practices, foster a healthy work environment, and enhance the overall well-being of the project's workforce.

1.3.3.4 High resolution Environmental Flow Assessment and Eflow Management Plan

A high resolution Eflow Assessment has been undertaken for the Project based on the WB/International Finance Corporation (IFC) international standards and the Bhutan E-Flow Guidelines 2019. The high resolution EFlow Assessment carries out the following:

- Evaluate the current structure and functioning of Kurichhu river, and its tributaries, including upstream of the proposed dam, in the dewatered reach between the dam and the tailrace outlet, and downstream of the tailrace outlet.
- Conduct an appropriate EFlow assessment to assess future impacts on the functioning of the river, including impacts from the Dorjilung HPP both in terms of dewatered section and hydropeaking.
- Propose EFlow regime requirements for Dorjilung HPP to meet the requirements of the WB ESF, especially ESS6, and related EFlow management and monitoring plan.

The accompanying standalone EFlow Management Plan outlines a series of measures designed to manage the potential EFlow impacts, mostly associated with the dewatered segment of the river and hydropeaking operations.

1.3.3.5 Land Acquisition and Livelihood Restoration Plan

The LALRP documents how Land Acquisition and Livelihood Restoration have been planned and how they will be implemented. The LALRP is governed by the requirements of the RGoB and the WB, with the following objectives:

- Avoid, and when it is not possible, minimize and mitigate impacts of involuntary resettlement on affected persons resulting from the implementation of the project.
- Provide full and accurate information about the project, and afford Project Affected Persons (PAPs) meaningful opportunities for participation in design, implementation and monitoring, with particular attention paid to the requirements of vulnerable households and women.
- Ensure that people who are adversely affected are fully compensated and successfully resettled; the livelihoods of economically displaced people are re-established, and that their standard of living is, wherever possible, improved.
- Set up consultations with all stakeholders, including people affected by the project, to ensure that local expectations are considered for compensation measures.
- Prevent the impoverishment of affected persons as a consequence of compulsory land acquisition or loss of livelihood due to project activities.
- Make certain that all PAPs are informed of the resettlement process and are aware of the grievance resolution system available through the project.
- Provide, when needed, additional assistance for vulnerable groups, such as women-headed households.

1.3.3.6 Stakeholder Engagement Plan

The SEP has been developed to serve as a management tool to guide stakeholder engagement during the whole project lifecycle. It includes mapping of stakeholders, stakeholder engagement process, roles and responsibilities for stakeholder engagement, monitoring and evaluation and a Project Grievance Redress Mechanism (GRM).

The main objectives of the SEP are to:

- Ensure appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible, and appropriate manner and format.
- Provide project-affected parties with accessible and inclusive means to raise issues and grievances and allow Borrowers to respond to and manage such grievances.

The sub-objectives of the SEP are to:

- Identify stakeholders: recognize all individuals, groups, or entities affected by or having an interest in the organization or project.
- Understand stakeholders needs, consult stakeholders to gather their concerns, expectations, and requirements to address them effectively.

- Build relationships: establish and nurture relationships with stakeholders to foster trust, transparency, and collaboration.
- Communication strategy: develop a clear and effective communication plan tailored to different stakeholder groups, ensuring the right message reaches the right audience at the right time.
- Manage expectations: align stakeholders' expectations with the organization's capabilities, objectives, and constraints to minimize conflicts or misunderstandings.
- Involvement and participation: encourage stakeholder involvement in decision-making processes, where appropriate, to ensure their perspectives are considered.
- Mitigate risks: identify potential risks associated with stakeholder engagement (such as conflicts of interest or resistance to change) and devising strategies to mitigate these risks.
- Evaluate and adapt: continuously assess the effectiveness of engagement activities and adapting the plan as needed to improve stakeholder relationships and achieve desired outcomes.

1.3.3.7 Cultural Heritage Management Plan

The purpose of the CHMP is to document the approach required for the implementation of measures to minimise and manage potential impacts on cultural resources by the construction of the Project, as well as to establish a chance finds procedure.

The objectives of this sub-plan are to:

- Protect cultural heritage from adverse impacts of project activities and support its preservation
- Address cultural heritage as an integral aspect of sustainable development
- Promote meaningful consultation with stakeholders regarding cultural heritage
- Ensure adequate operational standards and correct procedure in case of unexpected archaeological discoveries during construction works.
- Ensure the activation of a specific procedure for the notification of objects or sites found to relevant Bhutanese government bodies.
- Ensure the protection of the area, from impacts of further work and from artifact theft, until an assessment of a designated qualified specialist (a trained archaeologist);
- Ensure the training of the personnel in implementation of the chance finds procedure and to the preliminary identification of chance finds.
- The CHMP is developed as a stand-alone document. It includes the location and description of cultural heritage site already identified.

The CHMP includes a Change Find Procedure, which has been duplicated in the ESMP and will be further defined by the construction contractor.

1.3.3.8 Gender, SEA/SH and Vulnerability Action Plan

The GSVAP and its sub-plans are an important element of compliance with the social and environmental safeguards that are mandatory for the approval of infrastructure development projects under the World Bank's Operational Policies. The project is considered to present a high risk in terms of Gender- Based violence (GBV) and SEA/SH, justifying the development of a stand-alone management plan.

It provides an overview of the gender situation at national and local levels, identifies project-related impacts/risks and gender gaps, proposes specific actions to address gender gaps as well as indicators to monitor progress in addressing identified gender gaps. The assessment also identifies stakeholders, possible service providers and assess their capacity to support its implementation and aid in grievance redressal.

The gender and vulnerability assessment bases on a literature review, consultation with key informants and local women- their views have been taken into consideration to develop appropriate measures-, and the results of the household survey conducted in the project area, to establish the social baseline of the ESIA.

The overall action plan includes short- and long-term objectives aimed at:

- Reducing the social vulnerability of women, youths, and children.
- Enabling local women to have a voice and a role in decision-making.
- Creating an environment in which women and youths can benefit from the project, access employment opportunities, and develop their income-generating activities over the long term.

A sub-plan is detailed to manage the GBV/SEA/SH risks associated with the project. The plans also aim at improving the capacity of the project to manage and monitor women, children and youth issues and GBV/SEA/SH risks.

1.3.3.9 Biodiversity Management Plan

A BMP has been prepared under the ESIA and is presented as a stand-alone document. The report complies with the WB ESS6 (Biodiversity Conservation and Sustainable Management of Natural Resources) as well as with RGoB laws and regulations applicable to biodiversity conservation. The BMP is a project wide planning document to inform the later preparation of the operational document(s), known as Biodiversity Action Plan(s) (BAP).

The BMP concludes the analysis carried out at the ESIA level. In addition to its own impact management measures, the BMP relies on all the measures developed in the ESMP, in particular those allowing the preservation of the physical environment and the management of social influxes. These detailed measures and implemented in various dedicated management plans are the first line of defence for the preservation of biodiversity. If necessary, the BMP will add more specific measures to these plans which must be considered in their operational plan version which will be developed subsequently before construction.

This BMP is a planning document and includes actions leading to the conservation or enhancement of biodiversity for the Dorjilung HPP. The aim is to achieve "no net loss" (NNL) or even "net gain" as a result of the Project by ensuring that the biodiversity is protected and enhanced where possible. The ecological assessments of the ESIA provide the baseline upon which the BMP objectives and conservation priorities are based. A BMP is required for projects located in critical habitat and is recommended for high-risk projects in natural habitats. The BMP describes (i) the composite of actions and a rationale for how the project's mitigation strategy will achieve net gain (or no net loss), (ii) the approach for how the mitigation hierarchy will be followed, and (iii) the roles and responsibilities for internal staff and external partners.

1.3.4 ESIA Team

This ESIA has been prepared by ARTELIA with PCS as its Bhutanese partner. The ESIA and supporting documentation has been prepared by a large team, with the key members noted in Table 8.

Table 8: ESIA team

Aspect	Team members
Overall	Guillaume PRUDENT-RICHARD, Deki P. YONTEN, Dr Bernard YON, Clément MOREL, Corentin CAILLE, Ugyen LHENDRUP, Joel GARRIGUES,
Ecological	Maud COTTET, Dr Frederic MATHIEU, Emmanuelle COROLLEUR, Dr. Dhan Gurung, Dorji RINCHEN
Physical	Joël TSAMBANG, Ugyen LHENDRUP, John Philip BUTLER, Dendup TSHERING, Tshering NIDUP, Aby GIRAUD, Arnaud VANDEL
Social	Dr Alexandre TINOCO, Saroj K. NEPAL, France QUANTIN, Juliette RIMLINGER, Alexandra JAUMOUILLE,
Social - Gender	Diane CAROEN, Manju GIRI
Labour	Kunzang YONTEN, Sonam Y JATTU

2 LEGAL AND INSTITUTIONAL FRAMEWORK

Key points – Legal and Institutional Framework

- Central Government Agencies and their local offices at Dzongkhag level are the main organizations engaged during Project planning and implementation.
- The Dzongkhag Administration represented by the Dasho Dzongdas are the main relays at the Provincial level. They are complemented by the Gups at the Gewog and Chiwog levels.
- Bhutan has a comprehensive legal framework governing E&S management which is aligned with most of the World Bank ESF principles. Bhutan has multiple regulatory tools and governance arrangements for E&S management, including on gender. One of the most notable exceptions is in relation to economic displacement, livelihood restoration and people using lands without a title. This is further detailed in the LALRP.
- Bhutan is a signatory to several international conventions but is not a member of ILO.
- The ESIA has been prepared in compliance with Bhutan national ESHS obligations and with WB ESF safeguards.

2.1 Bhutanese Governance for Project Implementation

Several Bhutanese institutions, at central and local levels are concerned with the DOR HPP development and implementation. The following sections detail the institutions concerned and their relevance to the project implementation.

2.1.1 Central government agencies

This concerns Ministries through their specialized Departments which have responsibilities related to permitting and monitoring in line with applicable laws and regulations. The key agencies include:

- Ministry of Energy and Natural Resources (MoENR): Department of Energy (DoE_, Department of Environment and Climate Change (DoECC), Department of Water (DoW), Department of Forest and Park Services (DoFPS), Department of Geology and Mines and Electric Regulatory Authority.
- Ministry of Agriculture and Livestock (MoAL): Department of Agriculture, National Research and Development Centre for Riverine and Lake Fisheries, Department of Livestock, National Biodiversity Centre, National Plant Protection Centre, National Soil Services Centre.
- Ministry of Education and Skills Development (MoESD): Department of School Education and Women and Children Division.
- Ministry of Industry, Commerce and Employment (MoICE): Department of Labour, Competition & Consumer Affairs Authority (CCAA).
- Ministry of Infrastructure and Transport (MoIT): Department of Surface Transport (DoST), Bhutan Construction and Transport Authority (BCTA), Department of Human Settlement, Department of Infrastructure Development.
- Ministry of Health (MoH): Department of Public Health.
- Ministry of Home Affairs (MoHA): Department of Local Governance and Disaster Management (DLGDM), Department of Culture and Dzongkha Development (DoCDD).
- Autonomous Bodies and Corporations: National Land Commission Secretariat (NLCS), Gyalsung Infra Project, Bhutan Power Corporation Limited (BPC), Natural Resources Development Limited (NRDCL), and Green Bhutan Corporation Limited (GBCL).

2.1.2 Local authorities and organizations

The project falls within the jurisdiction of **Lhuentse and Mongar Dzongkhags** which is staffed with a Dzongda, Dzongrab (assistant District Administrator) and various sector heads (education, health, forest,

environment, land, culture, election) responsible for activities in their respective areas. The district also has the Dzongkhag Courts and the Royal Bhutan Police responsible for maintaining law and order.

Gewog Administration-The project gewogs in Mongar Dzongkhag include Tsamang, Saleng, Chhaling, Tsakaling and Mongar. Only Tsenkhar gewog in Lhuentse Dzongkhag falls under the project area.

There are several regional and local offices in Mongar and Lhuentse. This includes the BCTA and DoST under the Ministry of Infrastructure and Transport (MoIT), CCAA under MoICE, and the Agriculture Research and Development Centre, MoAL.

2.1.3 Relevance to Dorjilung HPP ESHS concern

Table 9 documents the main agencies and organisations considered as interested parties in relation to ESHS aspects of Project implementation.

Table 9: Main agencies and organisations for the Dorjilung HPP

Project interested Party	Project Activities/Impact	Remarks
National Agencies and Organisations		
DoECC, MoENR	Compliance with national ESIA ToR requirements and regulatory monitoring during implementation	DoECC issues the ToR for the National ESIA requirements and is responsible for issuance of National Environmental Clearance. DoECC is also responsible for ensuring compliance with National Environment standards. These standards set the permissible emission standards for ambient air quality, workplace emission, effluent standards, vehicular emission, and noise limits.
DoW, MoENR	Regulatory role on water resource management activities. Determination of minimum environment flow and impacts on Aquatics, water abstraction and coordination and facilitation for effective water resources management	The project is required to follow the Environmental Flow Assessment, seek clearance for water abstraction as required and ensure nature-based solutions for watershed management
National Statistics Bureau (NSB)	Determine study area and sampling frame	The NSB is the nodal agency for relevant and reliable statistics for the project area and responsible for issuance of survey clearance.
NLCS	Land Acquisition, Resettlement, loss of livelihood	Land acquisition and compensation will be carried out as per the Land Act and prevailing Property Assessment Valuation Agency (PAVA) and Bhutan Schedule rate (BSC). The process requires the approval of the NLCS.
DoFPS, MoENR	Forest clearance, impacts on habitat and biodiversity, aquatic studies, community forests,	DoFPS is mandated to ensure the sustainable management of State Reserved Forest Land (SRFL), conservation of wildlife, designation and management of protected areas including biological corridors, preparation of all types of conservation and management plans (for protected areas, community forest, forest management units), issuance of forestry clearances/permits, fishing permits, prevention and control of forest fires, afforestation and reforestation as well as waste management within SRFL

Project interested Party	Project Activities/Impact	Remarks
DoCDD, MoHA	Impacts on Physical Cultural, Historical sites and Intangible cultural heritage. Impacts on Indigenous People	DoCDD is responsible for the conservation of all tangible and intangible cultural heritage and integration of cultural heritage conservation in developmental activities.
MoH	Pressure on existing health facilities from influx of workers and their families	MoH is responsible for the provision of quality traditional and modern healthcare and to ensure the provision of sustainable healthcare services throughout the country.
MoESD	Pressure on existing educational facilities from influx of students from employee/worker families	MoE is responsible for the provision of quality educational services throughout the country.
NRDCRLF, MoAL	Impacts on fisheries	This is the only centre with extensive information on fish species distribution and experience in implementation of fisheries conservation programs.
NSSC, MoAL	Land degradation and impacts on soils	The NSSC co-ordinate soil/land management research activities, promotion of related technology and is the only source of information on soils in the country.
NBC, MoAL	Impacts on biodiversity	Leads the preparation of the National Biodiversity Strategies and Actions Plans and is the focal point for Nagoya Protocol on access to genetic resources and the fair and equitable sharing of benefits arising from their utilization. It is the repository and national clearinghouse for biodiversity information and implements ex-situ conservation and agro-biodiversity programs.
MoIT	Impact on settlements, infrastructure including roads and highways, requirement for additional infrastructure and facilities	MoIT is responsible for planning and implementation of infrastructure and associated facilities for all settlements, from air and surface transport, construction, infrastructure development, housing, postal services, urban planning and development and water and sanitation.
DLGDM, MoHA	Natural hazards (landslides, earthquakes, windstorms), GLOF and dam burst	Responsible for the formulation of policies, rules and regulations on disaster management and is the decision-making body and central coordination agency of all disaster related planning and mitigation.
NRDCL	Forest clearance, impact on sand quarries	NRDCL has the responsibility of sustainable and commercial management of timber, sand, stone and other natural resources as approved by DoFPS.
BPC	Power evacuation, impact on existing transmission lines	BPC is responsible for the delivery of electricity supply services in the power sector.
GBCL	Compensatory afforestation measures due to forest clearance	GBCL is responsible for implementation of afforestation and reforestation plantations in the country.
NGOs and CSOs - Ability Bhutan Society (ABS), The Disabled People's Organization of	Project benefits and impacts to the local communities	These NGOs and CSOs work with the marginalized and vulnerable groups

Project interested Party	Project Activities/Impact	Remarks
Bhutan (DPOB), Respect, Educate, Nurture and Empower Women (RENEW), Tarayana Foundation, Royal Society for Protection of Nature (RSPN)		
Donor agencies - Bhutan Trust Fund for Environment Conservation (BTFEC), WWF Bhutan	Impacts on Protected Areas, critical habitats, endangered species and biodiversity	The BTFEC and WWF fund conservation programs including those in the project area.
Regional and District level Agencies and Organisations		
Dzongkhag Administration, Mongar and Lhuentse	Implementation of the project	All necessary local government approvals and/or clearances must be approved by Dzongkhags. The Local Government Act 2009, Section 213 mandates consultation with Local Government before any project or program is implemented in their jurisdiction, and the involvement of Local Governments in planning, coordinating and implementation of national projects.
Dzongkhag Administration, Mongar and Lhuentse	Land Acquisition, Resettlement, loss of livelihood, Project developmental clearance and Project impacts	The land acquisition and compensation process involve verification by the Gewog and Dzongkhag Administration and approval of the NLCS.
DoST, Lingmethang under MoIT	Impacts on Secondary highway	The DoST is responsible for all primary and secondary highway development and maintenance works.
DFO Mongar and Range Offices Phrumsengla National Park office and field offices	Impacts on the Phrumsengla National Park and Biological Corridor #7	These offices are responsible for the management of forest areas within their respective jurisdictions. All forest clearance applications will be approved or verified by these offices and forwarded to the DoFPS with their field reports for approval.
BCTA Mongar, MoIT	Traffic impacts	The BCTA is responsible for issuance of motor vehicle and equipment licenses as well as ensuring the safety, reliability and efficiency of the construction sector and surface transport system including bus services.
Royal Bhutan Police (RBP)	Impacts on traffic, and potential social conflicts or issues arising from influx of employees and workers	The RBP is responsible for maintenance of law and order in their respective jurisdictions (districts).
Druk Petroleum Corporation	Increase in demand for fuel and gas	The DPCL is the distributor for fuel and gas in the project area.

Project interested Party	Project Activities/Impact	Remarks
Limited (DPCL) offices		
Gyelpozhing Gyalsung Academy	Impacts on existing Gyalsung areas	Provision of Gyalsung Training as per the Gyalsung Act of the Kingdom of Bhutan 2022
KHP Management	Downstream impacts including risk of dam burst on Kurichhu Dam and Hydropower generation	The 60 MW KHP is located about 26 km downstream of Dorjilung dam site and will act as a demodulation basin during peaking operation.
Local/Community level		
Gewog Administration, Project Gewogs	Implementation of the project	Local Governments represent the interests of local communities. All necessary local community approvals and/or clearances must be verified by Gewogs. Consultation with local government as per Local Government Act (as mentioned in #3 above).
Businesses downstream of the dam	Dam failure, Changes in River flow	Public and private businesses that may be at risk due to dam failure or flash floods.
Schools	Increase in demand for student enrolment	It is anticipated that the children of Project employees will be enrolled in the schools in the project area, primarily at the dam site and the powerhouse but potentially also at other project component locations.
Health facilities	Increase in demand for health services	It is anticipated that additional employees and workers will exert pressure on existing Health centres and Hospitals.
Religious institutions	Project impacts and increase in religious services	It is anticipated that the project will require the services of the religious institutions for religious ceremonies during construction.

2.2 Applicable environmental and social laws and regulations

Table 10: Applicable Bhutanese Laws, rules, regulations, standards and guidelines

Focus area	Laws, Rules, Regulations, Guidelines
Environmental Clearance	Environmental Assessment Act, 2000 Regulation for Environmental Clearance of Projects (RECOP), 2016 National Environment Protection Act, 2007 National Environment Strategy, 2020 Bhutan Environmental Standards 2020, and Drinking Water Quality Standards, 2016 National Biodiversity Framework Guide for environmental clearance application procedure, 2022 Environmental assessment general guideline, 2012 Environmental assessment guideline for Hydropower projects, 2012 Environmental assessment guideline for roads and highways, 2012 Environmental assessment guideline for power transmission line projects, 2012 Environmental codes of practice, highways and roads, 2000 Environmental codes of practice, installation of underground and overhead utilities, 2004
Land	Land Act of Bhutan, 2007 Rules and Regulations for Lease of Government Reserved Forest Land & Government Land, 2018
Forest and Biodiversity	National Forest policy, 2011

Focus area	Laws, Rules, Regulations, Guidelines
	Forest and Nature Conservation Act, 2023 Forest and Nature Conservation Rules and Regulations, 2023 Forest and Nature Conservation Bill, 2021 Biodiversity Act, 2003
Climate change	Climate Change Policy of the Kingdom of Bhutan, 2020 Regulation on Substances that Deplete the Ozone Layer and Hydrofluorocarbons, 2021
Water	Water Policy, 2007 Water Act of Bhutan, 2011 Water Regulation of Bhutan, 2014 Guideline for Development of Hydropower Projects, 2018 Guideline to Determine Minimum Environmental Flow Regulations for Dewatered Reaches of Hydropower Projects in Bhutan, 2019 Bhutan Drinking Water Quality Standard, 2016
Waste	Waste Prevention and Management Act of Bhutan, 2009 Waste Prevention and Management Regulation, 2012 (amended 2016) National waste management strategy, 2019
Emissions	Environmental Standards 2020
Labour, employment and Occupational Health and Safety	Labour and Employment Act (LEA), 2007 Regulations on Occupational Health, Safety and Welfare, March 2012 Regulations on Working Conditions, 2022 (first edition in 2009) Regulations on Occupational Health and Safety for Construction Industry, 2022 Regulations on Occupational Health, safety and welfare, 2022 Revised national workforce wage rate, 2015 Guideline for the approval, employment, and management of border town foreign workers (BTFW), 2022 National Gender Equality Policy (NGEP) 2020 and the specific provisions in the law that criminalize sexual harassment in the workplace
Traffic	Road Safety and Transport Act, 1999 Road Safety and Transport Regulations, 2021
Disaster	Disaster Management Act of Bhutan, 2013
Indigenous Peoples	No policy documentation of Indigenous Peoples from the Government is publicly available in Bhutan.

2.2.1 Social, Cultural and Safety

2.2.1.1 The Constitution of Bhutan, 2008

Article 7 provides all Bhutanese the right to life, liberty and security, freedom of speech, opinion and expression, right to information, right to freedom of thought, conscience and religion.

Article 9(3) ensures protection of fundamental human rights, freedom, dignity, and freedom from discrimination, oppression, and violence of all people.

Article 5(2) requires the Government to ensure a safe and healthy environment.

2.2.1.2 The Local Government Act of Bhutan, 2009

The Local Government Act of Bhutan (2009) promotes decentralization and devolution of power and authority to the Local Governments that represent the interests of local communities. The Dzongkhag Tshogdu (Dzongkhag Tshogdu means the District Council and highest decision-making body in the district, while the Gewog Tshogde means the County Committee (Source: Department of Local Governance, Ministry of Home and Cultural Affairs https://www.dlg.mohca.gov.bt/) and the Gewog Tshogde are the highest decision-making bodies at the dzongkhag and gewog level.

As per chapter 14 of the Local Government Act, all activities undertaken by different sectors of the government must be routed through and coordinated by Local Government offices.

Section 213 requires that all national agencies conduct periodic consultations with the Local Government before any project or program is implemented in their area, as well as involve Local Governments both in the planning and implementation of national projects.

The Local Government Act has provisions to undertake activities consistent with other relevant laws and policies of the country that are formulated towards conserving the environment within its area and reduce the impact on public health and accelerate socio-economic development.

2.2.1.3 Labour and Employment Act, 2007

More detailed information on the relevant section of the Act is provided in the standalone Labour Management Procedures document.

The Department of Labour has been assigned the responsibility of overseeing labour administration and labour issues. Labour administration in the country is guided by the Labour and Employment Act of the Kingdom of Bhutan, 2007 and its regulations such as:

- Regulations on Working Conditions, 2022.
- Regulation on Foreign Workers Management, 2022.
- Regulation on Occupational Health, Safety and Welfare, 2022.
- Regulation on Occupational Health and Safety for Construction Industry, 2022.

The Labour and Employment Act of Bhutan 2007 prohibits 'forced or compulsory' labour and 'worst forms of child' labour, discrimination against employees or job applicants for vacancies in connection with recruitment, dismissal, transfer, training, and demotion, or for wages and working conditions. It also defines and restricts sexual harassment and wrongful dismissal. The Act also touches on Compensation and benefits of employees and Occupational Health and Safety (OHS).

Chapter IX relating to OHS details the requirements of employers to provide and maintain a safe working environment for its employees, through hazard identification, instituting management, systems, procedures and identifying roles and responsibilities, for implementation, monitoring and recording and reporting systems back to the Chief Labour Administrator. The Chapter also details the rights, roles and responsibilities of employees as well as the appointment of a health and safety representative between employees, employers and the Department of Labour.

All contractors are required to abide by the Regulation on Occupational Health and Safety for the Construction Industry, 2022. This regulation clearly restricts the employment of people below the age of 18 for any construction activity (Section 7). It requires contractors to prepare a health and safety (HS) policy, appoint both an HS committee, a Safety Officer, and a Safety Representative, an Emergency Action Plan, provision for Personal Protective Equipment for its workers and detail safety measures for specific types of activities including maintenance of construction machines and equipment, demolition works and blasting. Worker Health and Safety measures include provisions for safe sitting, gender friendly worker accommodation (that houses four workers per room), with toilets that is safe against wind, cold, rain and heat, safe drinking water, access to medical facilities, first aid.

All sites are to be adequately illuminated in compliance with the Electricity Act of Bhutan, 2001.

The Regulation also requires measures to ensure safety to the neighbouring Community and measures to minimize physical environmental impacts such as dust, gas, and fumes with safety signage.

2.2.1.4 Road Act, 2013

This Road Act was enacted in 2013 and repealed the Road Act 2004. The Act applies to all road and road issues. Roads hierarchy is categorized as follows:

- National Highways. National Highways are further categorized into:
- International/Asian Highways,
- Primary National Highways,
- Secondary National Highways.
- Dzongkhag Roads.
- Thromde Roads.
- Farm Roads.
- Access Roads.

The national authority for all roads is the Department of Roads (now the Department of Surface Transport - DoST) but Thromde, Dzongkhag and Gewog are responsible for roads within their jurisdiction.

Sections 19 and 20 empower the DoST and the local Government to approve take-off design for all access roads that branch out from roads under their administration.

Section 22 requires that proponents must submit their plans and specifications (which must comply with required standards) for new roads to the DoST or the Local Government for approval.

2.2.1.5 Road Safety and Transport Act 1999 and Road Safety and Transport Regulations, 2021

This Act applies to all vehicles registered in the country, as well as vehicles registered outside the country but driving in the country. It establishes systems and procedures for the licensing of drivers and registration of motor vehicles and aims to ensure an efficient and safe public transport system. The Road Safety and Transport Authority has a mandate to enforce this Act and Regulation.

It mandates all vehicles to be registered and drivers to have the appropriate driving license and determines the appropriate speed limits, traffic, and total vehicular load and conducts alcohol testing of drivers.

Where there is no speed limit sign the speed limits to be observed are:

- 50 km/h for light vehicles and two wheelers.
- 35 km/h for medium and heavy vehicles.

Vehicular emission levels in the country must follow National standards prescribed by DoECC. Vehicle emission tests are to be carried out annually for private vehicles and bi-annually for commercial vehicles and obtain the Pollution under Control Certificate (PUC). The certificate is issued by DoST, MoIT.

The Regulation details traffic regulations to be observed with appropriate penalties for violations.

2.2.1.6 Cultural properties

Movable Cultural Property Act of Bhutan 2005 pertains to the conservation and protection of movable cultural property owned by government, community, or private individuals. Such property is required to be listed and registered with photographs and maintained by the Lhakhang and the concerned Dzongkhag.

Chapter IV Section 33 on community owned valuable cultural property prohibits the photography of Valuable Properties without prior approval from the Department of Culture, except for private owners of the cultural property (section 41).

Chapter IV Section 34 requires the approval of the Department of Culture to carry out conservation works on Cultural Properties based on a qualified conservator.

Chapter V covers privately owned valuable cultural property. Chapter V Section 40 permits the sale, exchange, inheritance, gifting and transfer of cultural property to other locations within the country matter, but this must be reported to the Department of Culture through the respective Dzongkhag within one month to update the Thram, which must be maintained by the new owner.

Section 54 requires the discovery of valuable cultural properties discovered from below ground during the construction of roads, buildings or any other related works, this discovery is immediately reported to the Department of Culture through the concerned Dzongkhag.

"Valuable Cultural Properties" refers to all items with artistic, historical, cultural, religious, social, archaeological, or technical value and interest and have been grouped into 13 categories under section 59.

It includes Ku Sung Thugten and ritual objects, ornaments, ritual objects made from animal parts (elephant tusk, rhino horn, animal skin and bones), old weapons, archaeological materials and fossils, furniture, carpets and costumes, architectural heritage (wood or other valuable objects resulting from the total dismemberment of architectural heritage, objects of Zorig Chusum (the 13 traditional arts and crafts), kitchen accessories, agricultural implements, musical instruments, coins and maps, rare objects and objects obtained from outside the country. The key criterion is that these objects must be 100 or more years old.

Cultural Heritage Bill of Bhutan (2016). Section 37-39 requires that any entity intending to undertake large-scale development activity must obtain a development permit from the Dzongkhag Administration who will turn forward the application for large-scale development activity to the Department of Culture and Dzongkhag Development for review and issue of cultural landscape clearance.

Under Section 143, the Cultural Heritage Committee may define the buffer zone of a Designated Heritage Building or Site upon the recommendation of the DCDD

Section 153 requires approval from the DCDD for any work on an existing building in the Important Cultural Site, a Registered Archaeological Site, or the conservation zone of Registered or Designated Heritage Building.

The bill also details the steps to be undertaken in case of archaeological find.

2.2.2 Land laws

(More detailed information on the relevant sections of the Acts listed below is provided in the LALRP.)

2.2.2.1 Land Act of Bhutan, 2007

The primary legal instrument for Land Acquisition and Resettlement in Bhutan is the Land Act (amended in 2007), which regulates ownership, sales, and the land acquisition by the RGoB when land is acquired. The Land Act of Bhutan 2007 provides the acquisition mechanism for land and other property falling under the eminent domain whenever required for a public purpose.

The National Land Commission Secretariat (NLCS) is the apex agency for all matters pertaining to land registration, sale, exchange, or compensation. The NCLS, based on the land classifications and regulations, will pay compensation, or provide alternative land.

The ownership can be either (a) "private" or (b) "public". The Land Acquisition and Compensation Rules and Regulations (LACRR), 2022, spearheaded by the Property Assessment & Valuation Authority of the Ministry of Finance (RGoB) states that private registered land shall be acquired only if unavoidable and can be acquired only once the substitute land is registered or cash compensation has been paid.

The rates of compensation are reviewed by the RGoB periodically - by law every three years - the latest of which is described in the Land Compensation Rate 2022 (PAVA), Cash Compensation Rates 2022 for Cash crops/Fruit trees/Annual crops, Bhutan Scheduled Rates (BSR 2022) for the affected structures.

In the case of landless people, the land can be allotted free of cost by the Government as a Kidu (assistance/welfare provided by His Majesty)

This Act only recognizes legal title holders and does not consider assessing socio-economic aspects (livelihood restoration) or vulnerability as a requirement during land acquisition.

2.2.2.2 Land Exchange Rules and Regulations, 2022

As specified in the Land Act, 2007, this regulation covers the mechanism of exchanging private registered land with State Land (SL). This is only applicable where Private registered plots are affected by Natural Calamities, fall within the Critical Watershed area and Natural Wetland; and in case of scattered private registered plot(s) located within State Forests. The responsibility for this lies with the National Land Commission Secretariat (NLCS) who are mandated to ensure that land allocation is carried out in a transparent, sustainable, and holistic manner while improving the lives and livelihood of the people.

2.2.2.3 Land Lease Rules and Regulations, 2018

Chapter 7 of this regulation covers the lease of land for Hydropower, Renewable Energy Projects (HPREP) and other associated transmission systems.

Section 112 of the regulations enables the relevant Agencies to assess areas within the country including private land for development of hydropower and its allied associated facilities.

Sections 113-118 detail the procedure to be followed. The details of the identified land along with the project proposal is to be submitted to the NLCS for review and consent. Once that is approved, the Agency must process the lease through the Dzongkhag Land Record Office. The lease period will be fixed by the NLCS in consultation with the Agency. The lease is executed for the construction period only and the Dzongkhag and Agency must execute a new lease deed upon commissioning of the project. The underground cavern or the underground tunnel system is not required to be leased apart from the permanent access areas for caverns and tunnels. The NLCS may consider leasing this based on requirements submitted by the Agency.

The same process is to be followed for transmission towers and their buffer areas.

2.2.3 Gender and social inclusion

The RGoB has adopted several international and national laws, policies and frameworks that are relevant from a gender and social inclusion perspective.

2.2.3.1 National Frameworks

The **Constitution of the Kingdom of Bhutan**, 2008 provides an overarching framework and foundation within which gender equality is enshrined. It conveys a powerful message for gender equality through articles on fundamental rights (Article 7) and the Principles of State Policy (Article 9). Article 7, section 15 states: "All persons have the right to life, liberty and security of person and shall not be deprived of such rights except in accordance with the due process of law." Subparagraphs of the Article identify the following rights: the right to security, to speak, to vote, to movement and to own property. "Nobody shall be discriminated against on the grounds of race, sex, language, religion, politics or other status."

Article 9, section 17 on **Principles of State Policy** states: "The State shall endeavour to take appropriate measures to eliminate all forms of discrimination and exploitation against women including trafficking, prostitution, abuse, violence, harassment and intimidation at work in both public and private spheres".

The law criminalizes rape and makes no reference to gender in its definition of rape. Spousal rape is illegal and prosecuted as a misdemeanour.

The law prohibits domestic violence, including physical and sexual abuse. Physical abuse is prosecuted as battery; penalties for convicted perpetrators range from one month to three years' imprisonment. Sexual abuse is prosecuted as a corresponding sexual offense and is punishable by three to 15 years imprisonment. The law provides for increased sentences for conviction of second (and subsequent) domestic violence offenses.

Sexual Harassment: The law includes specific provisions that criminalize sexual harassment in the workplace. NGOs reported these provisions were generally enforced. According to UNICEF, the Royal Civil Service Commission operated the Civil Service Support Desk to address sexual harassment in the civil service. The commission designated points of contact to assist civil servants who experienced sexual harassment in the workplace.

National Gender Equality Policy (NGEP) 2020: The NGEP envisions a society where substantive equality is practiced providing equal opportunities for women and men, boys and girls to achieve their full potential and benefit equitably from the social, economic and political development in the country. The purpose of the NGEP is to provide an effective framework within which legislations, policies, programmes and practices ensure equal rights, opportunities and benefits for women and men in the family, community, workplace and in society at large. The policy serves as a guiding framework which echoes and reaffirms the commitment of the Royal Government of Bhutan (RGoB) to ensure the achievement of substantive equality through gender responsive policies, plans and programme explores gender equality through the lens of three domains i.e., political, social and economic. The policy aims to:

- Provide a coherent strategic framework for the Government's priorities on gender equality.
- Strengthen accountability and operational strategies to address priority gender issues.
- Facilitate deeper collaboration across sectors and stakeholders towards a common vision of gender equality.

Statement 5.9 of the NGEP establishes the link to climate change: "Mainstream gender in all disaster and climate change related initiatives through acknowledgment of differentiated impacts of disasters and climate change on women and men, and the positive roles that women can play in adaptation and mitigation efforts".

The **NGEP Implementation Plan (2020)** further identifies actions (statement 5.9), as follows:

- Assess gender differentiated capacity needs and develop a gender responsive capacity-building strategy for climate change actions.
- Develop capacity of Gender Focal Points (GFPs), Gender Expert Group (GEG), Mainstreaming Reference Group (MRG), Climate change coordination committee (C4) and Local Government (LG) on mainstreaming gender and NDC targets into sectoral policies, plans, programmes and projects.
- Conduct a gender assessment of selected Nationally Determined Contribution (NDC) sectors
- Develop gender mainstreaming toolkit for selected NDC sectors.
- Prepare local adaptation plans including support needs, based on complete gender analysis that consider the needs of rural women.

The **Inheritance Act of 1980** guarantees equal inheritance rights to men and women.

The **Loan Act of 1981** determines that women are eligible to possess land and collateral for getting a loan.

The amended **Land Act of 2007** establishes that the minimum age for registering land is 18 years for both women and men.

The **Domestic Violence Prevention Act of Bhutan, 2013**, covers the prevention of physical, sexual, psychological, and economic and emotional violence.

The **Disaster Management Act 2013** provides for establishment and strengthening of institutional capacity for disaster management, mainstreaming of disaster risk reduction, and for integrated and coordinated disaster management focusing on community participation. It underlines the importance of women's participation in making decisions related to disaster management and risk reduction.

The **Climate Change Policy, 2020** is responsive to gender issues impacted by climate change and promotes the development of tools for assessing, planning, integrating, and implementing adaptation and mitigation measures at all levels and considering opportunities for synergies and cross-cutting issues, including gender equality considerations and disaster risk management. Gender issues are to be integrated across all climate change actions informed by situational analysis of gender gaps and the inter linkages with climate change in Bhutan. The policy's action plan is also gender mainstreamed and the details of the policy's institutional arrangement have identified NCWC as one of the potential partners which will provide support in mainstreaming gender responsive climate actions.

The **National Youth Policy, 2011** mainstreams gender issues very well. It sets out goals to provide youth proper education and training opportunities, provide access to information in respect of employment opportunities and to other services, including entrepreneurial guidance, financial credit and strengthening of private sector to promote a strong and vibrant Bhutanese society.

The **National Policy for Persons with Disabilities of Bhutan, 2019** ensures that the vulnerable and marginalized group enjoy the same rights and opportunities as the rest of the population and seeks to improve the lives of persons with disabilities through the following objectives:

- Empower persons with disabilities and ensure their participation as equal members of the society and in socio–economic development process.
- Mainstream disability initiatives in plans, policies, and programs in all sectors.
- Improve access to opportunities and services for people with disabilities.
- Improve the socio-economic condition of people with disabilities and their family.
- Promote healthy living among people with disabilities through sports, recreation, and cultural participation.
- Promote positive attitude and behaviour of society towards people with disabilities.

This policy is anchored on active participation/involvement of persons with disabilities, their caregivers or their representatives in planning, implementation, monitoring and evaluation of plans, policies, and programmes at all levels.

2.2.3.2 Institutional Framework related to Gender Equality in Bhutan

Regarding gender, the RGoB policies show a positive evolution over time. The country has a specific and robust regulatory framework to promote gender equality; it is a signatory and has ratified the main declarations and conventions to promote women's rights; and it has the National Gender Equality Policy in place. This has had a major impact on the government's efforts to mainstream gender in every sector's plan, policies, and programmes.

The RGoB has committed and accorded top priority to improve the status of women by integrating the issues of women since the 10th Five Year Plan (2002-2007). Accordingly, the government has taken various steps and measures to eliminate more serious and indirect forms of discrimination at home and at work. The issues on Gender Equality and Women Empowerment (GEWE) have been given top priority in the preparation of the country's five-year plans and in the decentralization process of the local government.

The **National Commission for Women and Children (NCWC)** was established in 2004 as the principal agency for gender mainstreaming and leadership for promoting and protecting the rights of women and children in Bhutan. The Commission was upgraded to an autonomous agency in 2008 due to the rising number of issues and their increasing responsibilities. In 2010, the NCWC drafted the National Plan of

Action for Gender (NPAG), which was developed to facilitate and guide mainstreaming of gender issues into all future policies and programs, projects, and activities in the country. It suggested that the overall gender mainstreaming strategy will focus on strengthening the capacity of gender focal points, the Gross National Happiness Commission (GNHC) and the NCWC focus on strengthening collection, analysis and use of sex disaggregated data and gender related information and integrating gender into monitoring and evaluation. In January 2023, the National Commission for Women and Children (NCWC) published the Standard Operating Procedure for Gender–Based Violence Prevention and Response, which lays out policies and procedures related to gender-based violence and the roles and responsibilities of the government and civil society in combating it. The NCWC is implementing an internal framework to address gender matters in the workplace, including preventing and responding to sexual harassment. NCWC is now under the Department of Education Programmes, Ministry of Education and Skills Development and functions with the same mandates.

Gender Focal Points (GFPs) and Gender and Child Focal Points (GCFPs) have been instituted in the Ministries, Dzongkhags, CSOs and private sector with gender mainstreaming as coordinating entities and drivers for gender mainstreaming. The GFP plays very diverse roles, such as awareness-raising and sensitization on gender issues and initiatives to create gender friendly and enabling workplace. The GFPs are supported and trained by the NCWC.

According to the ADB report, 83 government officials (33 women, 50 men) and 62 private sector representatives (43 women, 19 men) were appointed as GFPs as of 2015, and they were expected to participate in training on gender mainstreaming1. Currently, 24 GCFPs are active in 20 Districts and 4 Municipalities (7 females, 17 males), and 32 GFPs at central level (16 females, 16 males); totalling to 56 focal persons.

A **Gender Expert Group (GEG)** has been established of individual persons with well-established gender expertise in diverse sectors to provide technical support to the NCWC. The members of the GEG help the NCWC in reviewing policies from a gender perspective and in capacity building and training people. It has six-member representations from government agencies, private sector and CSO. Since 2013, efforts have been made to trickle down the work of GFPs at district, local and community levels. Under the decentralization process the role of local governments in gender mainstreaming has been emphasized as well. However, there is still a need for more capacity building, awareness raising and advocacy on gender issues at local level.

Gender Equality Monitoring System (GEMS): The GEMS is an ADB initiated online web-based portal to help NCWC manage, monitor and track progress on gender mainstreaming activities that are being implemented by different sectors and agencies in the country. The GEMS is the first of its kind in South Asia. Data and information on the GEMS can be accessed or updated in different ways by changing different parameters like date of coverage, disaggregation of results, and purpose of reporting by sector and/or agency. Currently, the GEMS will be accessed and used primarily by a network of Gender Focal Points operating at the national sector level as well as at the local government level to plan and report progress on gender-mainstreaming activities.

2.2.4 Environmental Protection

Constitution of Bhutan, 2008

Article 5 of the Constitution of Bhutan 2008 is entirely devoted to the environment. It places responsibilities on every Bhutanese, on the royal government and requires the parliament to conserve the rich biodiversity of Bhutan.

As per Article 1(12), all rivers, lakes, forests and mineral resources belong to the state and their use shall is regulated by law. This is echoed in Section 5(a) of the Water Act of Bhutan (2011), wherein the rights of

water resources as a property of the state includes beds and banks of water resources. At the same time, Section 5(c) recognizes that 'every individual shall have access to safe, affordable, and sufficient water for basic human needs.

National Environment Strategy, 2020

The strategy enshrines the concept of sustainable development. It is structured around four chapters, namely water, air, life, and land. It provides a framework to monitor every sector and enhances the implementation and operationalization of the existing legislation from government to local level.

Climate Change Policy, 2020

The vision of this policy is 'A prosperous, resilient and carbon neutral Bhutan where the pursuit of gross national happiness for the present and future generations is secure under a changing climate.

The policy provides strategic guidance to ensure that Bhutan remains carbon neutral, adapts to climate change in an efficient and effective manner; ensure meaningful participation of all relevant stakeholders in climate change action and ensure that the challenges and opportunities of climate change are addressed at all appropriate levels, through adequate means of implementation (finance, technology, capacity building and awareness) and integration into relevant plans and policies. There are four policy objectives: Pursue carbon neutral development, build resilience to climate change, ensure means of implementation and effective and coordinated actions.

All government agencies and institutions must assess priorities and needs on mitigation and adaptation and integrate such actions within their plans and programs.

Disaster Management Act of Bhutan, 2013

This act mandates the establishment and strengthening of institutional capacity for disaster management, mainstreaming disaster risk reduction, and ensuring an integrated and coordinated disaster management through community participation. The national Disaster Management authority headed by the Prime Minister is the apex body for disaster management.

Under Section 24 and 25, every Dzongkhag must constitute a Dzongkhag Disaster Management committee, headed by the Dzongda, which (Sections 30, 31) is responsible for coordinating and managing all disaster management operations under the direction and supervision of the National Disaster Management Authority

Section 58 mandates the Department of Disaster Management to serve as the secretariat and executive arm of the National Disaster Management Authority and the National Coordinating Agency for disaster management.

Section 60 requires the Department to ensure agencies mainstream disaster risk reduction into their development plans, policies, programmes, and projects and ensure that contingency plans and disaster management activities are implemented.

2.2.4.1 Environmental Assessment of Projects

The national E&S approval process is managed separately to this ESIA and is not strictly reflected in this ESIA. The Environmental Clearance (EC) process has been outlined for reference in Section 2.2.6.

Environmental Assessment Act, 2000

The Environment Assessment Act outlines procedures for assessing the potential impact of projects on the environment and formulates policies and measures to reduce potential adverse effects on the environment. Based on the above premise, environmental clearance is required prior to the execution of any project that may entail adverse impacts on the environment. To this effect, the DoECC previously the National

Environmental Commission (NEC) is empowered to implement the EA Act 2000 by setting out guidelines for securing an environmental clearance for a project. The Environmental Assessment Act is expected to be applicable to this project considering foreseeable impacts on the surrounding environment.

National Environmental Protection Act, 2007

The National Environmental Protection Act, 2007 (NEPA) established the role of the Competent Authority within Ministries, Thromdes or Districts to screen, review and issue or deny environmental clearance, a mandatory requirement for any development activity.

Regulation for Environmental Clearance of Projects 2016 and the Environmental Assessment Process

The Regulation for Environmental Clearance of Projects, 2016 (RECOP, 2016) outlines procedures and responsibilities for implementing and supplementing the Environmental Assessment Act, 2000 to issue environmental clearances. The Guide for environmental clearance application procedure, 2022, outlines the process for project categorization and seeking environmental clearance.

The EC process is further detailed in Section 2.2.6.

Environmental assessment guideline for hydropower projects, 2012

Under this guideline the process of scoping the Terms of Reference (ToR) for the Environmental Assessment is submitted to the DoECC for review and approval. The approved ToR is the basis for the appraisal committee to decide whether the EIA report meets all the requirements or not. The guideline requires approximately 19 environmental plans, environment monitoring plan and details of the review process.

Bhutan Hydropower Guidelines

Part B of the Bhutan Hydropower Guidelines presents guidance on E&S aspects and are linked to National environmental assessment processes and requirements and are designed to be equally applicable to transmission lines. Part 1 addresses Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) processes and methods, institutional responsibilities and regulatory processes, stakeholder engagement, ESIA scoping and Terms of Reference, sections of the ESIA, and the ESMP. Part 2 provides topic-specific guidance for eleven topics namely: water use and downstream flows; water quality; erosion and sedimentation; waste disposal and waste management; air quality, noise and vibration; terrestrial biodiversity and invasive species; aquatic biodiversity and invasive species; project-affected communities; community health and safety; cultural heritage; and labour and working conditions.

It mandates compliance with the Environmental Assessment Act 2000 and the Regulation for Environmental Clearance of Projects 2016 and adherence to the national environmental clearance process and requirement of No Objection Certificates wherever necessary.

It emphasizes the identification of all stakeholders directly and indirectly affected by the project's activities and infrastructure and identification of appropriate communication needs for each group of stakeholders within a Stakeholder Engagement Plan.

A project specific grievance mechanism is also mandatory wherein the roles of the project grievance committee, responsible parties for maintaining records of grievances raised, actions taken, relevant dates, feedback provided, and the closure of issues and maintenance of a grievance register is required.

Specifically, predicted impacts are to be described in terms of type, nature, magnitude, extent, timing, duration, reversibility and significance of impacts.

Mitigation measures are to follow the mitigation hierarchy: "Avoid, Minimise, Mitigate and Compensate". All significant residual impacts to be well-understood by those who bear the consequences of those impacts and sign NOCs in relation to them and ideally aim for net gain of biodiversity and environmental quality compared to pre-project conditions.

Mitigation sections of the ESIA are to be structured in terms of a) Objective, Implementation requirement, Stakeholder views, Construction and operation costs and responsibilities, Risks and contingency requirements, Proposed commitment and Residual impacts.

Recognizing the difficulty in costing of certain mitigation measures, it is suggested to estimate costs based on past similar projects in Bhutan and the contingency budget must include guidance on when and how it would be allocated.

The proposed outline for reporting on Cumulative impacts is also provided. The potential cumulative impacts must describe the Bio-Physical Impacts (Hydrology, Flows and Water Use, Water Quality and Water Treatment, Erosion and Sediments, Excavated-Waste Disposal, Air Quality, Noise and Vibration, Solid Waste Disposal, Terrestrial Biodiversity and Invasive Species and Aquatic Biodiversity and Invasive Species, Socio-Economic Impacts in terms of Project-Affected Communities and Project Benefits, Land Acquisition and Involuntary Displacement, Vulnerable Groups, Community Health and Safety, Cultural Heritage and Labour and Working Conditions

For Mitigation and Monitoring, the Management Framework for ESMP Implementation with specific sub-plans format is also provided.

2.2.4.2 Management of pollution sources

Landfill sites are required to have facilities for collection and treatment of leachate to prevent pollution of nearby water bodies, as well as adequate facilities to manage the landfill gas to prevent risk of fire and associated environmental hazards. Hazardous waste and infectious waste must not be disposed in the landfill intended for municipal waste unless they are pre-treated and made safe for disposal. Any incineration facility must be approved by the DECC.

It is the duty and responsibility of every business (including contractors) to provide appropriate facilities for waste segregation into bio-degradable, non-biodegradable waste and hazardous waste. The minimum standards and requirements for the transport of waste includes avoidance of littering during loading and during transportation, covering all vehicles or containers used for the collection and transportation of waste, use of separate collection schedules or separate trucks for specific types of waste (Waste Prevention and Management Regulation 2012).

Waste Prevention and Management Act, 2009.

The Act prohibits the illegal dumping or release of all forms of waste into the environment. It covers the collection, storage, transportation, disposal, as well as import and export of waste in Bhutan. It promotes reducing the generation of waste at source and promotes waste segregation, reuse, recycling, and environmentally sound disposal. It also defines the roles and areas of implementation of the implementing agencies for the purpose of establishing a sound waste management system including monitoring procedures.

Waste Prevention and Management Regulation 2012 was adopted under section 53 of the Waste Prevention and Management Act, 2009. This was amended in 2016. The relevant sections of these regulations are summarized below.

The amended regulation promotes strategies to achieve zero waste and introduces a system of incentives for waste prevention and management on the principle that waste is an asset.

For non-hazardous waste, implementing agencies must ensure the reduction, reuse, recycling and disposal of waste by providing facilities for waste segregation and reduction mechanisms at the source, and ensuring the collection and adequate management of waste at an approved site or facility inter alia composting for organic wastes.

For hazardous waste agencies must ensure the reduction, storage, treatment, and disposal of hazardous waste are addressed in an environmentally sound manner.

Under Section 10 Hazardous waste can be exported with prior written consent of the importing country in compliance with the packaging and required health and safety procedures of the country.

Section 12 details provisions for Sanitary landfill or open dump sites. These sites must be identified in consultation with the DoECC. These are restricted in the following areas:

- Within a distance in or around human settlements that pose environmental and health hazards.
- Near water catchment areas.
- Near rivers, wetlands, water bodies or ground water sources.
- Unstable or landslide prone areas.
- Areas are notified as habitat of endangered flora and fauna.
- Within a motorable distance of three kilometres from a Dzong or other monuments of cultural or historical importance.

Section 18 details the requirements for sanitary landfill sites.

Section 16 covers hazardous/infectious waste and requires implementing agencies to have a systematic handling and safe disposal of hazardous waste generated within its jurisdiction, pre-treatment, safe storage and transportation to designated approved site for such dumping or release, signage to notify hazardousness of wastes at prominent work place, labelling on containers to indicate risk and danger of its contents, provision of appropriate PPE and equipment to personnel handling hazardous waste, record keeping of all incidents of injuries and accidents related to hazardous waste.

Section 22 requires waste to be categorized into 4 categories: Medical, Municipal, Industrial Waste or E-Waste. Medical waste is further categorized in Section 47 into general, pathological, infectious, sharp, pharmaceutical, chemical, radioactive, pressurized containers and Section 48 details the management procedures for each category.

Construction waste is defined as 'any solid or liquid materials generated directly from excavation, demolition, alteration, remodelling, renovation or new structural construction or infrastructures such as roads and building works including all civil structures '. Section 85 and 86 detail the responsibilities of the Construction and Business Sector.

Minimum requirements for waste management include the following:

- Provide facilities for waste segregation into bio-degradable and non-biodegradable waste.
- Provide appropriate bins for waste storage and safe collection.
- Segregate hazardous waste within the premises.
- Maintain cleanliness of the respective premises or surroundings.
- Transport construction wastes without spillage.
- Dispose construction waste and excavated soil in designated sites.
- Safely store the construction waste at the site to avoid public inconvenience.
- Follow labelling, pre-treatment, storage, record keeping, transportation, and disposal procedures for hazardous waste.
- Provide safety gear for the personnel handling hazardous or infectious waste.
- Tracking hazardous waste using the Tracker sheets provided in the Waste Regulation.

Mines and Minerals Management Act 1995 and the Mines and Minerals Bill 2020

The Mines and Minerals Management Act 1995 was repealed by the Mines and Mineral Bill 2020. The bill only allows the Department of Geology and Mines or agencies authorized by the Department to conduct exploration of mineral resources. For lease of any mine, feasibility studies must be undertaken before a mining lease can be granted. This bill includes surface collection for commercial purpose, fossicking and artisanal mining and mandates the Mining Regulatory Authority, an autonomous body to approve mine feasibility studies to lease mines, revoke leases, approve mine closure and reclamation plan and utilization of the mine reclamation fund, decide on compensatory afforestation or reclamation activity, among others. A valid environmental clearance shall be a prerequisite for leasing and operating mines and for surface collection for commercial purposes.

The bill repeals section 51(d) and 53(d) of the Local Government Act, 2009 wherein the Dzongkhag Tshogdu was empowered to issue clearances for the establishment of mines and quarries; (3) section 3g(iv) of the Forest and Nature Conservation Act, 1995 where forest produce included boulders, stone, sand, gravel and rocks; and (4) section 26(b) of the Water Act of Bhutan 2011 which allowed collection of sand and boulders along banks of watercourses by a state agency.

Quarry and borrow pits opened as part of the Project fall under this Act and would likely require a separate ESIA under national regulations. The ESIA will be required to be prepared and approved before the Contractors contract award.

2.2.4.3 Applicable Pollution Control Standards

The Environmental Standards 2020 issued by the DoECC sets the permissible emission standards for ambient air quality, workplace emission, vehicular emission, and noise limits. These standards differ for Mixed Areas and Sensitive areas. A mixed area means area where residential, commercial or both activities take place while a sensitive area means an area where sensitive targets such as hospitals, schools, sensitive ecosystems are located (Environmental Standards, 2020).The Drinking Water Quality Standards, 2016, developed in accordance with Section 13 (f) and Section 42 (a) and (b) of the Water Act of Bhutan, 2011 describes the quality parameters set for drinking water and the maximum permissible limit for each of the set parameters, to limit the level of contaminants in drinking water.

Table 11 to Table 17 summarize the ambience air quality, workplace emission, noise level, effluent standards, drinking water quality, motor vehicle emission and vehicular noise levels to be followed by the project during construction and operation.

Table 11: Ambient Air Quality Standards

Parameter	Averaging Period*	Bhutan's Ambient Air Quality Standard, 2020**(µg/m^3)		
		Industrial Area	Mixed Area***	Sensitive Area****
TSP	24-hour	500	200	100
	Annual	360	140	70
$PM_{2.5}$	24-hour	60	60	60
	1-year	40	40	40
PM_{10}	24-hour	200	100	75
	Annual	120	60	50
SO_2	24-hour	120	80	30
	Annual	80	60	15
	10-minute	-	-	-
NO_2	24-hour	120	80	30

Parameter	Averaging Period*	Bhutan's Ambient Air Quality Standard, 2020**(µg/m³)		
	Annual	80	60	15
	1-hour	-	-	-
CO	8-hour	5,000	2,000	1,000
	1-hour	10,000	4,000	2,000
	15-minute	-		
Ozone	8-hour	100	100	100
Ozone	1-hour	180	180	180

* *Due to short term duration of civil work, the shortest period will be more practical to use.*

** *Taken from Environmental Standards, National Environment Commission, Royal Government of Bhutan, 2020.*

*** *Mixed Area means area where residential, commercial or both activities take place.*

**** *Sensitive Area means area where sensitive targets are in place like hospitals, schools, sensitive ecosystems.*

^ *Source: Environmental, Health and Safety General Guidelines, 2007. International Finance Corporation, World Bank Group.*

^^ *Source: Air Quality Guidelines for Europe, Second Edition, 2000; WHO Regional Office for Europe, Copenhagen*

Table 12: Workplace Emission Standards (Environmental Standards, 2020)

Parameter	Averaging Period*	Unit	Standard
TSPM	8-hour average	mg/m^3	10
	8-hour average	mg/m^3	5
$PM_{2.5}$	24-hour average	mg/m^3	25
	1 year average	mg/m^3	10
SO	8-hour average	mg/m^3	1
NO	8-hour average	mg/m^3	1
CO	8-hour average	mg/m^3	5
Pb	1-hour average	mg/m^3	0.0005
Oxone	8-hour average	ppm	0.08

Table 13: Noise Level Standards

Receptor/ Source	(dB)		WHO Guidelines Value For Noise Levels Measured Out of Doors** (One Hour LA_q in dBA)	
	Day***	Night****	07:00 – 22:00	22:00 – 07:00
Industrial area	75	65	70	70
Mixed area	65	55		
Sensitive area	55	45	55	45

* *Taken from Environmental Standards, National Environment Commission, Royal Government of Bhutan, 2020*

** *Guidelines for Community Noise, WHO, 1999.Source: Environmental, Health and Safety General Guidelines, 2007. International Finance Corporation, World Bank Group.*

*** *Day time is from 0600 hours to 2200 hours (human activities).*

**** *Nighttime is from 2200 hours to 0600 hours (limited human activities).*

Maximum value allowed in the workplace at any point in time is 75 dB (A).

Table 14: Effluent Standards for Sewage Treatment Plant

Parameters	Unit	NEC Standards,2020 mg/l [a]
Biochemical Oxygen Demand	mg/l	30.0
Total Suspended Solids	mg/l	100
Fecal Coliform	CFU/100ml	1,000

Parameters	Unit	NEC Standards,2020 mg/l [a]
pH	pH scale	6.5 – 9.0
Chemical Oxygen Demand	mg/l	125

Source: Environmental Standards, NEC 2020

Table 15: National Drinking Water Quality Standards, 2016

Group	National Drinking Water Quality Standards, 2016* (for Urban Drinking Water Supply)		
	Parameter	Unit	Max. Concentration Limits
Physical	Turbidity	NTU	5
	pH		6.5 – 8.5
	Color (TCU)	Hazen Unit	15
	Taste and Odor		Non- objectionable
Chemical	Iron	mg/l	0.3
	Manganese	mg/l	0.4
	Arsenic	mg/l	0.01
	Fluoride^	mg/l	1.5
	Lead	mg/l	0.01
	Nitrate	mg/l	50
	Calcium	mg/l	75
	Mercury	mg/l	0.006
	Residual Chlorine	mg/l	0.2 - 0.5
	Sulphate	mg/l	250
Microbiological	E-coli	CFU/100ml	0

* *Taken from Bhutan Drinking Water Quality Standard, 2016, National Environment Commission, Royal Government of Bhutan, 8 March 2016.*

** *Health-based guideline values*

^ *To be tested for ground and spring water only.*

^^ *From WHO (2003) Chlorine in Drinking-water, which states that this value is conservative.*

Table 16: Motor vehicle emission standards

Fuel Type	Vehicle registered prior to Jan 1, 2005	Vehicle registered after Jan 1, 2005	Vehicle registered prior to Jan 1, 2021	Vehicle registered after Jan 1, 2021 (Approval type: Euro 6/BS VI)
Petrol (%CO)	4.5%	4.0%	4.0%	0.5%
Diesel (%HSU)	75%	70%	70%	50%

Source: Environmental Standards, National Environment Commission, Royal Government of Bhutan, November 2010.

Table 17: Vehicular noise level limits

SN	Type of Vehicle	Sound pressure level limits dB(A)
1.	Two-Wheeler	
1.1	Displacement up to 80cc	75
1.2	Displacement more than 80cc but up to 175cc	77
1.3	Displacement more than 175cc	80
2	Vehicles used for carriage of passengers and capable of having not more than nine seats including the driver's seat	74
3	Vehicles used for carriage of passengers and capable of having more than nine seats, including the driver's	

SN	Type of Vehicle	Sound pressure level limits dB(A)
	seat and a maximum gross vehicle weight (GVW) of more than 3.5 tons	
3.1	With engine power less than 150 KW	78
3.2	With engine power more than 150 KW	80
4	Vehicles used for carriage of passengers and capable of having more than nine seats, including the driver's seat: vehicles used for carriage goods	
4.1	With maximum GVW not exceeding 2 tons	76
4.2	With maximum GVW greater than 3 tons but not exceeding 3.5 tons	77
5.0	Vehicles used for carriage of transport of goods with a maximum GVW exceeding 3.5 tons	
5.1	With engine power less than 75 KW	77
5.2	With engine power more than 75 KW or above but not less than 150 kv.	78

Source: Environmental Standards, National Environment Commission, Royal Government of Bhutan, November 2010.

2.2.4.4 Water Management

Water Policy, 2007

The policy focuses on the conservation of all forms of water resources and calls for integrated water resource management through extensive soil conservation, watershed area treatment, conservation of forests and increasing the forest area.

Water Act of Bhutan, 2011.

In terms of priority for water abstraction and use, the Water Act 2011, accords with the highest priority for drinking and sanitation followed by agriculture, energy, industry, tourism, recreation and finally, other uses. In line with the EA Act, 2000, and the Regulation for the Environmental Clearance of Projects (RECOP) (2002, revised in 2016), when there is a requirement of water abstraction, the applicant must adhere to the Water Act of Bhutan (2011) and the Water Regulation (2014), and seek Environmental Clearance for water abstraction and use.

The salient features of the Act relevant to hydropower development are:

- Chapter 7 on Water abstraction and Use: This covers the requirement of approval for feasibility studies and **prohibition to abstract water without Environment Clearance**. One of the criteria for issuance of EC is the effect of abstraction on existing users, water resources and water reserved /allocated for environmental use, existence of customary water use practices.
- Chapter 8 on Prevention and Control of Water Pollution: This chapter restricts the discharge of effluent directly or indirectly to any water resource.
- Chapter 10 on Construction and Safety of Water Infrastructure: This requires consultation with affected parties if their property is affected, and requires compensation to be paid to the beneficiaries, (including damages to people's property), for land acquired as per the Land Act. Also, wastewater must not cause inconvenience within the locality. Competent Authorities in consultation with the DoECC commission are required to set safety criteria and to ensure monitoring of the same.
- Chapter 12 on Water-related emergencies and other Special Circumstances. The DoECC/Commission may revoke the terms and conditions of the Environmental Clearance in the event of risk of drought or serious water scarcity, or other threats relating to water resources, and Competent Authorities are required to undertake all measures to mitigate such threats.
- Chapter 13 on financial provisions includes a section on Payment for Watershed Services so that the cost of conserving water in the upper watershed areas is shared by downstream users.
- Chapter 15 on Monitoring and Enforcement. The DoECC is required to conduct monitoring, inspection, and verification either by themselves or through the Competent Authorities or jointly,

according to the procedures for inspection and verification under Chapter VIII of National Environment Protection Act, 2007. The DoECC or Competent Authority has the authority to stop any activity relating to that poses an imminent threat to human health or the environment. Competent Authorities are required to submit annual reports on the enforcement and implementation of the provisions of this Act.

- Chapter 16 Offences and Penalties. This covers administrative sanctions and penalty assessment that may be issued for violating the provisions of the Water Act.

Water Regulation of Bhutan, 2014

This Regulation covers requirements to ensure fish movement and sustenance of water ecology. The relevant sections include:

- Section 8 and Section 9 promulgate the Polluter Pay Principle and the User Pays Principle respectively.
- Section 64 requires that a minimum environmental flow be determined during the EIA and maintained in watercourses to sustain water ecology and environment. Where scientific study reports are unable to determine this, at least 30% of lean season flow shall be maintained.
- Section 66 restricts development activities within one hundred (100) feet, measured from the determinable high flood level of either side, of any water body without an Environmental Clearance.
- Section 69 requires dams without design for fish movement to explore possibilities of retrofitting the dam with passage or other measures to allow fish movement.
- Section 78 requires new users to consult existing water users(s) of the same facility to get their consensus. If the request is declined, the proposal must be routed through the Gup to Dzongkhag, within 30 days. The Dzongkhag will assess the water availability and provide a written technical recommendation to the water user(s) with copy to the Gup. If there is a need to determine water availability during different seasons of a year, the Chairperson of the Water user's association or the Gup will inform the Dzongkhag Administration to conduct a technical analysis for the following seasons within the next winter or summer season and decisions will be based on this assessment.
- Section 81 details the information required to be submitted for the abstraction of water from a new water source, and Section 83 states that for temporary users, if the proposed water source for abstraction is not tapped by water users, the permit for the same can be obtained from the concerned Gewog Administration.

2.2.4.5 Preserving biodiversity and habitats

Forest and Nature Conservation Act (FNCA) of Bhutan, 2023

The Department of Forests and Park Services is mandated to enforce this act and is empowered to propose to the Ministry to designate various forest management regimes, and the preparation of their management plans, propose the listing and delisting of species, regulate and facilitate trade in forest products, develop technical guidelines, issues forestry permits, conduct national inventories, establish forest check gates and checkpoints. It is also responsible for representing and implementing international treaties or conventions relevant to forest and conservation.

This Act repeals the FNCA, 1995, and sections 490, 491, 492, and 493 of the Penal Code of Bhutan 2004 which covers offenses related to protected species, and sections 30 (k)(i) and (k)(ii) of the National Environment Protection Act of Bhutan, 2007, wherein the NEC was empowered to recommend to the Parliament to declare species as protected or declared protected areas. The Act states that any Permit, forestry clearance, or certificate issued under the FNCA 1995 is only effective until the expiry of the term.

The Act mandates the creation of an expert Scientific Authority to advise the Management Authority on import, export, or re-export of wild flora and fauna.

Government Reserved Forests have now been termed as State Reserved Forest Land (SRFL) and any inclusion into or exclusion from State Reserved Forest Land must follow the provisions of the Land Act of Bhutan.

The related provisions of the Act are summarized below.

Section 36, only the Parliament can declare National Park, Wildlife Reserve, Nature Reserve, Protected Forest, Biosphere Reserve, Critical Watershed, Biological Corridor, or significant wetland of international importance, based on the proposal of the Ministry.

Section 37 – Protected areas are delineated into various zones (core zone, transition zone, buffer zone, and multiple use zone), This is based on the wildlife habitat, species richness, traditional right, dominant land use, and resource extraction areas.

Section 38 – No mining, quarrying or developmental activities are permitted in the core zone of a protected area (PA).

Section 39 – Quarrying is permissible outside the core zone for rural use or developmental activities within the PA.

Section 44-46 – Forest clearance from the Department of Forests and Park Services is required for any activity within the State Reserved Forest Land (SRFL). The authority to issue FC is delegated to the field office based on technical categorization of the activity. FC will not be issued for core zones or areas outside the core zone of protected areas except for native inhabitants for their domestic use and national developmental activity, critical watersheds, high forest (High Forests" shall mean trees raised by means of natural seedling and when the crown cover of the forest is 40% and more), declared wetland, or areas where there are critical ecological sites along the roads, landslide prone areas, risk of damaging roads and bridges, significant landmarks or heritage sites, areas within 100 feet from the bank or edge of any water body, water recharge area identified by the Department, areas within 500 meters from the plinth of the monastery or Dzong, where there are no settlements nearby except for Monastery or Dzong.

Section 47 enables the DoFPS to institute mechanisms for Payment for Environmental Services (PES), to enhance resilience against climate change impacts and for green accounting and financial plough back to enhance conservation and sustainable management of forest resources.

- PES in Bhutan is a recent initiative and is currently operational on a limited pilot scale focusing mostly on PES for small water conservation schemes with payments being made to community forest groups upstream by water users such as the municipality downstream. The Forest and Nature Conservation Management Code of Best Practices Volume V details the steps for developing PES. This includes the followings steps for planning, design, and implementation of PES.
- Steps 1: Identifying the potential environmental service, ES users, ES providers and assessing legal policy and land ownership context.
- Step 2: Identifying project financing source.
- Step 3: Evaluating existing institutions and technical capacity gaps, surveying available PES support services and organizations and capacity development for both ES providers and users.
- Step 4: Structuring agreements and supporting analysis that involves ES valuation and opportunity cost analysis, reviewing option for payment types, negotiation process, designing PES agreements.
- Step 5: Implementing PES.
- The code of best practice acknowledges the need for technical capacity to develop PES schemes, and the requirement of additional support from government agencies for project design and development, as reflected in step 3.

Sections 51-56 covers the establishment and management of Community Forest. Section 55 enables the Government to implement and execute any developmental activity of national importance in the

Community Forest. In such as case, fair compensation as determined by the DoFPS must be paid to the Community Forest Management Group.

Section 67 covers plantation in SRFL. The Department may carry out by itself or outsource plantation works to any authorized agency and this must be carried out as per the Technical Guidelines issued by the Department. Section 70-71 states that the agency responsible for deforestation must carry out compensatory plantation and this will be monitored by the Department.

Section 73-77 covers forest fires for which restoration after fires to be coordinated and carried out by the Department.

Chapter 5 covers nature conservation and probits the killing, capture, collection, cultivation or trade in any wild flora and fauna, unless with a permit. All flora and fauna that warrant protection are listed in Schedule I-III of the Act and any new species discovered is to be listed under schedule III unless it warrants upgradation. Schedule I species cannot only be killed, injured, or destroy in defence against attack, imminent threat to human life or for population management if recommended by the Scientific Authority. Schedule II and III species are also protected as Schedule I species with the exceptions for approved fishing, scientific research, population management, defence against attack or imminent threat on human life, livestock, damage to crop or other private property. Any wildlife injured or killed must be immediately reported for rescue and rehabilitation to the nearest forest office If killed, the specimen must be handed over. Feeding of wildlife is prohibited except for scientific research.

Fishing is covered in Section 112. Fishing is regulated by the Department as per the procedure prescribed in the Rules. Fishing right may be granted to the local communities if their livelihood depends on fishing, with approved Community-based Fishery Management Plan. Fishing by river diversion, using large net, trap or snare, use of poison, dynamite, explosive, electrical device, building dam is prohibited. Fishing is also prohibited during certain religious days and months.

Forest and nature conservation rules and regulations of Bhutan 2017 and its amendment, 2020

The Forest and Nature Conservation Rules and Regulations of Bhutan, 2020 supersedes the Forest Fire Rules 2013, guidelines, notifications and circulars and specific provisions of the Forest and Nature Conservation Rules and Regulations of Bhutan, 2017 that have been amended.

Section 14 on the criteria for forest clearance has been amended to allow the Department to issue forestry clearance for construction of transmission line/tower, water pipeline, irrigation channel or roads in areas containing high forests based on impact assessment. This requires authorization by the Department if the slope is greater than 45 degrees or if this is within 100 feet of the bank or edge of any river, stream, water course/water source or within 600 feet uphill or 300 feet downhill of a motorable road.

Section 14 (9) delineates the level of authority between various offices for forest clearance for allotment of land, construction of road; or construction or maintenance of transmission line (Range Office: Up to 1 acre of land or up to 1 Km of road; Division: 1-5 acre of land or 1-5km of road with more than 5km of land or road only from the Department. Only the Department can issue FC for developmental activities inside a protected area.

Section 19 has been revised to allow forest clearances to be valid for a period of project or activity. This was only permitted for 1-2 years in the FNCR 2017.

Demarcation of SRFL (Section 23) requires the issuance of forestry clearance and approval by National Land Commission Secretariat (NLCS). Once this is received, a joint survey and demarcation is to be conducted by the Range Office and Dzongkhag Surveyor in the presence of the applicant and submitted to the Division.

Section 86 enables Community Forest Management Groups (CFMG) to allow the developmental activity within and through the CF on condition that the CFMG are compensated for the damage caused to the resources based on the guidelines developed and issued by the Department.

Section 87 states that FC will only be issued upon receipt of clearance from the Chairperson of the CFMG.

Section 112 -116 requires all mega projects to fund Compensatory plantation for double the State Reserved Forests area used. Funds must be made available prior to commission of the project, based on the details contained in the Detailed Project Report or financial estimate developed by the Department. The areas selected for the compensatory plantation program will not j be limited to project area but may also extend to other potential SRF areas. The plantation may be outsourced by the Department and must be executed as per terms and conditions of the outsourcing guideline and technical approval issued by the Department. Under Section 120, the CFO is responsible for supervising, monitoring and evaluation of nurseries and plantation, and must submit annual report to the Department.

Section 235 restricts the hunting, killing, trapping, transporting, capturing, breeding, cultivating, possessing or keeping as pet any totally protected species listed in Schedule I except if a special permit has been issued by the Ministry or in self-defence due to a direct threat to a person life or safety.

Section 237 also restricts the hunting, killing, trapping, transporting, capturing, breeding, cultivating, possessing or keeping as pet all other species of wildlife not included in totally protected species, except a)if required to control/prevent the spread of diseases that can be transmitted to humans, b) to defend against damage to crops and other private property in private registered land or c)for self-defence or to scare off the animal to prevent destruction of his property, livestock, or crops during sudden encounters. If such cases do occur, these must be reported as per Section 238.

Section 284 states that the Forest Department is mandated to manage waste in the State Reserved Forests by the Waste Prevention and Management Regulation, 2012

Section 364 states that aside from surface collection of sand and stones, all other minerals including stone quarry are the responsibility of the Department of Geology and Mines.

Section 387 on forest fires requires that the agency responsible for power line and substations must a) construct adequate fire lines around substations and other installations, b) carry out regular maintenance of transmission corridors and power lines and c) remove overhanging branches over the transmission lines.

Chapter XII lists the activities prohibited in state forest reserve lands. This includes a) littering and disposal of garbage or other waste material, and pollution of waterbodies, or water sources, b) quarrying and mining in protected area or significant wetlands, c) development of temporary or permanent habitation/settlement in critical watershed areas; d) hunting/capturing/poisoning/injuring of any wildlife or otherwise taking any animal and plant listed under the Schedule I, e) lists the dates and locations (e.g. within 500m of a monastery or Dzong), and means (eg. Poisoning, use of dynamites, explosives, electrical devices, damming, firearms, closed nets except for research and by use of live bait) by which fishing is prohibited.

Fishing

Section 251, 163 states that fishing within protected areas and state forest areas requires a valid permit.

Sections 271-283 details the requirements for fishing permits, which are non-transferable and valid only for a week and must be carried at the time of fishing.

Section 282 permits fishing for trading (with a valid trade license as a prerequisite) as an occupation by use of line rod for which a fee of Nu. 25000/- per year.

Section 283 permits those communities having customary rights to harvest fish from designated river/stream/water bodies in accordance with the management plan developed in collaboration with the relevant Department/agency.

Biological Corridor Rules, 2007

Biological corridor (BC) rules were promulgated in July 2007 as an addendum to Forest and Nature Conservation Rules 2006.

"Biological Corridor" means an area set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife. BC is managed centrally by the Department of Forests and Park Services (DoFPS). Any form of construction activities is prohibited inside BC except with a written permit or authorization such as Forestry Clearance from the Department based on technical regulations.

This would apply to the Biodiversity Corridor #7 in the Dorjilung HPP reservoir area.

The Biodiversity Act of Bhutan, 2022 and the Biodiversity Rules and Regulations, 2023

The Biodiversity Act and regulation cover conservation and sustainable use of biodiversity, access to genetic resources, access to traditional knowledge associated with genetic resources, fair and equitable sharing of benefits, Bhutan access and benefit sharing fund, and registry, records, and disposal of genetic resources.

The National Focal Point to implement this legislation is the National Biodiversity Centre under the Ministry of Agriculture and will represent the country on all matters pertaining to access and benefit sharing. NBC is the designated clearing house of all information related to the provisions of the Act and regulation and the national repository for all genetic resources and biological collections.

Although the act and the regulation address the conservation and sustainable use of genetic resources in detail, both act and the bill do not cover species or ecosystem diversity.

2.2.5 Key E&S Guidelines and standards

There are a several guidelines for health and medical waste management, education, environmental assessment, planning and development of human settlements construction of buildings and disaster management planning. Table 18 present the main Bhutanese E&S Guidelines and Standards.

Table 18: Main Bhutanese E&S Guidelines and Standards

Guideline	Prepared by	Description
Occupational health and safety: Guidelines for health professionals	Occupational Health and Safety Program Department of Public Health	Management and certification of occupation related issues and medical certification processes pertaining to medical screening for employment, immigration and disability compensation purposes
National guideline on infection control and medical waste management	Health Care & Diagnostic Division Department of Medical Services Ministry of Health	Health care associated infection (HCAI) and infection control measures and waste management
32nd Education Policy Guidelines and Instructions, 2018	Policy and Planning Division Ministry of Education	Reference on all education policies, guidelines and circulars that have been issued since the previous publication
Environmental codes of practice highways and roads 2000	Department of Roads Ministry of communications	Road construction and maintenance activities
Environmental assessment general guideline – 2012	National Environment Commission	Environmental assessment process

Guideline	Prepared by	Description
A Guide to Environmental Clearance Application Procedure – 2022	National Environment Commission	EC application process
Environmental assessment guideline for hydropower projects – 2012	National Environment Commission	Environmental assessment for Hydropower Projects
Environmental assessment guideline for roads and highways – 2012	National Environment Commission	Environmental assessment for Roads and Highways
Environmental assessment guideline for power transmission line projects – 2012	National Environment Commission	Environmental assessment for Power Transmission lines
Guideline to Determine Minimum E-flow Regulations for Hydropower Projects in Bhutan	National Environment Commission	E-flow determination
Bhutan Drinking Water Quality Standard 2016	National Environment Commission	Water quality standards
Environment Standards 2020	National Environment Commission	Standards for physical environment and project emissions (air, noise, emission, sewage)
Protected Area Zonation guidelines 2020	Department of Forest and Park Services	Classification of protected areas into different zones as per the functions of the area with prescriptions on management interventions
Guidelines for Planning and Development of Human Settlements in Urban and Rural Areas of Bhutan, 2013,	Department of Human Settlement, Ministry of Works and Human Settlement	Promotion of eco-friendly technologies, conservation of natural environment, management of environmental hazards (resilience planning)
Building code of Bhutan 2018	Department of Human Settlement, Ministry of Works and Human Settlement	Sets out technical requirements, standards and design considerations applicable for construction of buildings
Differently-abled-friendly-construction-Guideline	Department of Engineering Services Ministry of Works and Human Settlement	
Bhutan Architectural-Guidelines 2014	Ministry of Works and Human Settlement	Construction, repair and restoration of traditional structures and construction of modern buildings with respect to traditional architectural designs
Traditional architecture guidelines	Department of Urban Housing and Development Ministry of Works and Human Settlement	Guide on traditional architectural elements for buildings
Bhutan Green Building Design Guidelines 2013	Department of Engineering Services Ministry of Works and Human Settlement	Green principles and approaches mainly for new design and construction of buildings
Contingency Planning Guidelines for Bhutan 2014	Department of Disaster Management Ministry of Home and Cultural Affairs	Guide for preparing realistic and implementable Contingency Plans
Disaster Management Planning Guideline 2014	Department of Disaster Management Ministry of Home and Cultural Affairs	Guide for preparing disaster management plans

2.2.6 Bhutanese Environmental Clearance

The process for Bhutanese E&S Approvals, known as Environmental Clearance (EC) is outlined below. This process is separate to the International ESIA process. The specific requirements of the Dorjilung HPP project in relation to EC is unknown at this stage.

EC means the decision issued in writing by the National Environment Commission Secretariat (NECS) or the Competent Authorities (CAs), to let a project proceed, which includes terms and conditions to ensure that the project is managed in an environmentally sound and sustainable way. EC is issued by either NECS or CAs depending on the level required. The EC is issued for a maximum of 5 years. However, shorter EC periods are also accorded based on the complexity and nature of the projects.

Activities/projects are categorized into three color-coded categories as per the· 'Classification of projects/categorization of projects into color-coded categories, 2020'. Activities falling in the green category do not require EC, those falling in the blue category will be subjected to Initial Environmental Examination (IEE) level of assessment, and activities falling in the red category will be subjected to ESIA level of assessment. Any activity not falling in any of the categories will be subjected to IEE level of assessment. For activities requiring EIA, ToR need to be endorsed by DoECC.

Dorjilung HPP: It is expected that the project would be considered in the red category. It is noted that national requirements require that a separate EC is obtained for quarries and power evacuation line with the Section 15 of the Environmental Assessment Act, 2000 and Section 8 and 24 of the Regulation for Environmental Clearance of Projects, 2016. The National EIA also requires a study to provide information on current water use in keeping with the principles of the National Integrated Water Resources Management Plan, 2016.

For red category projects excluding industrial projects, the following shall apply:

- An applicant submits the draft ToR to the concerned CA for review and assessment.
- CA must forward the draft ToR to the DoECC for endorsement.
- The DoECC will issue the endorsed ToR to the applicant and share a copy with the CA.
- Based on the TOR endorsed by DoECC, the applicant will prepare ESIA report.
- The applicant will submit the ESIA report to the CA. The CA will forward the ESIA report to the DoECC for review and assessment.

Decision on EC by DoECC will be made by Environment Assessment and Technical Committee (EATC). EATC will decide to issue/reject EC or subject the application for further studies and review. For red category projects, public announcement will be made as per Section 28 of the EA Act 2000.

After issuance of EC the proponent is obliged to:

- Adhere to the requirements under other laws.
- Prepare and submit Detailed Implementation Plan after 3 months of EC issuance.
- Carry out self-monitoring to ensure compliance to EC terms and conditions, Environmental Standards 2020, and other environmental norms.
- Submit monitoring reports as stipulated in the EC terms and conditions.
- Apply for renewal at least three months prior to the expiry of EC.
- Prior approval must be sought should there be modification (as described under section 26 of the RECOP 2016).

2.3 International treaties and conventions supported by Bhutan

2.3.1 Environmental Conventions and Protocols

Table 19: Bhutan status regarding Environmental Convention and Protocols

Name	Objective	Bhutan Status and Relevance for Dorjilung HPP
Convention on Wetlands of International Importance (Ramsar, Iran, 1971), called the "Ramsar Convention"	The Convention's mission is "the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".	The RAMSAR Convention into force for Bhutan in 2012. Bhutan has 3 RAMSAR sites, in Khotokha, Phobjikha and Bumdeling. None of these sites will be affected by Dorjilung HPP.
UN Convention on Biodiversity (part of the Rio Convention) (1993)	0bjectives of this Convention are the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources, including by appropriate access to genetic resources and by appropriate transfer of relevant technologies, considering all rights over those resources and to technologies, and by appropriate funding (Convention, Article 1 Objectives).	Bhutan ratified the Convention in 1995. Not of direct relevance for Dorjilung HPP
CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora (1975)	International agreement between governments. Its aim is to ensure that international trade in specimens of wild animals and plants does not threaten their survival.	Bhutan ratified the CITES in 2002. The Department of Forest and Park Services is the focal agency to the CITES. Not of direct relevance for Dorjilung HPP
World Heritage Convention (WHC), into force on December 1975	Convention concerning the Protection of the World's Cultural and Natural Heritage.	Bhutan ratified the Convention in 2001 but has not yet any WH site. Not of direct relevance for Dorjilung HPP.
Vienna Convention for the protection of Ozone layer (1985)	Framework for international cooperation concerning the protection of the ozone layer	Bhutan became the party to the Vienna Convention on 23 August 2004.
Montreal Protocol (1989) and Kigali Amendment (2016)	International agreement to regulate substances depleting the ozone layer and particularly to phase-down the use of hydrofluorocarbons (HFCs).	Bhutan is party since 2004 and deposited the Instrument of Ratification with the UN in 2019. No relevance for Dorjilung
The United Nations Framework Convention on Climate Change (UNFCCC) (1994)	The UNFCCC aims "to achieve, in accordance with the relevant provisions of the convention, stabilization of greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.	Bhutan ratified the convention in 1995. Indirect relevance for Dorjilung (GHG emission control through design and implementation).
Kyoto Protocol (2005)	The Kyoto Protocol operationalizes the UN Framework Convention on Climate Change by committing countries to limit and reduce GHG emissions in accordance with agreed individual targets	Bhutan ratified the convention in 2002. Same indirect relevance as for UNFCCC above

Name	Objective	Bhutan Status and Relevance for Dorjilung HPP
Paris Agreement (2015)	The purpose of the Paris Agreement is to strengthen the global response to the threat of climate change through: a) a "temperature goal" of limiting the increase in global average temperature to < 2°C in relation to pre-industrial levels, and preferably < 1.5°C. b) increasing the ability to adapt to adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development. c) making financial flows consistent with efforts for low greenhouse gas development and climate resilient development.	Bhutan ratified the Paris Agreement in 2017.
The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1992)	The Basel Convention regulates the transboundary movements of hazardous wastes and other wastes and obliges its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner.	The Basel convention entered into force in Bhutan on 24/11/2002

2.3.2 Human Rights Conventions

The Office of the United Nations High Commissioner for Human Rights (OHCHR) states 9 core international human rights instruments. Indeed, Bhutan has signed 6 and ratified 4 treaties (Table 20).

Table 20: Bhutan's signature and ratification of The Core International Human Rights Instruments

Treaty	Date	Signature Date by Bhutan	Ratification Date by Bhutan
International Convention on the Elimination of All Forms of Racial Discrimination (ICERD)	21 Dec 1965	27 Mar 1973	-
Convention on the Elimination of All Forms of Discrimination against Women (CEDAW)	18 Dec 1979	17 Jul 1980	31 Aug 1981
Convention on the Rights of the Child (CRC)	20 Nov 1989	04 Jun 1990	01 Aug 1990
Convention on the Rights of Persons with Disabilities (CRPD)	13 Dec 2006	21 Sep 2010	-
Optional protocol to the Convention on the Rights of the Child on the involvement of children in armed conflict (OP – CRC – AC)	25 May 2000	15 Sep 2005	09 Dec 2009
Optional Protocol to the Convention on the Rights of the Child and the sale of children, child prostitution and child pornography (OP – CRC – SC)	25 May 2000	15 Sep 2005	26 Oct 2009

Source: OHCHR

2.3.3 International Labour Organization (ILO) Conventions

International labour standards are legal instruments drawn up by the ILO's constituents (governments, employers and workers) and setting out basic principles and rights at work. They are either Conventions (or Protocols), which are legally binding international treaties that may be ratified by member states, or Recommendations, which serve as non-binding guidelines. The 11 fundamental instruments of ILO are listed below:

- Freedom of Association and Protection of the Right to Organise Convention, 1948.
- Right to Organise and Collective Bargaining Convention, 1949.

- Forced Labour Convention, 1930*.
- Protocol of 2014 to the Forced Labour Convention.
- Abolition of Forced Labour Convention, 1957.
- Minimum Age Convention, 1973.
- Worst Forms of Child Labour Convention, 1999.
- Equal Remuneration Convention, 1951.
- Discrimination (Employment and Occupation) Convention, 1958.
- Occupational Safety and Health Convention, 1981.
- Promotional Framework for Occupational Safety and Health Convention, 2006.

Bhutan is a non-member state of the ILO, such as Andorra, Liechtenstein, Micronesia, Monaco and Nauru. Despite that, the country has incorporated aspects of certain ILO Conventions into its national laws and regulations. Here are some areas where Bhutan's national laws cover aspects of ILO Conventions:

Child labour	Bhutan has laws prohibiting child labour and promoting compulsory education, which align with the principles outlined in ILO Convention No. 138 (Minimum Age Convention) and Convention No. 182 (Worst Forms of Child Labour Convention).
Occupational safety and health	The country has regulations aimed at ensuring workplace safety and health, possibly inspired by the principles of ILO Convention No. 155 (Occupational Safety and Health Convention) and Convention No. 187 (Promotional Framework for Occupational Safety and Health Convention).
Employment Discrimination	Bhutanese laws cover aspects related to non-discrimination in employment and occupation, echoing principles within ILO Convention No. 111 (Discrimination in Employment and Occupation Convention). The 2022 Bhutan Human Rights Report states that "all eligible Bhutanese citizens shall have equal opportunity for employment and career advancement in the Civil Service on the basis of merit, qualification, fair and open competition without discrimination on the grounds of race, sex, language, religion, and other status." (https://www.state.gov/wp-content/uploads/2023/02/415610_BHUTAN-2022-HUMAN-RIGHTS-REPORT.pdf). That said, in the report "Freedom in the World 2022" (https://freedomhouse.org/sites/default/files/2022-02/FIW_2022_PDF_Booklet_Digital_Final_Web.pdf) the American NGO Freedom House noted ethnic Nepali residents often could not obtain a police security clearance certificate; without that certificate, they faced difficulties in starting a business, enrolling in higher education, or obtaining passports or government jobs, and the process of registering property could also be lengthy for them. The report also states that the government did not permit NGOs to work on matters involving the status of ethnic Nepalis.
Forced labour	The Bhutanese legislation addresses issues related to forced labour, reflecting some aspects of ILO Convention No. 29 (Forced Labour Convention). Section 6 of the Labour and Employment Act of Bhutan (2007) (https://antislaverylaw.ac.uk/wp-content/uploads/2019/08/Bhutan-Labour-Law.pdf) states that "no person shall make use of, cause or permit any form of forced

or compulsory labour that is extracted from any person under the menace of any penalty and for which the person has not offered himself or herself voluntarily."

2.3.4 Cultural Property

Bhutan ratified in 2002 the UNESCO 1970 Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of Ownership of Cultural Property 1970.

Bhutan ratified in 2005 the UNESCO 'Convention on safeguarding of the Intangible Cultural Heritage 2003.

2.4 International framework

2.4.1 Environmental and social standards

World Bank group E&S Standards

The Project will likely seek international financing through the WB. The development and associated E&S documentation need to address applicable international WB ESS. The WB ESP (2017) with its 10 ESSs consolidate guidance for international best practices and provide a framework for specific objectives, systems, policies, and practices to be followed by a project proponent seeking WB financing (and more broadly as a robust international E&S standard).

Applicability of WB ESS

An initial summary of WB ESS and their applicability to the Project is provided in Table 21. This reflects some early stakeholders' feedback and preliminary site observations.

Table 21: Applicability of ESS to the Project

ESS from WB	Applicability to the Project
ESS 1: Assessment and Management of Environmental and Social Risks and Impacts ESS 1 sets out the Borrower's responsibilities for assessing, managing and monitoring environmental and social risks and impacts associated with each stage of a project supported by the Bank through Investment Project Financing, in order to achieve environmental and socialoutcomes consistent with the ESSs.	**Applies –** The proposed HPP is considered a High-Risk project and triggers a full ESIA. This determination has been made by the World Bank after considering relevant issues, such as the type, location, sensitivity, and scale of the project; the nature and magnitude of the potential environmental and social risks and impacts; and the capacity and commitment of the Borrower to manage the environmental and social risks and impacts in a manner consistent with the ESSs. For High-Risk projects the Bank requires the Borrower to carry out appropriate ESIA. The ESIA documentation will address, in an adequate manner, the key risks and impacts of the project, and will provide sufficient detail to inform stakeholder engagement and Bank decision making.
ESS 2: Labour and Working Conditions ESS 2 recognizes the importance of employment creation and income generation in the pursuit of poverty reduction and inclusive economic growth. Borrowers can promote sound worker- management relationships and enhance the development benefits of a project by treating workers in the project fairly and providing safe and healthy working conditions.	**Applies –** Based on early estimation, construction would require a large workforce at peak (6000+ persons, to be further defined) with a significant proportion of foreign workers expected (90-95%, to be further defined). ESS2 applies to project workers including fulltime, part- time, temporary, seasonal, and migrant workers. A specific focus on labour conditions and employment was further confirmed by DGPC.
ESS 3: Resource Efficiency and Pollution Prevention and Management ESS 3 recognizes that economic activity and urbanization often generate pollution to air, water, and	**Applies –** Building the entire HPP scheme and accommodating a population of 6000+ workers will lead to consumption of large amount of energy, water and other resources. Other HPPs built in Bhutan have been

ESS from WB	Applicability to the Project
land, and consume finite resources that may threaten people, ecosystem services and the environment atthe local, regional, and global levels. This ESS sets out the requirements to address resource efficiency and pollution prevention and management throughout the project life cycle.	associated with conflicts on water resources. The worker population and multiple facilities and construction activities will generate significant volumes of waste. There are also risks associated with pollution (water and soil contamination) and general impacts on human amenities (noise, air – soil – water quality).
ESS 4: Community Health and Safety ESS 4 addresses the health, safety, and security risks and impacts on project- affected communities and the corresponding responsibility of Borrowers to avoid or minimize such risks and impacts, with particular attention to people who, because of their particular circumstances, may be vulnerable.	**Applies –** Needs to be considered through the labour influx angle for potential impacts on the community as a result of a large workforce and the construction activities (traffic, excavation, live electrical equipment, etc.). The ESIA needs to include an assessment of security risks to project staff and equipment, particularly with the anticipated large influx of population into the project area. The risk assessment shall be included in the ESIA, and the necessary management plans will be included in ESMP and a standalone security management plan.
ESS 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement ESS 5 - involuntary resettlement should be avoided. Where involuntary resettlement is unavoidable, it will be minimized and appropriate measures to mitigate adverse impacts on displaced persons (and on host communities receiving displaced persons) will be carefully planned and implemented.	**Applies –** The Project will require the acquisition of over 800 acres (320ha) (could be up to 1000 Acres (400ha)). A large part of it is government land but some of it is private land. The Project would impact some households by loss of livelihood / economic displacement and 1 HH is requiring physical resettlement; another household loses all its built assets.
ESS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources ESS 6 recognizes that protecting and conserving biodiversity and sustainably managing living natural resources are fundamental to sustainable development and it recognizes the importance of maintaining core ecological functions of habitats, including forests, and the biodiversity they support. ESS6 also addresses sustainable management of primary production and harvesting of living natural resources.	**Applies –** Includes the objective to apply the mitigation hierarchy and the precautionary approach in the design and implementation of projects that could have an impact on biodiversity. Key relevance for ESS6 is whether there are risks or impacts to biodiversity of significant importance, natural habitats, likely critical habitats, protected areas, invasive alien species, sustainable management of living natural resources, and primary suppliers. Should specific elements as natural habitats, critical habitats, protected areas, IUCN listed species, etc. be impacted by the project, a Biodiversity Management Plan shall be prepared. These obligations apply as: - A part of the land acquired and cleared for the Project is natural habitat. - The reservoir will intersect with the Biodiversity Corridor #7. - The project dewaters a stretch of river and impact another habitat of IUCN listed fish species.
ESS 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities ESS7 ensures that the development process fosters full respect for the human rights, dignity, aspirations, identity, culture, and natural resource-based livelihoods of Indigenous Peoples/Sub- Saharan African Historically Underserved Traditional Local Communities. ESS7 is also meant to avoid adverse impacts of projects on Indigenous Peoples/Sub-	**Does not apply –** based on the ESS 7 screening documented in Section 2.4.2, it was considered that ESS 7 does not apply to this Project. This is subject to further determination by the WB. Please refer to the IP memo on this topic, provided separately to WB for review and included in Appendices.

ESS from WB	Applicability to the Project
Saharan African Historically Underserved Traditional Local Communities, or when avoidance is not possible, to minimize, mitigate and/or compensate for such impacts.	
ESS 8: Cultural Heritage ESS8 recognizes that cultural heritage provides continuity in tangible and intangible forms between the past, present and future. ESS8 sets out measures designed to protect cultural heritage throughout the project life cycle.	**Applies –** The design of the Project has already reflected consideration of a significant heritage item. For instance, the level of the reservoir has been determined in a way to avoid flooding the Autsho Chongden. No major cultural heritage item is expected to be impacted and early feedback indicates that the river does not hold specific cultural value to local communities.
ESS9: Financial Intermediaries (FI) ESS9 recognizes that strong domestic capital and financial markets and access to finance are important for economic development, growth, and poverty reduction. FIs are required to monitor and manage the environmental and social risks and impacts of their portfolio and FI subprojects, and monitor portfolio risk, as appropriate to the nature of intermediated financing. The way in which the FI will manage its portfolio will take various forms, depending on a number of considerations, including the capacity of the FI and the nature and scope of the funding to be provided by the FI.	**Does not apply –** based on current information.
ESS10: Stakeholder Engagement and Information Disclosure ESS10 recognizes the importance of open and transparent engagement between the Borrower and project stakeholders as an essential element of good international practice. Effective stakeholder engagement can improve the environmental and social sustainability of projects, enhance project acceptance, and make a significant contribution to successful project design and implementation.	**Applies –** The Project is considered a High-Risk project and will require a comprehensive stakeholder engagement, public consultation, and public disclosure of E&S Documentation.

Applicability of World Bank Operational Policies (OPs)

The Kurichhu river on which the Dorjilung HPP is implemented is an international river: The upper (and highest) part of its catchment is located in China and the lowest reach of the river crosses the Indian border. For these reasons, OP 7.50 (Projects on International Waterways) is triggered.

Word Bank Group Environmental, Health, and Safety (EHS) Guidelines and Resources

The Word Bank Group EHS Guidelines are technical reference documents with general and industry-specific examples of GIIP and are referred to in the World Bank's Environmental and Social Framework. The EHS Guidelines contain the performance levels and measures that are normally acceptable to the World Bank Group, and that are generally considered to be achievable in new facilities at reasonable costs by existing technology.

The following EHS Guidelines and WB Resources are considered relevant to the Dorjilung HPP and have been accessed in the preparation of this ESIA and associated documentation:

- World Bank Group General Environmental Health and Safety Guidelines. The General EHS Guidelines contain information on cross-cutting environmental, health, and safety issues potentially applicable to all industry sectors.
- World Bank Group Industry Sector Guidelines for Construction Materials Extraction. This document includes information relevant to construction materials extraction activities.
- World Bank Group Industry Sector Guidelines for Electric Power Transmission and Distribution. Provides information relevant to power transmission between a generation facility and a substation located within an electricity grid, in addition to power distribution from a substation to consumers located in residential, commercial, and industrial areas.
- World Bank Directive on Addressing Risks on Disadvantaged or Vulnerable Individuals/Groups. This directive highlights the need to pay particular attention to those who could be subject to retaliation or reprisals for participating in project consultations, voicing an opinion, or raising a complaint.
- World Bank Directive on Environmental and Social Directive for Investment Project Financing. This Directive establishes directions for Investment Project Financing and applies to the Bank.
- World Bank Guideline on managing the risks of adverse impacts on communities from temporary project induced labour influx. Provides guidance on identifying, assessing and managing the risks of adverse social and environmental impacts that are associated with the temporary influx of labour, including and workers' camp issues.
- World Bank Group Good Practice Handbook for Environmental Flows for Hydropower Projects. Provides guidance to practitioners on determining a project's environmental flow commitments through a rigorous assessment of impacts on downstream river ecosystems and people.
- ESF-Guidance Note for borrowers, ESF for IPF Operations ESS7: Indigenous Peoples/ Sub-Saharan African Historically Underserved Traditional Local Communities. A key purpose of this ESS is to ensure that Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities present in or with collective attachment to the project area are fully consulted about, and have opportunities to actively participate in, project design and the determination of project implementation arrangements.
- World Bank Good Practice Note on Gender and addressing GBV in IPF involving major civil works. Developed to assist Task Teams in identifying risks of sexual exploitation and abuse, and sexual harassment – as opposed to all forms of gender-based violence that can emerge in Investment Project Financing involving major civil works contracts – and to advise Borrowers on how to best manage such risks.
- World Bank Guides to develop a community based GRM for sexual exploitation and abuse, for sexual harassment, to write and implement a workplace policy for prevention of sexual harassment.
- World Bank Group Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets. This handbook provides guidance in the identification of cumulative impacts and in the effective design and implementation of measures to manage such cumulative effects.

2.4.2 Specific assessment regarding the applicability of ESS7 (ref. ESF Guidance Note 7 Indigenous Peoples)

2.4.2.1 Application

The ESF Guidance Note 7 Indigenous Peoples has been referenced for this assessment.

ESS7 applies to all groups under the various terms used "Indigenous Peoples/ Sub-Saharan African Historically Underserved Traditional Communities" "Indigenous ethnic Minorities" "Aboriginals", "hill tribes", "vulnerable and marginalized groups" "minority nationalities" "scheduled tribes" "first nations" or "tribal groups".

For the purpose of this ESIA the term used will be "Indigenous Peoples" (IP).

The objectives of ESS7 are:

- To ensure that the development process fosters full respect for the human rights, dignity, aspirations, identity culture, and natural resource-based livelihoods of IPs.
- To avoid adverse impacts of projects on IP or when avoidance is not possible, to minimize, mitigate, and/or compensate for such impacts.
- To promote sustainable development benefits and opportunities for IPs in a manner that is accessible, culturally appropriate, and inclusive.
- To improve project design and promote local support by establishing and maintaining an on-going relationship based on meaningful consultation with the IPs affected by a project throughout the project's lifecycle.
- To obtain the Free, Prior and Informed Consent (FPIC) of affected IPs, if one of the three circumstances described in Paragraph 24 if the ESS7 is met.
- To recognize, respect and preserve the culture, knowledge and practices of IPs, and to provide them with an opportunity to adapt to changing conditions in a manner and in a timeframe acceptable to them.

2.4.2.2 Screening process

The screening process aims at assessing if the ESS7 applies (according to paragraphs 8 and 9 of ESS7): this assessment is based on existing literature review, official documents, key informant interviews (KII) and results of focus-group discussions (FGDs) and household (HH) survey. Please also refer to the social baseline in Section 8.2.3 of ESIA for more details.

Table 22: IP Screening for Dorjilung HPP

Criteria	Situation for Dorjilung HPP	Applicable to Dorjilung HPP
1- If a distinct social group and cultural group possesses:		
(a) self-identification as members of a distinct Indigenous social and cultural group and recognition of this identify by others	Despite the recognition, in the field, of the presence of different socio-cultural groups that mark Bhutan's cultural diversity (such as Chalip, Kurmaed, Khengpa, Sharchop, and a few Southern Bhutanese), it was not reported that these cultural differences imply deep social differences to the point of claiming the need to recognize that they belong to a distinct social (indigenous) group. Each socio-cultural group recognizes itself as such, and the other groups respectively, but they see themselves as part of the diversity that makes up Bhutanese society as, for example, the Chhalips and Kurmaed as being part of the broader Scharchop group. No group sought to define itself predominantly by its differences, on the contrary, always emphasizing customs and habits that they share with other communities. The very idea of "indigenous" doesn't make sense to local communities, and as a result, they don't really claim this recognition.	No

Criteria	Situation for Dorjilung HPP	Applicable to Dorjilung HPP
(b) collective attachment to geographically distinct habitats, ancestral territories, or areas of seasonal use of occupation, as well as to the natural resources in these areas	In Bhutan, land ownership is primarily delineated into two categories: private ownership, held by individuals and institutions, and government ownership. Wangchuk's (2000) analysis underscores that historically, a significant portion of Bhutan's land was privately owned, contrasting with the conventional understanding of feudal systems. This private ownership extended to forest areas, which were managed and utilized by individual families or communities based on customary practices. However, with the introduction of the Land Act and subsequent forest regulations, there was a shift in the management and ownership of forest areas. Before these regulations, forest areas, even if communal, were managed with a significant degree of individual or local community discretion. Post the Land Act and forest regulations, the distinction between private and community forests became more pronounced, with the state playing a more active role in the management and conservation of these areas. The regulations brought about a more structured approach to forest management, emphasizing conservation, sustainable use, and state oversight. Within the proposed project area, no group perceives their lands and resources as collective assets, even in the case of community forests. These community forests, while communal in nature, do not hold any socio-cultural major significance. Furthermore, there's an absence of any collective attachment to geographically distinct habitats or ancestral territories. Wangchuk's conclusions suggest that, even in communal settings, the relationship with the land in Bhutan historically also has an individualistic dimension, emphasizing the predominance of private land ownership by the peasantry rather than a concentration in the hands of a collective ownership or few elites. The practices and uses of natural resources differ very little from community to community. Despite cultural differences, they are well interacted economically.	No
(c) customary cultural, economic, social or political institutions that are distinct or separate from those of the mainstream society or culture, and	No distinct institutions (whether formal or informal) for the local groups have been identified. In Bhutan, equity in balanced regional development is a Constitutional provision (Article 9-Principles of State Policy). The local planning processes in the Chiwog, Gewog and Dzongkhag (district) levels are inclusive of all resident population, regardless of their ethnic or group belongings. In no community were the meetings led by someone who was not, at the same time, someone from the community and formally linked to the formal administrative and political authority. In no community were the meetings mediated by a local traditional and/or religious leader other than the formal representative.	No

Criteria	Situation for Dorjilung HPP	Applicable to Dorjilung HPP
(d) a distinct language or dialect, often different from the official language or languages of the country or region in which they reside.	Although Dzongkhag is the national language, Bhutan has at least 19 different languages. In the project area, 40% of respondents in the HH survey speak Tsangla, 29% speaks Dzongkha, 24% Kurmedkha and 7% other languages. While the Chhalipas and Kurmaedpas, along with the linguistically diverse groups within the Sharchokpas, exhibit unique linguistic characteristics, their overall cultural and social integration with the larger Sharchokpa ethnic group in Bhutan suggests they might not meet the specific criteria for recognition as Indigenous Peoples under ESS7.	Yes – however not considered to meet ESS7
2- OR		
A community or groups of IPs has lost collective attachment to distinct habitat/ ancestral territories in the project area because of forced severance, conflict, government resettlement programs, dispossession of their land, natural disasters, urbanising.	The field research and bibliographic review in the project area, predominantly inhabited by the Sharchopas and other socio-cultural groups, reveal their cultural and traditional integration into the wider Bhutanese society. This integration is a key indicator of their lack of a distinct, collective connection to specific natural resources or ancestral lands. Furthermore, the historical patterns of land ownership in Bhutan, characterized by individual rather than collective ownership, further demonstrate the absence of a deep, communal tie to the land that is typically associated with indigenous communities. This lack of collective attachment to ancestral territories among the groups in the study area significantly contributes to the non-applicability of this criterion. There are no communities in the region without enough land to plant or graze, to the same extent as their neighbouring communities. In other words, there are no differences that could be a sign of some kind of discriminatory imposition of loss against any community.	No

2.4.2.3 Conclusion on ESS 7 for Dorjilung HPP

In conclusion, the intricate socio-cultural dynamics of Bhutan, as explored in the research and field surveys conducted for the ESIA and considered against the World Bank's ESS7, indicate that the proposed Dorjilung Hydropower Project area does not include indigenous communities as defined by ESS7. Bhutan's rich diversity, resulting from numerous waves of migrations, has fostered a tapestry of languages, traditions, and customs. This multicultural fabric, while distinct, does not align with the characteristics of "indigenous" as per ESS7.

The ESIA research, incorporating socio-economic surveys, reveals no self-identification or reference to "indigenous" traits among groups like the Chhalipas and Kurmaedpas, cited in the KII. Despite their unique dialects, these groups demonstrate considerable cultural, traditional, and customary congruence with the larger Sharchokpas group, challenging their classification as distinct entities under ESS7. Their assimilation into mainstream Bhutanese society, particularly in customs and traditions, and the absence of a unique connection to natural resources suggest a cultural and social integration that does not meet the ESS7 criteria for indigenous recognition.

Given these factors, the Dorjilung HPP, based on the ESS7 screening, does not consider the Indigenous Peoples (IP) criteria applicable. This conclusion is provisional, pending the World Bank's final determination on the applicability of ESS7.

The following measures will be applied for the Project:

- Respecting the principle of the Constitution of Bhutan 2008 to guarantee to all citizens equality before the law and with inclusive outreach and participation of all socio-cultural processes in the development process; and
- Including participatory approaches of planning from the grassroots, continuous engagement and informed consent are in place.

2.4.3 Other applicable E&S Standards and Guides

In addition to WB other lenders also have their own E&S standards even though they tend to be largely aligned with the WB. Some of them will be considered as relevant; this includes but is not limited to:

- Bhutan National Environmental Commission Guideline on Environmental Flows
- IFC Good Practice Note on Environmental, Health, and Safety Approaches for Hydropower Projects
- Managing Environmental and Social Impacts of Hydropower in Bhutan
- EBRD/IHA/WB (2019), "Hydropower Resilience Guidelines".
- IPCC (2006), "Guidelines for national greenhouse gas inventories", Appendix 2: estimating CO2 emissions from flooded land and Appendix 3 CH4 emissions from flooded land".
- ADB/ILO (2006), "Core Labor Standard Handbook".
- International Labour Organisation, "Labor standards, convention and recommendations".
- IFC FC Worker's Accommodation: Processes and Standards (2009).
- DGPC is not seeking International Hydropower Association Sustainable Certification for Dorjilung HPP.

2.5 Gap analysis Between National Legislation and International Policy

Table 23: Gap Analysis and Measures to Bridge Gaps Between National Legislation and International Policy

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
ESS 1: Assessment and Management of Environmental and Social Risks and Impacts	- To identify, evaluate and manage the environment and social risks and impacts of the project in a manner consistent with the ESSs. This includes analysis of associated facilities, alternatives and cumulative impacts Includes evaluating the nature and significance (low, moderate, substantial, high) of the environmental and social risks and impacts. - To adopt a mitigation hierarchy approach to: (a) Anticipate and avoid risks and impacts; (b) Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels; (c) Once risks and impacts	- The process for Bhutanese E&S Approvals is known as EC. - Activities/projects are categorized into three color-coded categories. Since Hydropower falls in the Red category, it will be subjected to the Environmental Impact Assessment (EIA) level of assessment. - For activities requiring EIA, ToR needs to be endorsed by DoECC. - The assessment of minimum E-flow must be in line with the "Guideline to Determine Minimum Environmental Flow Regulations for Dewatered	International E&S standards are more stringent and should be applied. The Project will: - Prepare ESIA and associate documentation to WB requirements. - Evaluate the nature and significance (low, moderate, substantial, high) of the environmental and social risks and impacts. - Adopt a mitigation hierarchy approach (avoid / minimize / mitigate / offset). - This includes an Environmental and Social

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
	have been minimized or reduced, mitigate; and (d) Where significant residual impacts remain, compensate for or offset them, where technically and financially feasible. - Adopting differentiated measures so that adverse impacts do not fall disproportionately on the disadvantaged or vulnerable, and they are not disadvantaged in sharing development benefits and opportunities resulting from the project. - To utilize national environmental and social institutions, systems, laws, regulations and procedures in the assessment, development and implementation of projects, whenever appropriate. - To promote improved environmental and social performance, in ways which recognize and enhance Borrower capacity.	Reaches of Hydropower Projects in Bhutan, 2019". - Stakeholder and community consultation are required as part of the impact assessment and for planning of mitigation measures. The ToR does not specify how to engage vulnerable people. - Consent from affected persons/households and the community is a prerequisite. - Separate EC for all the ancillaries' facilities such as a construction power line connection, access roads, concrete batching plants, aggregate processing plants, must be applied separately through a separate Initial Environmental Examination form.	Commitment Plan (ESCP). - The full list of documentation to be prepared is detailed in 1.3.3. • Tender documents will incorporate ESF and ESCP requirements. • Contractors (including any subcontractors) will be required to operate in a manner that meets the requirements of ESF and ESCP. This includes requirements for contractors to prepare Contractor's Environmental and Social Management Plans (C-ESMPs) that are in line with the ESIA and ESMP.
ESS 2: Labour and Working Conditions	- To promote safety and health at work. - To promote the fair treatment, non-discrimination and equal opportunity of project workers. - To protect project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, in accordance with this ESS) and migrant workers, contracted workers, community workers and primary supply workers, as appropriate. - To prevent the use of all forms of forced labour and child labour.	- The Labour and Employment Act of Bhutan 2007 prohibits 'forced or compulsory' labour and 'worst forms of child' labour, discrimination against employees or job applicants for vacancies in connection with recruitment, dismissal, transfer, training, and demotion, or for wages and working conditions. It also defines and restricts sexual harassment and wrongful dismissal. The Act also touches on Compensation and benefits of employees and Occupational Health	International E&S standards are more stringent and should be applied. The Project will: - Consider this ESS in the preparation of ESIA. - Prepare a standalone Labour Management Procedures. - Prepare a standalone GSVAP. - Request from the Contractor the preparation of an Occupational Health and Safety Plan based on obligations presented in the ESMP/Labour

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
	- To support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law. - To provide project workers with accessible means to raise workplace concerns. - To have a clear human resources policy	and Safety (OHS). Occupational Health and Safety.	Management Procedures and detailed in the ESHS Section of the bidding documents. - A workers Grievance Redress Mechanism will be requested from all subsidiaries.
ESS 3: Resource Efficiency and Pollution Prevention and Management	- To promote the sustainable use of resources, including energy, water and raw materials. - To avoid or minimize adverse impacts on human health and the environment by avoiding or minimizing pollution from project activities. - To avoid or minimize project-related emissions of short and long-lived climate pollutants (This includes all GHGs and black carbon (BC). - To avoid or minimize generation of hazardous and non-hazardous waste. - To minimize and manage the risks and impacts associated with pesticide use.	- Landfill sites are required to have facilities for collection and treatment of leachate and adequate facilities to manage the landfill gas. - Hazardous waste and infectious waste must not be disposed of in the landfill intended for municipal waste. - Any incineration facility must be approved by the DECC. - It is the duty and responsibility of every business (including contractors) to provide appropriate facilities for waste segregation into bio-degradable, non-biodegradable waste and hazardous waste. - Minimum standards and requirements for the transport of waste are applied.	International E&S standards are more stringent and should be applied. The Project will: - Conduct a Greenhouse Gas Assessment for the reservoir. - Require contractors to prepare a variety of plans including a waste management plan, hazardous substances management plan, water quality monitoring plan, erosion and sediment control plan, muck disposal planning and management plan.
ESS 4: Community Health and Safety	- To anticipate and avoid adverse impacts on the health and safety of project-affected communities during the project life cycle from both routine and nonroutine circumstances. - To promote quality and safety, and considerations relating to climate change, in the design and construction of infrastructure, including dams.	- All contractors are required to abide by the Regulation on Occupational Health and Safety for the Construction Industry, 2022. It requires contractors to prepare a health and safety (HS) policy, appoint both an HS committee, a Safety Officer, and a Safety Representative, an Emergency Action Plan,	International E&S standards are more stringent and should be applied. The Project will: - Consider this ESS in the preparation of ESIA. - Prepare Labour Management Procedures. - Prepare a standalone GSVAP.

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
	- To avoid or minimize community exposure to project-related traffic and road safety risks, diseases and hazardous materials. - To have in place effective measures to address emergency events. - To ensure that the safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the project-affected communities.	provision for Personal Protective Equipment for its workers and detail safety measures for specific types of activities including maintenance of construction machines and equipment, demolition works and blasting.	- Prepare a climate change risk assessment. - Prepare a dam safety analysis. • Require contractors to prepare a variety of plans including; Construction Supervision and Quality Assurance Plan, Instrumentation Plan, Emergency Preparedness Plan, Operation and Maintenance Plan, Construction Sites Access And Security, Management Of Construction Worker Colonies (Camps), Occupational Health And Safety Plan, Communities Health And Safety Management Plan.
ESS 5: Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	- To avoid involuntary resettlement or, when unavoidable, minimize involuntary resettlement by exploring project design alternatives. - To avoid forced eviction. - To mitigate unavoidable adverse social and economic impacts from land acquisition or restrictions on land use by: (a) providing timely compensation for loss of assets at replacement cost and (b) assisting displaced persons in their efforts to improve, or at least restore, their livelihoods and living standards, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher. - To improve living conditions of poor or vulnerable persons who are physically displaced, through provision of	- The Land Act of Bhutan 2007 provides the acquisition mechanism for land and other property falling under the eminent domain whenever required for a public purpose. This act does not consider assessing socio-economy or vulnerability as a requirement during land acquisition. Where private land is impacted, the number of affected families must be identified. - The Land Acquisition and Compensation Rules and Regulations (LACRR), 2022, RGOB state that private registered land shall be acquired only if unavoidable and can be acquired only once the substitute land is registered or cash compensation has been paid. - The land Act 2007 only mentions legal title holders.	International E&S standards are more stringent and should be applied. In Bhutan there are: - No requirement for the development of resettlement and land acquisition plan or framework obligatory for involuntary resettlement. - No specific complaints or grievance policy. - There is no specific livelihood restoration mitigation/ monitoring policy. - There is no specific public consultation and disclosure policy. The Project will: - Prepare a LALRP. - Conduct consultation with affected persons, socio-economic surveys and consideration of vulnerability, particularly the inclusion of female-

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
	adequate housing, access to services and facilities, and security of tenure. - To conceive and execute resettlement activities as sustainable development programs, providing sufficient investment resources to enable displaced persons to benefit directly from the project, as the nature of the project may warrant. - To ensure that resettlement activities are planned and implemented with appropriate disclosure of information, meaningful consultation, and the informed participation of those affected. - Recognize rights for customary use of land, even without land title.	It is not specifically spelled out that the absence of formal land title to the land is a bar to compensation. Landless or people/farmers using state land without land ownership can be eligible to Kidu or Rehabilitation lands. - Article 302 and 305 of the Land Act highlight that the acquisition of land shall entail a fair compensation or with a substitute land or by cash compensation. However, the government uses the Property Assessment & Valuation Agency Land and Cash Crop Compensation Rates (2022- or prevailing) to calculate the compensation, which is below the market rates for land, and therefore is not a 'fair' compensation which the Land Act purports to provide to affected people. - The landowner can choose substitute land or cash compensation. The landowner shall have no choice over the location of substitute land provided by the government and no assistance is provided for relocation. - Also, compensation for loss of livelihood for no title holders is not considered. - While poor and vulnerable groups are not excluded there are no provisions directly relating to these groups and towards improving the standards of living.	headed households and their access to compensation and assistance. - Seek ways to avoid resettlement wherever possible, minimize and mitigate adverse impacts. - Commit to compensate people whether they are the formal owners. - Present options for compensation to PAPs wherever practical. - Avoid community asset acquisition (road realignment is treated separately). - Cash compensation agreements are based on replacement cost. - Commit that DGPC will establish a transparent and accessible grievance redress mechanism for PAPs to use throughout the land acquisition process. - Compensation will be agreed prior to the handover of assets and prior to any works commencing in affected areas. - Households significantly affected by the Project will benefit from livelihood restauration measures. - Livelihood restoration will be monitored during Project implementation via internal monitoring and resettlement completion audits.

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
ESS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	- To protect and conserve biodiversity and habitats. - To apply the mitigation hierarchy and the precautionary approach in the design and implementation of projects that could have an impact on biodiversity. - To promote the sustainable management of living natural resources. - To support livelihoods of local communities, including Indigenous Peoples, and inclusive economic development, through the adoption of practices that integrate conservation needs and development priorities.	- The Department of Forests and Park Services is mandated to enforce the Forest and Nature Conservation Act (FNCA) of Bhutan, 2023. - The Act and Rules restrict development activities within core zones in protected areas. - No development activities are permitted within 30m of a water course/river. - For any activity requiring forest clearance, a permit is required from the DOFPS. For Dorjilung, forest clearance for all components must be applied together through the online system. - The impact assessment does not detail the requirement for critical habitat studies. - It requires a compensation fund to be paid for loss of forest cover at 2 times the size of the state reserve forest land, irrespective of whether there are trees/vegetation on it. Compensatory afforestation activities are then delegated by the DOFPS to agencies such as Green Bhutan Corporation Limited and the implementation monitored by the DOFPS. - The National ToR requires the preparation of Biodiversity Conservation & Wildlife Management Plan for conservation and preservation of endemic, rare and endangered species of flora and fauna and a species rescue plan, if required.	National requirements also include the preparation of a BMP, but International E&S standards are more stringent and should be applied. The Project will: - Conduct a Critical Habitat Analysis as per ESS6 as part of the ESIA. - Consider this ESS in the preparation of ESIA. - Prepare a standalone Biodiversity Management Plan - Prepare a standalone Environmental Flow study and associated EFlow Management Plan.

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
ESS 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities	- To ensure that the development process fosters full respect for the human rights, dignity, aspirations, identity, culture, and natural resource-based livelihoods of Indigenous Peoples/ Sub-Saharan African Historically Underserved Traditional Local Communities. - To avoid adverse impacts of projects on Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities, or when avoidance is not possible, to minimize, mitigate and/or compensate for such impacts. - To promote sustainable development benefits and opportunities for Indigenous Peoples/SubSaharan African Historically Underserved Traditional Local Communities in a manner that is accessible, culturally appropriate and inclusive. - To improve project design and promote local support by establishing and maintaining an ongoing relationship based on meaningful consultation with the Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities affected by a project throughout the project's life cycle. - To obtain the Free, Prior, and Informed Consent (FPIC) of affected Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities in the three circumstances described in this ESS.	Bhutan does not subscribe to having" Indigenous people" or "minorities" as defined by international standards.	**Does not apply –** based on the ESS 7 screening documented in Section 2.4.2, it was considered that ESS 7 does not apply to this Project. This is subject to further determination by the WB. Please refer to the IP memo on this topic, provided separately to WB for review and included in Appendices.

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
	- To recognize, respect and preserve the culture, knowledge, and practices of Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities, and to provide them with an opportunity to adapt to changing conditions in a manner and in a timeframe acceptable to them.		
ESS 8: Cultural Heritage	- To protect tangible and intangible cultural heritage from the adverse impacts of project activities and support its preservation. - To address cultural heritage as an integral aspect of sustainable development. - To promote meaningful consultation with stakeholders regarding cultural heritage. - To promote the equitable sharing of benefits from the use of cultural heritage.	- The Movable Cultural Property Act of Bhutan 2005 pertains to the conservation and protection of movable cultural property. - Such property is required to be listed and registered with photographs and maintained by the Lhakhang and the concerned Dzongkhag. - Chapter IV Section 34 requires the approval of the Department of Culture to conduct conservation works on Cultural Properties based on a qualified conservator. - Section 54 requires the discovery of valuable cultural properties discovered from below ground during the construction of roads, buildings or any other related works, this discovery is immediately reported to the Department of Culture through the concerned Dzongkhag. - There is also the Cultural Heritage Bill of Bhutan (2016). Section 37-39 requires that any entity intending to undertake large-scale development	National and international standards require a Cultural Heritage Management Plan. International E&S standards are more stringent and should be applied. The Project will: - Consider this ESS in the preparation of ESIA. - Prepare a standalone Cultural Heritage management Plan - Prepare a chance-find procedure (included in the ESMP and CHMP).

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
		activity must obtain a development permit from the Dzongkhag Administration who will turn forward the application for large-scale development activity to the Department of Culture and Dzongkhag Development for review and issue of cultural landscape clearance. - Under Section 143, the Cultural Heritage Committee may define the buffer zone of a Designated Heritage Building or Site upon the recommendation of the DCDD. - Section 153 requires approval from the DCDD for any work on an existing building in the Important Cultural Site, a Registered Archaeological Site, or the conservation zone of Registered or Designated Heritage Building. - The bill also details the steps to be undertaken in case of archeological find. - The ESIA ToR requires that any cultural heritage present in the project area and study area must be verified by the Department of Culture and Dzongkhag Development, MoHCA and Local Government and their views must be sought and submitted with the ESIA. - A Cultural heritage (both tangible and intangible) management plan must be prepared in consultation with Dzongkhag Administration and	

Objectives of WB ESS		Bhutanese E&S Regulations	Gaps Identified and measures taken to address
		Department of Culture.	
ESS9: Financial Intermediaries (FI)	n/a	n/a	Does not apply – based on current information.
ESS10: Stakeholder Engagement and Information Disclosure	- To establish a systematic approach to stakeholder engagement that will help Borrowers identify stakeholders and build and maintain a constructive relationship with them, in particular project-affected parties. - To assess the level of stakeholder interest and support for the project and to enable stakeholders' views to be considered in project design and environmental and social performance. - To promote and provide means for effective and inclusive engagement with project-affected parties throughout the project life cycle on issues that could potentially affect them. - To ensure that appropriate project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible and appropriate manner and format. - To provide project-affected parties with accessible and inclusive means to raise issues and grievances and allow Borrowers to respond to and manage such grievances.	- Section 213 of The Local Government Act of Bhutan, 2009 requires that all national agencies conduct periodic consultations with the Local Government before any project or program is implemented in their area, as well as involve Local Governments both in the planning and implementation of national projects. - The ESIA requirement requires that all stakeholders are consulted during the impact assessment and preparation of the respective management plans. - The national ESIA ToR requires all written consents and records of public consultation signed by the members(s) of the concerned local authority present during the public consultation for granting environmental clearance for the proposed project. It also requires a brief on how the public was consulted, issues raised, resolved, and pending.	While national regulations also require stakeholder consultations, the International E&S standards are more stringent and should be applied. The Project will: - Consider this ESS in the preparation of ESIA. - Prepare a standalone Stakeholder Engagement Plan

3 PROJECT DESCRIPTION AND AREA OF INFLUENCE

Key points – Project Description and Area of Influence

- The Dorjilung HPP is a proposed Run of River hydropower development of 1125 MW on the Kurichhu River in Eastern Bhutan (Mongar and Lhuentse Dzongkhags).
- It involves the construction of a 139.5 m high concrete dam (85 m above riverbed) and the creation of a 44 Mm^3 reservoir. Water will be conveyed through a 14.97 km headrace tunnel on the right bank connecting to an underground powerhouse with 6 Francis units with short twin tailrace tunnels (360 m).
- An estimated 974 acres (394 Ha) will be cleared for the project, including the submergence area (359.89 acres / 145.64 Ha) and ancillaries for construction (620 acres / 250 Ha).
- An estimated 585 acres will be impacted from river flow changes (dewatered). The dewatered section from the dam to the powerhouse is approximately 16 km long and the Powerhouse would be near Lingmethang township.
- Ancillary areas for construction will include new access roads, new (re-aligned) public roads and improved existing roads. Also expected to be required will be 12 muck disposal sites, 9 contractor construction facilities, 4 stockyards, 5 explosive magazines, 5 batching plants and 5 quarry locations. Construction power will be supplied by 18 km of temporary transmission line.
- Two approximate routes for power evacuation transmission line have been proposed from Dorjilung HPP powerhouse to Durungri sub-station (approximately 40 km to the south).
- The HPP scheme is planned to be operated in peaking mode; the existing Kurichhu HPP reservoir (the reservoir is located about 1 km downstream of Dorjilung HPP tailrace tunnels) will largely act as a large demodulation basin.
- The total project schedule for is 78 months or 6.5 yrs. Construction is expected to last about 5 years, and it is anticipated that about 6350 contracted workers will be required at its peak; a large portion (90%) of them are expected to be foreign workers. In addition, there will be about 460 Bhutanese workers mobilised by DGPC. Multiple ancillary facilities are required (construction camps, technical installations, muck disposal sites, access roads, etc.).
- The Area of Influence have been defined: the Direct Area of Influence corresponds to the Project footprint + 5 km buffer (land distance); the Indirect Area of Influence extends the buffer to 10 km (aerial distance); and the cumulative Area of Influence extends downstream to the proposed Kuri-Gongri HPP and upstream to the Yungichhu HPP currently under construction. The AoI are further adjusted for specific aspects of the impact assessment. Section 3.9 details the AoI further.

3.1 Project Overview

The 1,125 MW Dorjilung HPP is a large-scale energy infrastructure initiative aimed at harnessing the hydropower potential of the Kurichhu River. This project is poised to contribute significantly to regional energy security, economic growth, and sustainable development by generating clean and renewable energy. With a planned capacity of 1,125 MW, the project is expected to supply a considerable portion of energy to both domestic and regional markets, supporting economic development and reducing reliance on fossil fuels.

The Dorjilung HPP is being developed through a collaborative framework with financing from the World Bank and other international financiers. It is designed in line with global best practices, ensuring compliance with environmental and social safeguards. As part of this, the project has adopted rigorous standards for ESIA and will adhere to WB ESF requirements. This includes stringent measures for environmental protection, social inclusion, OHS, and stakeholder engagement throughout its lifecycle.

The Dorjilung HPP also emphasizes sustainable and inclusive development. Key areas of focus include resettlement planning, social inclusion with special attention to gender equality, and active community participation. The project will require extensive stakeholder engagement, capacity building, and partnerships to ensure that the benefits of the project are shared equitably and that any potential adverse impacts are adequately mitigated.

3.2 Project Location

The Dorjilung HPP is located on Kurichhu River in eastern Bhutan. The Kurichhu River originates in the Tibet Autonomous Region of People's Republic of China, crosses into Bhutan approximately 70 km North of the Project, and then flows south from the Project to join the Manas River - a transboundary river in the Himalayan foothills in southern Bhutan.

The Manas River is a tributary of the Brahmaputra River which is in addition shared between the Republic of India and the People's Republic of Bangladesh. Due to the existence of distinct rainy and dry seasons, there are large seasonal variations in river flows.

The dam and powerhouse are in the province of Mongar Dzongkhag with parts of the reservoir extending north into Lhuentse Dzongkhag. The dewatered section from the dam to the powerhouse is approximately 16 km long and the Powerhouse would be near Lingmethang township.

The powerhouse for the Project is proposed approximately 10 km upstream of the existing 60 MW KHP, with the dam wall located approximately 36 km upstream of KHP. Most construction activities are located in the Mongar Dzongkhag with some part of the reservoir stretching into Lhuentse Dzongkhag as well as a few temporary facilities. The dam site is located about 7 km downstream of Autsho township.

Figure 9 provides the location of Dorjilung HPP. Figure 10 through to Figure 12 provides the general arrangement of Dorjilung HPP. Figure 9 provides an overview of key village and Gewogs in the Project area.

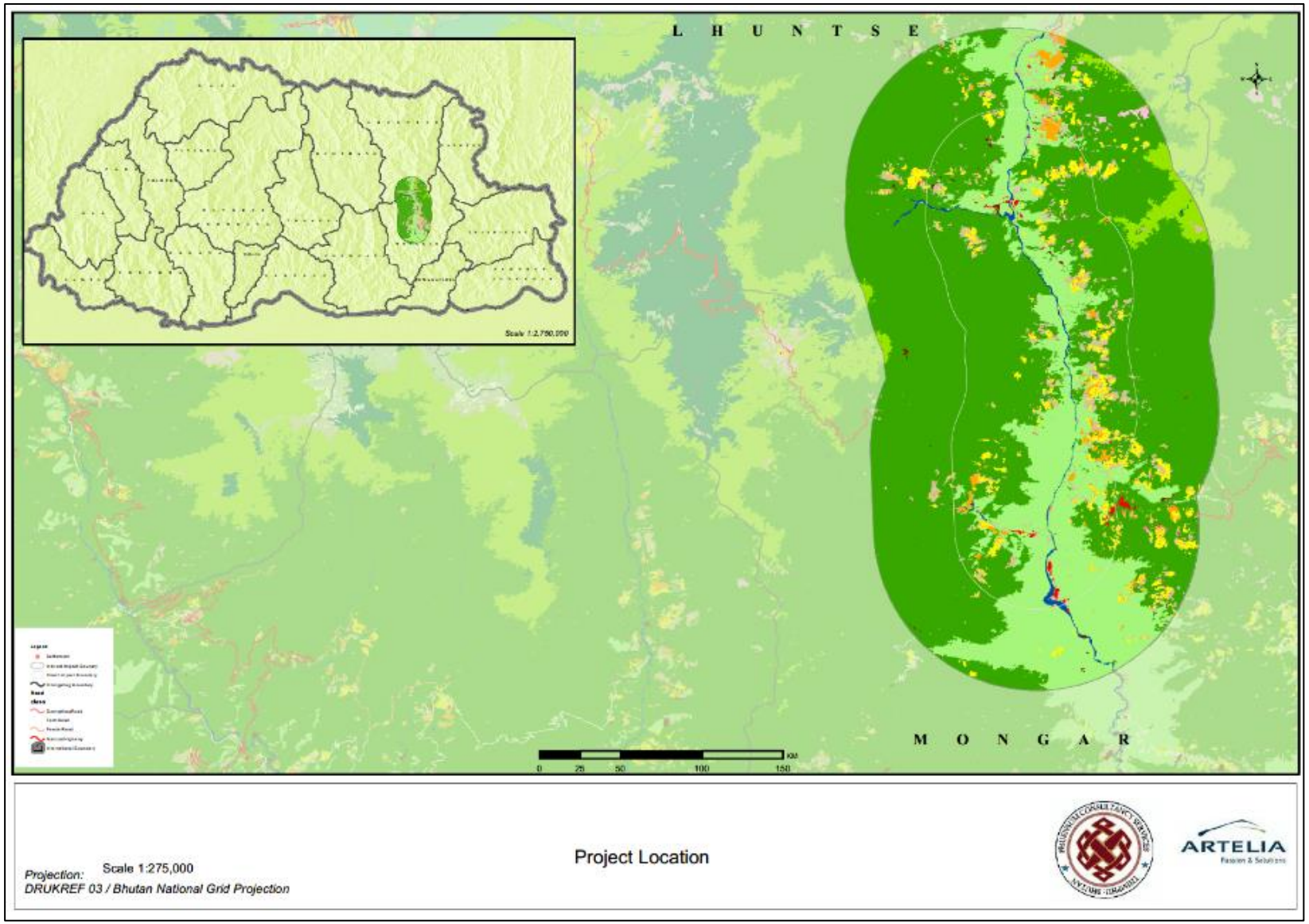


Figure 9: Dorjilung HPP location

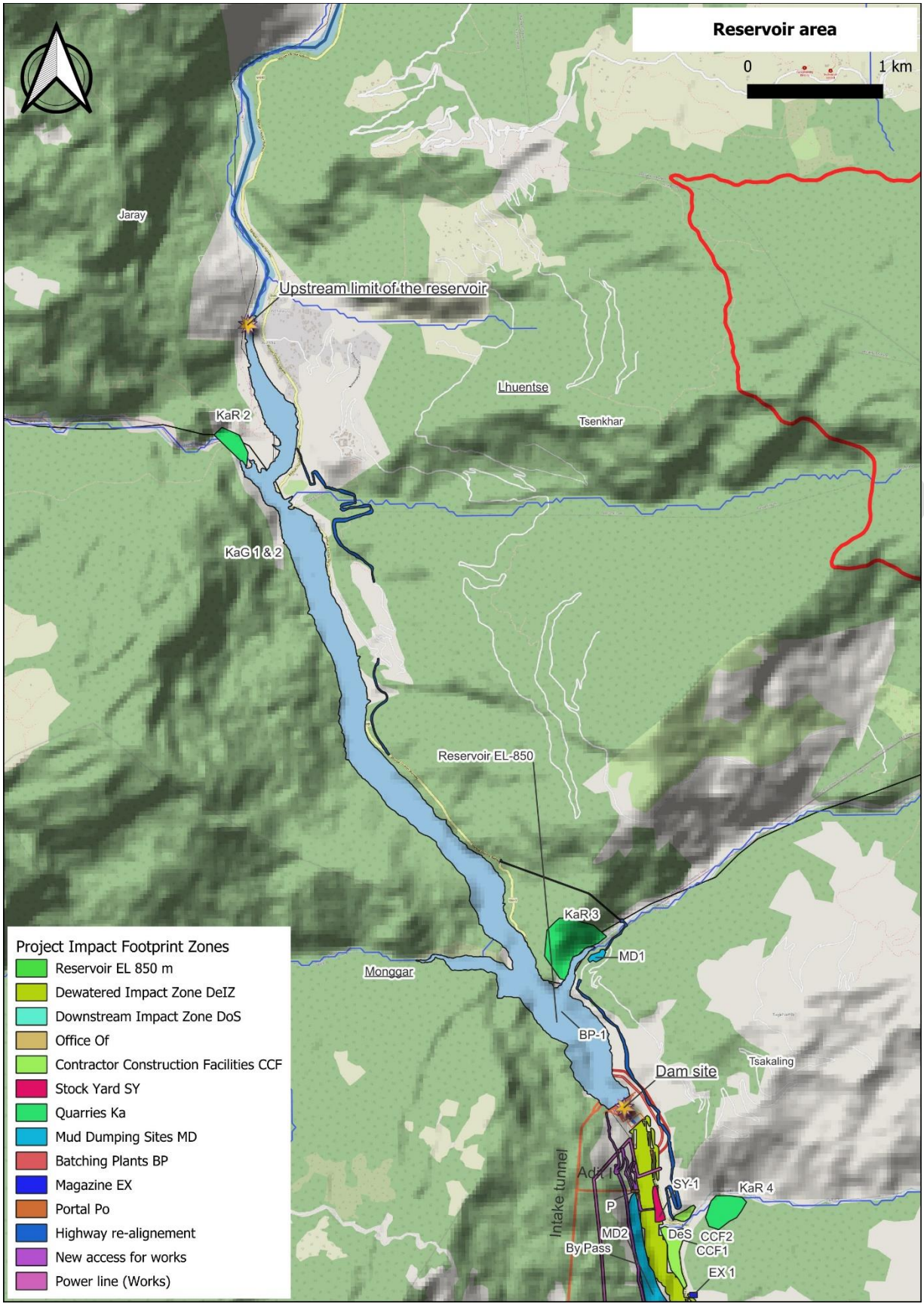


Figure 10: General Arrangement of Dorjilung HPP 1 – Reservoir Are

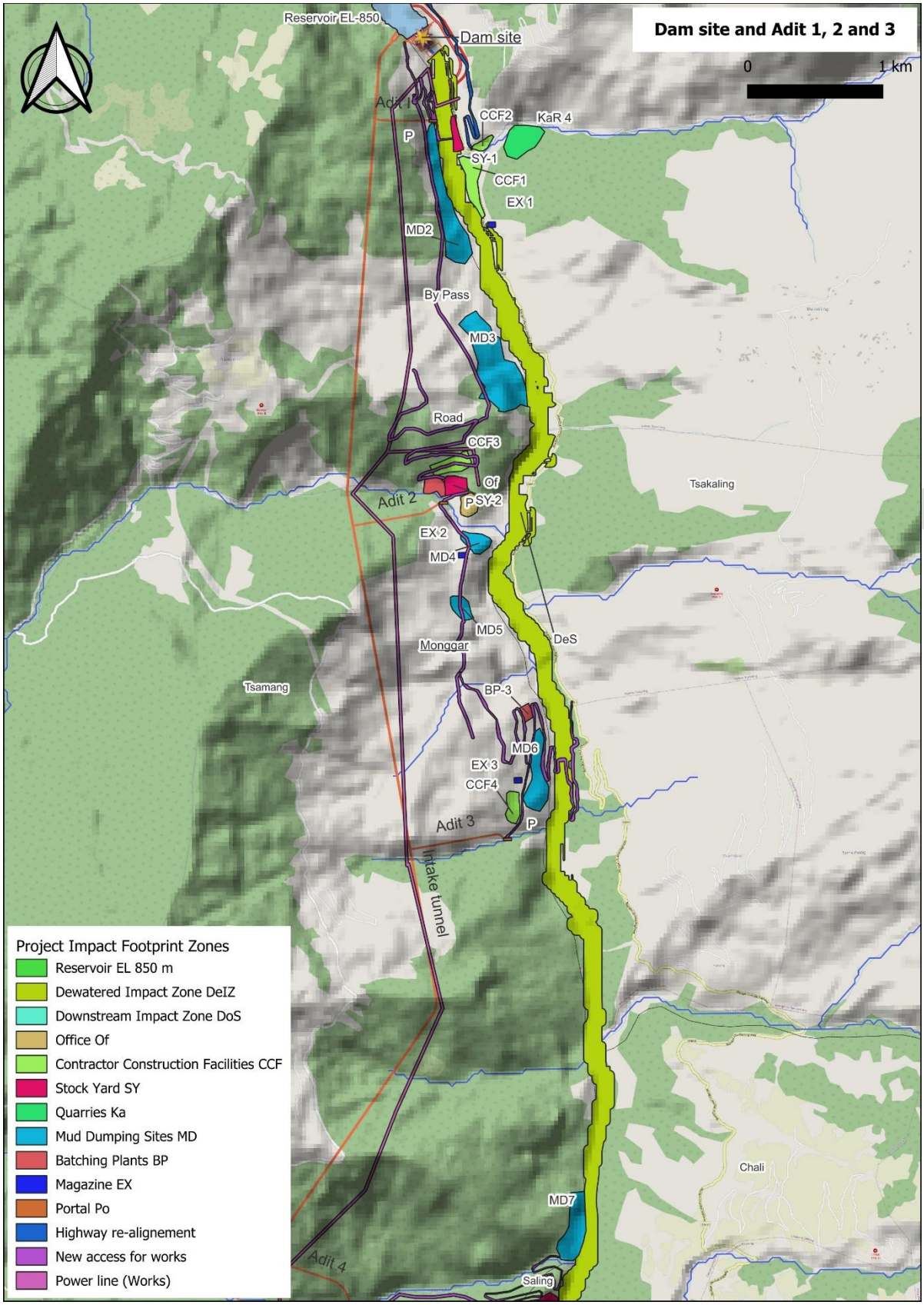


Figure 11: General Arrangement of Dorjilung HPP – Dam Site and Adit 1,2 & 3

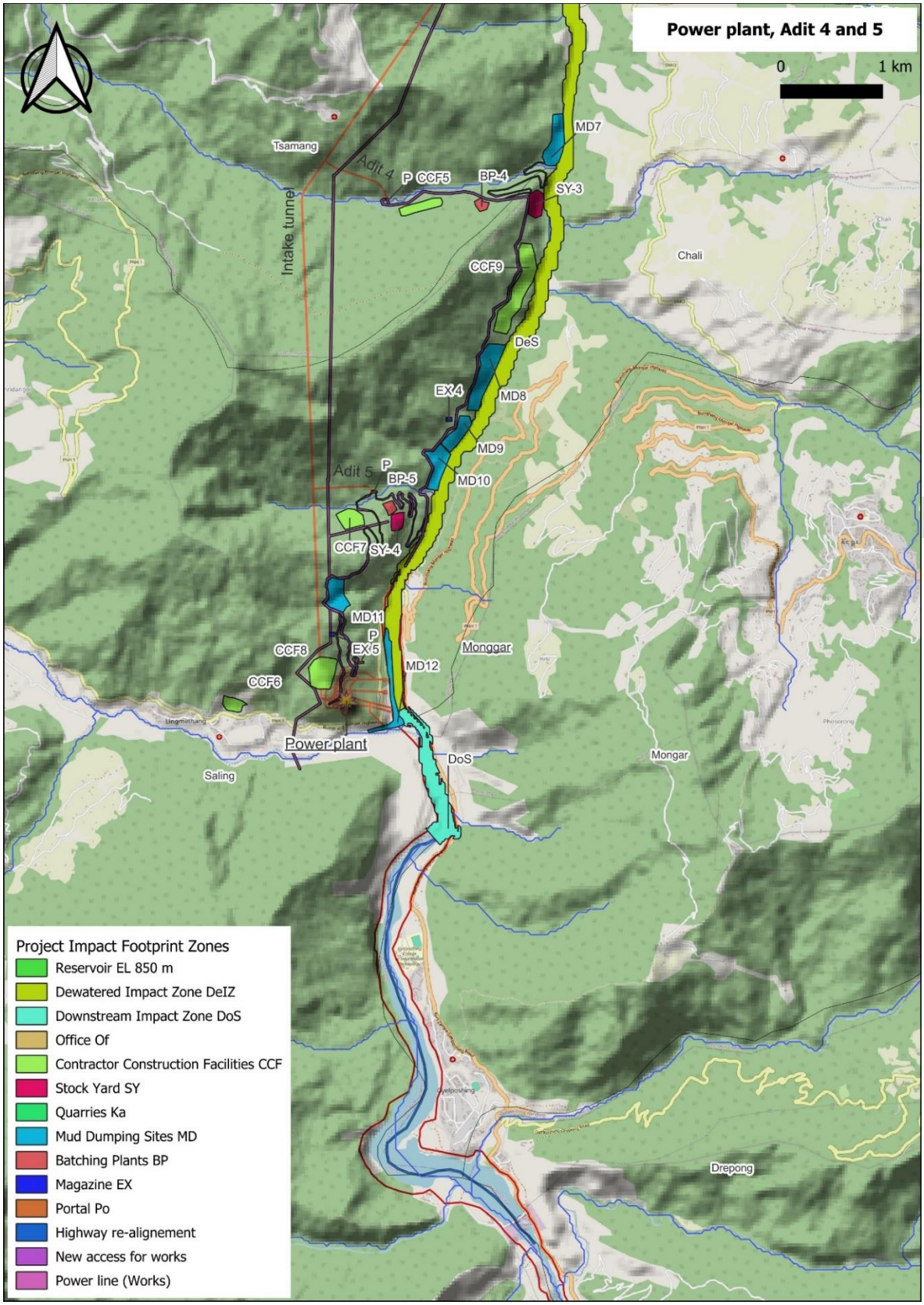


Figure 12: General Arrangement of Dorjilung HPP – Power plant, Adit 4 and 5

Source: Artelia

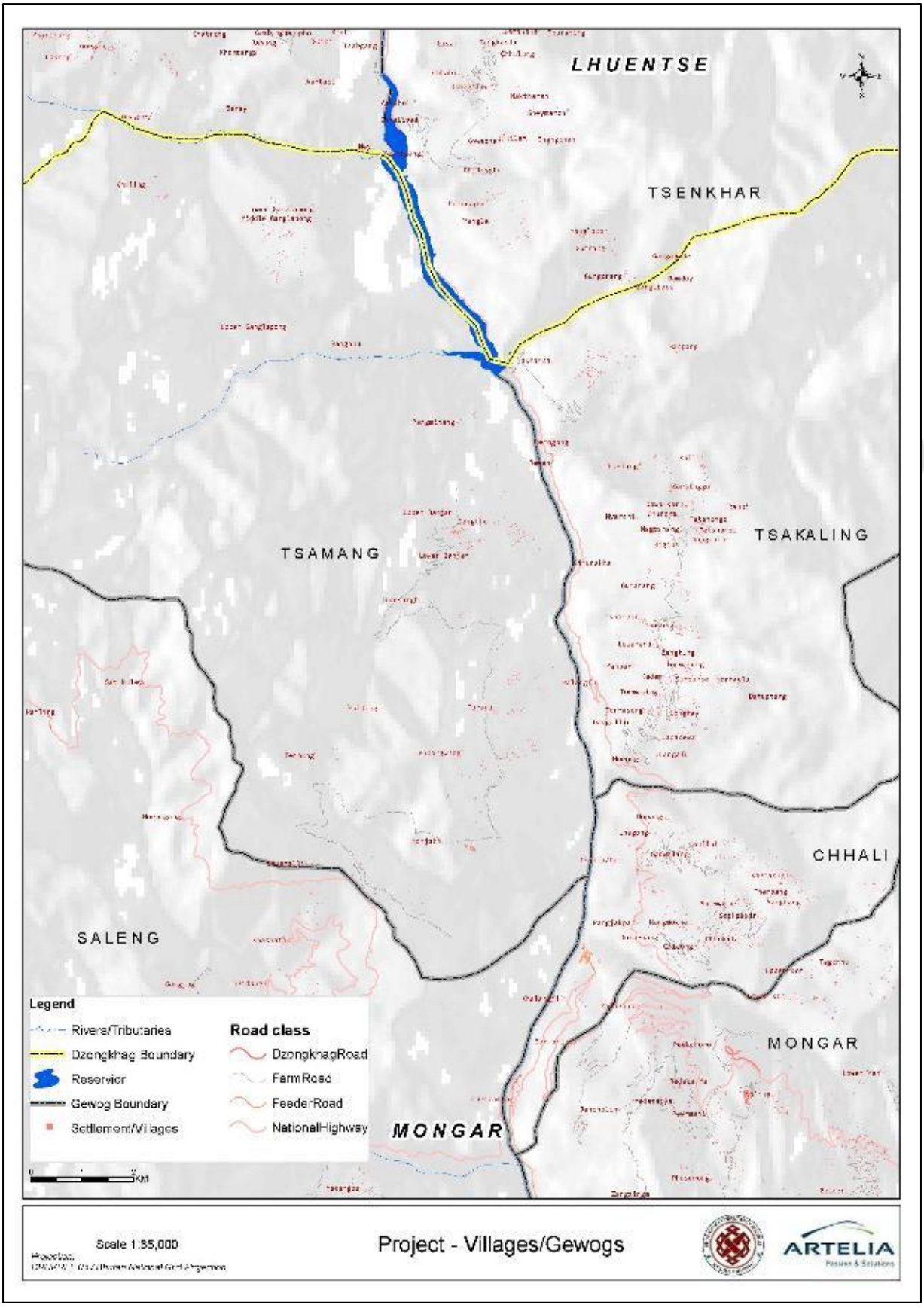


Figure 13: Overview of key village and Gewogs in the project area

3.3 Project Components

Table 24 details the location of various Project components in local administrative areas.

Table 24: Dorjilung HPP facilities and their location

Project component	Description	Location
Reservoir	The submergence area extends 6.80 km upstream of the dam axis. Total area of 359.89 acres (145.64ha).	Tsenkhar gewog (Gewog: An administrative division comprising a group of villages in Bhutan) in Lhuentse and Tsakaling gewog in Mongar
Dam site	RCC/Concrete gravity dam, with a maximum height is 139.5 m of which 85 m will be above the riverbed level. Full Supply level (FSL) is 850 masl, with live storage of 12.62 Mm^3, and gross storage of 44.17 Mm^3. Total area for dam works is 11.1 acres (4.45ha).	Located at Rewan, Monggar about 7 km downstream of Autsho township at 768 masl. (27°23'32.24" N, 91°11'52.67" E).
Headrace tunnel (HRT)	14.97 km long, 11m diameter single HRT to be constructed by drill and blast method.	Tsamang and Saleng gewogs
Adits	The HRT will be constructed through 6 intermediate construction adits of aggregate length of 3,675 m.	as above
Surge Shaft and Pressure Shaft	31 m circular open to sky surge shaft Three vertical steel lined pressure shafts each with a diameter of 5.50 m.	Saleng gewog
Powerhouse (PH)	Underground Powerhouse downstream of Kurizam on the right bank of Kurichhu Two Tailrace tunnel (TRT) of 8 m diameter horseshoe type with length of 350 m and 360 m to convey discharge back to Kurichhu located about 3.50 km upstream of the existing dam of Kurichhu Hydropower Plant (KHP).	Saleng gewog, Mongar
New access roads	27.58 km new access roads to various project components and work sites will be required to be constructed (approximately 96.04 acres).	Tsakaling, Saleng, Tsamang gewogs
New Public Road (re-alignment)	5.4 km of new road for realignment (approximately 24.9 acres/9.71ha), and 1 km of tunnel.	Tsamang and Saleng gewogs
Improvement of roads	8.93 km of road will require improvement (e.g. widening).	As above
Bridges	2 bridges required.	Tsakaling and Tsamang gewogs
Muck disposal sites (MDS)	12 MDS require approximately 198.743 acres to cater muck from access roads, HRT, Adits, Surge Shaft, Powerhouse.	As above
Site Offices	One temporary office will be established, requiring approximately 4.7 acres.	Tsamang and Saleng gewogs I
Residential complexes	Direct workers housed in existing buildings in Autsho, Gyelpozhing or Lingmethang. Contracted workers are housed in new buildings within CCF areas.	Tsakaling, Saleng, Tsamang gewogs
Contractor Construction Facility (CCF)	9 CCFs have been identified, which will require an estimate of 101.13 acres. The CCF will include colonies for employees (labour camps), site offices, stores/warehouse, workshops, parking yards for equipment, and fabrication yard.	as above

Project component	Description	Location
Stockyards	Four stockyards will be used for material stockpiling, totalling 21.46 acres.	as above
Explosive Magazine	5 Explosive magazines totalling 2.85 acres.	as above
Batching Plants	5 locations, totalling an area of 13.12 acres.	as above
Construction Power	Total length is approximately 19.81 km. This would result in approximately 58.74 acres of land required	Tsamang and Saleng Gewogs
Quarry	Two quarry locations have been considered for the Project, totalling 26.9 acres.	Tsenkhar and Tsakaling gewog
Construction Water	Estimated total construction water required per day is 476 m^3, sourced from tributaries.	Tsamang and Saleng gewogs
Power Evacuation Transmission Line (PETL)	Two approximate route options are proposed for Dorjilung HPP. The two proposed corridors lengths from Dorjilung HPP powerhouse to Durungri PS are approximately 33.5 km for TL1 and 39.5 km for TL2. The Transmission Voltage is 400 kV, and the Generation Voltage is 13.8 kV. Based on the TL standards available online from Bhutan Power Commission, it is expected the TL Right of Way (RoW) would be 48 m with a minimum 5.5 m clearance distance from any tree. Towers are assumed to be required at approximately every 350 m (300-500 m for 400 kV). *The information as presented is preliminary; awaiting DGPC final details.*	Approximately location extends south from Dorjilung HPP powerhouse to Durungri PS.

3.4 Hydropower Scheme Components

Key specifications are presented in the Table 24 and an overview map is presented in Figure 10 to Figure 12, further details are provided in the following section.

Table 25: Dorjilung HPP synoptic table

ITEM	UNIT	DORJILUNG HPP
Design flood	m^3 /s	16,225
Check Flood	m^3 /s	20,123
Reservoir-gross storage	Million m^3	44.17
Reservoir-live storage	Million m^3	12.62
Reservoir area at FRL	ha	145.82
Full Reservoir Level (FRL)	m	EL. 850
Minimum Drawdown Level (MDDL)	m	EL 840
Dam type	-	Concrete gravity (RCC and CVC)
Length of dam at top	m	241.0
Dam top	m	EL. 853.0
Maximum height of dam (above deepest foundation level)	m	139.5m of which 85m will be above the riverbed level
Spillway gates	-	6 gates(w) 9.0 m x (h) 15.10 m
Headrace tunnel	-	Single 14,974 m long concrete-lined with 11.0 m finished diameter
Surge Shaft	-	Single 135 m high restricted orifice with 4.1 m diameter

ITEM	UNIT	DORJILUNG HPP
Pressure shaft	-	3 nos. 332.8 m long steel-lined of 5.5 m finished diameter
Powerhouse	-	Underground with dimensions 210.0(l) x 23.0(w) x 60.5 m(h)
Tailrace tunnel	-	2 nos., 350.0 m & 360.0 m long, horseshoe shaped with 8.0m m diameter
Normal tail water level	m	EL. 544.0
Dewatered reach between the dam and tailrace tunnel	km	About 16
Catchment area	km^2	8,782 (of which 5,813 km^2 is outside Bhutan)
Installed capacity	MW	6 vertical Francis units at 187.5 MW = 1,125 MW
Design discharge	m^3/s	451
Gross head	m	300.45
Design Energy	GWh	4504
Firm power	MW	153
Construction Period	Months	60 months excluding 18 months of pre-construction activities

3.4.1 Concrete Gravity Dam

The project includes the construction of a concrete gravity dam with a maximum height of 139.5 m above the deepest foundation level. Dam axis has been kept at the same location as prefeasibility site with some optimization in the layout required for effective downstream energy dissipation.

Based on detailed dam height optimization, Full Supply Level (FSL) has been adopted as 850 masl. The Minimum Draw Down Level (MDDL) is at 840 m asl. The Dam height from the deepest foundation level will be 139.5 m of which 85 m will be the height above the riverbed level. The length of the dam at top is about 241.0m with six overflow blocks to pass the flood discharge safely. Spillway gates of 9.0 m(W) x 15.1 m (H) are proposed.

The elevation of the intake still is at 821 masl. At FSL it will create a water backflow of 5.4 km reaching slightly downstream of Autsho, Lhuentse Dzongkhag. The total volume of water that will be created at FSL would be 44.17 million m^3.

Based on detailed reservoir sedimentation numerical modelling carried out by M/s DHI (India), the underground desilting arrangement was found not necessary for the project as the reservoir itself can act as desilting facility.

3.4.2 Cofferdam and Diversion Tunnel

There will be two coffer dams, one upstream of the Dam and another downstream of Dam. There will be two diversion tunnels: each with an 11 m diameter and with respective lengths of 930 m and 821 m.

3.4.3 Intake

There will be two intake structures proposed on the right bank of Kurichhu for diversion of water for power generation. The intake structures will be provided with gates for flow regulations.

3.4.4 Reservoir

The FSL has been fixed at 850 masl based on the dam height optimization study. The total area at FSL is 359.89 acres.

The MDDL has been determined as 840 masl, which provides live storage of 12.62 million m^3 enough for continuous peaking of about 8 hours. Figure 14 show the area capacity curve.

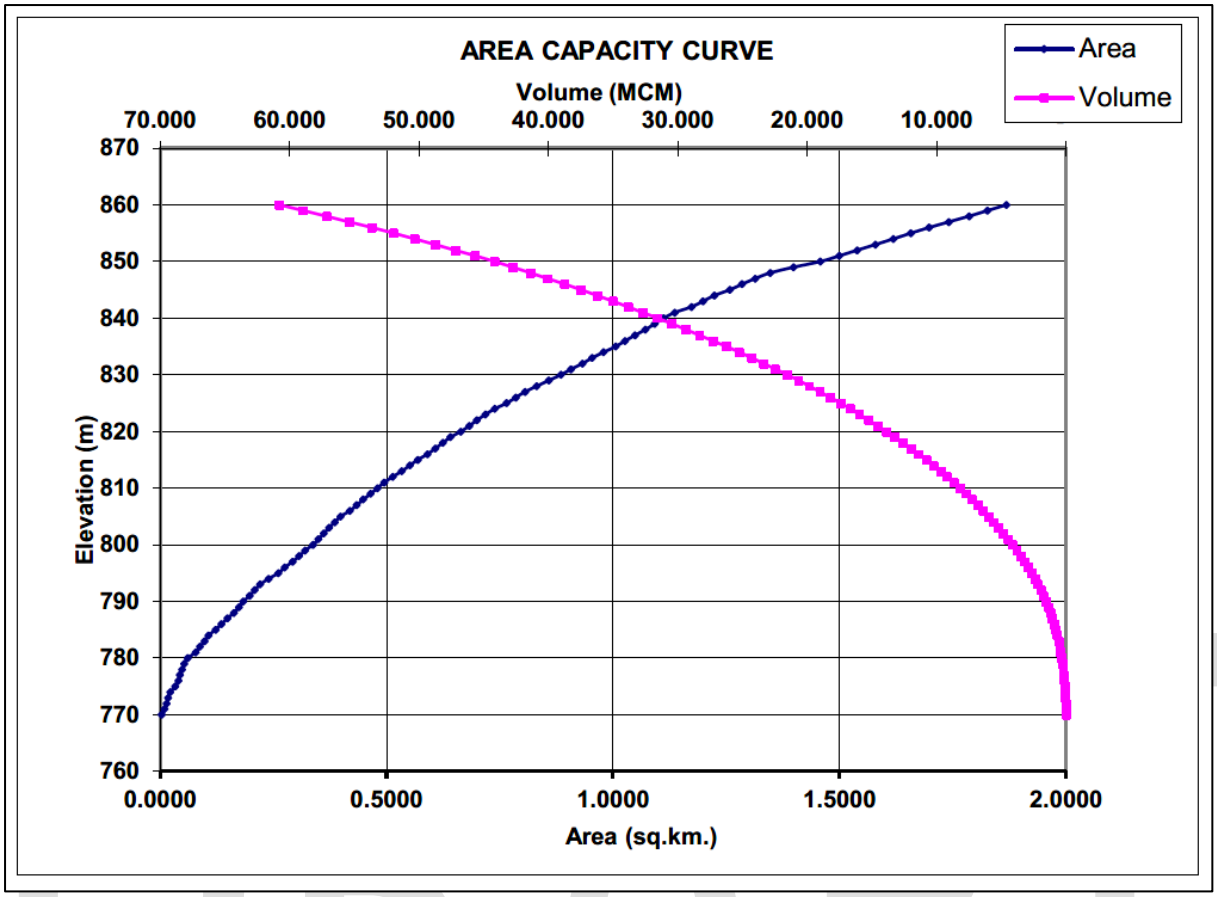


Figure 14: Area-Elevation-Volume of the Reservoir (DPR, 2016)

The proposed Project consists of a diurnal storage behind a gravity dam with a height of 85 m (above riverbed level). The important head water levels at dam and tail water levels at powerhouse and head available for power generation are given in Table 26.

Table 26: Reservoir and hydraulics key figures

Description	Units	Value
Full Supply Level (FSL)	m	850
Minimum Draw Down Level (MDDL)	m	840
Normal tail water level	m	544
Maximum Head	m	306
Minimum Head	m	296
Head Losses	m	24.4
Design Head	m	276.05
Gross Storage Capacity at FSL	million m^3	44.17
Live Storage Capacity	million m^3	12.62

3.4.5 Head Race Tunnel (HRT)

The HRT is located on the right bank of river Kurichhu. There are two feeder tunnels of 8.0 m diameter of horseshoe shaped, joining to form a single 14,974 m long HRT, 11.0 m finished diameter, with the objective of conveying 451 m^3 of design discharge from diversion site to powerhouse.

Construction of the HRT is expected to be via drill and blast.

Alternative construction method using tunnel boring machine (TBM) was considered in the DPR (2024) update, but it is understood that strong recommendation is to continue with drill and blast as the excavation

method. The TBM consideration is understood to have focussed mainly on the engineering feasibility/advantages/disadvantages. A note was included that there may be environmental advantages to TBM, including the reduction of traffic within the valley for logistical support and a reduction in the amount of diesel usage. However, if TBM was considered as a preferred excavation option, it would change the work and construction organisation quite significantly. Instead of having several (6) adits and associated work camps, the general organisation would be deployed on mostly one main site for the portal and treatment of spoil and tunnel wastewater and one to two additional sites. It also introduces another level of requirements in terms of bridge load, road upgrade and access.

To facilitate drill a blast, six intermediate construction adits with a total aggregate length of 3,675 m are expected. Details of Adits are provided in Table 27.

Table 27: Tunnel Adits

SN	Adit	Adit Length (m)
1	Adit-1	420.15
2	Adit-2	859.21
3	Adit-3	827.58
4	Adit-4	1,273.86
5	Adit-5	782.45
6	Adit-6	535.10

3.4.6 Surge shaft

An open to sky type surge shaft of 26 m circular finished diameter is placed at the end of the HRT to take care of surge during power plant operation and facilitate load variations. The height of the surge shaft is 135 m.

3.4.7 Pressure shaft

There will be three vertical steel lined pressure shafts of 5.5 m finished diameter. The total length of the main pressure shafts up to the bifurcation point is 332.8 m (PS-1 & PS-3) and 313.5 m (PS-2).

3.4.8 Powerhouse

Underground Powerhouse – 210.0 m (L) x 23.0 m (W) x 60.50 m (H) to house the six Francis machines of 187.50 MW each. Installed capacity and annual design energy of the project is 1,125 MW and 4,504 GWh. The design discharge and head are 451 m^3/s and 276.05 m.

The available net head and low flow regime indicates that Francis turbine is suitable. A Francis turbine allows running of the unit up to 50% of the design load.

3.4.9 Tail Race Tunnel (TRT)

Two horseshoe type TRT with an 8 m diameter and length of 350.0 m and 360.0 m will convey discharge back to the Kurichhu River.

3.5 Construction Ancillaries

3.5.1 Roads

3.5.1.1 New Access Roads

A total of about 27.58 km of new access roads (impacting approximately 96.04 acres) to various sites (adit portals, dam, diversion location, quarry, etc.) will be required to be constructed within the project area.

Table 28: Proposed New Access Road

SN	Project Site	Take off	Length (km)
1	Adit I and Dam top	LHS of Dorjilung	1.91
2	Adit II (Farm Road)	n/a	4.75
3	Adit II to Adit III	LHS of Dorjilung	0.6
4	Adit IV	Adit II	5.8
5	Road to MD 7	Kurizam	2
6	Adit V	n/a	2.05
7	Adit VI	Adit IV road	3.5
8	Surge shaft and Ph	Adit V	1
9	quarry road	Adit VI junction	3 (estimate only)
10	From Tsamang farmroad	Tsamang farm road	2.97
Total			**27.58**

3.5.1.2 New Public Road (re-alignment)

Road realignment is required where the existing public road is submerged by Project components. This will include the construction of a new tunnel. Total new road required for road realignment is 5.4 km, and 1 km of tunnel, summarised in Table 29.

Table 29: Proposed New Public Road (re-alignment)

PROJECT SITE	TAKE OFF	New Public Road (km)
Re-alignment 1	Rewan Bridge	2.4
Re- alignment 2	Takambi farm road	0.3
Re- alignment 1*	Highway	0.84
Re- alignment 2*	Doliphung farm road end	2
Total		**5.54**
Tunnel length	NA	1
Total		**1**

3.5.1.3 Improvement of Roads

Three roads will require improvement to support Project activities, totalling 8.93 km of improved roads.

Table 30: Proposed Improved Roads

Name	Location	Length (km)
Adit II	Tsamang farm road	4.33
Re-alignment 2	Farm road	2.50
Highway	PNH	1.40
Powerhouse	Lingmethang-Mongar road	0.70
Total		**8.93**

3.5.1.4 Proposed Bridges

Bridges will be required to allow the functioning of new roads constructed. A total of 2 bridges are required.

Table 31: Proposed bridges

SN	Bridge name	Location	Type & Capacity
1	Bridge - 1	Rewan for Adit – 1 & 2 and Dam Top (right bank)	Bailey bridge 40R
2	Bridge - 2	Downstream of suspension bridge at Dorjilung to access Adit – 3	Bailey suspension/reinforced cement concrete bridge 40R

3.5.2 Muck Disposal Sites

The construction of the project structures like dam, intake, HRT and powerhouse complex, etc. will involve huge excavation that would be disposed of in designated muck disposal areas. A total of 12 muck disposal yards have been proposed at various project locations, with a total area of 198.743 acres.

The capacity available at these MDS, and the volumes of muck generated during construction were estimated during ESIA preparation. Total muck estimated for the Project is 7,153,649.5 m^3. This includes 6,809,013.1 m^3 generated from adits, and 344,636.4 m^3 generated from roads. Total capacity estimated from the MDS is 7,306,595.50m^3.

The muck dumping sites are to be compacted by movement of dump trucks and excavators. Dumping sites will be managed to avoid any materials reaching the river or downstream. Management will include providing retaining walls to avoid spillage in the river systems.

A brief detail of proposed muck disposal areas is as shown in Table 32.

Table 32: Muck Disposal Sites

SN	Description	Capacity (m^3)
HEAD WORKS		
1	MD 1	51,085.2
2	MD 2	690,384.5
3	MD 3	2,455,894.0
ADIT 2		
4	MD 4	312,280.1
5	MD 5	256,410.1
ADIT 3		
6	MD 6	701,500.0
ADIT 4		
7	MD 7	752,438.5
ADIT 5		
8	MD 8	612,177.2
ADIT 6		
9	MD 11	291,037.5
Powerhouse & Tail Race Tunnel		
10	MD 9	319,664.7
11	MD 10	439,301.1
12	MD 12	424,422.6
Total	**Total Area 198.743**	**7,306,595.5**

3.5.3 Site Offices

One temporary site office will be set up near Adit I to facilitate effective monitoring and control of works. The Office site will utilise approximately 4.706 acres.

3.5.4 Residential Complexes

There will be no additional land required for accommodation of direct workers from DGPC (Bhutanese nationals), as these workers will be housed within existing facilities and within the CCFs. The direct workers accommodation would be largely split between Dam and Powerhouse. The direct workers for the powerhouse will be housed in existing facilities that are part of the Kurichhu HPP infrastructure, approximately 1 km from Gyelpozhing, and/or renting within Gyelpozhing or Lingmethang. The direct workers for the dam will be located within existing buildings within Autsho.

Contracted workers (internationals) accommodation will be in the CCF (see 3.5.5).

Section 3.6.2.2 provides further detail on the construction worker numbers and locations.

3.5.5 Construction Contractor Facilities (including Colonies)

As provided by DGPC in February 2024, the 9 temporary CCF required for the construction project will require an estimate of 101.13 acres (40.9ha). In Bhutan construction camps are referred to as "colony", this wording has been adopted here. The colonies for the Project will be located within the CCF. The contracted workers will be in the 9 CCF sites with most of them located at two main camps (one near the dam and one near the powerhouse).

The CCF areas will also be used for site offices, colonies for employees, stores/warehouses, workshops, parking yards for equipment, and fabrication yards. These sites will be in Tsakaling, Tsamang, Saleng gewogs in Mongar district. These are listed in Table 33.

Table 33: Construction Contractor Facilities

CCF ID	Designation
CCF1	Head work (Dam, Diversion tunnel and coffer dam)
CCF2	HRT & Adit I
CCF3	HRT& Adit II
CCF4	HRT& Adit III
CCF5	HRT& Adit IV
CCF6	Powerhouse
CCF7	HRT& Adit V
CCF8	HRT& Adit VI - Surge shaft & Pressure shaft
CCF9	Powerhouse
Total	**Total Area 101.131 acres**

3.5.6 Stockyards

Four stockyards, anticipated for material stockpiling, will be utilised for the Project. These stockyards are located near the Adits to facilitate construction. The total area utilised by the stockyards is approximately 21.456 Acres.

Table 34: Stockyards

Stockyard ID	To support	Location
SY1	Dam and Adit I	At Rewan
SY2	Adit II and III	Below adit III
SY3	Adit IV, V and VI	Below adit IV
SY4	Powerhouse	Along the proposed access road to Adit V
Total		**Total Area 21.456 acres**

3.5.7 Explosives Magazine

Five explosive magazines, for specific storage of explosives are anticipated. These are located near the Adits to facilitate construction. The total area utilized by the magazines is approximately 2.847 acres.

Table 35: Stockyards

ID	To support
1	Dam and Adit I
2	Adit II and III
3	Adit IV & V
4	Adit VI and Surge shaft

ID	To support
5	Powerhouse
	Total Area 2.847 acres

3.5.8 Batching Plants

Batching & Mixing Plant for concrete production batching plants are proposed for 5 locations, totalling an area of 13.121 acres.

Table 36: Batching Plants

Batching Plant	To support	Location
BP 1	Dam and Adit I	In the submergence area above the Dam
BP 2	Adit II and III	Near Adit II along the farm road to Banjar
BP 3	Adit IV & V	Between adit II and III
BP 4	Adit VI and Surge shaft	Along the proposed access road to Adit IV and MD 8
BP 5	Powerhouse	Along the proposed access road to Adit V
Total		**Total Area 13.121 acres**

3.5.9 Quarries

Two quarry sites (one each at Dam site and powerhouse area) are under assessment.

3.5.10 Construction Water

Construction water will be sourced from nearby tributaries, with pipelines for water transfer proposed to lay through road section. The approximate length of total pipeline for water transfer is 18.8 km. Estimated total construction water per day required is 476 m^3 per day. This information is understood to be maximum estimated at peak construction activities.

Table 37: Estimated Construction Water Requirements

SN	Project Component	Water requirement (m^3/day)	Total required per day	Source	Available flow per Second (m^3/s)	Available flow per day	Impact on Private plot
1	Head work (Dam, Diversion tunnel and coffer dam)	51.47	51.47	Rewanchhu	No data provided	No data provided	*No private land data is available. Pipeline proposed laying through the road section.*
2	Intake	12.87	38.61	Chimungri	No data provided	No data provided	
3	HRT & Adit I	25.74					
4	HRT& Adit II	51.47	51.47	Phelgangchhu	No data provided	No data provided	
5	HRT& Adit III	51.47	51.47	Sokpalumpa	No data provided	No data provided	
6	HRT& Adit IV	51.47	283.09	(YOEMARETOE)	0.02	1,555.20	
7	HRT& Adit V	51.47					
8	HRT& Adit VI	25.74					
9	Surge shaft	38.60					
10	Pressure shaft	38.60					
11	Powerhouse	77.21					
	Total	**476**					

3.5.11 Construction Power

Construction power estimates were provided in the 2016 DPR and are shown in Table 38.

Table 38: Construction Power Requirement

SN	Project Components	Power Requirement (kVA)
1	Powerhouse Complex	4,000
2	Dam site and Adit-I	4,000
3	Adit-II	3,500
4	Adit-III	
5	Adit-IV	
6	Adit-V	
7	TRT Area	750
8	Adit-VI, Surge Shaft & BFVC	1,500
9	Batching and Crushing plants	1,500
10	Workshops	1,000
11	Office and Labor Camps	1,000
	Total (kVA)	**17,250**
	Total (kW)	**14,662.50**

Construction power will be provided by temporary lines servicing the construction activities. The envisaged construction power arrangement has been planned in consultation with Bhutan Power Corporation, Thimphu. The estimated peak demand for the project is about 15 MW. To cater the construction power requirement for the project, construction of 2x10 MVA, 132/33 kV substation is being considered at Rewan by tapping from the existing 132 kV Kilikhar-Tangmachhu transmission line.

The construction power line would result in approximately 58.74 acres of land required.

Additionally,

- The Right of Way (RoW) to be maintained for the 33-kV line is 12 m (6 m on each side from the centre line).
- The land required for construction power is temporary.
- Location of electric pole footings will be determined from walk-on surveys and detailed design that is normally undertaken at the pre-construction phase during which private lands are avoided to the highest degree possible.

3.6 Construction Planning

3.6.1 Construction Programme and Project Schedule

The project is scheduled to be completed in a period of 60 months including 3 months of mobilization period from the award of the main works. Prior to the award of the main works, preconstruction activities have been planned over a period of 18 months to implement basic infrastructure works as well as some of the critical main works such as diversion tunnel, HRT adits, cable access tunnel, main access tunnel and pre-support tunnels in the underground powerhouse. The tendering for the main works comprising preparation of tender level design, tender documents and tendering process is planned during the pre-construction period. The "**zero date**" of the project has been reckoned from the date of signing of the contract agreement of main works.

3.6.2 Estimated Staffing arrangements

The following general staffing arrangements have been made:

- Estimated numbers of direct workers (excluding security workers who will be outsourced) are 70 during pre-construction, 466 during peak construction and 219 during operation and maintenance.
- It is estimated that about 6347 workers will be employed by the project during peak construction period.
- The number of supply chain workers is unknown at this stage.

3.6.2.1 Pre-Construction and Preparatory Works

About 70 direct workers will be required during the pre-construction period comprising of both males and females. Apart from the security that will be outsourced, all 70 direct workers will be employed by DGPC. They will be located at the field PMU office in Mongar district. During the pre-construction non-physical activities would be carried out such as acquiring requisite clearances, land acquisition, preparation of tender documents & tendering process for main works. During the Preparatory Works period the initial infrastructure works such as access roads to different project components, bridges, construction facilities, construction power, transit camps, site offices, water supply, etc. will be carried out, to complete these before the arrival of main contractors at the project sites. These workers will be located at the access roads sites, bridge sites, construction facility sites, and at the site offices. The type of jobs they will do will be skilled, semiskilled and unskilled jobs.

3.6.2.2 Construction

During peak construction period the following direct and contracted workers are estimated:

- Direct workers: 466 direct workers from the project authority (DGPC) will be required during the peak construction period and will comprise of both males and females. They will be located in the main project PMU office in Mongar, at the head office in Thimphu and in the 4 project site offices that will be located in the dam site, HRT site, surge shaft site, and the powerhouse site in Stealing, Tsamang, and Saleng gewogs.
- Contracted workers: It is anticipated that about 6347 contracted workers (See Table 39 and Figure 15) of which about 90% of them will be international migrant workers from India and will be employed by the project contractors and subcontractors during Peak Construction period. These workers will include skilled, semi-skilled, and non-skilled workers. Due to the nature of the construction works and risks associated with it these workers will be predominantly males.

Table 39: Estimated Construction Worker Numbers

	Y1	Y2	Y3	Y4	Y5
Skilled	735	3675	3675	2766	1838
Semi-Skilled	50	248	248	190	124
Unskilled	486	2432	2432	1750	1216
Total	1269	6347	6347	4700	3174
No. of local employment (based assumption that 90% will be international workers)	127	635	635	470	317
The distribution of manpower mentioned above is based on assumptions and DGPC experience from previous projects in Bhutan. The exact personnel need during the peak construction phases depends on how well the contractor mobilizes resources as per the site requirement.					

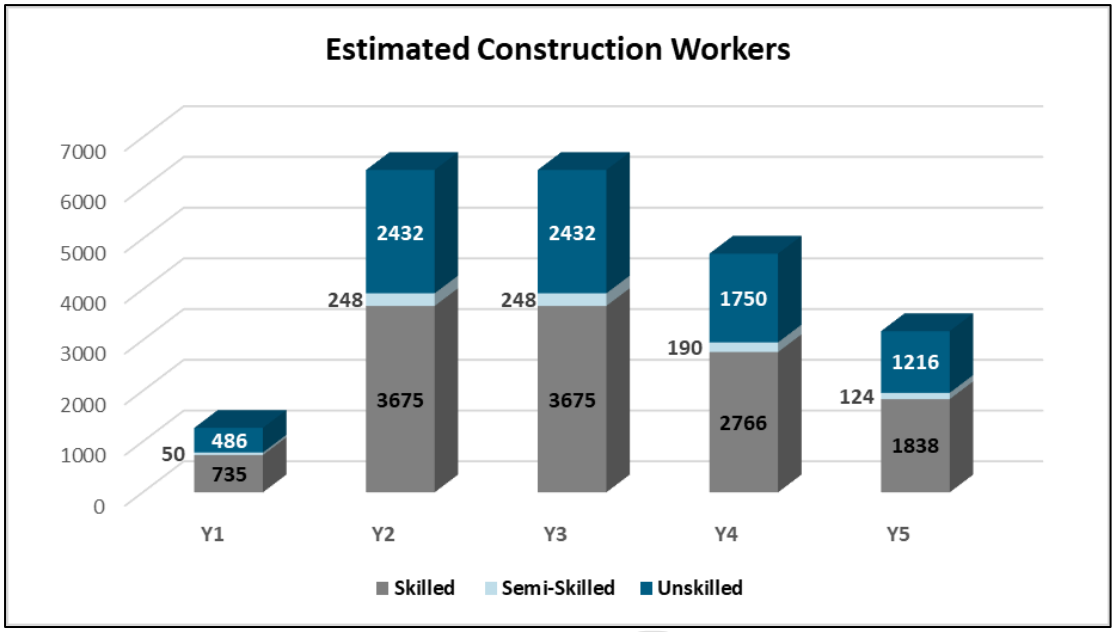


Figure 15: Estimated Construction Worker Requirements

Note: the data is the same as Table 40 but displayed in a graphic format.

Table 40: Manpower Location direct workers

SN	Designation	Autsho	Gyelpozhing / Lingmethang	CCF1	CCF2	CCF3	CCF4	CCF5	CCF6	CCF7	CCF8	CCF9	Total
1	MD Office	0	4	-	-	-	-	-	-	-	-	-	**4**
2	JMD Office	0	4	-	-	-	-	-	-	-	-	-	**4**
2.1	Administration Division	0	77	-	-	-	-	-	-	-	-	-	**77**
2.2	Quality Control Division	3	3	4	-	2	2	2	2	2	2	-	**22**
2.3	Coordination and Monitoring Division	1	1	2	-	1	1	1	-	1	-	-	**8**
2.4	Environment, Social, Health & Safety Office	2	2	-	-	-	-	-	-	-	-	-	**4**
2.5	Geology Division	2	2	3	0	2	2	2	2	2	2		**19**
3	Technical Department	0	7	-	-	-	-	-	-	-	-	-	**7**
3.1	Dam Circle	10		20	-	-	-	-	-	-	-	-	**30**
3.2	Head Race Tunnel Circle	0	5	8		9	9	9	8	9	9	8	**74**
3.3	Powerhouse Circle	0	98	-	-	-	-	-	-	-	-	-	**98**
3.4	Electro-Mechanical Circle	0	25	-	-	-	-	-	-	-	-		**25**
3.5	Contracts & Procurement Division	0	13	-	-	-	-	-	-	-	-		**13**
3.6	Infrastructure Circle		44	-	-	-	-	-	-	-	-		**44**
3.7	Electrical Distribution Division		16	-	-	-	-	-	-	-	-		**16**
4	Finance Department	0	21	-	-	-	-	-	-	-	-		**21**
	Total manpower requirement for the peak construction period	**18**	**322**	**37**	**-**	**14**	**14**	**14**	**12**	**14**	**13**	**8**	**466**

Table 41: Manpower Location of contracted workers

SN	Designation	CCF1	CCF2	CCF3	CCF4	CCF5	CCF6	CCF7	CCF8	CCF9	Total
1	Head work (Dam, Diversion tunnel and coffer dam)	686	-	-	-	-	-	-	-	-	**686**
2	Intake	-	172	-	-	-	-	-	-	-	**172**
2.1	HRT& Adit I	343	-	-	-	-	-	-	-	-	**343**
2.2	HRT& Adit II	-	-	686	-	-	-	-	-	-	**686**
2.3	HRT& Adit III	-	-	-	686	-	-	-	-	-	**686**
2.4	HRT& Adit IV	-	-	-	-	686	-	-	-	-	**686**
2.5	HRT& Adit V	-	-	-	-	-	-	686	-	-	**686**
3	HRT& Adit VI	-	-	-	-	-	-	-	343	-	**343**
3.1	Surge shaft	-	-	-	-	-	-	-	515	-	**515**
3.2	Pressure shaft	-	-	-	-	-	52	-	-	464	**515**
3.3	Powerhouse	-	-	-	-	-	103	-	-	926	**1,029**
	Total manpower requirement for the peak construction period	**1,029**	**172**	**686**	**686**	**686**	**154**	**686**	**858**	**1,390**	**6,347**

The number of primary suppliers at this point of time has not been estimated as there are many variables that will affect the number such as number of primary suppliers of construction materials, location of the primary suppliers, equipment, machinery, and supplies that will be contracted out, including their specifications, modes of transportation etc.

3.6.2.3 Operations

About 219 direct workers with a mix of males and females will be required during the Operations and Maintenance period. They will be located at the dam site, powerhouse site, head office in Thimphu, and mostly at the main project office site in Mongar.

3.7 Associated Facilities - Power Evacuation Transmission Line

The two options for Power Evacuation Transmission Line is as:

Option-I:

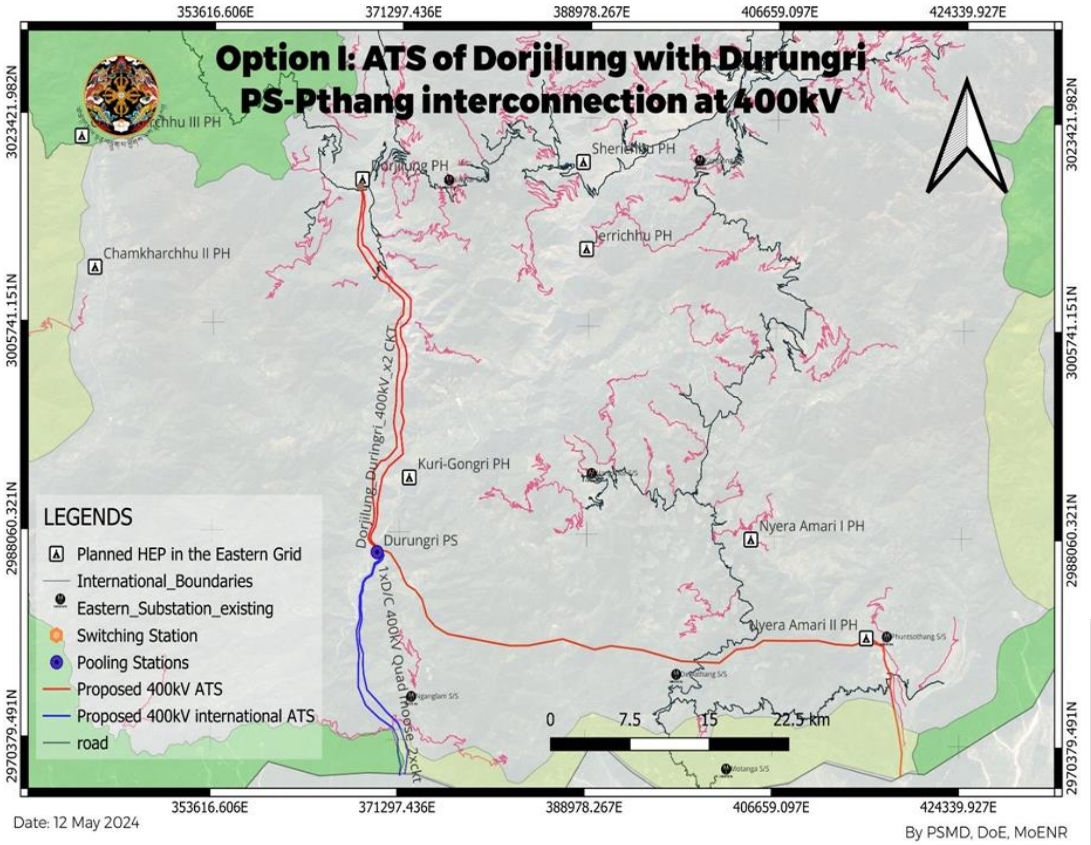
- This proposal suggests a 2xD/C 400 kV ACSR Moose twin configuration line running from Dorjilung to Durungri pooling station (PS). The power aggregated at Durungri PS will then be transmitted to India via a 1xD/C 400 kV ACSR Moose quad configuration line. This setup creates a radial connection between the Dorjilung HEP and the broader national grid. To support the four circuits from Dorjilung HEP to Durungri PS, two tower routes are needed up to the Durungri PS, from where the power will be sent to India via a 1xD/C Quad 400 kV line. As a contingency, an additional 1xD/C 400 kV twin moose line is proposed for evacuating Dorjilung power from Durungri to Phuntshothang, where the power will be pooled and evacuated to India via another 1xD/C 400 kV twin moose line, which is part of the Nyera-Amari ATS.
- The proposed ATS route is designed to avoid culturally sensitive areas, private lands, and community, institutional, and religious sites. It is also aligned near the existing national road network to ensure ease of access during construction and maintenance, and to minimize Right-of-Way (RoW) issues. The route does not pass through protected zones or biological corridors, and a 52-meter RoW is indicated along the proposed path. The route covers seven Gewogs in the Monggar and Pemagatshel dzongkhags.

- The ATS route intersects with the RoW of existing 132 kV S/C lines, with two crossing points identified. Avoiding these intersections could be possible by rerouting the ATS path towards Drepung Gewog, but this would require detailed site investigations and feasibility studies.

Option-II:

- In this alternative proposal, a 1xD/C 400 kV ACSR Moose twin configuration line is planned from Dorjilung HEP to Durungri PS. Additionally, a 1xD/C 400 kV Moose ACSR twin line is proposed from Dorjilung HEP to Gongri HEP for interconnecting hydroelectric plants. From Gongri HEP, the 1xD/C 400 kV line will connect to Durungri as part of the Dorjilung ATS. The pooled power at Durungri PS will be transmitted to India via a 1xD/C 400 kV ACSR Moose quad configuration line.
- The ATS route runs through Monggar and Pemagatshel dzongkhags, maintaining a 52-meter RoW for both tower lines. The route avoids culturally sensitive areas, private, community, institutional, and religious lands, and is positioned along the existing national road network for easy access during construction and maintenance while minimizing RoW issues. The route does not pass through protected zones or biological corridors.
- This route intersects with the RoWs of existing 132 kV S/C lines with two identified crossing points. These intersections cannot be avoided if the circuit is routed through Monggar.

Option-II offers flexibility for interconnecting Dorjilung HEP with Gongri HEP, unlike Option-I, which connects radially to the Durungri PS. Furthermore, Option-II optimizes the ATS for Kholongchhu, Dorjilung, and Gongri, reducing the need for an additional bay at Durungri. However, Option-II is estimated to cost Nu. 4,376 million more than Option-I. Based on system studies, feasibility evaluations, and cost assessments, Option-I is recommended for the 1,125 MW Dorjilung hydroelectric project. Option-II may be considered if there are complications with tower/circuit alignment or space constraints at Durungri PS.



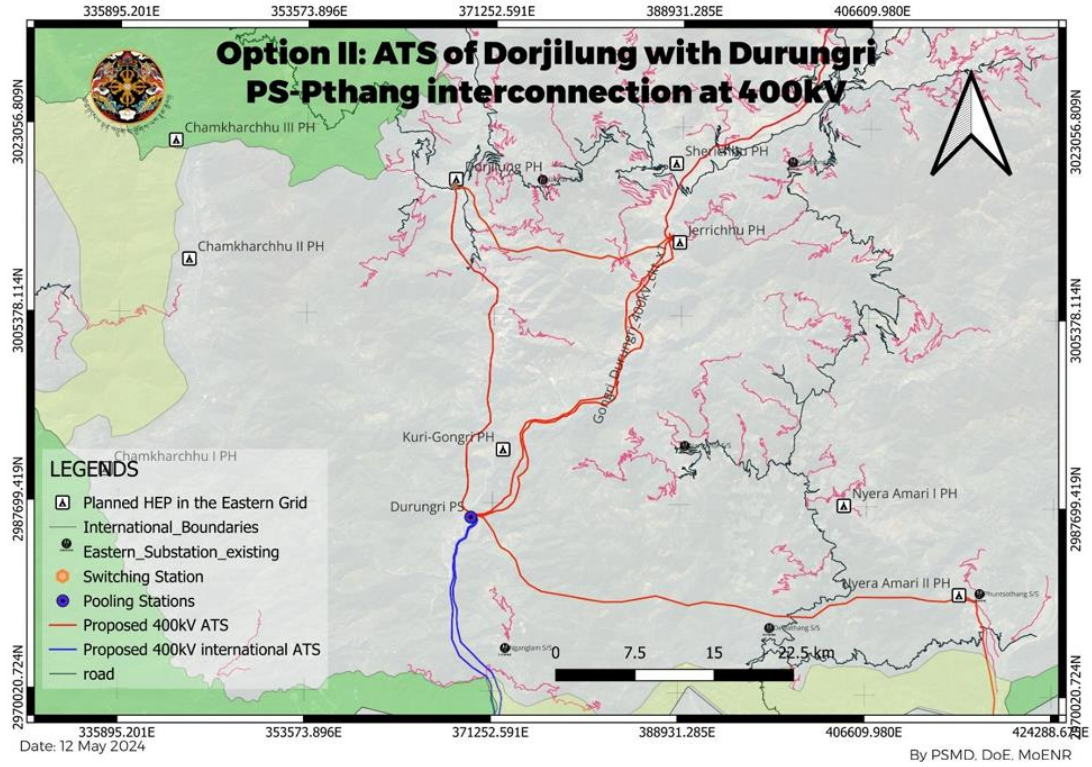


Figure 16: Power Evacuation Transmission Line route options

3.8 River Profile

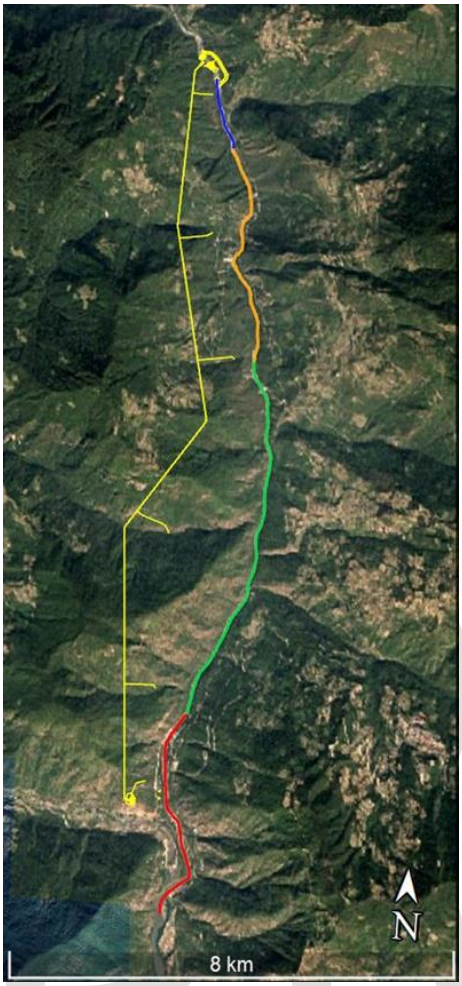


Figure 17: Dorjilung River Profile

Table 42: Sub-reaches Characteristics

Sub-Reach	Mean Slope ($m.m^{-1}$)	Length (m)	Width (m)
SR1	0.015	1500	78
SR2	0.032	4600	59
SR3	0.014	7000	62
SR4	0.006	4000	66

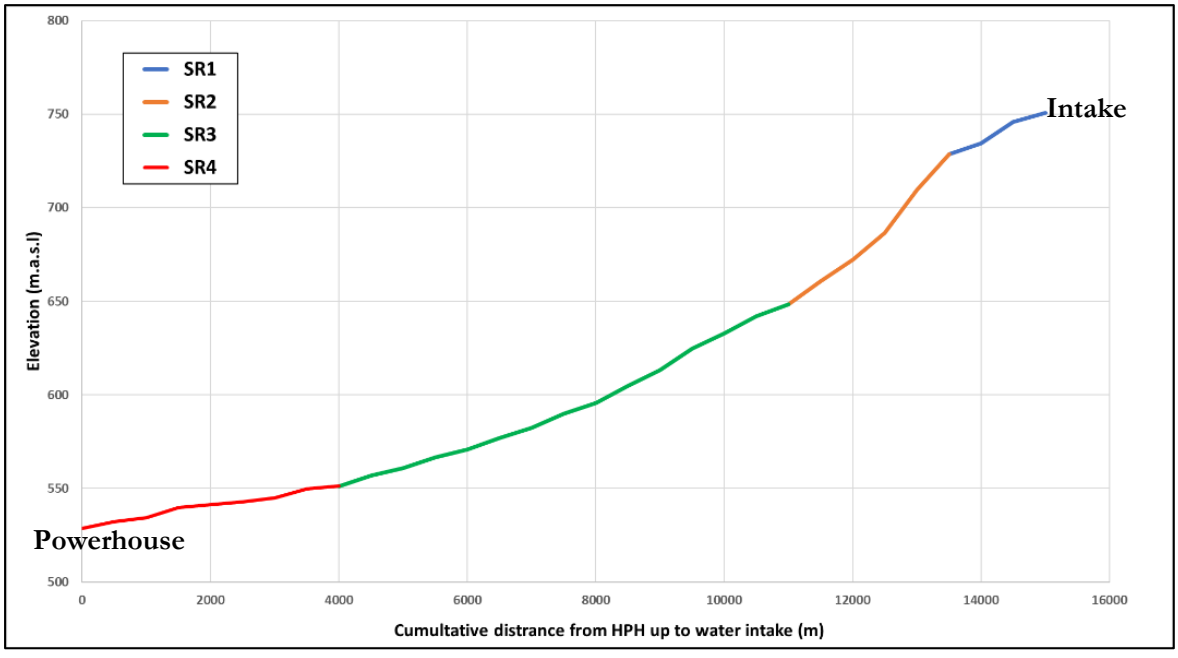


Figure 18: Longitudinal Profile of the Affected Reach of the Dorjilung HPP

3.9 Area of influence

Determination of the Project Areas of Influence (AoI) has been carried out in an iterative manner following consideration of the project components and operation plan (see Section 3.3), potentially affected receivers (See Section 6,7 and 8) and stakeholder engagement (See Separate Stakeholder Engagement Plan).

The Project Areas of Influence (AoI) are defined in a way to:

- Comprehend the influence of the Project on the natural, ecological and socio-economic environment.
- Capture the direct and indirect impacts resulting from the Project in accordance with EB ESS1.
- Capture the cumulative impacts (with other developments and in particular other HPPs) resulting from the Project in accordance with EB ESS1. This is covered specifically in Section 11 of ESIA.
- Reflect engagement with stakeholders in Bhutan (the extent of the AoI is also echoing the national regulatory requirement).
- Meet the requirements of the WB ESS6 requiring that biodiversity impacts are considered at the 'landscape' level and that management measures are articulated with other initiative at the regional scale when feasible.

In response to these requirements, three main AoI have been defined for the Project. They are shown in Table 43 and in the maps on the following pages. Please note that where required for detailed analysis, the AoI has been adjusted depending on the aspect considered in the analysis and is referred to as the Area of Analysis (AoA). For some ecological aspects, the AoA is wider than the AoI and for some, it is narrower. This is detailed further where it is applied in the baseline and impact discussion (Section 10 of ESIA).

Table 43: Area of Influence

Area of Influence	Definition as WB ESS1 Guidance note 23	Main description
Direct	- A direct impact is an impact which is caused by the project and occurs contemporaneously in the location of the project.	- This Direct AoI includes the direct footprint of the Project facilities (both temporary and permanent installations, including the submergence area because of the reservoir) and extends to a 5 km radius (land distance). This is in response to both the WB ESS1 requiring a consideration of direct impacts associated with the footprint and the direct construction activities; and the distance used in Bhutan for consideration of direct impacts. - For terrestrial flora, the direct impact zone is generally limited to the footprint plus a buffer of 50 m to 100 m. • For Aquatic impacts the downstream extent of the AoI stops at the existing Kurichu HPP as it is considered that this reservoir will effectively act as a demodulation basin to the Dorjilung HPP peaking operations. The upstream extent of the AoI has been set at the Yungichu HPP (currently under construction about 30 km u/s of Dorjilung HPP). - For the socio-economic studies this includes 56 villages in 7 gewogs.
Indirect	- An indirect impact is an impact which is caused by the project and is later in time or farther removed from distance than a direct impact, but is still reasonably foreseeable, and will not include induced impacts.	- This Indirect AoI includes an additional buffer zone of 10 km (aerial distance) around the Direct AoI. This captures the broader Biodiversity Corridor #7 (some of it falls within the Direct AoI). This is in response to both the WB ESS1 requiring a consideration of indirect

Area of Influence	Definition as WB ESS1 Guidance note 23	Main description
		impacts deriving from the Project; and the distance used in Bhutan for consideration of indirect impacts. - For aquatic biodiversity, in particular migratory species, the area of indirect influence may extend downstream and upstream in a watershed logic according to the migration patterns of the identified species and knowledge on their biology. The downstream extent of the AoI stops at the existing Kurichhu HPP as it is considered that this reservoir will effectively act as a demodulation basin the to the Dorjilung HPP peaking operations. The upstream extent of the AoI has been set at the Yungichu HPP (currently under construction about 30 km u/s of Dorjilung HPP). - For the habitat, the area of influence of the project is also to be considered in an area of 5 km to 10 km around social influxes depending on the results of studies on the human environment. - For mobile and threatened terrestrial fauna species or those with limited distribution, the area of influence may extend according to the logic of population dynamics, continuity of habitats, corridors or designated/proposed protected areas. - For the socio-economic aspects, the Mongar and Lhuentse district headquarters were added.
Cumulative	- The cumulative impact of the project is the incremental impact of the project when added to impacts from other relevant past, present, and reasonably foreseeable developments.	- This Cumulative AoI includes the Kuri-Gongri HPP for the d/s boundary and the Yungichhu HPP for the u/s boundary. This also captures the ongoing Industrial Estate development at Lingmethang (which is also covered by the Direct AoI due to its proximity to the Powerhouse). - This encompasses about 2 Districts. - See Section 11 of ESIA for further details.

3.9.1 Direct Area of Influence

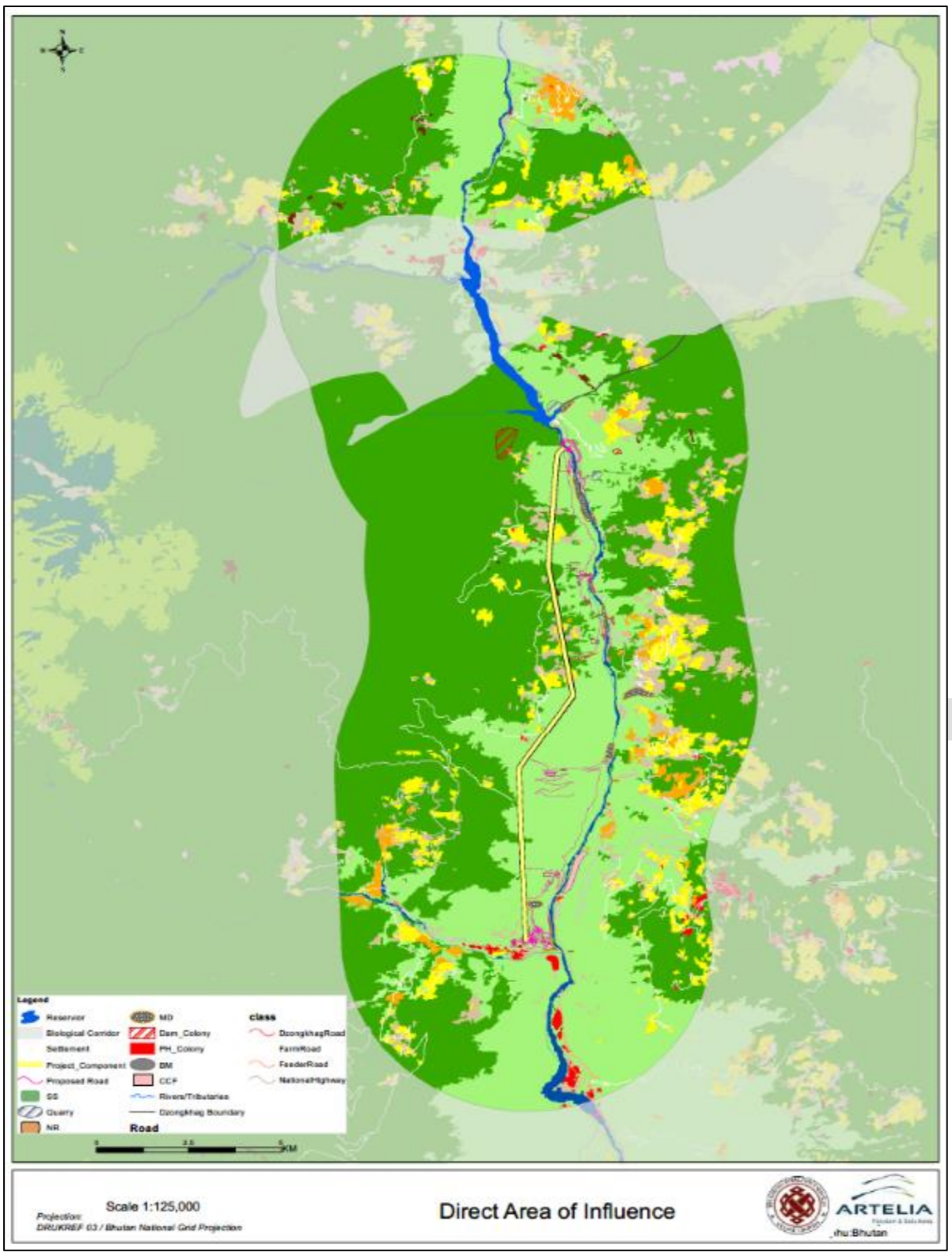


Figure 19: Direct Area of Influence

3.9.2 Indirect Area of Influence

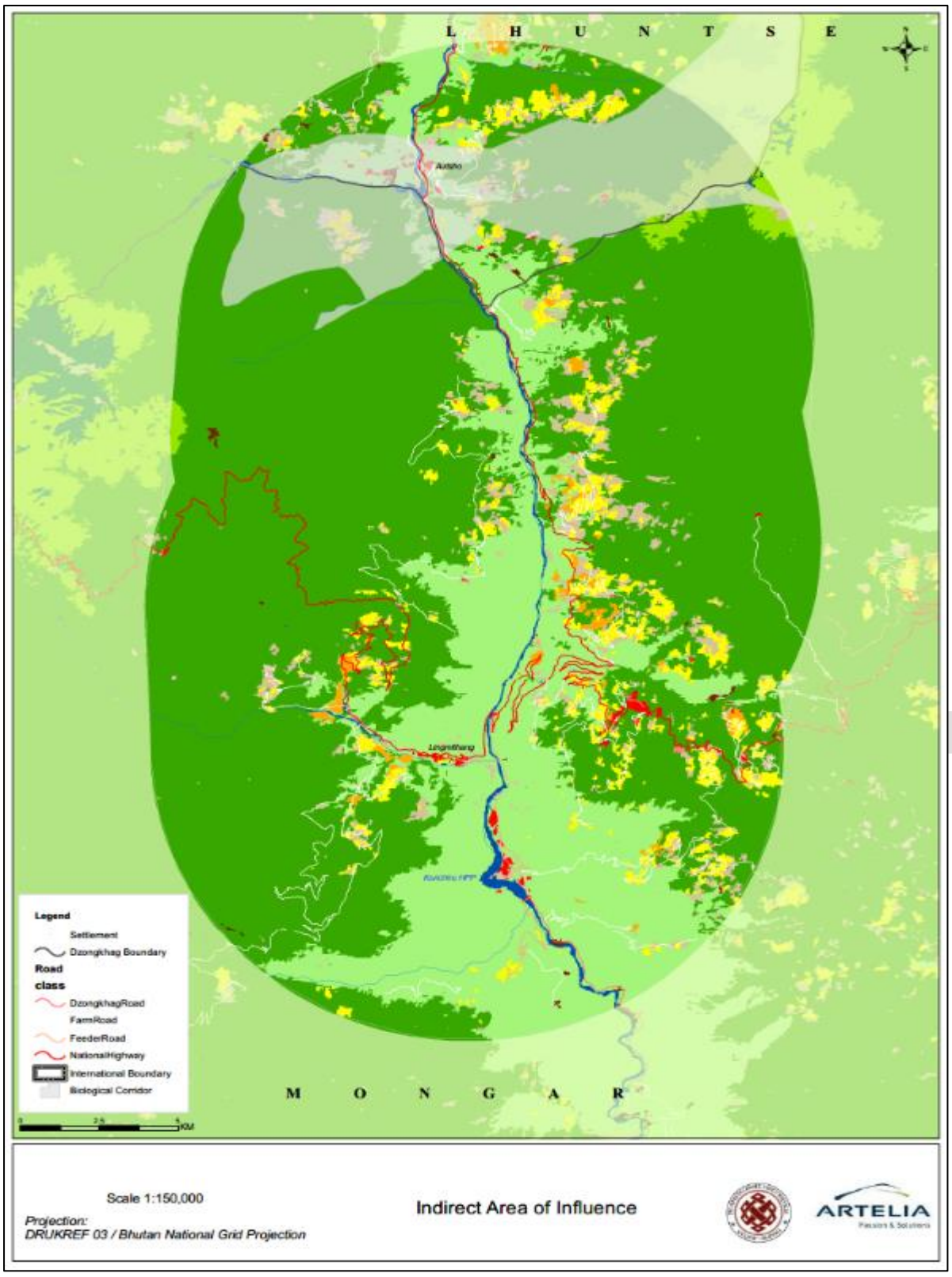


Figure 20: Indirect area of influence

3.9.3 Cumulative Area of Influence

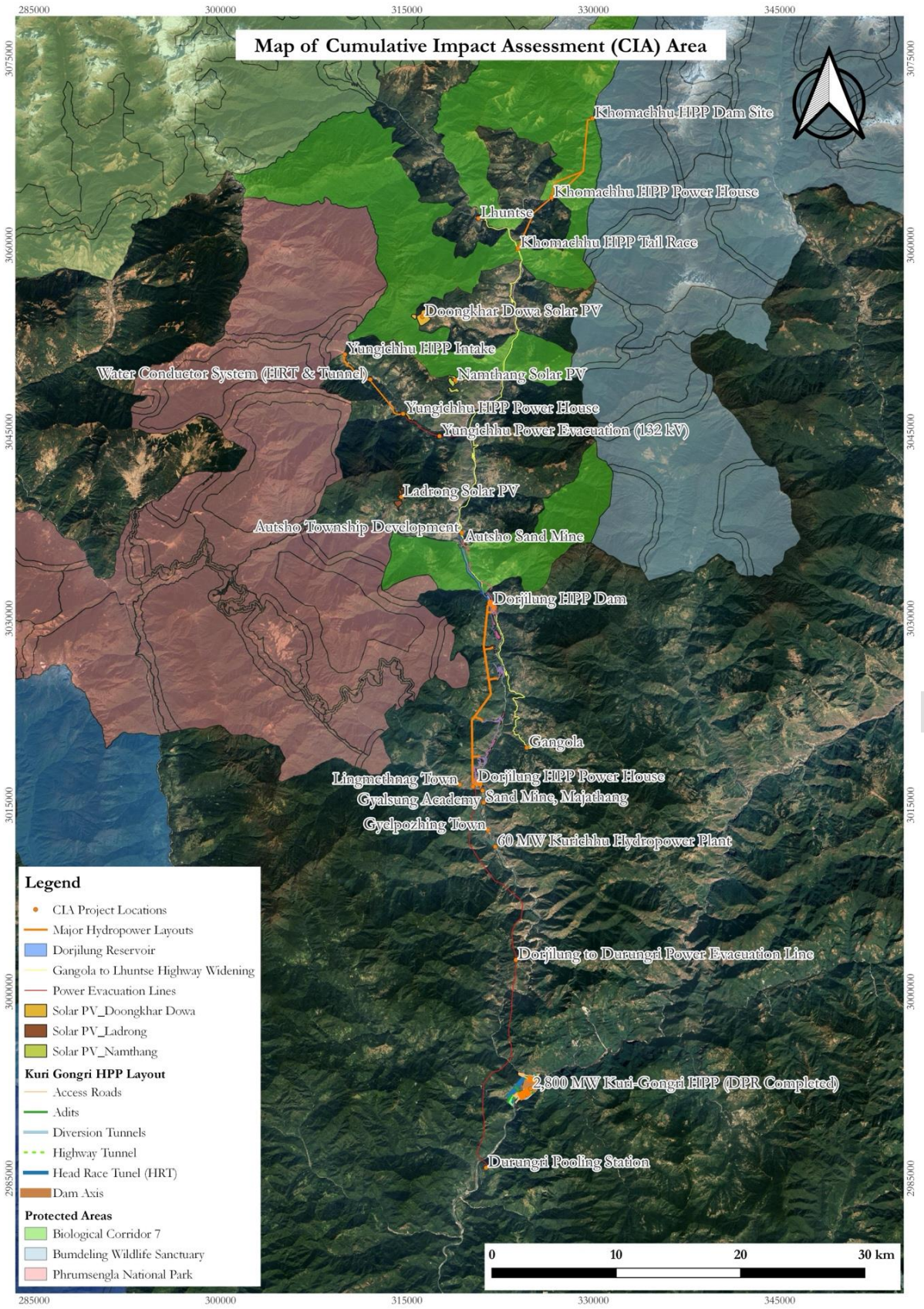


Figure 21: Cumulative impact area

4 PROJECT JUSTIFICATION

4.1 General

The Kingdom of Bhutan is a landlocked country, which is bordered with China in the north and with India to the south, east and west. It lies between latitudes 26.7°N and 28.4°N and longitudes 88.7°E and 92.2°E. Bhutan's landscape ranges from 100 masl in the sub-tropical plains in the south to 7,500 masl in the northern sub-alpine region. By virtue of its geographical location, Bhutan is blessed by nature with altitudinal varying land mass with good vegetation cover, perennial rivers and fair climatic conditions. Although Bhutan's natural heritage is still largely intact, the government has given highest priority in conserving and protecting its environment. Out of the country's total area of 38,394 km2, about 80% of the land is under forest cover.

Thus, Bhutan has abundant potential to harness hydropower energy. Most of the schemes identified are run-of-the river type. In the most recent updated version of the Bhutan Power System Master Plan (PSMP-2040), the estimated hydropower potential of Bhutan stands at 37 GW from 155 sites out of which 33 GW from 90 sites is techno-economically feasible. Hydropower has been the country's main engine of growth over the last two and half decades since the full commissioning of the first mega project in 1986-88. Bhutan's fast flowing rivers have been tapped to build run-of river hydropower plants that have in turn driven economic growth and greatly boosted progress in meeting many of the country's social-economic development objectives.

Out of the estimated 33 GW of techno-economically feasible hydropower potential, a little over 2,453 MW (including 9 MW of embedment generation) or only about 7.50% has been harnessed so far. According to the annual report published by the Royal Monetary Authority (RMA), the share of hydropower to the GDP is 13.40% in the year 2022.

The development of several more mega hydropower projects is likely to see an even greater prominence of the electricity sector within the national economy. The harnessing of hydropower in the country has been possible because of the close and friendly ties with its neighbour, India.

4.2 Bhutan – Power Sector

The electricity was first introduced in Bhutan in 1966 with the installation of a 256kW diesel generator in Phuntsholing. Bhutan's first hydropower plant was commissioned in 1967 in Thimphu with an installed capacity of 360 kW. The construction of 336 MW Chukha hydroelectric project started in 1978, which was fully commissioned in 1988 marking the major milestone in the sustainable development of the hydroelectric sector in the country.

The institutional structure of the power sector in Bhutan went through major structural changes in 2002. From a vertically integrated government department that was responsible for policy and planning, regulation and utility functions, clear delineation and separation of functions was introduced through the enactment of the Electricity Act 2001. The structure of the power sector in Bhutan as of 2024 stands as follows:

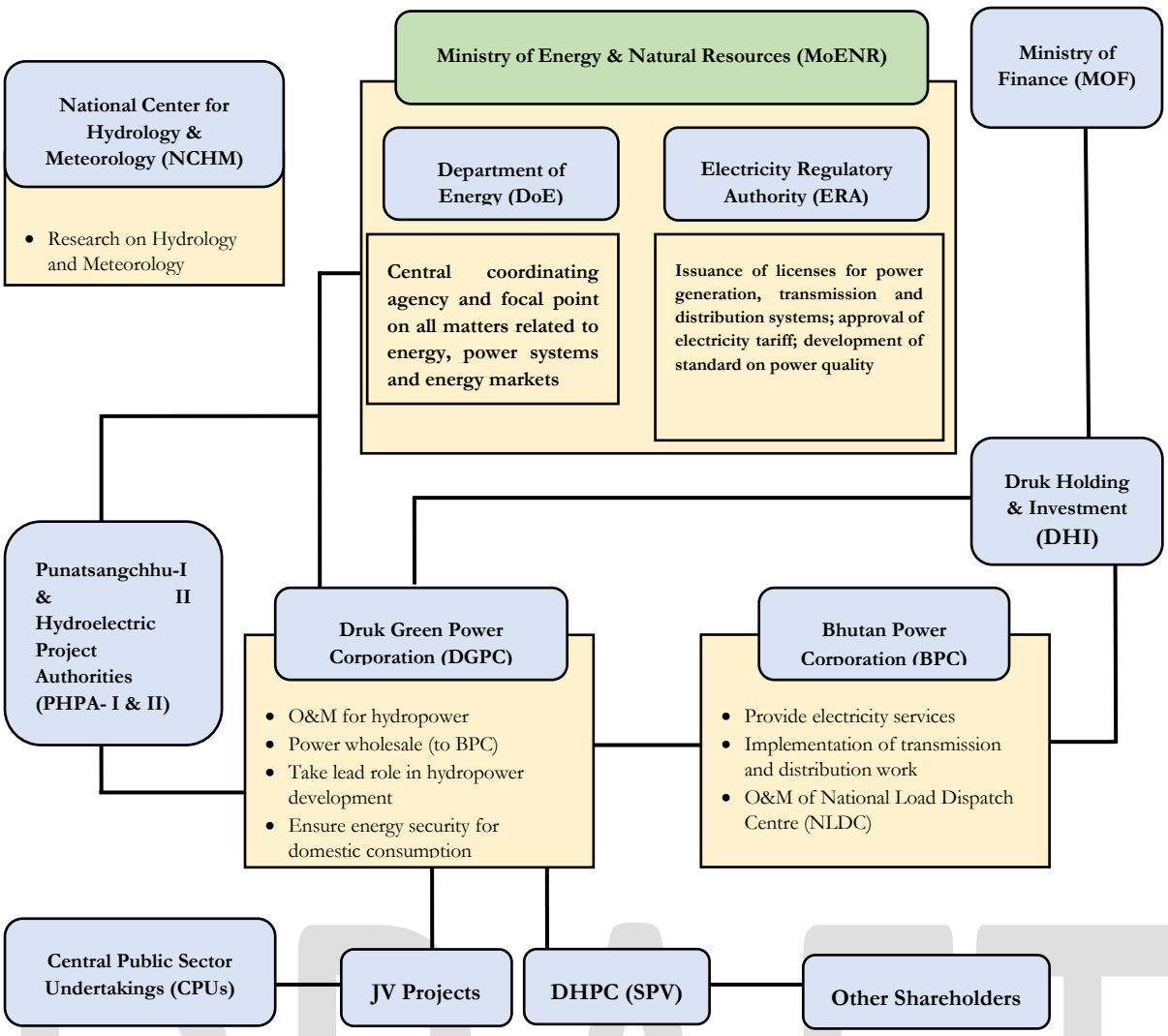


Figure 22: Current Structure of Power Sector of Bhutan

Source: SP, draft DRP update, 2024

The Department of Energy (DoE) under the Ministry of Energy & Natural Resources (MoENR) is the nodal agency responsible for policy development and planning including monitoring of hydropower and renewable energy projects in the country. The Bhutan Electricity Authority (BEA) which was a fully autonomous body has now been placed under the MoENR as the Energy Regulatory Authority (ERA). The Druk Green Power Corporation (DGPC) and Bhutan Power Corporation (BPC) are state owned enterprise with the former being a generation company and the latter a transmission and distribution utility.

4.3 Bhutan – Status of Hydropower & Transmission System

The hydropower is the backbone of the Bhutanese economy. The glacial mountains of the great Himalayan range in northern Bhutan provide an important renewable source of water for the country's river systems. Bhutan has built hydropower plants to tap the energy of fast flowing rivers, which in turn resulted in economic growth and greatly helped in achieving her socio-economic development objectives.

4.4 Need for the Project

Bhutan has abundant hydropower potential and is generating surplus power which is exported to India. Thus, most of the power, generated at Dorjilung HPP would also be exported to India.

The electricity demand in India is going to rise due to various economic development activities, rural electrification and India's goal to replace current highly polluting energy sources with cleaner renewable energy sources mainly solar and wind power. According to data available with the Central Electricity Authority (CEA), India, All India peak demand reached 215 GW during year 2022-2023 registering a 6.34% year on year increase from 203 GW in the financial year 2021-2022. Also, All India energy consumption requirement reached 1,512 BU during year 2022-2023 registering 9.57% year on year increase from 1,380 BU during financial year 2021-2022. Based on this data, India has been in energy deficit for all these past years and however, the deficit has been decreasing over the years from about 10% in year 2009-2010 to 0.5% in year 2022-2023. Although the deficit has reduced significantly over the years, the deficit in absolute value is huge for about 8 billion units. On the other hand, the peak deficit has been increasing post pandemic due to easing of pandemic-related restrictions.

In the case of Bangladesh (Annual Report 2022-23, Bangladesh Power Development Board), the power generation is predominantly fueled by gas and oil exceeding 70%. Bangladesh also relies on power supply through power import from India of 2,656 MW constituting about 10.66% share of power supply source at a weighted average price of INR 6.46 per unit. The energy deficit is about 700 MW in 2021. The peak and average demand is expected to increase significantly over the next 10 years with peak demand expected to reach 34.6 GW and average demand of 22.5 GW. It was observed that the power demand in Bangladesh will be complementary for Bhutan's energy generation. When Bhutan is energy surplus during the monsoon

seasons, the energy requirement in Bangladesh is peak. Conversely, when Bhutan is deficit during lean winter months, the energy requirement is minimal.

Bhutan's vast hydropower potential estimated at about 37,000 MW will not only contribute to the development of these regions, but by using these abundant resources effectively within the countries in South Asia including Bangladesh, it will also contribute to alleviating climate change. Moreover, hydropower generation is excellent in load following capability since it is rich in frequency adjustment functions; there are various advantages for countries in South Asia to establish a firm electric power network in the future. If the SAARC Energy Ring and tripartite agreement for cross border power trade between India, Bhutan and Bangladesh get through, power from Dorjilung HPP is expected to meet Bangladesh, India and other energy deficient member state's growing power need.

5 ANALYSIS OF ALTERNATIVES

The chapter presents discussion on the project alternatives. During development of the project from the original master plan in 2004, though prefeasibility in 2011, the DPR 2016 and the updated DPR (in production), the layout and scheme has been adjusted in response to engineering, environmental and social constraints as they were identified. For brevity, all the changes have not been documented here (refer to 2016 DPR for more information). Focus has been applied to changes made since 2016 DPR and/or key E&S changes identified in 2016 DPR.

5.1 'No PROJECT' Alternative

A 'no project' alternative would avoid significant negative impacts such as long-term change in the hydrology of the Kurichhu River, disruption/loss of habitat and biodiversity, and physical and economic displacement of communities. However, a robust ESIA and the implementation of mitigation measures will make it possible to Avoid / Reduce / Restore / Offsetting for these impacts and make the project acceptable.

However, not developing the Dorjilung HPP will result in a significant gap for the national economic development of Bhutan. There is currently no alternative economic activity which could result in a similar amount of revenue and hard currency for the country. The 'no project' alternative represents a significant risk for national development with negative flow-on effects to the country and society.

5.2 Alternative Energy Sources

The Bhutan Energy Data Directory 2022, prepared by the Department of Energy, Ministry of Energy and Natural Resources, summaries the energy sector of Bhutan and has been referenced for information on alternative energy sources.

The Directory reveals that Bhutan's total energy supply increased to 793,263.3 tons of oil equivalent (TOE), with thermal energy sources accounting for 62.4 percent of the energy mix and electricity contributing the remaining 37.6 percent. As of 2022, Bhutan's installed capacity stood at 2,344.35 MW. Much of this capacity is derived from hydropower plants, accounting for 2,334.1 MW. Electricity from alternative renewable sources like solar and wind contributed less than 1 percent combined (Figure 23).

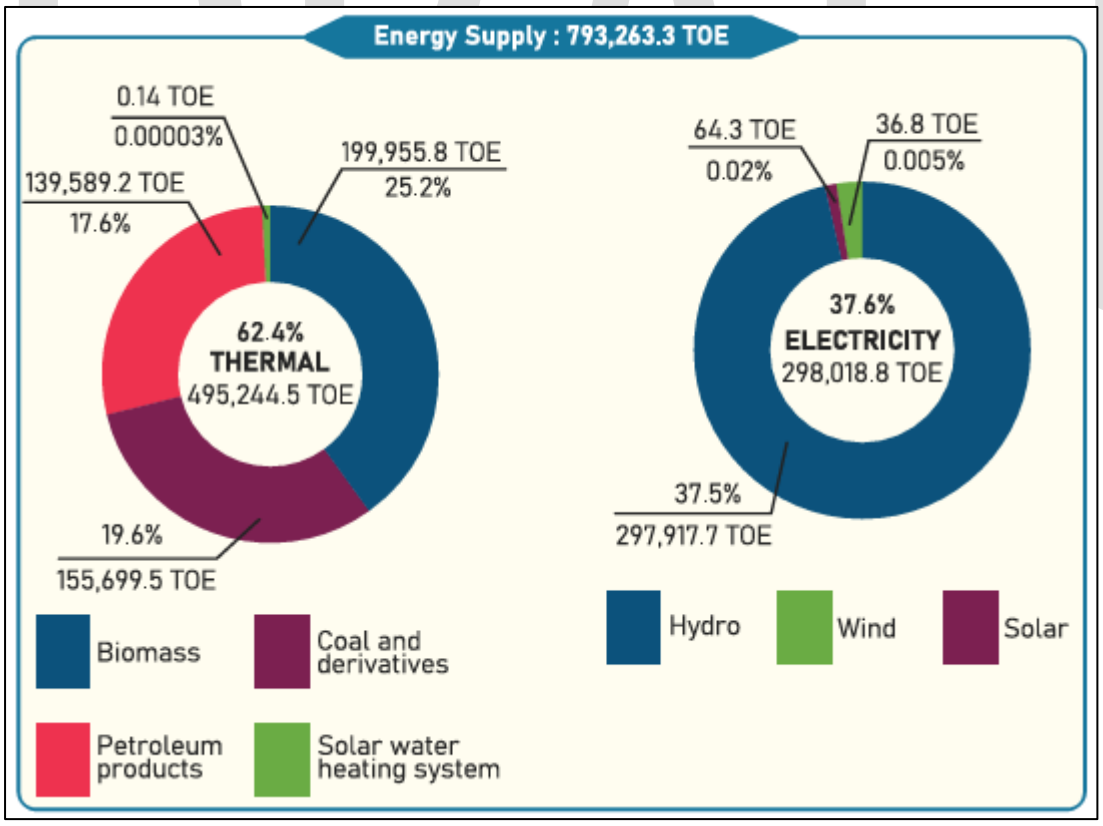


Figure 23: Bhutan Energy Supply in 2022 (tons of oil equivalent [TOE])

Source: Bhutan Energy Data Directory 2022

5.2.1 Solar

Currently the role that solar renewable energy generation provides in Bhutan is low. In 2022, a total of 745.7 MWh of solar electricity was generated, with the majority originating from institutional and commercial buildings (Bhutan Energy Data Directory 2022).

Bhutan has a sizeable theoretical potential for solar power generation based on solar irradiance, however when considering constraints (such as rugged terrain, national protected areas, and other restrictions) the restricted development potential is approximately 12,000 MW (Renewable Energy Resource Assessment 2015).

Solar power is therefore not considered a robust and equivalent alternative to the hydroelectric development of Dorjilung HPP (both in installed power and annual production). A solar alternative would not provide the same benefits in terms of peak production and "systemic benefits".

5.2.2 Wind

Bhutan has substantial capacity for leveraging wind power systems. The restricted theoretical development potential for wind power in the country is estimated to be approximately 761 MW (DRE, 2015). In 2022, Bhutan generated a total of 427.7 MWh of electricity from wind power.

Wind power is therefore not considered a robust and equivalent alternative to the hydroelectric development of Dorjilung HPP (both in installed power and annual production). A wind alternative would not provide the same benefits in terms of peak production and "systemic benefits".

5.2.3 Waste to Energy

The theoretical capacity for producing electricity from waste in Bhutan is projected to reach a maximum of 49.23 MWh per day (equivalent to 17,967 MWh annually). Specifically, household waste alone has the potential to generate approximately 23.3 MWh per day (or 8,506 MWh annually). This renewable energy source has the capability to fulfill a significant portion of the energy requirements for households and businesses, thereby reducing reliance on conventional energy sources.

However, this electricity production method is not considered suitably mature in Bhutan. While some small-scale examples exist, there are no current examples of large-scale waste-to-energy production plants in Bhutan.

Waste to energy power is therefore not considered a robust and equivalent alternative to the hydroelectric development of Dorjilung HPP (both in installed power and annual production). A Waste to energy alternative would not provide the same benefits in terms of peak production and "systemic benefits".

5.2.4 Thermal

Currently in Bhutan the use of diesel generators is the second largest source of electricity, contributing 8.93 MW to the overall capacity in 2022.

An analysis of the GHG emissions profile of the Dorjilung HPP was conducted using the IHA GRES tool (see Section 10.5.1.4 GHG Emissions). Artelia used the information provided on Dorjilung HPP in the Climate Resilience Assessment to prepare a comparison of theoretical alternative considerations. The international practice is to express GHG in CO_2 equivalents (CO_2e). Emissions of gases other than CO_2 are translated into CO_2e by multiplying by the respective global warming potential (GWP). These estimations are taken from the comparison of life-cycle emissions from thermal power generation (IPCC, 2014). In accordance with IPCC (2006), the lifetime assessment period for net GHG emissions is 100 years.

Building and operating a hydroelectric facility rather than a thermal installation of the same power is more advantageous and less impactful in terms of greenhouse gas emissions and air quality. Equivalent means of thermal production would have emission factors of around 400 gCO2eq/kWh for natural gas, 800 gCO2eq/kWh for Diesel or even 1000 gCO2eq/kWh for coal.

Table 44: Comparison of energy alternatives to produce 4 504 GWh/year installed capacity

	Units	DORJILUNG HPP	Diesel	Gas	Charcoal
Annual Production	GWh/yr	4504	4504	4504	4504
Total Lifetime emission	kT CO_{2eq}	678	364,640	182,320	455,800
Total Emission per year	kT CO_{2eq}/yr	6.78	3646.40	1823.20	
GHG Emission Intensity	g CO_{2eq}/kWh	1.4	800	400	1000

In 2023, DoECC, MoENR published Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy. This strategy outlines the objectives of always remaining carbon neutral. Thus, the thermal alternative, as it would emit a proportion of GHGs much higher than those from a hydroelectric alternative, does not appear compatible with the country's ambitions.

5.3 Alternative Project Location and Equipment – DPR 2016

Several alternatives were studied and documented in the previous DPR (2016) and are synthetised below.

Master Plan – The proposed project has been first studied in the 2004 Power System Master Plan (PSMP-2004) with a development along left bank of Kurichhu with the dam site located near Dorji Lung (formerly known as Rotpashong). The initial concept had a gross head of 117 m and a design discharge of 401.6 m^3/s. The dam was located at EL 716 masl and the tail water level was set at 640 masl. The length of the HRT was 1600 m long, and the installed capacity was 400 MW.

Prefeasibility Study - In the PFS – 2011, three alternative dam sites have been studied.

- The first dam site, D-1, is located approximately 400 m downstream of the confluence of Kurichhu and Shemkichhu.
- The second dam site, D - 2 is located about 1 km downstream of D-1 and the third dam site.

- D-3 is located downstream of Chorten near Autsho.

Two alternative powerhouse sites were studied. The first site PH-1 was located on the right bank just u/s of the confluence of Kurichhu and Meralungchhu and the second site PH-2 was located near Kurizam with TRT outfall near the confluence of Kurichhu and Shongarchhu.

The proposed alternative dam site D-1 was located about 400 m downstream of the confluence of Kurichhu and Shemkichhu. The river at this site flows through a moderately narrow valley with steep abutments that expose phyllitic schist with quartz-chlorite rich gneiss belonging to Shumur Formation of Daling-Shumur Group. The riverbed is covered by fluvial deposits comprising medium grained sand with boulders, cobbles and pebbles. It is observed that the proportion of clasts in these deposits is high as compared to sand. The bedrock comprising phyllitic schist with quartzite is exposed on the abutments right from riverbed level. In addition to numerous joint sets particularly in quartzite, the general foliation ranges considerably.

Profuse injections of quartzo-felspathic veins along the foliation in phyllite bands is observed. The depth of bedrock as indicated by subsurface exploration was found to be at a depth of around 30 m.

The D-2 dam site proposed during prefeasibility stage studies was located about 1km d/s of the alternative site D-1. The river at this alternative site flows through a moderately narrow valley with steep abutment slopes. The riverbed is covered by medium to fine grained sand with boulders, cobbles and pebbles of gneiss and quartzite. It is observed that the proportion of coarser fractions in the riverbed deposits is high as compared to fines. Both the abutments at the site are steep. The bedrock comprising phyllitic schist are exposed at dam site. The schist is slightly weathered and medium to thickly bedded and greyish white in colour. The subsurface exploration carried out at the site indicated bedrock depth of 33.6 m.

The D-3 dam site was located just downstream of the Chorten near Autsho. This site would not allowed for the creation of a sufficient reservoir for daily peaking as it would have resulted in the possible submergence of Autsho. The head race tunnel would also have to cross a deep valley just u/s of the D-2 dam sit. D-3 dam was not considered further due to these constraints.

Out of the remaining two alternatives of (D-1 and D-2), D-2 was preferred over D-1 due to the occurrence of a landslide upstream of D-1, which would interfere with the intake location and threaten the construction activities. D-1 also had challenges with an unfavourable location of intake, insufficient width for required crest length of overflow spillway. Additionally, D-2 offered better orientation of the river downstream of D-2 dam for energy dissipation and comparatively good rock condition for tunnel adits.

Based on selected dam site (D-2) and considering two powerhouse locations (PH-1 and PH-2), two alternatives of project layout were studied in the pre-feasibility stage:

- Alternative-1: Under this alternative, the project is aligned on the right bank of Kurichhu with dam site D2 and underground powerhouse at PH-1.
- Alternative 2: Under this alternative, keeping the dam site same as alternative 1, the underground powerhouse has been shifted further downstream at Kurizam (PH-2) to take advantage of additional head. Under this alternative, Shongarchhu has been proposed to be diverted in a surge shaft.

Through a techno-economic assessment, Alternative 2 was selected as the preferred alternative for the development of Rotpashong HPP in pre-feasibility design.

Detailed Project Report (DPR) - In the DPR, based on large scale topographical maps and geological investigations, alternative sites for major project components mainly dam and powerhouse had been studied besides the alternative sites studied during PFS stage.

Based on DPR level assessment, dam site has been kept at same site as PFS located at about 1.0 km upstream of Rewan while the underground powerhouse site has been shifted near the confluence of Kurichhu and Shongarchhu. Considering techno-economic assessment, the integration of Shongarchhu with Dorjilung HPP was found not to be feasible. Considering the above, the project layout has been finalized.

5.4 Alternative Project Location and Equipment – DPR UPDATE

5.4.1 DPR Update 2024

The DPR of 2016 is currently in process of being updated (August 2024) by Studio Pietrangeli of Italy (SP) who is supporting DGPC. A draft of the DPR update section on project alternatives was provided in August 2024, and key points have been summarized here.

The objective of the update is to bring it to the standards of the newly approved Bhutanese Guidelines for Development of Hydropower Projects (2018) to reflect international good practice and thereby make the project bankable for international financing. The World Bank has provided a technical assistance grant for DPR update under the Sustainable Hydropower Development Project.

The project alternatives and the final layout of the project considered in the DPR-2015 in terms of general layout and location of major components of the project have been reviewed in close collaboration with the engineering consultant M/s Studio Pietrangeli of Italy (SP) who is supporting DGPC in the DPR update.

The reports prepared by DGPC and SP have been reviewed and vetted by the Experts from the World Bank and by the high-level Panel of Experts. The joint inspection of the project sites had been carried out by the Experts from the World Bank, Panel of Experts, SP and DGPC during the preparation of DPR Update. The Experts from SP together with DGPC have also visited the project sites several times during the DPR Update.

5.4.2 Dam

The location of the dam and its layout as considered in the DPR-2015 have been reviewed and assessed to be techno-economically and socio-environmentally suitable and appropriate for sitting a concrete gravity dam with all its appurtenant structures. The axis of the dam therefore was kept unchanged from DPR-2015. However, SP has carried out detailed updates and optimization of the design of the dam considering the updated geo-structural model of the dam site, hydraulics and revised design flood for the project.

Table 45: Changes in Hydrological Parameters

Aspect	DPR 2015	Updated DPR 2024
PMF (m^3/s)	14,300	11,885
GLOF (m^3/s)	1,521	4,340/20,123
Design flood (m^3/s)	15,821	16,225 / 20,123
Temporary diversion flood (m^3/s)	2,430	2,671
e-flow (m^3/s)	4.85	6.0

5.4.3 HRT

There is no change in the alignment of HRT on the right bank of Kurichhu as conceived in the DPR-2015. However, based on the detailed deliberations among the experts including the recommendations of the Panel of Experts, the alignment of HRT, especially on the deep creek/depressions near Adit-2 and Adit-4 have been reviewed and re-evaluated which required slight change in the alignment of the HRT.

As a result of the re-evaluation, the length of HRT has increased from 14,883 m to 14,974 m (increased by about 91 m). Consequently, the length of Adit-4 has increased from 746 m to 1,274 m. The realigned HRT will have to pass through the maximum overburden cover of about 994 m against 829 m in the DPR 2015. With the realigned HRT, the minimum cover along the valley crossings, especially at Adit-2 and Adit-4 will have sufficient cover to prevent any potential leakages. However, as recommended by the Panel of Experts, the borehole drillings at these valley crossings along with lugeon tests followed by hydro-frac (HF) tests have been recommended to be carried out to validate the minimum available in-situ stresses, based on which further optimization may be considered as necessary during detailed design stage.

5.4.4 Powerhouse

As part of DPR update, SP have evaluated the feasibility of a surface powerhouse option and identified two possible locations through a preliminary drone survey and site visit:

- Alt. 1 on the right bank of Kurichhu
- Alt. 2 on the left bank of Shongarchhu – a right bank tributary of Kurichhu

After the site validation in consultation with ESIA experts, extensive discussions were carried out and it was concluded that:

- Alt. 1: The proposed location is already under development from Gyelpozhing Industrial Estate and that the site is highly vulnerable to flood risk, as the site is located close to the confluence of Kurichhu and Shongarchhu and the area proposed is a flood plain.
- Alt. 2: The site is already under development by Gyalsung Infrastructure. Additionally, Bhutan Agro Industries Limited (BAIL) is established in the vicinity. There is a risk of flooding of infrastructures of Gyalsung project under construction along Shongarchhu river from the tailrace water.

Furthermore, for strategic reasons, the usual preference is to build underground powerhouses when the installed power exceeds about 300 MW, as is the case with Dorjilung HPP.

Therefore, for the above reasons, it was decided to proceed with the underground alternative as already conceived in the 2015 DPR. The underground powerhouse option had already been planned and an extensive investigation campaign completed during previous phases of the design.

5.4.5 Residential Accommodation and Colonies

DPR 2016 included the provision of dedicated residential complexes and construction camps (colonies). Total area estimated required was approximately 60 acres (24.3ha) (Alternative 1). Residential complexes were proposed at dam and powerhouse sites. Additionally, two colonies, one temporary at dam site and one permanent for powerhouse were also included in this alternative.

An Alternative arrangement (Alternative 2) was considered during DPR update, with no colonies required. Direct workers from DGPC (Bhutanese nationals), would be housed within existing facilities and within the CCFs. The direct workers accommodation would be largely split between Dam and Powerhouse. The direct workers for the powerhouse will be housed in existing facilities that are part of the Kurichhu HPP

infrastructure, approximately 1 km from Gyelpozhing, and/or renting within Gyelpozhing or Lingmethang. The direct workers for the dam will be located within existing buildings within Autsho. Contracted workers (international) accommodation will be in the CCF.

Alternative 2 removes the 60 acres (24.3ha) of potential impact. This Alternative also reduces the access roads required. Alternative 2 was selected as the preferred alternative, and no dedicated colonies are included in the project layout.

5.4.6 New access roads

Alternative 1. To facilitate construction of the project, 12 new access roads are proposed with a total of 40.68 km access roads to various project components and work sites.

Table 46: Alternative 1 for access road construction

Alternative	Length (km)	Technical aspects (m)	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
Access road to Dam colony B	2.00 + 5.5 km road widening	extended through the existing farm road leading to Takhambi village. Requires the widening of the existing farm road to Takhambi	NA		7.41 acres chirpine (2.99ha)
Access Road to Construction Adit-1	2.58	Take off from Left bank of Kurichhu, d/s lower coffer dam. Requires the construction of a 60m bailey bridge across the river. Construction work on the left bank can be mobilized immediately.	71.80	0.49 acres (0.2ha) of cultivated land on mountain slopes (non-title holders)	0.08 acres (0.03ha) Broadleaf 2.57 acres (1.04ha) chirpine and 0.49 acres (0.2ha) encroached land.
Access Road to Construction Adit-2	7.00	Take off Near Manmari Includes the construction of a 65 m bailey bridge across the river. The slope on the L/B of the identified bridge site is very steep.	148.65	0.30 cultivated land on mountain slopes.	23.57 SRFL (22.82 chirpine, 0.75 eroded land)
Access Road to Construction Adit-3	1.20	Take off from the proposed access road to Adit II Only possible access road to Adit II (alternative II) is constructed	20.22	No impact on private land	4.32 acres (1.75ha) of SRFL (chirpine forest)
Access Road to Construction Adit4	8.72	Take off from the right bank of Kurizam 12m bridge required to cross a stream	152.63	No impact on private land	31.06 SRFL (10.38 broadleaf, 20.68 chirpine)
Access Road to Construction Adit-5	2.8	Take off Right bank of Kurizam Access to Adit-5 follows the contours with 8 hairpin bends	47.20	No impact on private land	9.12 acres of SRFL and 0.24 rocky outcrop.
Access Road to Construction Adit-6	2.30	Take off from Near forest & Park office, at Lingmethang. Road will extend uphill from the highway and run almost parallel to the Chorten area.	38.76	No impact on private land The new road construction creates disturbance in Lingmethang area. -Risk of damage to the highway from road cutting immediately above	8.00 SRFL (Chirpine)
Access Road to Surge Shaft top	3.11	Take off from Adit VI portal.	52.42	No impact on private land but	10.15 SRFL (Chirpine)

		Extension from the portal road. Includes 8 hairpin bends		located above the national highway	
Access Road to MAT & TRT	1.06	This will take off from the road to PH.	NA		1.06 chirpine
Access road to Powerhouse Colony	3.00	Mild terrain, take off from the main road in Lingmethang	NA	Loss of industrial estate land	11.12 acres chirpine forest
Quarry Road	2.30		NA		3.71 acres of SRFL (no details on forest type)
Bypass road	4.61	Take off from from Adit – 2 to Dam top on the right bank. use 7.0 km of access road constructed for Adit – 2 (alternative II) plus new road of 4.61 km to be constructed	100		17.16 SRFL (2.66 broadleaf, 14.50 chirpine)
Total	**40.68**				

Alternative 2

10 new access roads are proposed with a total of about 27.58 km access roads to various project components and work sites. Access to the two colonies (dam and powerhouse) have been removed as there are no colonies. The access to MAT and TRT has been merged with the Access Road to Surge Shaft top and PH. A new road to MD 7 has been proposed.

Table 47: Alternative 2 for access road construction

Alternative	Length (km)	Technical aspects (m)	Estima-ted cost (Mill Nu.)	Social impacts	Environmen-tal impacts
Access Road to Dam and Construction Adit-1	1.91	Take off from Left bank of Kurichhu, d/s lower coffer dam. Requires the construction of a 60m bailey bridge across the river. Construction work on the left bank can be mobilized immediately.	NA	0.205 acres of Private wetland belonging to 3 households will be impacted	6.176 acres of SRFL (5.94 chirpine, 0.228 broadleaf, and 0.08 river).
Access Road to Construction Adit-2 (farm road)	4.75	Take off from the Tsamang farm road. This road will connect to the existing farm road to Banjar village. Requires the construction of a Reinforced Cement Concrete bridge (40R/70R) across Kurichhu and smaller bailey bridge across phelgangchhu and smaller culverts along 3 streams.	NA	0.761 acres of private land will be impacted) will benefit the community, providing them with a shorter route to access to the national highway.	18.634 of SRFL (2.12 broadleaf and 16.5 chirpine)
Access Road to Construction Adit-3	0.60 km	Take off From Adit II access road Only possible access road to Adit II-	NA	0.138 acres of land (0.186 chhuzhing and 0.713 kamzhing)	1.61 acres of SRFL (1.47 chirpine and 0.136 broadleaf)

Alternative	Length (km)	Technical aspects (m)	Estima-ted cost (Mill Nu.)	Social impacts	Environmen-tal impacts
		(alternative IV) is constructed. Will cross along the top of MDS # 7		from 7 households.	
Access Road to Construction Adit4	5.80	Take off on the right bank of the Kurichhu river. As it is on the right bank, there is no need to construct a bridge but there are 3 stream crossings for which a culvert will be required	NA	No impact on private land	22.5 acres of SRFL (chirpine) and 0.288 stream crossing
Road to MD 7	2 2	Take off from the proposed road to the right bank near Kurizam/bridge This road will also provide access to MDS # 10 and CCF # 8.	NA	No impact on private land	4.984 acres of SRFL (chirpine).
Access Road to Construction Adit-5	2.05	Take off from the selected access road to Adit IV. 5 sharp bends	NA	No impact on private land	7.536 acres of SRF (Chirpine)
Access Road to Construction Adit-6	3.5	Take off from Adit V junction. Extends from the north to the south above the Highway. No sharp bends.	NA	No impact on private land No risk to the highway.	14.57 SRFL (Chirpine forest)
Access Road to Surge Shaft top and PH	1	Take off from Adit VI junction. Extension of the road from Adit V.	NA	No impact on private land	4.032 SRFL (3.578 chirpine and 0.454 shrub).
Quarry Road	3	No details	NA	No details	No details
Bypass road	2.97	Take off from Tsamang farm road and connect to the proposed road to Adit 1 and dam site	NA	No private land	26.41 SRFL (2.5 Broadleaf and 23.92 chirpine)
Total	**27.58**				**106.45**

Table 48: Comparison of the two alternatives

Description	Alternative 1	Alternative 2
Number of new access roads	11 roads	9 roads Under this alternative, since there is no dam or powerhouse colonies, there is no requirement for access roads for these two components The road to the MAT and TRT has been removed as these will be accessed by the PH road. Additional access road to MD # 7 has been included.
Total length	40.68 km	27.58km
Forest area to be cleared	138.5 acres (56ha)	106.45 acres (42.9ha)
Impacts private land	0.79 acres (0.32ha)	1.104 acres (0.45ha)

NOTE- current estimates of land use is based on the 20m buffer from the road centre and therefore the impacted area is higher for alternative 2. The cost of some of the components is not available and the rates 2015 rates.

Alternative 2 was selected as the total distance is lower, resulting in reduced clearing required and likely reduced cost.

5.4.7 Bypass road

To bypass Dorjilung slide, a separate re-alignment of Monggar – Lhuentse Secondary National Highway (SNH) is proposed on the right bank of Kurichhu along the ridge opposite to Dorjilung slide.

Alternative 1. The bypass road will use 7.0 km of access road constructed for Adit – 2 and construct a new road of 4.61 km from Adit – 2 to Dam top on the right bank. It will impact 17.16 acres (6.95ha) of SRFL and have no impact on private land.

Alternative 2. The bypass road will take off from the Tsamang farm road to Banjar to the dam top on the right bank and is 2.97 km in length. It will impact 26.41 acres (10.69ha) of SRFL, and no private land will be impacted. It will also provide access to MDS # 2 and MDS # 3.

Table 49: Alternatives for Bypass Road construction

Alterna-tive	Total Length (km)	Technical aspects (m)	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
Alt – I	4.61	Take off from Adit – 2 to Dam top on the right bank. use 7.0 km of access road constructed for Adit – 2 (alternative II) plus new road of 4.61 km to be constructed	590	No impact on private land	17.16 SRFL (2.66 broadleaf, 14.50 chirpine)
Alt-II	2.97	Take off from Tsamang farm road and connect to the proposed road to Adit 1 and dam site	NA	No impact on private land	26.41 SRFL (2.5 Broadleaf and 23.92 chirpine).

Alternative 2 was selected as it will connect to the selected alternative for access to Adit 1 and dam top. It is also shorter than Alternative 1.

5.4.8 Road realignment

The reservoir will submerge 3.72 km of existing Monggar – Lhuentse Secondary National Highway (SNH). Two alternative routes of re-alignment were considered.

Alternative I– A 10.89 km road realignment of Secondary National Highway from Rewan to Autsho. This alternative will take off from Rewan and involve construction of 5.4 km of new road, 0.75 km of highway tunnel and improvement of a small stretch of (1.40 km) existing highway which will be used in the re-alignment of highway. This alternative will impact 53.55 acres (21.67ha) of SRFL and 4.567 acres (1.85ha) of private land and 0.90 acres (0.36ha) of agriculture land on mountain slopes.

Alternative II– A 6.54 km road realignment is proposed, this involves the construction of 5.54 km of new roads, 1km tunnel and 1.40km of road improvement. The first take off like Alternative I and II and is at Rewan (2.4km new road), the new road will join Takhami farm road. The second take off from the farm road will be followed by a 1km km of highway tunnel, that will connect to the national highway. From this a third take off (0.84km) will connect the highway to Doliphung farm road. The fourth take off from this farm road will connect the farm road back to the highway near the town. The total distance from Rewan to Autsho after realignment is 6.64 km. This alternative will impact 20.988 acres (8.50ha) of SRFL and 0.827 acres (0.33ha) of private land belonging to 9 households.

Table 50: Alternatives for Road realignment

Alterna-tive	Total Length (km)	Technical aspects (m)	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
Alt – I	8.25km	Take off at Rewan. 8.25 km of new road, 0.75 km of highway tunnel and improvement of a 1.40 km of the existing highway. Requires a small bridge over Rewanchhu and a culvert.	590.00	4.567 acres of land will be impacted and 0.90 agriculture on mountain slopes	53.55 SRFL (8.24 broadleaf, 44.41 chirpine) Longer length of new road (involving road cutting on slopes)
Alt-II	6.64 km+	2.4km new access road with take-off after the Rewan bridge. This joins the Takhambi farm road, from where it will take off for 0.30km, followed by a tunnel that will end up rejoining the highway. From this, a 0.8km new road will be constructed that will join the Doliphung farm road.		0.827 acres of private land belonging to 9 households. (0.718 kamzhing, and 0.02 institutional land). Doliphung community will benefit from the improvement of the road, as the realignment will	20.988 acres of SRFL (15.531 chirpine, 5.291 broadleaf, and 0.166 shrubs).

Alterna-tive	Total Length (km)	Technical aspects (m)	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
		From the farmroad, the last stretch of the new road will connect to the SNH in Autsho. Will require 1 culvert before the tunnel and a bridge over the stream before joining the highway at Autsho		connect Doliphung village to Autsho. There is also the possibility of employment and sale of farm produce to workers for both communities (Takhambi and Doliphung). At the same time, there will be an increase in traffic, dust and pollution during construction and during operation as it becomes used as a SNH, and potential risk due to influx of workers during the construction period.	

Alternative – II is the preferred alternative as it is much shorter than the first two alternatives. The Doliphung farm road was constructed in 2019 and with the realignment will have to be improved to the standard of a SNH. In terms of social impacts, alternative 2 will also only impact on 0.827 acres (0.33ha) of private land compared to the first alternative where 4.567 acres (1.85ha) of land will be impacted and 0.90 acres (0.36ha) agriculture on mountain slopes (non-title holders) are impacted. Also, alternative II will require 20.988 acres (8.94ha) of SRFL as compared to alternative I where 53.55 acres (21.67ha) will be cleared.

5.4.9 Muck Disposal Sites

Two alternatives were considered for sites.

Alternative -1. Under this alternative, 15 MDS sites were proposed totaling an area of 259.7 acres (105ha) with a total capacity of **10,726,395.46 m³**. All the MDS sites are in SRFL, and no private land is impacted. Of the 15 sites, 6 are located on the left bank of the Kurichhu river and 9 are located on the right bank. The MDS sites together will have an excess capacity of 2,143,757.34 m³. This includes CCF 14 (with an area of 49 acres (19.8ha) and capacity of 1,353,943.80 **m³** was proposed to supplement muck disposal.

Table 51: Alternative I Muck disposal sites

	Alternative	Area (acres)	Area (ha)	Volume (m³)	Technical aspects	Social impacts	Environmenta l impacts
MD-1	Left bank of Chimungri valley.	12.28	4.97	142,535.00	Will require retention wall for about 575m along the stream.	The site is opposite proposed quarry # 3, the MDS site will add to the dust and air pollution in the valley	12.28 acres (4.97ha) of broadleaf
MD-2	Right bank of Kurichhu near Adit-1	40.00	16.19	2,146,733.33	Will require the construction of a 1.5km retaining wall	Cultivated land (tseri) 1.55 acres. Almost at the same level as CCF 2. Residents of CCF 2 will be exposed to dust for a longer period	39.85 acres of SRFL (28.16 chirpine, 10.14 broadleaf, and 1.55 Tseri mountain slopes).
MD-3	Left bank of Kurichhu, Rewan	6.32	2.56	133,715.00	Will require the construction of a 0.5 km retaining wall	As the site is located below the national highway, there will be traffic congestion and dust pollution	6.32 SRFL (0.23broadleaf, 6.09 chirpine)

	Alternative	Area (acres)	Area (ha)	Volume (m^3)	Technical aspects	Social impacts	Environmental impacts
						for local travellers	
MD-4	Along Phelgangchu, Adit-2	8.18	3.31	231,525.00	Will require the construction of a 260m retaining wall	No impact on private land	8.18 SRFL (8.15 chirpine and 0.03 eroded land) Risk of debris falling into the stream Will require a short extension from the farmroad to the MDS site.
MD-5	Left bank of Kurichhu, d/s of suspension bridge at Phelgangchu	6.29	2.55	243,210.00	Will require the construction of a 280m retaining wall	No impact on private land Located below the national highway and therefore may cause traffic congestion and cause dust pollution	6.29 SRFL (chirpine) It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-6	Left bank, u/s of Palangphu	8.47	3.43	94,815.00	Will require the construction of a 500 m retaining wall	No impact on private land Located below the national highway and therefore may cause traffic congestion and cause dust pollution	8.47 SRFL (chirpine) It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-7	Left bank, u/s of Palangphu (above road)	4.41	1.78	147,480.00	Will require the construction of a 200 m retaining wall	0.27 cultivation on mountain slope Located above the national highway and therefore may cause traffic congestion dust pollution with the risk of muck spilling onto the highway	4.15 SRFL (chirpine)
MD-8	Right bank, opposite of Palangphu	5.00	2.02	134,640.00	Will require the construction of a 370 m retaining wall	No impact on private land	5.15 SRFL (chirpine) It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-9	Right bank of Chukchemey ri, near Tokari	12.62	5.11	460,950.00	This is long (along the edges of the stream) and narrow and will require the construction of a 730 m retaining wall.	0.75 cultivation on mountain slope	11.88 SRFL (11.63 broadleaf, 0.25 chirpine) It is close to the Tokari stream - the risk of debris falling into the stream
MD-10	Right bank of Kurichhu, Adit – 4	18.68	7.56	2,635,250.00	This will require the construction of a 550 m	No impact on private land	18.68 SRFL (chirpine)

	Alternative	Area (acres)	Area (ha)	Volume (m^3)	Technical aspects	Social impacts	Environmental impacts
					retaining wall.		It is close to the confluence of the Meralongchhu stream and the Kurichhu river- risk of debris falling into the stream
MD-11	Along right bank of Kurichhu & left bank of Shongarchhu near Powerhouse	21.00	8.50	104,910.00	This will require the construction of 1.6 km retaining wall along two stretches – along the Kurichhu river and the Shongarchhu river stretch		21.00 Chirpine forest
MD-12	Left bank of Kurichhu, above Khalanzi Powerhouse	2.00	0.81	39,480.00			2 acres chirpine
MD-13	Valley along Horongri (R/B)	38.00	15.38	2,243,310.00			38.00 broadleaf and chirpine forest
MD-14	Lingmethang, above Forest & Park office	3.70	1.50	500,213.33	will require and access road (about 3.5km) to the site that will take off from the national highway above Lingmethang	cause disturbance and dust pollution especially to the park office and the surrounding community.	3.70 Chirpine forest
MD-15	Along the access road to Adit-6 from Adit-5	16.39	6.63	113,685.00			16.39 chirpine forest
CCF-14	Opposite Kurizam, left bank	49.00	19.83				
	Total	**259.70**	**105.10**				

Alternative 2

Under the second alternative, the number of MDS sites has been reduced to 9, totaling an area of 194.88 acres. All the MDS sites are in SRFL, and no private land is impacted. The MDS sites together will have an excess capacity of 287,700.31 m^3. This includes Stockyard 1 (with an area of 3.3 acres where 134,754.4 **m^3** of soil will be dumped to level the area and make it suitable as a stockyard.

Table 52: Alternative II Muck disposal sites

		Alternative	Area (acres)	Area (ha)	Volume (m^3)	Technical aspects	Social impacts	Environmental impacts
MD-1	Head works	Same location- reduced in size to accommodate road realignment	1.683	0.68	51,085.2	Will require retention wall for about 175m the stream	Since the size of the MDS is smaller, the impact of dust pollution will be lower than	1.683 of SRFL (chirpine) The potential area of impact to the stream is approximately 175m

		Alternative	Area (acres)	Area (ha)	Volume (m^3)	Technical aspects	Social impacts	Environmental impacts
							alternative 1	
MD-2	Adit 1	Same location, reduced in size	27.306	11.05	690,384.53	Will require the construction of a 1 km retaining wall	At a higher level than CCF 2. Exposure to dust will be lower and for a shorter period due to the lower carrying capacity.	27.306 acres chirpine forest Less impact on the Kurichhu river, since the MDS is further upslope.
MD-3	Head works	Shifted to the right bank	43.364	17.55	2,455,894.00	Will require the construction of a 0.9 km retaining wall	Dust pollution will be limited to the right bank.	43.364 Chirpine forest
MD-4	Adit 2	Same general location, but shifted upslope	6.176	2.50	312,280.09	Will require the construction of a 240m retaining wall	Located along the farm road to Banjar and therefore may cause inconvenience to community travellers	6.176 SRFL (Chirpine) Lower risk of debris falling into the stream, no need for road extension
MD-5	Adit 2	Shifted to the right bank	5.071	2.05	256,410.06	Shifted closer to adit (1km) Will require the construction of an 180m retaining wall	Located along the farm road to Banjar and therefore may cause inconvenience to community travellers and cause dust pollution	5.071 SRFL (Chirpine) No stream nearby
MD-6	Adit 3	Shifted to the right bank	15.119	6.12	701,500.00	Shifted to the right bank. Will require the construction of a 650m retaining wall	No settlement or road nearby. Will utilize the new access road to the portal	15.119 SRFL (0.135 Broadleaf, 5 Chirpine) No stream nearby
MD-7	Adit 4	Shifted to the right bank	16.91	6.84	752,438.46	Shifted to the right bank. Will require the construction of a 500 m retaining wall	No settlement or road nearby. Will utilize the new access road to the portal	16.91 acres of Chirpine forest It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-8	Adit 5	Shifted closer to adit new location as previous one was	25.21	10.20	612,177.24	Will require the construction of a 750 m retaining wall	No impact on private land	25.21 SRFL (Chirpine) It is close to the Kurichhu river - risk of debris

		Alternative	Area (acres)	Area (ha)	Volume (m^3)	Technical aspects	Social impacts	Environmental impacts
		near the river						falling into the Kurichhu
MD-9	PH & TRT	new location as previous one was near the river	13.02	5.27	439,301.14	Reduced in size and renamed MD 12. The retaining wall is about 1km due to reduced area along Shongarchhu		13.02 SRFL (Chirpine)
MD-10	PH & TRT	Rename as MD 7	11.288	4.57		New location as previous one was near the river. Will require the construction of a 350 m retaining wall	No impact on private land	11.228 acres of Chirpine forest It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-11	Adit 6 & SS	Renamed MD 12	13.031	5.27		Same location but reduced in size		13.031SRFL (Chirpine)
MD-12	PH & TRT	Removed	14.98	6.06	319,664.66	Rename as MD 7 Will require the construction of a 400 m retaining wall	No impact on private land	14.98 SRFL (Chirpine) It is close to the Kurichhu river - risk of debris falling into the Kurichhu
MD-13			Removed					
MD-14			Removed					
MD-15			Renamed MD 11					
	Adit 1	Stockyard 1	3.3	1.34	Described in Section 0			
			194.88	78.87				

Comparison of the two alternatives

Alternative 2 was selected because under alternative I, 6 of the MD sites are located on the left bank of the Kurichhu river, of which 5 are located below or above the SNH, which will cause traffic congestion and dust pollution. Also, in terms of social impacts, there are 2.57 acres (1.04ha) of cultivated land on SRFL (non-title holders).

Under alternative 2, only one site (1.68 acres (0.68ha)) is on the left bank. All other sites are located on the right bank, so impacts due to trucks plying on the SNH are greatly reduced. Also, there is no impact on private land.

Table 53: Comparison of Alternatives for Muck disposal sites

Alternative	Total sites	Total area (acres)	Total Capacitym^3	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
Alt – I	15	259.70	10,726,395.46	NA	Will impact 1.55 acres of private land and 1.02 acres of cultivated land on SRFL	199.79 acres SRFL (34.28 acres broadleaf and 164.48 acres chirpine and 0.03 acres eroded land)
Alt-II	9	194.98	7,441,349.86	NA	No impact on private land	194.057 acres SRFL (0.271 acres broadleaf, 193.215 acres chirpine, 0.571 shrubs) and 0.928 water body

5.4.10 Contractor Construction Facility (CCF)

The CCF will accommodate both owners' employees as well as contractors' workers. There are two alternatives.

Alternative 1: Under the first alternative the CCFs will not only accommodate workers and employees but also have non-residential areas for Batching Plant, stores, site office, worker camps, explosive magazine, DG shed, water storage and substations. Under this alternative 2, there are 11 CCFs covering an area of 96 acres. Four of the CCFs are located on the left bank (3 near the Dam site at Rewan) and one near the Kurichhu bridge. Four CCFs are less than 3 acres.

Table 54: Alternative I -CCF

CCF Location		Area (Acres)	Technical details	Social impacts	Environmental impacts
CCF1	Head work (Dam, Diversion tunnel and coffer dam). Intake, HRT and Adit I	5.36	Located at Rewan on the left bank of the Kurichhu, Tsakaling gewog. There is no need to construct access roads, as this is below the National Highway.	2.39 acres private land	5.36 SRFL (3.75 Chirpine + plus 1.61 cultivated forest land
CCF2	Head work (Dam, Diversion tunnel and coffer dam). Intake, HRT and Adit I	8.21	Located at Rewan on the left bank of the Kurichhu, Tsakaling gewog. There is no need to construct access roads, as this is below the National Highway.	Loss of livelihood from cultivation on government land	8.21 (6.54 Broadleaf, 0.01 chirpine, 1.66 cultivated forest land)
CCF3	Head work (Dam, Diversion tunnel and coffer dam). Intake, HRT and Adit I	2.10	Located at Rewan on the left bank of the Kurichhu, Tsakaling gewog. There is no need to construct an access road, as this is above the National Highway.	0.84 acres private land	1.44 Broadleaf, 0.66 cultivated forest land
CCF4	HRT& Adit II	3.30	Left bank of Phyelgangchhu, near Adit-2, gangtho village, Tsamang Gewog.	No impact on private land	All chirpine forest
CCF5	HRT& Adit III	2.80	Near Tokari village, left hand side of Adit-3, Tsamang Gewog	No impact on private land	All chirpine forest
CCF6	HRT& Adit IV	4.60	Right bank of Meralungchhu	No impact on private land	4.60 broadleaf
CCF7	HRT& Adit V	5.00	Infront of Adit-5 portal	No impact on private land	All chirpine forest
CCF8	HRT& Adit VI, Surge shaft & Pressure shaft	8.50	Near Surge Shaft Top	No impact on private land	All chirpine forest
CCF9	Powerhouse	5.07	Near TRT	No impact on private land	All chirpine forest
CCF10	Powerhouse	2.05	Near Powerhouse	No impact on private land	All chirpine forest
CCF11	Powerhouse	49.00	Near the left bank of Kurizam	No impact on private land	All chirpine forest
Total		**101.13**			

Alternative 2

Under this alternative the number of CCFs has been reduced to 9. In most cases, where the CCFs are less than 3 acres, these have been increased to accommodate both contract workers and owner's employees. Also, these sites will only accommodate DG sheds, water storage and substations. Of the 9 CCFs, two CCFs are located on the left bank (at Rewan, near the dam site). 6 CCFs will be connected by the access road to the portals. One CCF is located at Lingmethang.

Table 55: Alternative II -CCF

CCF	Designation	Area (Acres)	Technical details	Social impacts	Environmental impacts
CCF1	Head work (Dam, Diversion	10.03	Located at Rewan on the left bank of the Kurichhu, Tsakaling gewog	5.539 acres private land	4.49 acres SRFL (0.118 Broadleaf, 2 Chirpine and 2.728

CCF	Designation	Area (Acres)	Technical details	Social impacts	Environmental impacts
	tunnel and coffer dam)				shrubs) and 0.01 water body
CCF2	HRT & Adit I	2.24	Left bank of Phyelgangchhu, near Adit-2, gangtho village, Tsamang Gewog	0.461 acres private land	2.24 acres Chirpine forest
CCF3	HRT& Adit II	7.58	Along the Tsamang farm road, near Adit II	No impact on private land	All chirpine
CCF4	HRT& Adit III	5.19	Below Tokari village, near Adit-3, Tsamang Gewog	No impact on private land	All chirpine
CCF5	HRT& Adit IV	9.18	Next to Adit 5 portal	No impact on private land	All chirpine
CCF7	HRT& Adit V	9.72	On the other slope across the Adit IV portal, Saleng Gewog	No impact on private land	All chirpine
CCF8	HRT& Adit VI, Surge shaft & Pressure shaft	14.34	Above Surge Shaft top	No impact on private land	All chirpine
CCF6	Powerhouse	4.50	Along the access road to Adit V	No impact on private land	All chirpine
CCF 9	Powerhouse	33.15	On the slope immediately above the Lingmethang highway, near Lingmethang town. No need to construct access roads.	No impact on private land	All chirpine
	Total	**95.92**			

Comparison of the two alternatives

Although the two alternatives take up the same total area, alternative II was selected because of the reduced number of sites and because 7 of the 9 CCFs are located on the right bank, closer to the adits in terms of travel distance. Under Alternative I, aside from the 3 CCFs located near the dam site, one is located near the Kurichhu bridge which will potentially cause disturbance to the Shedra. Four CCFs are less than 3 acres and will not accommodate all the contract workers and client employees.

Table 56: Comparison of Alternatives for CCF

Alter-native	Total sites	Total area	Estimated cost (Mill Nu.)	Social impacts	Environmental impacts
Alt – I	11	95.99		Will impact 3.23 acres of private land and 3.27 acres of cultivated land on SRFL	100.64 acres SRFL (11.14 acres broadleaf and 89.5 acres chirpine)
Alt-II	9	95.92	NA	Will impact 6 acres of private land	93.57 acres SRFL (0.01 Broadleaf, 90.3 acres chirpine, 2.7 acres shrubs) and 0.01 water body

5.4.11 Batching Plants

The civil contractors will require setting up a crushing and Aggregate Processing Plant (APP), Batching and Mixing (B&M) plant.

Alternative 1 comprises 3 sites for the batching plants covering an area of 29.33 acres. Two of these (site 1 and 2) are located upstream of the dam site, in the submergence area, while the third site was selected on the right bank slightly north of the Kuri bridge.

Table 57: Alternative I -Batching Plant

SN	Details	Location	Gewog	Area (Acre)	Bank	Social impacts	Environmental impacts
1	For Dam and Adit	upstream of the Dam site, in the submergence area on the left bank of the Kurichhu river	Tsakaling	8.46	Left	1.81 acres of wetland	5.18 SRFL (chirpine) and 1.46 acres of the river

SN	Details	Location	Gewog	Area (Acre)	Bank	Social impacts	Environmental impacts
2	For Dam and Adit	Below BP 1, upstream of the Dam site, in the submergence area	Tsakaling	6.26	Left		5.55 SRFL (Chirpine)and 0.72 acres of the river
3	For powerhouse	Right bank of the Kurizam/bridge	Saleng	14.61		No impact	14.61 SRFL chirpine forest
Total land				**29.33**			

Alternative 2 comprised of 5 sites for batching plants. These were spread more evenly across all components. These total 13.29 acres of which 0.893 acres is in private land while the remaining 12.4 acres is in SRFL (chirpine forest). This alternative ensures a better spread of the batching plants across the entire site as well.

Table 58: Alternative II -Batching Plant

SN	Details	Location	Gewog	Area (Acre)	Bank	Social impacts	Environmen-tal impacts
BP 1	For Dam and Adit I	Same area as Alternative 2 but reduced in size	Tsakaling	0.98	Left	0.89 private land	0.089 SRFL (chirpine forest)
BP 2	For Adit II and III	Near Adit II Portal	Tsamang	4.426	Right	No impact	4.42 SRFL (0.114 acres broadleaf and 4.3 acres chirpine forest_
BP 3	Adit IV & V	Between adit II and III	Tsamang	2.21	Right		2.043 chirpine forest
BP 4	Adit VI and Surge shaft	Closer to Adit IV portal	Tsamang	2.85		No impact	2.85 Chirpine forest
BP 5	For powerhouse	Right bank of the Kurizam/bridge	Saleng	2.82		No impact	2.82 Chirpine forest
Total land				**13.12**		**0.89**	**12.232 SRFL**

Of the two alternatives, alternative II was selected because a) these are spread across the dam site, adits and PH, b) the total land requirement is less than half of alternative I therefore impacting only 12.4 acres of SRFL compared to 25.3 acres under alternative 1. Under alternative I, 1.81 acres of wetland will be impacted due to BP1, while under alternative II, 0.89 acres of private land will be impacted.

5.4.12 Stockyards

The Contractors will require setting up storage sheds, space for open storage of raw materials and parking machines and trucks.

Alternative 1. No separate stockyard is planned. Instead, all stockyards will be located with each CCF and in areas where the batching plants are designated.

Alternative 2. Four separate stock yards are identified and spread across the project area from the dam to the powerhouse site. The sizes vary depending on the terrain. Stockyard 1 will impact almost 2 acres of private land, but these impacts are temporary and will allow the 5 private landowners an opportunity to earn from leasing the land. The Stockyard will impact 21.46 acres of SRFL.

Table 59: Alternative I -Stockyards

Stock-yard	For	Location	Approx. Area (Acre)	Social impacts	Environmental impacts
1	Dam and Adit I	Rewan, near Adit I	3.33	1.992 acres of private land belonging to 5 households	1.34 SRFL (0.497 Broadleaf, 0.842 Chirpine)
2	Adit II and III	Near Adit II	5.08	No impact on private land	5.08 SRLF (Chirpine)
3	Adit IV, V and VI	Along the proposed access road to Adit V	8.18	No impact on private land	8.18 SRLF (Chirpine)
4	Powerhouse	Near Adit V	4.86	No impact on private land	4.86 SRLF (Chirpine)
			21.5	**1.99**	**21.46 SRFL**

Alternative II was selected because under alternative 1, the stockyards will have to be accommodated within the existing CCFs, which can cause noise and disturbance and air and dust pollution to the residents in the CCF during material transportation, loading and unloading.

5.4.13 Explosive magazine

Two alternatives were considered for explosive magazines.

Alternative 1. Under this alternative two sites are proposed at the dam site and the powerhouse with a total area of 5.16 acres, all of which are on SRFL.

Table 60: Alternative I -Explosive magazine

SN	Details	Gewog	Area (Acre)	Bank	Social impacts	Environ-mental impacts
Site 1	left bank at Dam site about 3km along the Takhambi farm road	Tsakaling	1.91	Left	None	1.91 SFRL (chirpine)
Site 2	right bank of Kurichhu about 300m upstream of Kurizam	Saleng	3.25	Right	None	3.25 SFRL (chirpine)
Total land			**5.16**			

Alternative 2. Under this alternative five sites are proposed as magazine areas with a total area of 2.85 acres, all on SRFL.

Table 61 : Alternative II -Explosive magazine

SN	Details	Gewog	Area (Acre)	Bank	Social impacts	Environmental impacts
Site 1	Dam and Adit I	Tsakaling	0.57	Left	No impact	0.57 SRFL
Site 2	Adit II and III	Tsamang	0.57	Right	No impact	0.57 SRFL
Site 3	Adit IV & V	Tsamang	0.57	Right	No impact	0.57 SRFL
Site 4	Adit VI and Surge shaft	Tsamang	0.57	Right	No impact	0.57 SRFL
Site 5	Powerhouse	Saleng	0.57	Right	No impact	0.57 SRFL
Total land			**2.85**			**2.85**

Of the two alternatives, alternative II was selected as this provides easier access to the explosives at each work site and requires only 2.85 acres (1.15ha) of land. No private land will be impacted by either alternative.

5.4.14 Construction Power

Details are not adequate in the previous ESIA on the length of the power lines. The only information provided is that 58.74 acres of land will be impacted. Therefore, it is not possible to compare alternatives.

5.4.15 Power evacuation transmission line-

Section 14 includes information on the power evacuation transmission line and alternatives considered.

5.5 Operating Alternatives

5.5.1 Dam height

Alternatives for dam height, and thus the storage in the reservoir, were presented in the 2016 DPR. Nine alternatives were considered before selection of the current option (alt-7), which results in an FSL of 850 masl. Based on calculations in 2016 DPR, raising FSL to 855 masl would benefit Nu. 317.09 million annually but that will mean submerging part of Autsho Town.

Table 62: Dam Height Optimization to fix FSL (source: DPR 2016)

Alternative	Alt-1	Alt-2	Alt-3	Alt-4	Alt-5	Alt-6	Alt-7	Alt-8	Alt-9
FRL (masl)	820	825	830	835	840	845	850	855	860
Annual Benefit (Mill. Nu.)		317.09	634.18	951.27	1,268.36	1,585.45	1,902.54	2,219.63	2,536.72
Annual Cost (Mill. Nu.)		192.84	454.00	707.93	983.83	1,295.52	1,654.14	2,003.79	2,403.25
Benefit/Cost Ratio		**1.64**	**1.40**	**1.34**	**1.29**	**1.22**	**1.15**	**1.11**	**1.06**

5.5.2 Installed capacity

Alternative arrangements for operation/installed capacity have not been provided.

B.PHYSICAL, BIOLOGICAL AND HUMAN BASELINE

Physical environment: climate, geology and soils, hydrology, water quality, air and noise, natural hazards

Biological environment: terrestrial and aquatic habitats, fauna, flora and conservation areas

Human environment: inhabitants and their activities

6 THE PHYSICAL ENVIRONMENT

6.1 Climate

The climate baseline is based on bibliographical research and the Project report Volume III: Hydrology.

6.1.1 Climate in Bhutan

Bhutan has a broad variety of climates due to dramatic variations in altitude. In Bhutan, the climate is humid and subtropical on the southern plains and in the foothills, temperate in the inner Himalayan valleys of the southern and central regions, and cold in the north and, with year-round snow on the main Himalayan summits. Bhutan's generally dry spring starts in early March and lasts until mid-April. Summer weather starts in mid-April with occasional showers and continues through the early monsoon rains of late June. Autumn, from late September or early October to late November, follows the rainy season. It is characterized by bright, sunny days and some early snowfall at higher elevations. Winter sets in from late November until March, with frost throughout much of the country and snowfall commonly above elevations of 3000 m (FAO 2011). Figure 24 presents the key air temperature and precipitation values for Bhutan.

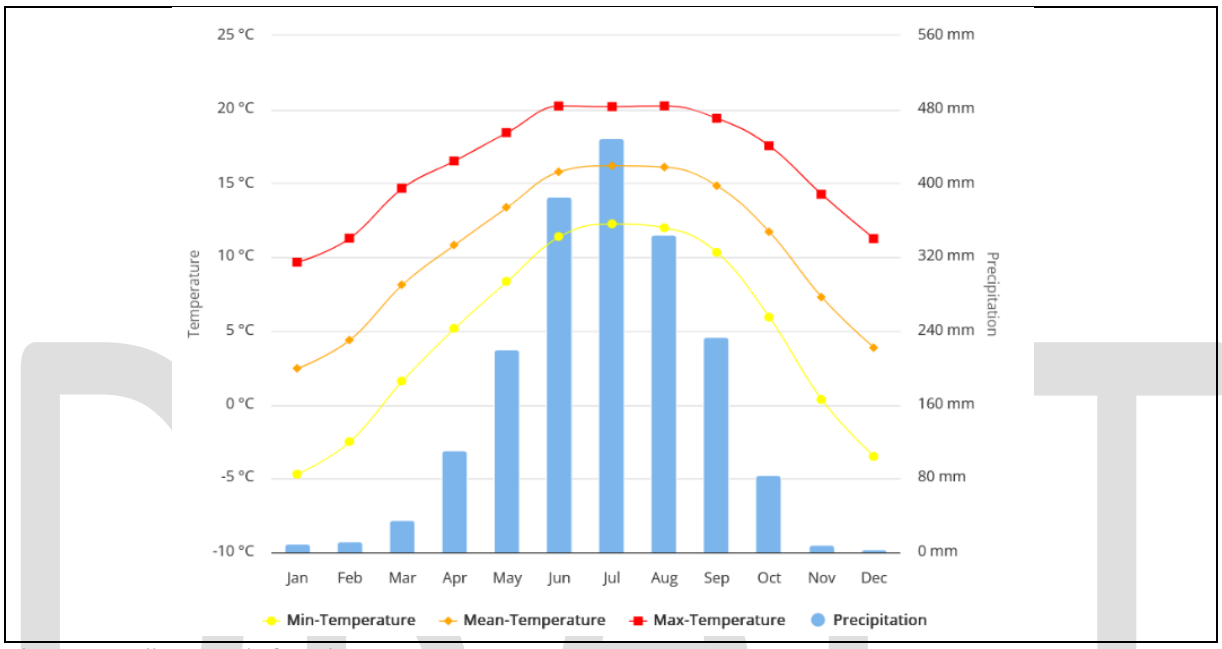


Figure 24: Climograph for Bhutan 1991-2020

Source: (worldbank, climateknowledgeportal s.d.)

Bhutan is divided into six agro-climatic regions, presented in Table 63 (Köppen Classification), distributed according to their elevation range, each with its unique climatic conditions and suitability for different agricultural practices The Dorjilung HPP is located in the Humid Sub-tropical agro-ecological zone (FAO 2011).

Table 63: Agro-climatic regions in Bhutan (Project area in bold)

Agro-ecological zone	Altitude (m)	Temperature °C			Rainfall (mm)
		Max	Min	Mean	
Alpine	>3500	12.0	-1.0	5.5	<650
Cool temperate	2500-3500	22.0	1.0	10	650-850
Warm temperate	1800-2500	26.0	1.0	13	650-850
Dry Sub-tropical	1200-1800	29.0	3.0	17	850-1200
Humid Sub-tropical	**600-1200**	**33.0**	**5.0**	**20**	**1200-1500**
Wet Sub-tropical	150-600	35.0	12.0	24	2500-5500

Source: FAO, 2011

6.1.2 Climate in the DHPP study area

Climatological data from project area were obtained from the RGoB's DHMS (now NCHM), which is actively collecting meteorological data from several meteorological stations inside and around the Kurichhu basin, five of which being in the basin. Most representative meteorological stations located in and around the Kurichhu basin are presented in Table 64.

Table 64: Meteorological Stations in and around the Catchment

SN	Name of Station	Elevation (masl)	Type of Station	Data Period	Lat (N)	Long (E)
1	Autsho	800	Class C	1990-2013	27:26:30	1:10:35
2	Dungkhar	2010	Class C	1990-2013	27:49:23	91:06:58
3	Khomachhu	1380	Class C	1990-2013	27:39:50	91:12:46
4	Lhuentse Dzong	1465	Class A	2006-2013	27:39:50	91:11:50
5	Lingmithang	700	Class C	1990-2013	27:15:59	91:09:59

6	Mongar	1600	Class A	1996-2013	27:16:42	91:14:18
7	Sherichhu	705	Class C	1995-2013	27:21:17	91:24:47
8	Tangmachhu	1750	Class C/AWS	2005-2011	27:35:42	91:11:48
9	Ura	3090	Class C	1990-2013	27:28:26	90:54:25
10	Yadi	1580	Class C	1990-2013	27:17:37	91:22:28
11	Yotongla	3530	Class C	2003-2013	27:34:29	90:35:16

Source: NCHM

6.1.2.1 Rainfall

During the period from November to March, limited rainfall occurs in Mongar. Rainfall increases from April and concentrates during the monsoon, from June to September. Of the five stations in the catchment, Dungkhar at an elevation of 2,010 masl receives the highest rainfall of 1,659 mm annually. Rainfall increases with altitude in the catchment. However, the current data only covers heights up to around 2,000 masl. It's worth noting that the catchment's highest point in China reaches a height of 7,300 m. Rainfall on the Tibetan plateau is generally characterized as low, potentially not exceeding 600 mm, and nearby areas like Shannan Prefecture experience average annual rainfall of only 200-300 mm.

Average monthly and annual rainfall observed at various regional station is presented in the following Figure 25 and Figure 26.

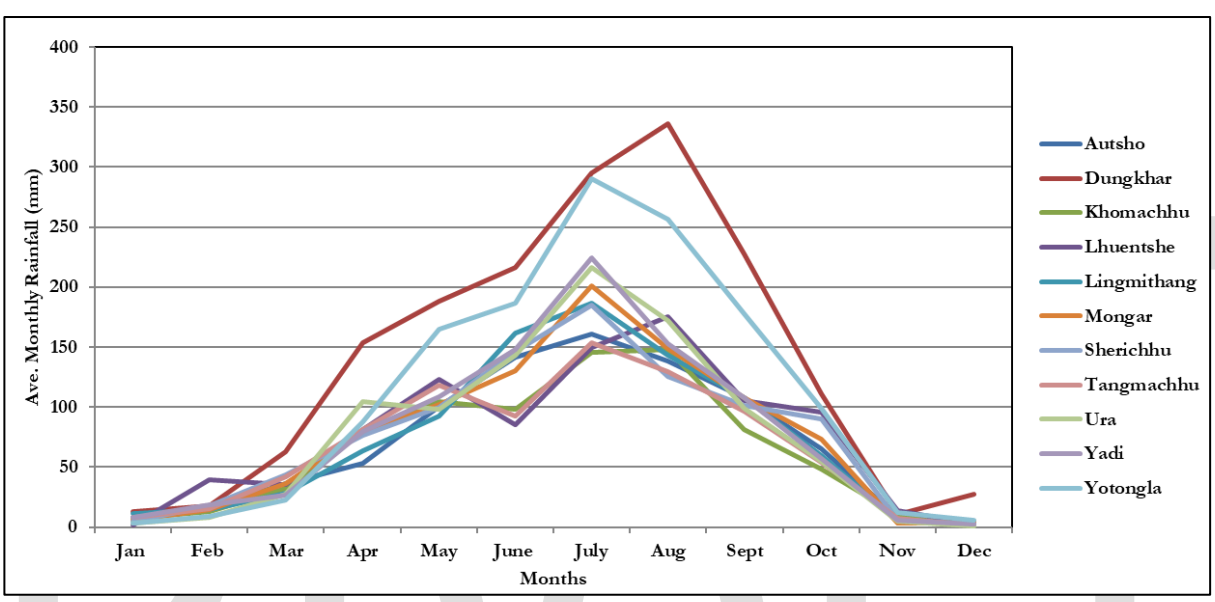


Figure 25: Average Monthly Rainfall in the Dorjilung catchment

Source: DPR, 2024

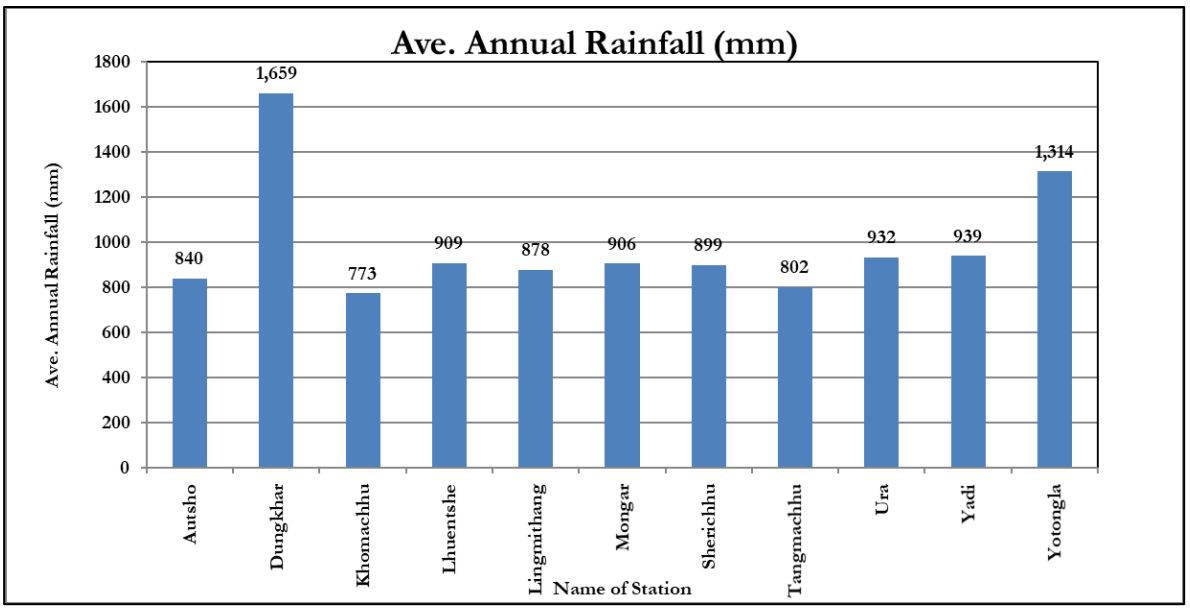


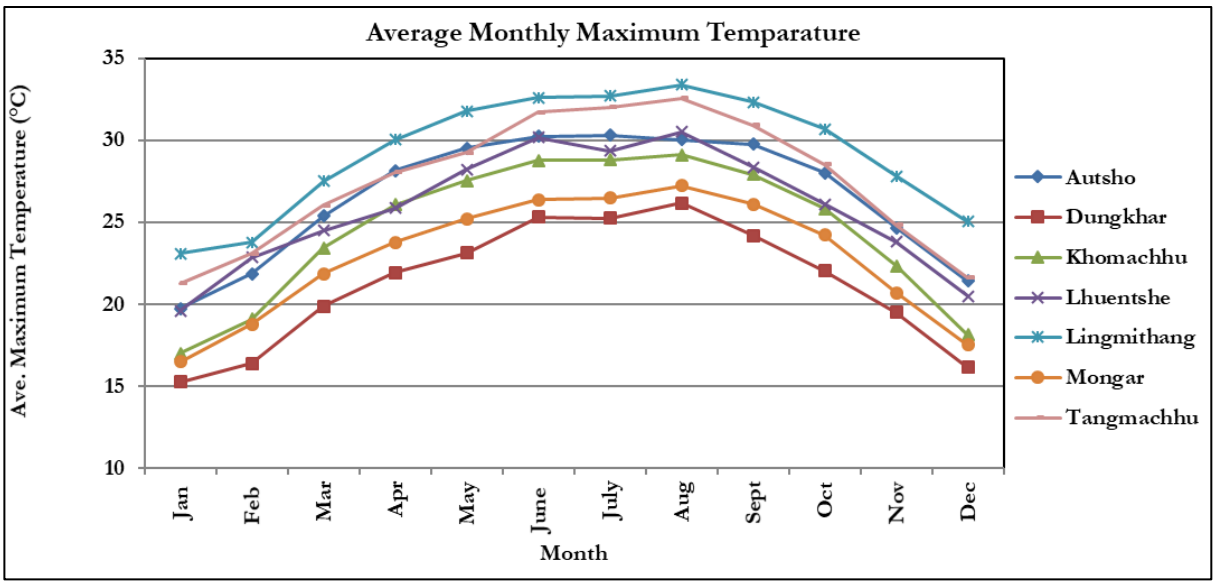
Figure 26: Average Annual Rainfall in the DHPP region

Source: DPR, 2024

6.1.2.2 Temperature

Temperatures in the Mongar region are influenced by factors such as elevation, proximity to the Himalayas, and monsoon weather patterns. Average temperatures might vary from 15°C to 24°C. Winter months (December to February) are notably colder, with temperatures dropping drastically. The average temperature during this period is below 10°C with regular frosts. (worldbank, climateknowledgeportal s.d.).

Temperature drops with altitude, with a lapse rate of 0.4°C to 0.6°C every 100 meters. Autsho, located about 6.5 kms upstream of the dam site, has an average monthly temperature ranging from 31°C in August and 8°C in January. Other stations show a similar situation as presented in the following Figure 27.



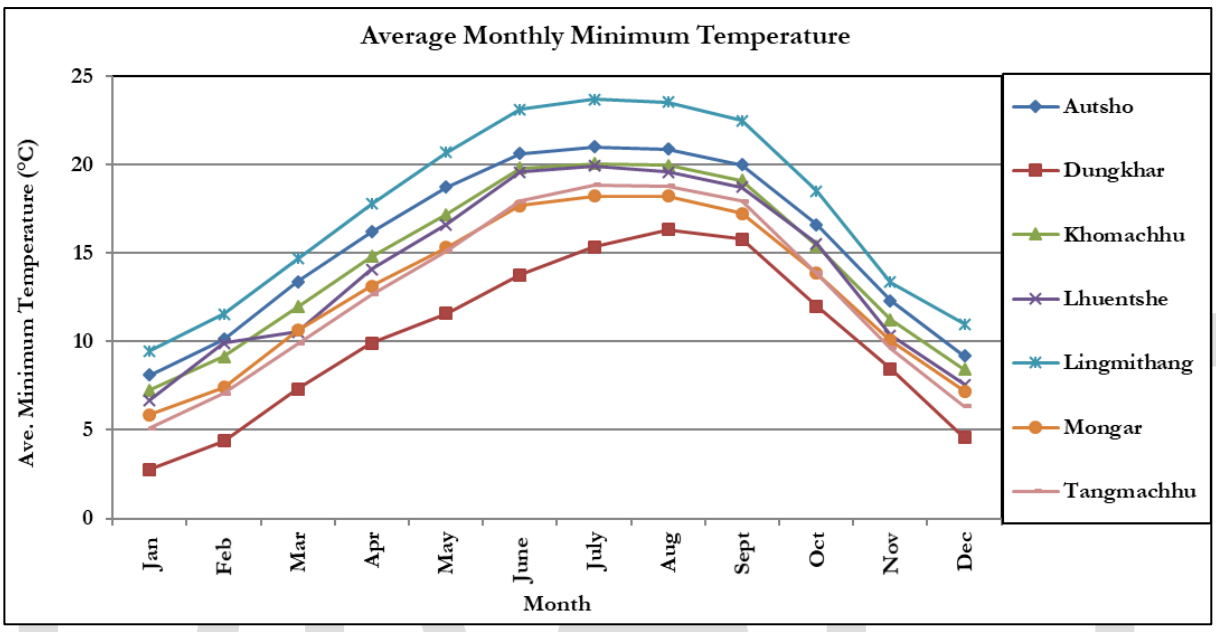


Figure 27: Average Monthly Tmax and Tmin in the Dorjilung catchment

Source: DPR, 2024

6.1.2.3 Evaporation

The Thornthwaite method was used to predict potential evapotranspiration (PET) monthly in the absence of accessible observed evaporation data at the dam site. The annual potential evapotranspiration (PET) at Autsho has been calculated to be 1,068 mm per year, as shown in Table 65. This method estimates evapotranspiration based on temperature, daylight parameters, and the region's specific heat index.

Table 65: Average Monthly Potential Evapotranspiration at Autsho

Month	Tm	im	Em	Nm	PET
Jan	13.91	4.64	30.39	0.88	26.72
Feb	16.00	5.72	42.02	0.93	39.22
Mar	19.38	7.63	65.54	1.00	65.54
Apr	22.17	9.34	89.55	1.07	95.52
May	24.12	10.60	108.86	1.12	122.00
Jun	25.44	11.48	123.16	1.15	142.14
Jul	25.66	11.63	125.67	1.14	143.46
Aug	25.46	11.49	123.35	1.09	134.65
Sep	24.87	11.09	116.84	1.03	120.24
Oct	22.30	9.42	90.78	0.96	87.37
Nov	18.48	7.10	58.68	0.90	52.57
Dec	15.30	5.35	37.87	0.87	32.82
I					105.49
A					2.32
Total PET (mm/ year)					1062

Source: DPR, 2023

6.1.2.4 Relative Humidity

The average lowest relative humidity in April is 74% for Autsho and 78% for Lingmithang. In contrast, the average maximum relative humidity for Autsho is 88% in August, while it is 86% in January for Lingmithang. The average monthly relative humidity at Autsho and Lingmithang is represented in Figure 28.

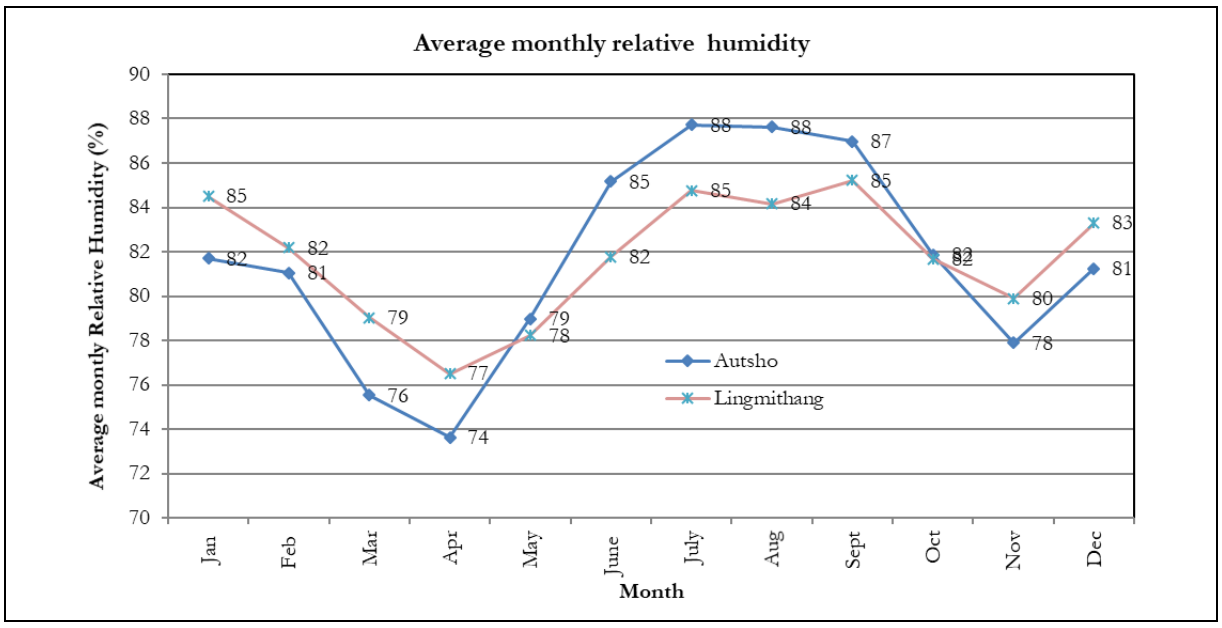


Figure 28: Average Monthly Relative Humidity in the Dorjilung catchment

Source: DPR, 2024

6.1.3 Climate change in the study area

This section provides a summary of the Climate Resilience Assessment prepared for the Dorjilung HPP by Studio Pietrangeli (March 2024, see ESIA Volume 3 Appendix O).

6.1.3.1 Climate Resilience Assessment Introduction

This Climate Change Report was conceived to:

- collect and analyse the main hydro-meteorological data available in the project area.
- assess the main impacts of climate change on the runoff over the watershed during the predicted technical/economical life under different climate change scenarios.
- evaluate the vulnerability of the design Probable Maximum Precipitation (PMP) and Probable Maximum Flood (PMF) on the climate change forcings.
- carry out a general overview on the existing documentation to understand the main potential impact of climate change on the Glacial Lake Outburst Floods (GLOF).
- develop the model to assess the greenhouse gases in the project area.

The climate projection has been evaluated based on the new Shared Socioeconomic Pathways (SSPs) scenarios, from the Coupled Model Intercomparison Project Phase 6 (CMIP6) global climate models (GCMs), whose results were used in the latest Intergovernmental Panel on Climate Change (IPCC, 2021) Assessment Report (AR6).

6.1.3.2 Climate Resilience Assessment Results

6.1.3.2.1 Impacts on Runoff

The analysis has been carried out following the Hydropower Sector Climate Resilience Guide (IHA, 2019), launched at the World Hydropower Congress in Paris in May 2019. This process is consistent with the World Bank bottom-up approach of the Decision Tree Framework (Ray and Brown, 2015), method for risk assessment in infrastructure investments associated with climate uncertainty for water resources.

The climate projection of future climate changes and related impacts on the temperature and rainfall are illustrated, considering the following base assumptions:

- three SSPs scenarios (SSP1-2.6, SSP2-4.5, SSP3-7.0).
- 27 GCMs.
- a time horizon from 2020 to 2079 with time ranges of 20 years covering the entire lifetime of the project.

Considering the above, the results of this analysis are:

- TEMPERATURE AND PRECIPITATION:

o soon (2020-2039), the projection clusters are less dispersed than the other time horizons considered. A maximum increase in temperature is about 1.5 °C and average variation in the precipitation ranges between -10% and +10%.
o in 2040-2059, average annual temperature will increase by a maximum of 2.5 degrees C, while average annual precipitation, depending on the model considered, could experience a decrease of up to 15 percent and an increase of up to 30 percent over current conditions.
o in the far-future (2060-2079), future projections are widely dispersed between 0.7-4.5 degrees of warming and variations from -10% to +30% in precipitation. A warmer and wetter future for Dorjilung basin is expected, with higher warming under SSP3-7.0 climate scenario.

- STREAMFLOW:

o with increasing temperatures, dry seasonal flow is expected to increase. With the earlier melting of snow and glaciers, river flow in the pre-monsoon months, dry season flow is expected to increase.
o wet season flow, on the other hand, will decrease with increasing temperature as snow and glaciers melt earlier.

- ENERGY PRODUCTION:

o for the near- and medium-future, it is expected that the energy production could range between -7% and +18% considering a variation of the precipitation between -10% and +20% and an increase of the temperature up to 3 °C from the baseline.

6.1.3.2.2 Estimation of the Future Probable Maximum Flood

The following table summarizes the future PMF value obtained for each scenario and model considering both the Maximum and Mean Anomalies of the PMP.

Table 66: Future PMF Values (reproduced from Climate Resilience Assessment)

Model	Reference period	SCENARIO SSP 1-2.6		SCENARIO SSP 3-7.0	
		From Max Anomalies of PMP	From Mean Anomalies of PMP	From Max Anomalies of PMP	From Mean Anomalies of PMP
		PMF	PMF	PMF	PMF
-	-	m^3/s	m^3/s	m^3/s	m^3/s
CURRENT DESIGN	-	11,885		11,885	
CMCC-CM2-SR5	2020-2039 2040-2059 2060-2079	10,822 14,295 15,352	11,648 14,468 15,270	14,345 18,470 16,279	15,663 13,403 15,531
CNRM-ESM2-1	2020-2039 2040-2059 2060-2079	12,286 16,091 13,878	10,184 12,115 10,118	14,283 14,190 14,158	10,881 12,527 12,275
EC-Earth3-Veg	2020-2039 2040-2059 2060-2079	16,335 12,562 15,125	13,447 11,819 10,096	11,694 13,927 20,617	12,460 13,514 18,785
MICROC6	2020-2039 2040-2059 2060-2079	10,048 12,827 14,553	10,604 11,971 12,547	10,191 12,913 17,283	11,006 12,636 13,572
MPI-ESM1-2-HR	2020-2039 2040-2059 2060-2079	18,806 13,461 11,941	11,460 12,962 11,019	19,757 12,377 12,628	13,056 12,860 11,945
NorESM2-MM	2020-2039 2040-2059 2060-2079	14,032 13,897 16,531	11,481 10,255 15,478	14,602 17,560 16,391	13,024 14,593 15,468
UKESM1-0-LL	2020-2039 2040-2059 2060-2079	5,057 4,554 3,665	10,647 11,139 10,323	3,541 4,393 5,372	10,621 10,952 11,893

As illustrated in the table above, a dispersion of the results has been obtained. Based on the models considered, the future PMF ranged between a minimum of 3,665 m3 /s (scenario SSP1-2.6, UKESMI - 0-LL model considering the max. PMP anomaly in 2060-2079) and a maximum value of 20,617 m3 /s (scenario SSP3-7.0, Ec-Earth3-veg model, for the 2060-2079). No specific rule of the trend in the futures PMF values have been observed.

The summary of this analysis depends on multi-model ensembles, considering all analysed models with and without UKESMI-0-LL model. The results have been provided for the mean, 25% and 75%, to evaluate the actual dispersion of the results between the analysed models.

Table 67: Future PMF Values – Ensemble (reproduced from Climate Resilience Assessment)

PMF ENSEMBLES (m^3/s)					
Ensembles	Reference period	SCENARIO SSP 1-2.6		SCENARIO SSP 3-7.0	
		From Max Anomalies of PMP	From Mean Anomalies of PMP	From Max Anomalies of PMP	From Mean Anomalies of PMP

ALL MODELS					
Mean	2020-2039	12,407	11,350	12,437	12,385
	2040-2059	12,484	12,104	12,662	12,923
	2060-2079	12,954	12,121	14,631	14,206
25%	2020-2039	15,129	11,622	14,515	13,067
	2040-2059	13,959	12,559	14,058	13,440
	2060-2079	15,177	13,872	16,966	15,496
75%	2020-2039	10,192	10,581	10,436	10,954
	2040-2059	12,650	11,467	12,613	12,535
	2060-2079	12,802	10,220	132,75	12,115
WITHOUT UKESM1-0-LL					
Mean	2020-2039	13,658	11,467	13,954	12,679
	2040-2059	13,831	12,265	14,074	13,251
	2060-2079	14,534	12,421	16,197	14,591
25%	2020-2039	15,666	11,658	14,606	13,073
	2040-2059	13,985	12,761	14,138	13,478
	2060-2079	15,264	14,535	17,125	15,514
75&	2020-2039	10,855	10,740	11,537	11,351
	2040-2059	12,982	11,834	12,901	12,642
	2060-2079	13,901	10,342	14,500	12,605

Considering the dispersion of the results, following the international guidelines, the multi-model ensample of the PMP has been considered to evaluate the future PMF in the Dorjilung Basin. The multi-model ensample represents the range and the distribution of the most plausible projected outcomes of changes in the climate system for a selected SSP.

As illustrated in the above table, when the UKESMI -0-LL model is included in the multi-model ensemble, the value of the PMP for the different time horizons is lower than the value obtained without this model. However, it can be pointed out that the maximum variation of the mean anomalies is about 5%.

The variability is slightly higher when the maximum anomaly of the PMP is applied. In this case, the maximum variability is recorded for the mean value, whose PMF has been calculated considering all models, and is about 10-12% lower than the value obtained without the UKESMI -0-LL model.

For the sake of safety, the results of the mean, 25%, and 75% evaluated for the multi-model ensemble without the UKESMI -0-LL model have been adopted for this study.

Considering the value of 75%, the variability of the PMF is lower than the mean. In this case, the application of the maximum PMP anomalies to the SSP 1-2.6 scenario resulted in a PMF value between 10855 m3/s and 13901 m3/s and a maximum variation of about 17% for the far future. Concerning the worst scenario, the maximum increase in the PMF is about 22% for the distant future and about 8.5% for the medium future.

Considering the maximum PMP anomalies applied to mean value of the multi-model ensemble, the PMF varies from +15 % (in near future) to +22% (in far future) for the first scenario (SSP1-2.6) and increases up to 36% in the period 2060-2079 for the worst scenario (SSP3-7.0).

However, considering the mean PMP anomalies, the maximum variation of the PMF in the far future (2060-2079) is almost equal to 23% for the worst scenario. Instead, for SSP1-2.6 scenario, the PMF value can be considered substantially like the design value, as the variation of the PMF is between -3.5% and 4%.

A general consideration on the mean value of the multi-model ensemble without the UKESMI -0-LL model is that the PMF value in the near and medium future (2020 – 2059) is not significantly different from the design PMF, being 18% the maximum value of the variation. Instead, the increase in the PMF in the far future (2060 - 2079) is between 4.5% and 36% (for the worst scenario analysed).

6.1.3.2.3 Impacts on GLOF

Studies suggest that while the frequency of Glacial Lake Outburst Floods (GLOFs) has not increased significantly, these events could rise in response to future global warming, particularly as lakes expand toward steep cliffs. Global warming, more pronounced in high mountain areas like the Himalayas, has led to unprecedented glacier mass loss, contributing to glacier retreat and the formation or expansion of glacial lakes. In Bhutan, a region highly affected by climate change, temperatures are expected to rise more sharply than global averages, leading to increased glacier melt. This has caused significant growth in glacial lakes over the past decades, particularly at elevations between 5000–5500 meters, where moraine-dammed lakes are most prevalent. As a result, these lakes pose an increasing GLOF hazard to downstream communities and infrastructure.

Projections for the future indicate substantial expansion of glacial lake areas across High Mountain Asia, including Bhutan. Under more severe climate scenarios (RCP 8.5), glacial lake volume and area could increase significantly by the end of the century, heightening the risk of GLOF events. This trend is particularly concerning for Bhutan, where the risk of GLOFs is currently higher than in neighboring regions

and may triple in the coming decades due to further lake development. The GLOF risk in Bhutan is expected to remain significant, especially in river basins like the Ganges, where the highest risks are forecast. Despite this growing threat, Bhutan's population and infrastructure, particularly hydroelectric plants, continue to expand in these high-risk areas, which may exacerbate the potential economic and environmental impacts of GLOFs in the future.

6.1.3.3 Climate Resilience Assessment Mitigation Measures

For the DHPP, several climate resilience assessment mitigation measures are critical to addressing the growing risks posed by climate change, particularly in terms of glacial lake outburst floods (GLOFs), changing precipitation patterns, and increased sedimentation. One of the primary mitigation measures is ensuring the structural integrity of the dam and related infrastructure, designed to withstand extreme weather events, including GLOFs, intense rainfall, and flooding. Specifically, the spillways of the Dorjilung HPP are engineered to safely accommodate up to 20,000 m^3/s of water, a critical feature to manage potential GLOF events. This design ensures that the dam has the capacity to handle catastrophic floodwaters, protecting both the infrastructure and downstream communities from damage. Regular inspections, maintenance, and upgrades of the dam's spillways and other key components will also be necessary to ensure that the system remains resilient to increasingly frequent and intense hydrological events due to climate change.

In addition to structural measures, sedimentation control will be essential for maintaining the dam's long-term operational efficiency. With the retreat of glaciers, sediment influx into the Dorjilung reservoir is expected to increase, which could impact on the reservoir's storage capacity and reduce the dam's efficiency. Implementing sediment bypass systems or silt traps will help manage the influx of debris and sediment. Continuous monitoring of sediment levels, combined with adaptive measures like dredging when required, will be vital for maintaining the dam's function. Furthermore, given the high risks posed by GLOFs due to the presence of glacial lakes like L42, L41, and L43 upstream, stabilizing these moraine-dammed lakes will be another key focus. Engineering solutions to reinforce or stabilize moraine barriers will reduce the likelihood of catastrophic breaches. Real-time data from ground-based monitoring and Early Warning Systems will provide early warning of potential threats, allowing for quick responses to mitigate risks. The detailed procedures in case of emergency are given in the Emergency Preparedness Plan.

6.2 Geology and Soils

The geological baseline was developed using 3 key data sources: The Project report Volume – V: Geology (2016), Volume-VIII ESIA (2016), the Field Work Report on Physical Environment (2023) and bibliographical research.

6.2.1 Geology of Bhutan

Based on the geology and tectonic history, Bhutan can be divided into four main geological units:

- The Tethys Himalaya or the Tibetan Himalaya with an independent Tectonic top of the crystalline sheets and involving a conformable stratigraphical column from late Precambrian to Eocene.
- The Greater Himalaya consisting of thick crystalline thrust sheets which form the base of the tethyan sediments to the North.
- The Lesser Himalaya with huge sedimentary sections of mostly late Precambrian age covered by Gondwana type rocks and by crystalline thrust sheets exposing a reversed metamorphism. This is the formation where the DHPP is located.
- Sub–Himalaya with a belt of molasses-like clastic deposits, the Siwaliks.

The study area is shown within the Red Ellipse on Figure 29**.**

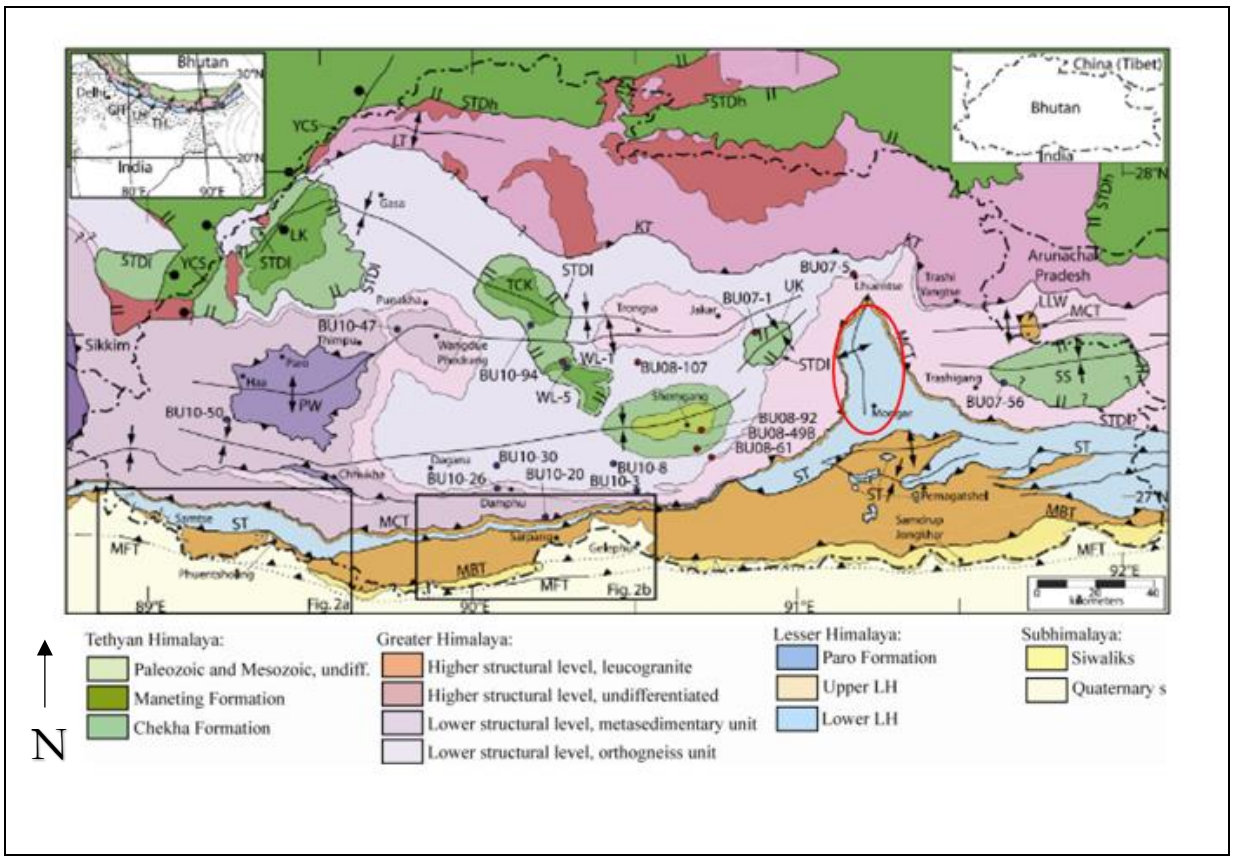


Figure 29: Geological map of Bhutan

Source: (Nadine McQuarrie 2012)

6.2.2 Geology of Project area

The study area falls under the Daling-Shumar Group (Gansser, 1983) also called the Shumar Formation (Bhargava, 1995) of Precambrian age. The Shumar Formation in the study area consists of alternating layers of quartzite and phyllite/mica schist with some carbonate and gypsum bands. It also contains intrusive basic skills and concordant mylonitised granite gneiss bodies. The formation is thicker in the Kurichhu valley, where it forms an anti-form and is affected by faulting and thrusting in the southern part of the area.

The geological conditions are reported as suitable for the construction of the dam, Powerhouse, and Headrace Tunnel, with phyllitic schist providing a stable foundation on both banks and the use of durable quartzite for critical structures ensuring the integrity and long-term performance of the hydropower project. Figure 30 present some typical Rock types observed on DHPP sites. Brief geological features of the project area are as stated below:

Dam site: The dam site is characterized by a moderately wide valley with steep abutments. The riverbed is covered with fluvial deposits, and the foundation of the dam is expected to encounter phyllite bedrock. The left abutment has overburden consisting of slope wash deposits and river-borne materials, while the right abutment is mostly exposed to bedrock with some slope wash deposits at higher elevations.

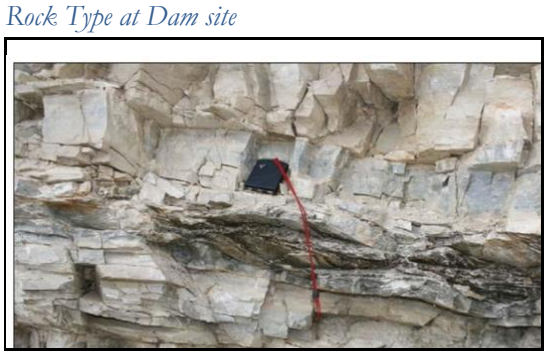
Headrace Tunnel (HRT): The geological conditions along the HRT alignment appear to be favourable for tunnelling, with predominantly strong rock types such as phyllite and quartzite. However, the presence of quartz veins and the high-stress conditions in certain sections will need to be carefully considered during the design and construction of the tunnel.

Power House: The Power House cavern has been located within strong to very strong moderately jointed, slightly weathered rock mass with number of thin shear seams and thick fracture zones represented by Shumar quartzite with a tentative vertical cover of about 300m to 255m. RMR values of the rock mass observed in the exploratory drift in progress in power house area vary between 35 and 49. On the basis of available information from drift and projecting the same on the power house, the overall percentage of rock class is anticipated to be 45% Class III and 55% Class IV.

Tailrace Tunnel (TRT): The area proposed for TRT portals is occupied by overburden material. Bedrock, however, is exposed just a few meters above the portal elevation and about 16m behind which goes vertically up to about 90m maintaining a moderately steep gradient. The hill slope above is covered with overburden material comprising slope wash deposit. The bedrock comprising quartzite is exposed in the area and shear seams traversing the rock mass have also been observed. The rock mass classification along TRT indicates that the tunnel is likely to encounter rock mass Class III for about 45%, 50% of Class IV and 5% of Class V of total length.

Rock Type at Dam site

Rock Type at Headrace Tunnel



Rock Type at Powerhouse

Field staff collecting soil samples (2023)

Figure 30: Typical Rock types observed on DHPP sites

Source: DPR, 2016

6.2.3 Soils characteristics

In general, the nature and properties of soil vary according to the topography and elevation of the area. Despite the steep gradients, there are many soils which are moderately or deeply weathered. Since many of the slopes are covered with polycyclic, layered drift materials, soil horizons depend equally on regolith heterogeneity and paedogenesis.

For this ESIA, a rapid soil survey was carried out by Sherubtse College to characterize soils in the upper part of the reservoir (stations S1 and S2) and near the powerhouse (stations S3 and S4). Stations details are provided in following Table 68. Two samples of the upper horizon for each site (A & B) have been collected for analysis. Site's locations are provided in section 6.3.6.

The soil composition in the study area is dominated by sand and gravel, with minimum quantities of fine particles (silt and clay). In May with gravel was dominant, with proportions up to 47.54 ± 26.47 % while the sand fraction became the predominant constituent with 52.29±14.39 % in November. Grain size distribution of collected samples is provided in Table 68 and results from analysis are provided in Table 69.

Table 68: Soil samples grain size distribution

Station	% Gravel		% Sand		% Clay & Silt	
	A	B	A	B	A	B
S1	11.186	21.52	64.076	61.57	24.738	16.91
S2	46.485	34.32	45.774	54.94	7.741	10.74
S3	59.918	63.26	36.996	31.21	3.086	5.53
S4	72.569	36.41	22.201	61.43	5.230	2.16
Average	47.54	38.88	42.26	52.29	10.20	8.83
STDV	26.47	17.54	17.50	14.39	9.88	6.44
Max	72.57	63.26	64.08	61.57	24.74	16.91
Min	11.19	63.26	22.20	61.57	3.09	16.91

Table 69: Soil samples analysis results

	pH		EC (µS/cm)		SOC (%)		TOM (%)	
	A		B		A	B	A	B
S1	6.42	6.3	142.70	15.35	6.214	0.08	10.564	0.18
S2	6.13	6.97	108.85	19.46	2.398	1.1	4.076	2.46
S3	6.74	6.75	99.64	25.26	2.662	1.1	4.525	2.46
S4	6.44	7.04	123.10	17.87	3.144	0.78	5.344	1.76
Average	6.43	6.77	118.57	19.49	3.60	0.77	6.13	1.72
STDV	0.25	0.33	18.76	4.21	1.77	0.48	3.00	1.08
Max	6.74	7.04	142.70	25.26	6.21	1.10	10.56	2.46
Min	6.13	6.3	99.64	15.35	2.40	0.08	4.08	0.18

Typically, a balanced soil pH ranges from 6 to 7.5 to maintain soil micro-organisms activity and nutrient availability. The study area soils comply with this observation, with pH ranging in average from 6.43 to 6.77. Soil EC confirms the absence of excess salt in the soil.

Organic matter content of the soils is rather moderate to low, which is understandable considering the very low fraction of fine material in the soils. This point is not the best for agricultural development but confirms

that only limited amounts of carbon will be released in the water from the flooded soil after the reservoir impoundment.

6.2.4 Topography

Geographically Bhutan forms a giant natural staircase. Starting from the plains of India, in the south, at an altitude of around 100m, the elevation rises to the high Himalayan peaks of over 7,000m in the north, on the borders with Tibet. Eastern Bhutan lies across the Donga range running north–south across the country and is crossed by the 3,780m high Thrumshingla pass. From this high pass the terrain drops precipitously to the low valleys of the Kurichhu. Location of Project is illustrated by red ellipse on Figure 31.

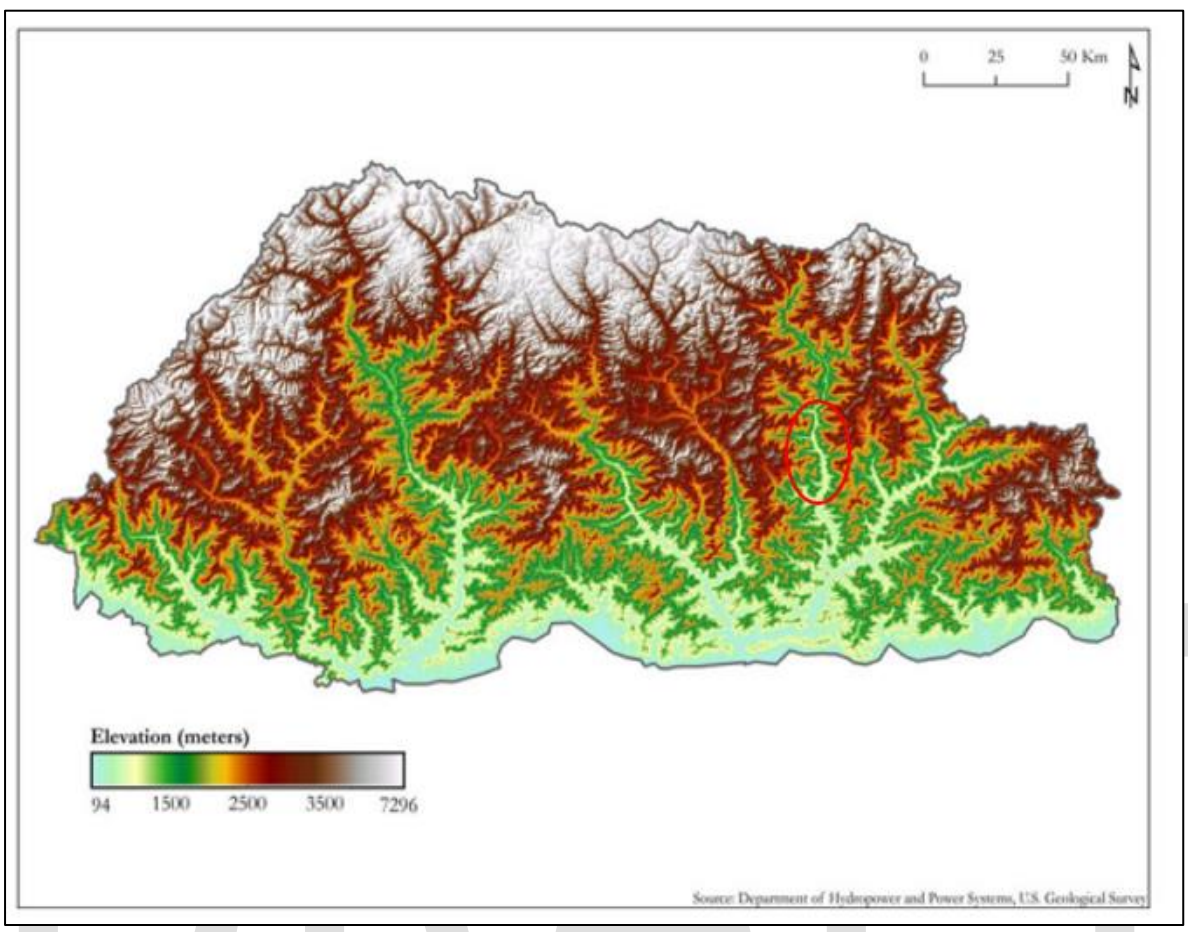


Figure 31: Topographical map of Bhutan

Source: (World Bank Group 2016)

6.2.4.1 Topography of the project Area

The Dorjilung hydropower project is located within the valley of the Kurichhu River, which is a prominent waterway in eastern Bhutan. This river has carved a scenic path through high ridges and deep valleys. The topographical features of the region surrounding the project site are characterised by rising peaks and steep hills, stretching over an altitude range of 1,000 to 2,500 masl.

In addition, the river flows southwards at an altitude of between 500 and 1,000 m. This diverse topography results from the Digital Elevation Model (DEM), see Figure 32, and showcases the varied elevations and terrains present within the project area.

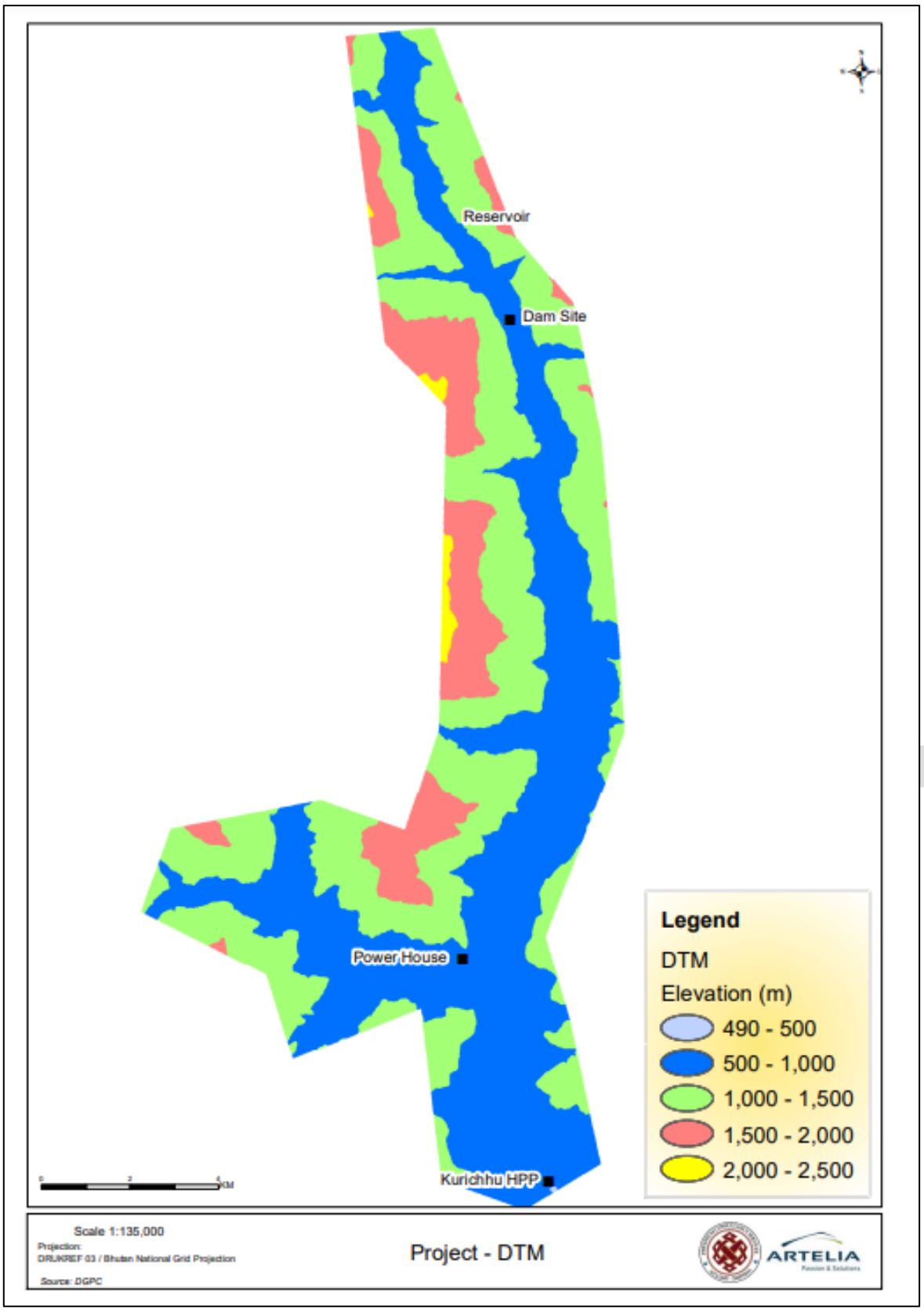


Figure 32: DEM Map of the project Area

6.3 Hydrology

There are four major rivers in Bhutan. The Drangmechhu, the largest river system, flows south-westerly from India's Arunachal Pradesh State, and has three major branches: the Drangmechhu, Mangdechhu and Chamkhachhu. The Kurichhu and the Gongrichhu rivers define the eastern headwater part of the Drangmechhu branch.

6.3.1 Dorjilung River system

The information on the Kurichhu hydrology provided below is mainly based on the Detailed Project Report (DPR) Volume III: Hydrology (March 2023). The Kurichhu originates in the eastern Tibet from the heavily glaciated northern slopes of the Higher Himalayan Range. In its upper reaches, the river is formed by two streams namely Lhobrakchhu and Hamachhu. After the confluence of these two streams the river is known as Kurichhu. The highest branches of the Kurichhu originates (i) for the western branches (2 branches) from the northern face of the Gangkar Puensum massif and from the Kula Gangri Range at an elevation above 6,000 masl and (ii) for the eastern branch (1 branch only) from the slopes of the Tarlha Ri range at an elevation of more than 5,000 masl.

The western and the eastern Kurichhu branches flow in China and join some 15 km before reaching the Bhutan-China border. Downstream from the junction, the Kurichhu starts to flow in the southern direction, the basin narrows, and the river enters Bhutan in a deep gorge. The length of the Kurichhu is about 264 km until its confluence with the Gongrichhu and its average gradient is 25 m/km. In total, the Kurichhu basin encompasses an area of about 9,646 km² until the confluence with Gongrichhu.

The dam site of the Dorjilung is planned at an elevation of 768 masl. The controlled catchment of the Kurichhu at dam site covers an area of 8,782 km². The area of the basin above 5,000 m elevation is 2,710 km² and the area between 768 m (dam location) and 5,000 m elevation is 6,072 km². About 66% of the catchment (5,813 km²) lies in China. The length of the river from its sources to the dam site is about 218 km. The Mean Catchment Elevation of the Dorjilung controlled catchment is 4,350 masl. From its water sources to Dorjilung HPP, the Kurichhu flows with an average gradient of 21.15 m/km, which is a steep gradient. The longitudinal profile of the river is depicted in Figure 33.

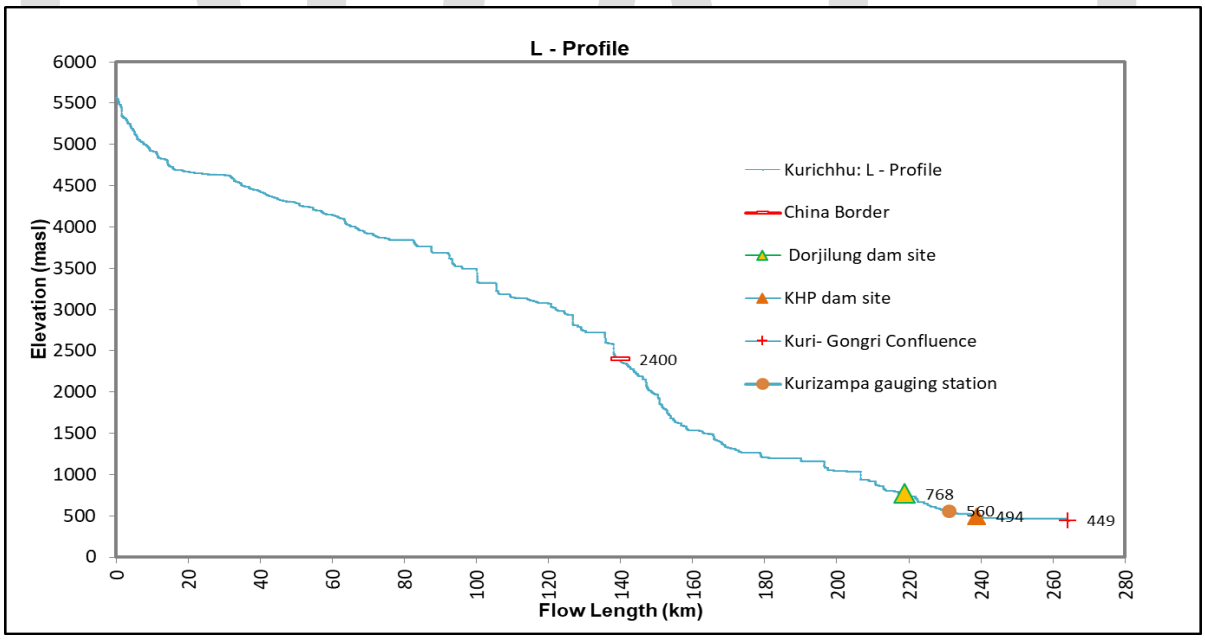


Figure 33: Longitudinal Profile of the Kurichhu

Source: DPR Hydrology, 2024

6.3.2 Catchment Area

The proposed Dorjilung dam will be built at an elevation of 768 meters above sea level. The dam site's authorized Kurichhu sub-basin has an area of 8,782 square kilometres. This basin is shared by China and Bhutan, with China accounting for approximately 66% of the watershed area of 5,813 square kilometres. The dam is located about 82 km downstream of the Chinese border. The basin above 5,000 m has an area of 2,710 square kilometres, whereas the region between 768 m (where the dam is located) and 5,000 m has an area of 6,072 square kilometres. The designed area for the Dorjilung catchment, including up to the dam site, has resulted in a mean elevation of approximately 4,350 masl. Figure 34 depicts the Dorjilung catchment area design up to the dam site. Figure 35 provides details on the location of the nearest meteorological (green dot) and gauging stations (star symbol).

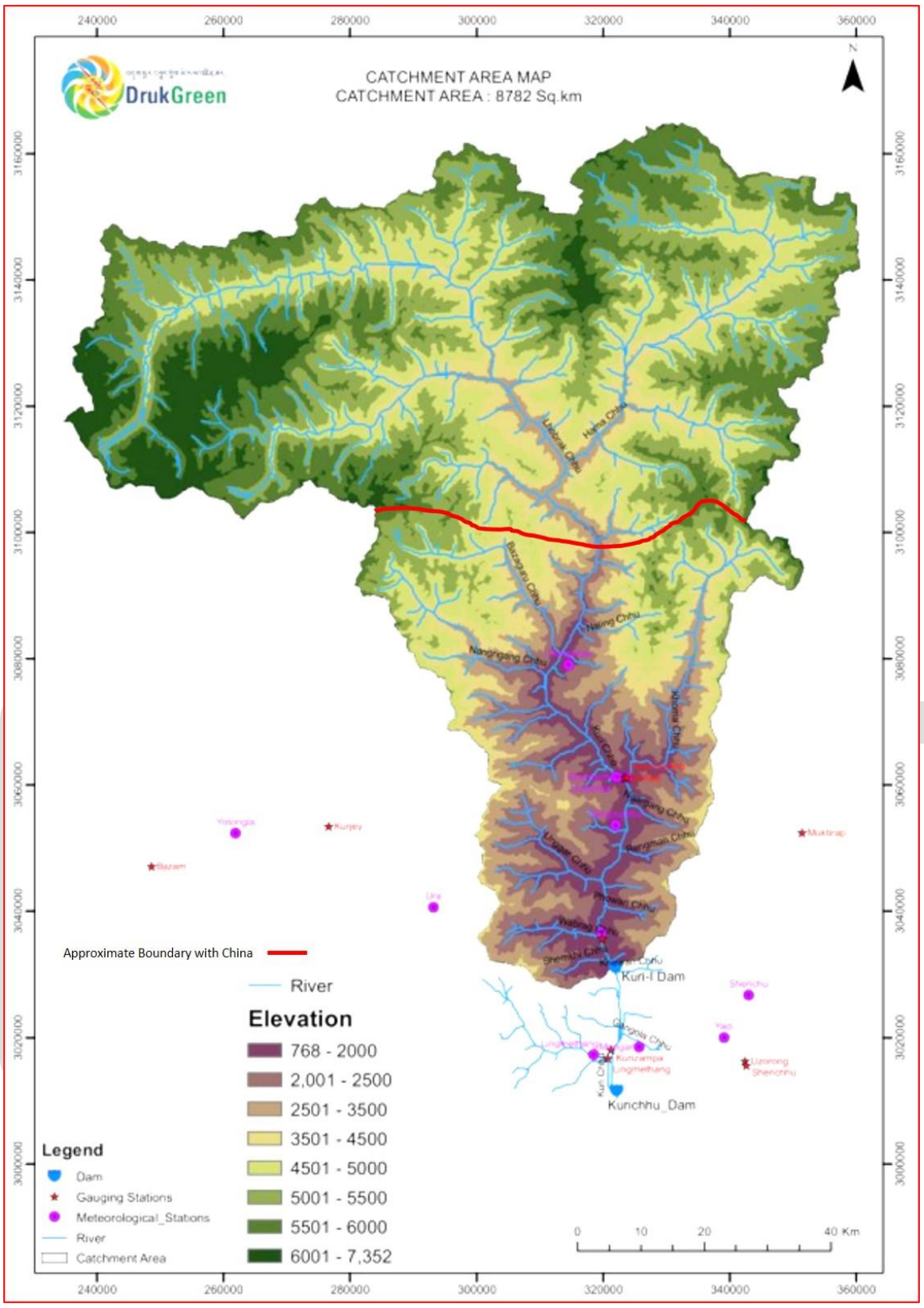


Figure 34: Catchment area of the Kurichhu River

Source: DPR, Hydrology, 2023

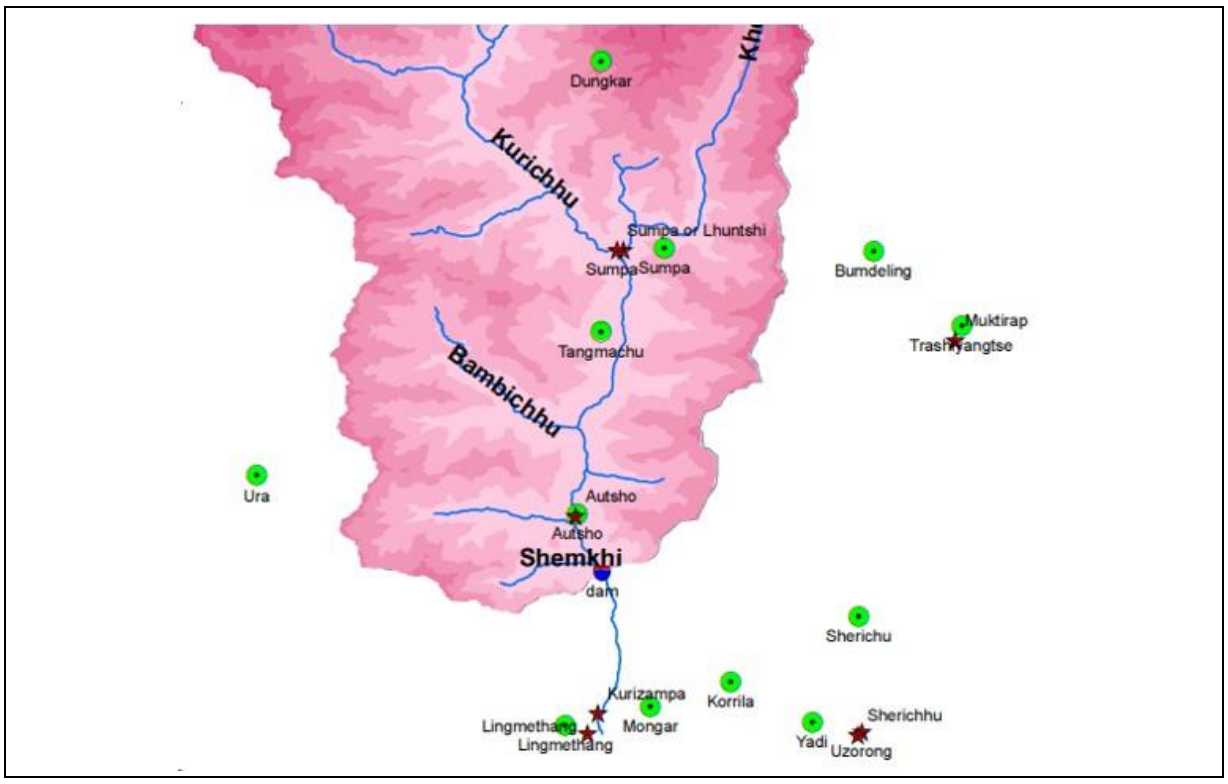


Figure 35: Name and location of nearest meteorological and gauging stations

Source: (DPR, Hydrology, 2024)

6.3.3 Kurichhu river flow

6.3.3.1 Gauging stations and flow series

Flow gauging in the Kurichhu basin was initiated in 1984. It was then developed during the preparation of the Kurichhu HPP and followed by the implementation of additional stations. The present status of gauging stations and periods of measurements is provided in the following Table 70.

Table 70: Summary of Kurichhu gauging stations and flows series

Station	River	Type	Station No.	Latitude (N)	Longitude (E)	Data Period	Basin Area (km²)
Autsho	Kurichhu	S	1635	27°26'01"	91°10'21"	1987-2022	8,556
Bjizam	Mangdechhu	P	1458	27°31'28"	91°27'01"	1994-2020	1,390
Kurichhu Hydropower Plant (KHP)	Kurichhu			27°12'59"	91°12'14"	2008-2022	9,374
	Kurichhu	Collected as per of DPR preparation of KHP		27°12'59"	91°12'14"	1984-1991	9,374
Kurizampa	Kurichhu	P	1620	27°16'28"	91°11'38"	1991-2022	8,999
Kurjey	Charmkharchhu	P	1549	27°35'13"	90°44'13"	1991-2012	1,350
Lingmethang-station closed in 2013	Shorgharchhu	S	1613	27°15'27"	91°11'01"	2000-2013	323
Muktirap	Kholongchhu	P	1767	27°35'16"	91°29'40"	2001-2022	905
Sherichhu	Sherichhu	S	1741	27°15'15"	91°24'36"	1992-2022	437
Sumpa	Khomachhu	S	1650	27°39'51"	91°12'36"	1986-2022	660
Sumpa	Kurichhu	P	1652	27°39'56"	91°12'21"	2007-2022	7,269
Uzorong	Gongrichhu	P	1740	27°15'38"	91°24'30"	1992-2022	8,560

Source: DPR, 2024

6.3.4 Surface flows

Kurichhu is one of the rivers in Bhutan which is properly gauged and has considerable amount of long-term data series compared to other basins. The water availability study was done based on a representative historical flow series at the project site.

From the monthly specific flow data, the specific flows gradually increase from January to July, indicating a trend of increasing water flow during the monsoon season. The highest specific flow is observed in July, which corresponds to the peak of the monsoon season when rainfall is at its maximum. After July, the specific flows start to decrease, indicating the end of the monsoon season and a reduction in rainfall. The lowest specific flow is recorded from December to March, which corresponds to the dry season when water flow is minimal.

The monthly specific flows expressed as l/s/sq.km for these stations is represented in Figure 36 and the Table 71.

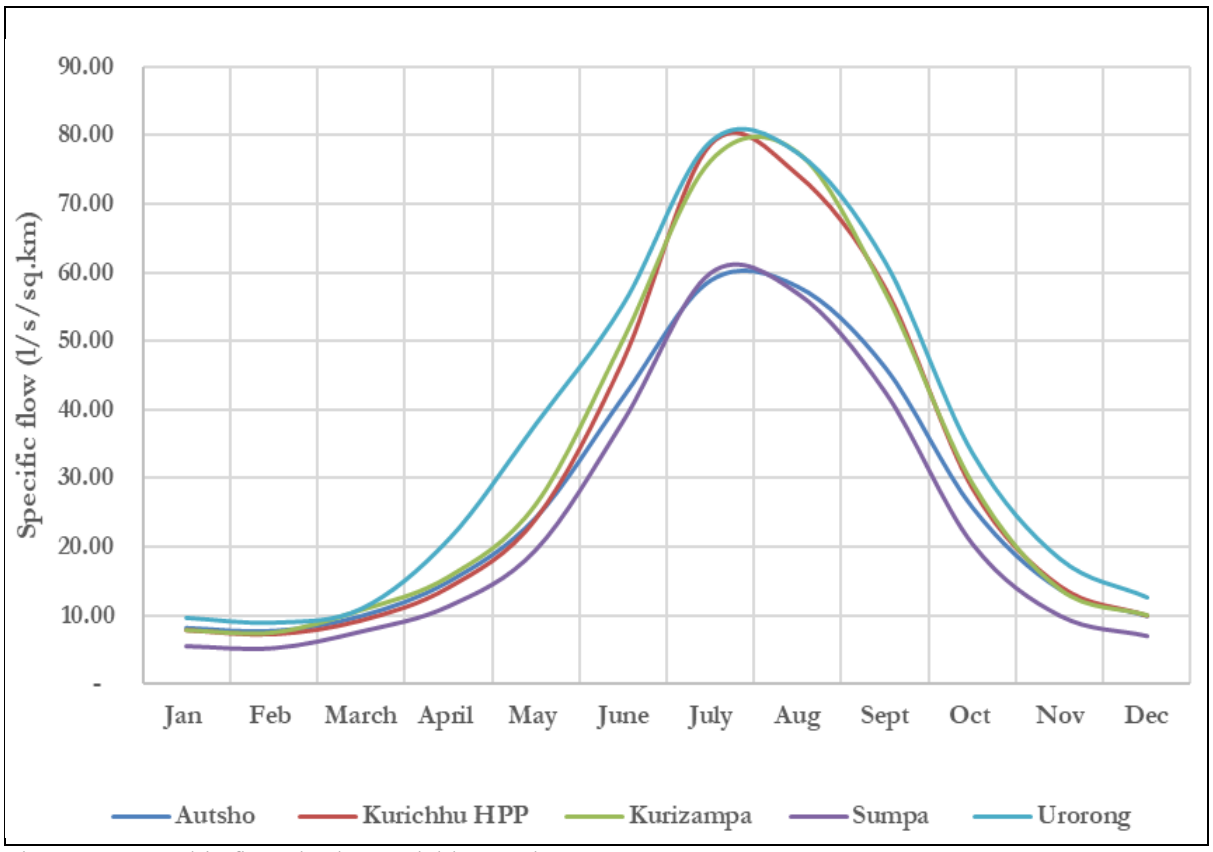


Figure 36: Monthly flows in the Kurichhu catchment

Source: DPR, 2024

Table 71: Summary of flows series

Description	Unit	Autsho	Kurichhu HPP	Kurizampa	Sumpa	Uzorong
Catchment area	sq. km	8,556.00	9,374.00	8,999.00	7,269.00	8,560.00
Average annual flow	m^3/s	228.20	280.71	288.83	173.50	306.17
Average maximum flow	m^3/s	884.56	1,253.19	1,381.45	889.01	1,275.30
Average minimum flow	m^3/s	59.59	55.27	60.68	35.09	69.50
Ave. annual Volume	MCM	7,201.47	8,858.98	9,115.18	5,475.77	9,662.17
Average sp. Runoff	l/s/sq. km	26.67	29.95	32.10	23.87	35.77
Average Runoff	mm	841.69	945.06	1,012.91	753.30	1,128.76
Average lean season flow	m^3/s	76.39	77.46	82.42	46.82	91.32
Lean Specific Runoff	l/s/sq.km	8.93	8.26	9.16	6.44	10.67

Source: DPR, 2024

There are two principal gauging stations in the Kurichhu basin: Sumpa and Kurizampa. In addition, three secondary gauging stations contribute to the hydrological data: Autsho, Khomachhu, and Lingmithang. The average annual specific runoff at Kurzampa is somewhat greater than the other three stations in the major Kurichhu inflow series (Autsho, Kurichhu Plant, Kurizampa, and Sumpa). The table below presents the summary of flows series.

Table 72 present the summary of inflows at Dorjilung HPP intake. The Dorjilung dam receives an average annual flow of 281.87 m^3/s, with a peak flow reaching 1,348.14 m^3/s. The annual inflow volume is substantial, averaging an 8,895.38 MCM. The average specific runoff, at 32.10 l/s/km2, highlights the significant runoff intensity in the catchment area. In terms of water availability, the dam experiences an average low flow season of 80.43 m3/s, indicative of periods with reduced precipitation. The minimum specific runoff of 9.16 l/s/km2 signifies the lowest possible flow rate in the catchment area.

Table 72 : Summary of inflows at Dorjilung HPP intake

Parameters	Unit	Dorjilung dam
Catchment area	sq. km	8,782.00
Average flow	m^3/s	281.87
Average Max flow	m^3/s	1,348.14
Average min. flow	m^3/s	59.22
Ave. Annual Vol.	MCM	8,895.38
Average sp. Runoff	$l/s/km^2$	32.10
Average Runoff	mm	1,012.91
Average lean season flow	m^3/s	80.43
Minimum Specific Runoff	$l/s/km^2$	9.16

Source: DPR, 2024

The flow-duration curve giving the percentage dependability for various flows is plotted in Figure 37.

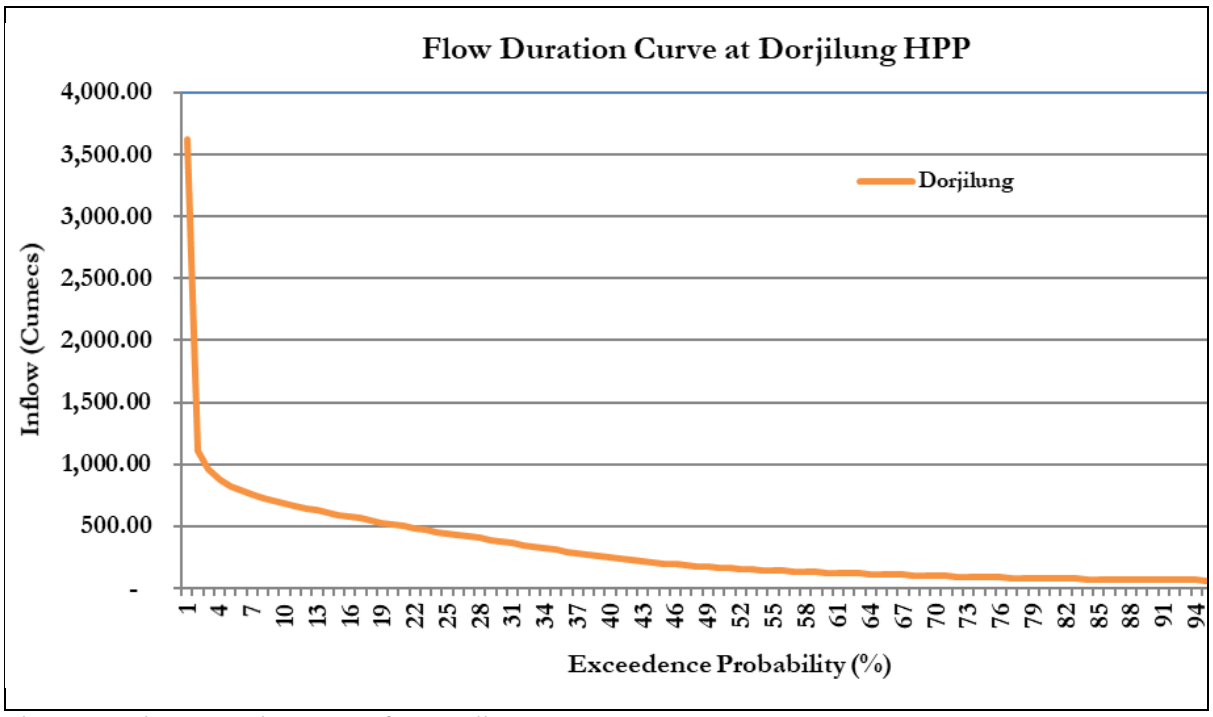


Figure 37: Flow-Duration Curve for Dorjilung HPP

Source: DPR, 2024

6.3.5 Floods

6.3.5.1 Flood Design Events

The design flood studies for the Dorjilung Dam Site have been carried out using both Hydro-Metrological and Flood Frequency Approach. Total catchment area of Kurichhu up to Dam site is 8,782 km². The catchment area above 5,000m elevation is snow-fed. Since the rainfed catchment area is larger than 5,000 km², the catchment was divided into three sub-catchments (viz- catchment A, Catchment- B and Catchment- C) of smaller sizes for estimating the design flood hydrographs. Catchment A, B and C specific characteristics are presented in the table below and represented in Figure 38.

Table 73: Catchment Characteristics

Catchment	Catchment-A	Catchment-B	Catchment- C
Catchment Area(km²)	3,305	2,044	3,433
Snow fed catchment (km²)	1,683	823	204
Rainfed catchment (km²)	1,622	1,221	3,229
Length of stream, L (m)	113.54	82	127
Length of Stream from outlet to centroid, L_c (m)	35.00	33	55
Equivalent slop(m/km)	15.83	19.31	21.55

Source: DPR, 2024

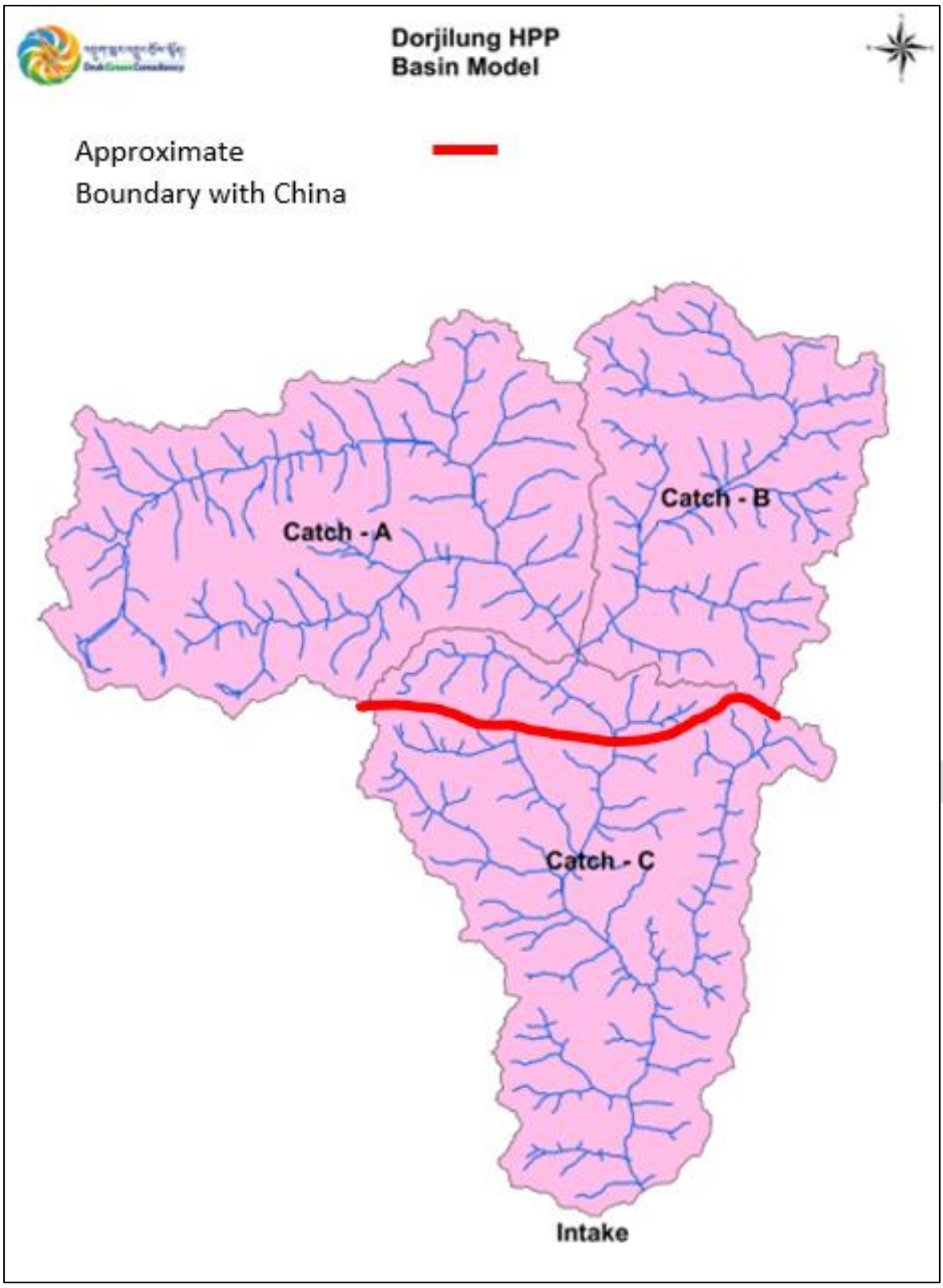


Figure 38: Sub-catchments of Dorjilung HPP

Source: DPR, 2016

The calculated PMF for Dorjilung HPP is 11,885 m^3/s (DPR 2024).

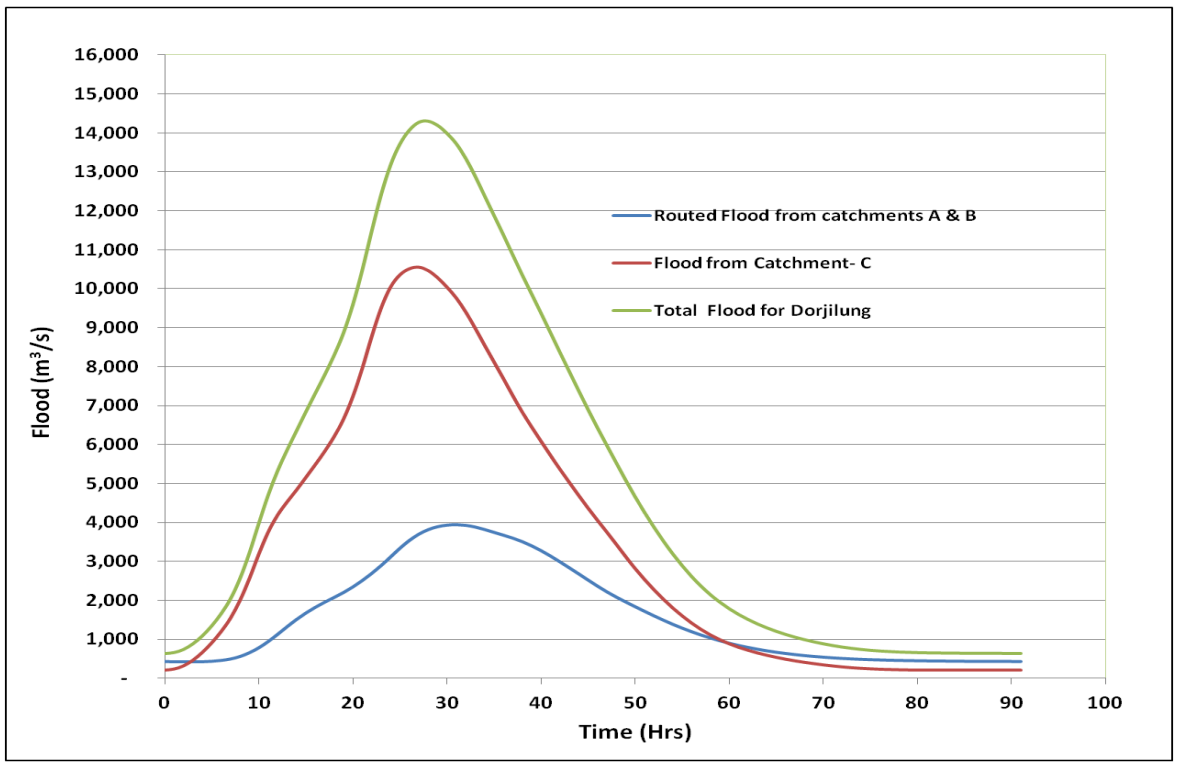


Figure 39: Flooding in Dorjilung catchment and sub-catchments (note, values superseded by draft DPR 2024 update, but new figure not provided)

Source: DPR, Hydrology, 2023

6.3.5.2 Flood peaks

Annual peak discharges are subjected to frequency analysis using appropriate distribution. Long term daily discharge data of Kurichhu at Kurizampa located about 13 km downstream of the dam from 1991 to 2012 (21 years). Catchment area of Kurichhu up to Kurizampa is 8999 sq km, which is comparable with the catchment area up to dam site. Hence this data has been considered for estimating the design flood using statistical approach. The mean and 95% upper confidence flood peak values for various return periods at Kurizampa have been obtained. The **table below** provides the estimated flood peak values for different return periods at both Kurizampa and Dorjilung Dam sites.

Table 74: Estimated Flood Peaks for Various Return Periods (m^3/s)

Return Period (Years)	Kurizampa		Dorjilung Dam Site	
	Mean Flood	95% Upper Confidence	Mean Flood	95% Upper Confidence
50	4,247	5,620	4,171	5,518
100	4,758	6,361	4,672	6,246
500	5,937	8,077	5,830	7,931
1000	6,444	8,815	6,328	8,657
10000	8,128	11,269	7,981	11,066

Source: DPR, Hydrology, 2023

Annual peak discharge data of Kurichhu at Kurizampa is available for 22 years. The extrapolation of annual flood peaks for a limited period of 22 years may not provide a reasonably accurate estimate of 1 in 1000 or 1 in 10000-year flood. However, considering the flood frequency value of 95% upper confidence limit value of 1000/10000-year flood may give a rough estimate of the PMF. Since annual flood peak values are available for a limited period only, the values of 1000/10000-year flood can't be relied, but may indicate a rough estimate of the PMF. In view of the above, to be on the conservative side design flood of 14,294 m^3/s (say 14,300 m^3/s) is adopted. Note, these values are understood to have been superseded by the draft DPR 2024, which lowers the PMF to 11,885 m^3/s.

Construction of Flood Design Events

Based on the DPR (2016), a 25–year return period flood has been estimated utilizing the instant annual flood peak series for the diversion flood. This flood design event reflects the constraint that foundation works for the dam cannot be completed during the non-monsoon period and its construction activities are likely to continue even during the flood season. The diversion flood at the dam site was determined as 2430 m^3/s (DPR, 2016). Figure 40 and Figure 41 illustrate the area with pictures taken by ARTELIA during the site visit.

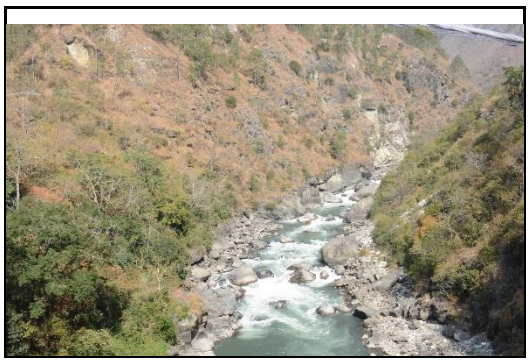
Dam axis, view D/S

Dam axis view U/S

Cultivated terraces in reservoir area

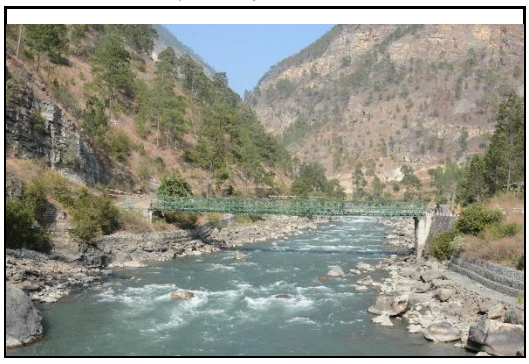
View of reservoir area

Figure 40: Photographic plate: Dam and Reservoir Area

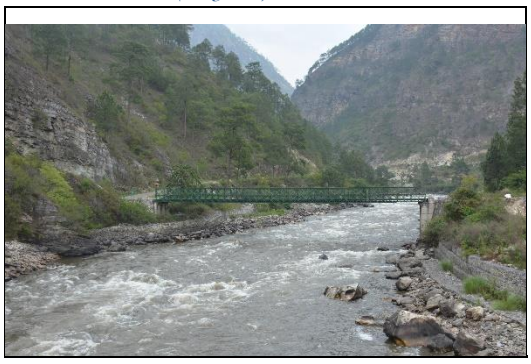


View d/s from bridge in what will be the future dewatered section (Feb 23)

View d/s from bridge in what will be the future dewatered section (May 23)



View u/s to Autsho bridge (Feb 23)

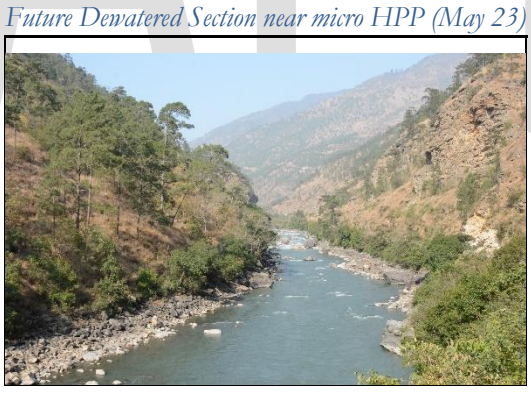


View u/s to Autsho bridge (May 23)

Future Dewatered Section near landslide (Feb 23)

Future Dewatered Section near micro HPP (May 23)

Kurichhu River downstream of Kurichhu HPP



Kurichhu River Upstream of Autsho

Figure 41: Photographic plate: Kurichhu River

6.3.6 Water quality

6.3.6.1 Monitoring program

The whole catchment of the Kurichhu shows very low density of population and large forested area. Human activities are mainly agricultural, and no significant industrial activities are reported. The sources of pollution are very limited in catchment, mainly domestic effluents from villages and animal dejections from cattle and wild fauna.

Water quality and sediment monitoring performed under the present ESIA study involved two sampling campaigns, one pre-monsoon (May 2023) and one post-monsoon (November 2023). Water samples and associated sediment samples were collected along the river within the DHPP area in ten sampling stations: Two upstream of the reservoir area at Autsho (WS3) and Phawan (WS1), one in the Shungmanchu tributary stream (WS2) before its confluence at Autsho, upstream of the reservoir area, at the intake site (WS4) and dam site (WS5). Downstream dam stations comprise three stations in the future dewatered section (WS6, WS7, and WS8) and two downstream tailrace outflows (WS9 and WS10). Sampling stations are detailed on Figure 42.

The analytical results for biological and physico-chemical parameters of water samples obtained were compared with the ambient water quality criteria, Class A, the guideline values established by the National Environmental Commission Secretariat (NECS) in 2020, the Royal Government of Bhutan.

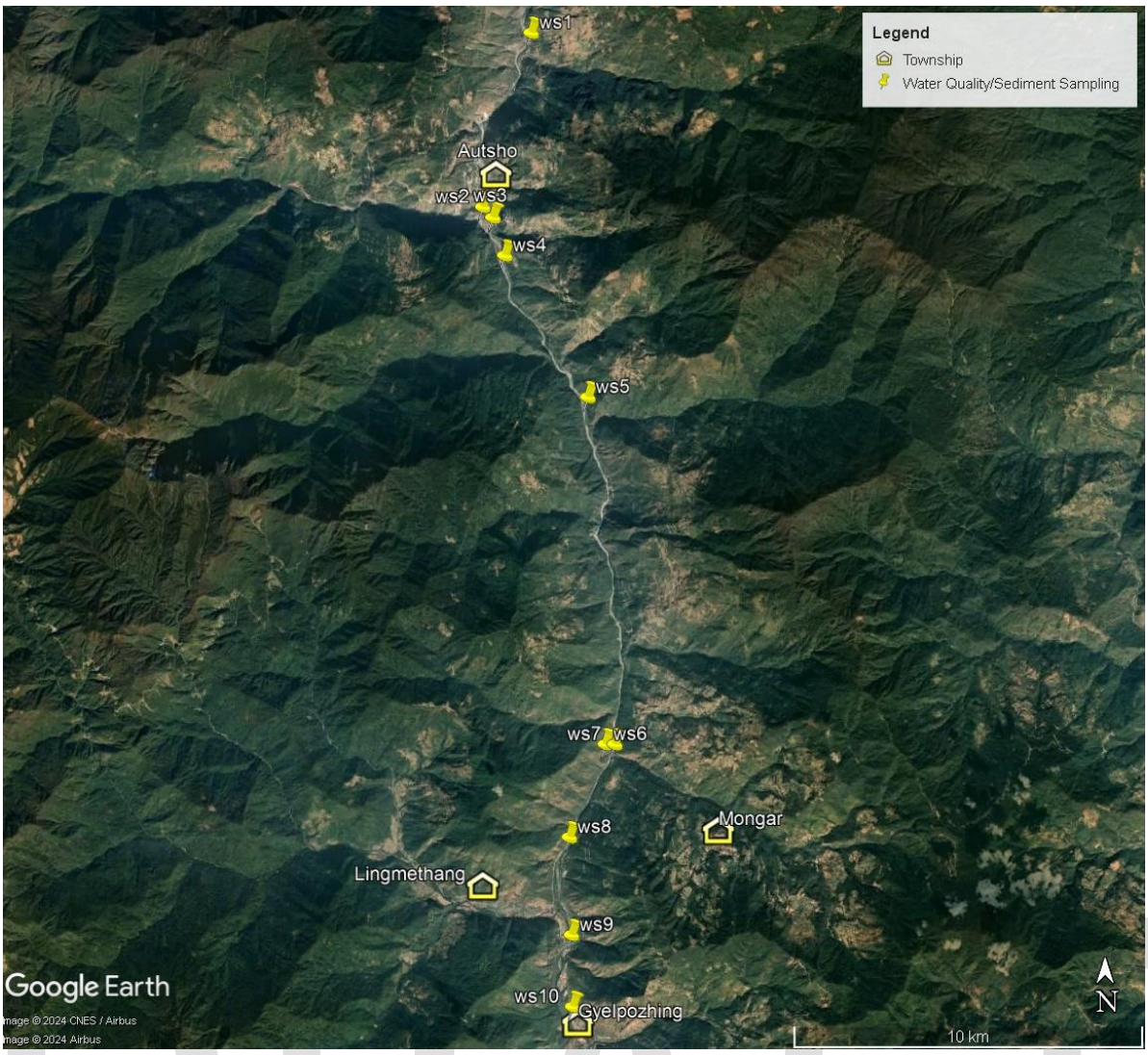


Figure 42: Location of water/sediment sampling stations

A total of 60 water samples were obtained for biological and physicochemical analysis, three water samples from each sampling site. In-situ and laboratory analysis concerned the following typical parameters:

- Physical parameters: Temperature, Dissolved Oxygen (DO), pH, Electro-conductivity (EC), Total Suspended Solids (TSS) and Turbidity.
- Chemical parameters: Chloride, Nitrate, Sulphate, Fluoride, Sodium, Potassium, Calcium, Magnesium.
- Biological parameter: Coliforms

6.3.6.2 Results and discussions for Physical Parameters

Graphic presentation of results is provided in Figure 43**.**

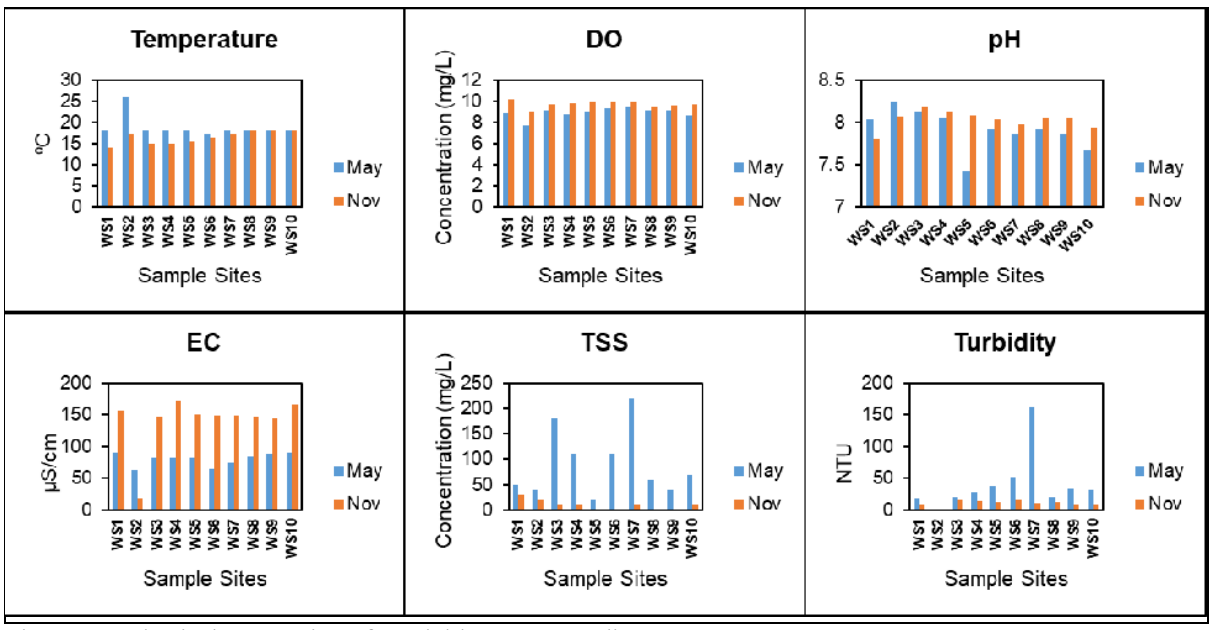


Figure 43: Physical properties of Kurichhu water quality

The average water temperature recorded was 18.7 ± 2.58 °C and 16.4 ± 1.45 °C in pre-monsoon and post-monsoon, respectively. This temperature is reasonably cool, allowing good dissolution of oxygen and convenient for aquatic life. To be noted that the Shungmanchhu tributary (WS2) shows a significantly higher water temperature (about +7°c) than the mainstream in pre-monsoon period and slightly higher in post-monsoon.

Dissolved oxygen concentrations observed range from 7.67 mg/l to 9.53 mg/l in May and 9.02 mg/l to 10.19 mg/l in November, well above the minimum requirement of 6 mg/L stipulated by the National Environmental Compliance Standards (NEC 2020) for ambient water. Aquatic life starts to be compromised when DO drops below 4 mg/l. The values obtained are typical of non-polluted mountain river water with cool temperature and turbulence which favour DO.

The pH values ranging from 7.43 to 8.25 in May and 7.8 to 8.19 in November, slightly alkaline, match perfectly with the permissible range of 6.5 to 8.5 defined by the National Environmental Commission Standards (NEC 2020) for ambient water.

The electro-conductivity (EC) of the water reflects the concentration of dissolved inorganic solids. Generally, the EC of natural water bodies is mainly controlled by the type of rock minerals through which they flow, but may also reflect, at higher concentrations, anthropogenic pollution. In the present study, the average EC of water samples in May and November were 79.91 ± 9.68 µS/cm and 139.58±0.11 mg/l, respectively, well compliant with NEC 2020 standard (EC<800 µS/cm). In November, EC is almost double from May values, explained by the higher quantities of material solubilized during the monsoon (run-off) increasing concentration in water when the flow decreases.

Total suspended solids in water represent the load of fine material (silt and clay) suspended in the water and transported by the flow. Turbidity is the optical expression of the TSS plus microscopic algae, which alters the transparency of water. The average TSS and turbidity values in water samples from May were 90 ± 65.49 mg/l and 40.64 ± 44.37 NTU, respectively. However, the maximum value observed is 220 mg/l (WS7) while minimum value is 20 mg/l (WS5). These erratic values are to correlate with storms which occurred in the catchment the days before sampling. The average value of TSS still complies with river water Class A (<100 mg/l) of NEC (2020) ambient water criteria. Class A quality refers to water devoid of any significant pollution outside some organic contamination from human and animal origine. In November, the average TSS and turbidity values of water samples were 9.00±9.94 mg/l and 10.58±4.63 NTU, respectively, high quality condition also well compliant with NEC Class A.

Coliforms are an indicator of organic/faecal contamination from human and animal origin. In May, the range was 0.0–8.0 CFU/100 mL, and in November, it was 0–8 CFU/100 ml. Contamination levels observed for a natural stream remain extremely low and fully compliant with Class A river (<50 CFU/100 ml).

Table 75 : Results from WQ sampling surveys: physical & microbiological parameters

Station	T	DO	pH	EC	TSS	Turbidity	Coliforms
Unit	°c	mg/L	NTU	µS/cm	mg/L		CFU/100 ml
PRE-MONSOON SURVEY (MAY 2023)							
WS1	18	8.89	8.04	90.25	50	19.05	2
WS2	26	7.67	8.25	62.85	40	1.62	5
WS3	18	9.12	8.12	81.68	180	20.6	3
WS4	18	8.79	8.06	81.89	110	28.1	1
WS5	18	8.97	7.43	82.03	20	38	1
WS6	17	9.32	7.92	65.21	110	51.9	2
WS7	18	9.53	7.85	73.85	220	161	8
WS8	18	9.1	7.92	83.14	60	20.1	0
WS9	18	9.16	7.85	88.35	40	35	4
WS10	18	8.61	7.68	89.86	70	31	1
Average	18.700	8.916	7.912	79.911	90.000	40.637	2.700
STDV	2.584	0.510	0.233	9.678	65.490	44.365	2.406
Maximum	26.000	9.530	8.250	90.250	220.000	161.000	8.000
Minimum	17.000	7.670	7.430	62.850	20.000	1.620	0.000
POST-MONSOON SURVEY (MAY 2023)							
WS1	14	10.19	7.80	156.3	30	8.15	5
WS2	17	9.02	8.07	17.96	20	0.65	0
WS3	15	9.70	8.19	145.4	10	16.29	1
WS4	15	9.80	8.12	171	10	13.42	1
WS5	15.5	9.92	8.09	151.25	0	12.10	0
WS6	16.5	9.98	8.04	149.2	0	15.98	2
WS7	17	9.96	7.98	148.25	10	11.29	0
WS8	18	9.53	8.06	146.45	0	11.94	0
WS9	18	9.60	8.06	143.6	0	8.19	0
WS10	18	9.74	7.94	166.35	10	7.79	0
Average	16.400	9.744	8.034	139.576	9.000	10.580	0.900
STDV	1.449	0.321	0.108	43.686	9.944	4.625	1.595
Maximum	18.000	10.190	8.190	171.000	30.000	16.290	5.000
Minimum	14.000	9.020	7.800	17.960	0.000	0.650	0.000

6.3.6.3 Results and discussions on water chemical parameters

Results from May and November surveys are provided in Figure 44 and Table 76**.**

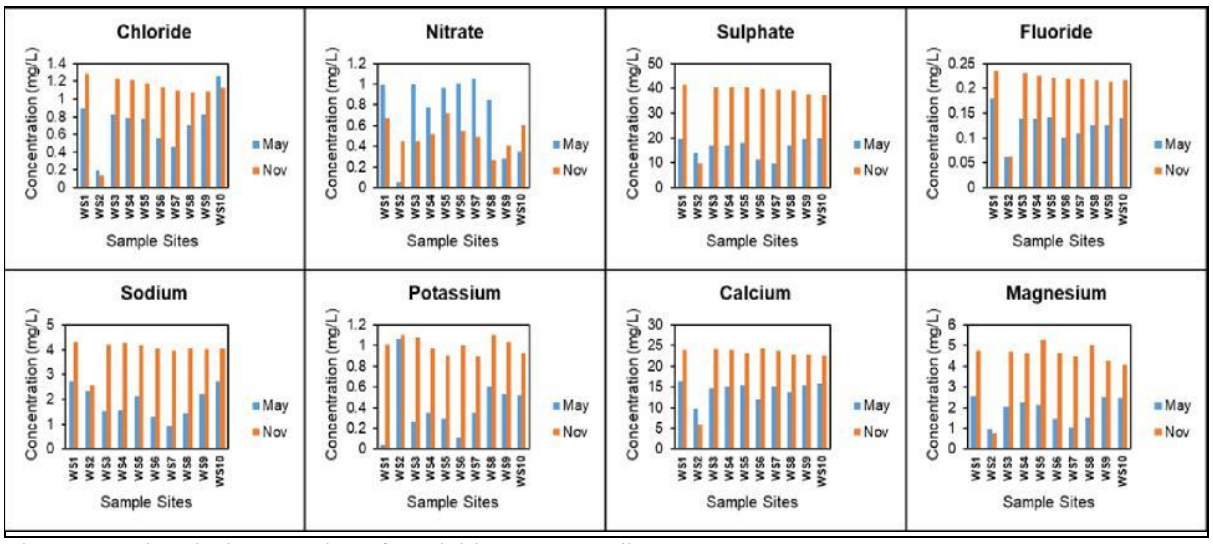


Figure 44: Chemical properties of Kurichhu water quality

Measured concentrations of chloride ions (Cl^-)in water samples were recorded at 0.73±0.28 mg/l and 1.06±0.33 mg/l for May and November, significantly lower than the national ambient water quality maximum allowable criteria for Class A, which is set at 50 mg/L (NEC 2020).

The average sulphate (SO_4^{2-}) concentration measured was 16.29±3.50 mg/l and 36.65±9.54 mg/l in May and November water samples, respectively. The SO_4^{2-} concentrations recorded were much higher in November suggesting increased concentrations due to reduced flow volume in post-monsoon season. The oxidative weathering of pyrites is one of the primary sources of sulphates in the higher Himalayan streams (Pandey, Singh, and Hasnain 1999). The concentrations of SO_4^{2-} in the study area were much lower than the permissible limits (SO_4^{2-}: 25 mg/l) of NECS criteria for ambient water quality (Class A) (NEC 2020).

The average concentrations of F^- measured in water samples in the present study were 0.13±0.03 mg/l and 0.21±0.05 mg/L in May and November, respectively. The F^- concentration in the water samples showed minimal spatial variability, however, it was slightly higher in November. The Fluoride concentrations measured were much lower than the NECS permissible criteria for ambient water quality for Class A (1 mg/L) (NEC 2020); and WHO recommended guideline value (1.5 mg/L) for drinking water (WHO 2017).

Sodium is an important cation which can, at high concentrations, affect the use of water for agriculture or as drinking purpose. The average Na^+ concentration in water samples measured in May was 1.89±0.3 mg/L and 3.97±0.50 mg/L in November. These values are low and fully compliant with WHO threshold of 200 mg/l from drinking water. Na^+ is not considered as a criterion for ambient water quality by NEC.

The average Potassium concentrations in water samples measured were 0.41±0.29 mg/l and 1.00±0.08 mg/l respectively in May and November. There was minimal variation in K+ concentrations across the sample sites. K^+ is not considered as a criterion for ambient water quality by NEC.

Water hardness serves as a consequential parameter in water quality assessment. While not inherently indicative of pollution, it plays a pivotal role in evaluating water suitability for domestic, drinking, agricultural, and industrial applications: water exceeding 200 mg/L in hardness may prompt scale deposition in treatment facilities, distribution systems, and building infrastructure, thereby influencing maintenance requirements. The average hardness values in water samples were recorded at 43.49±7.10 mg/l and 71.80±19.13 mg/l for May and November, respectively.

In May, the average values for Ca^{2+} and Mg^{2+} measured in the water samples are 14.29±2.01 mg/l and 1.90±0.60 mg/l, respectively (Table 76**)**. The average values for Ca^{2+} and Mg^{2+} measured in water samples in November are 21.72±5.61 mg/l and 4.26±1.28 mg/l. In the present study, Ca^{2+} and Mg^{2+} measured is considerably lower than the permissible limit of the ambient water quality criteria, class 'A', for Ca^{2+} and Mg^{2+}, which is 200 mg/l (NEC, 2020).

Table 76: Results from WQ sampling surveys: chemical parameters

Station	Cl^-	NO3	$SO4^{--}$	F^-	Na^+	$NH4^+$	K^+	Ca^+	Mg^{++}	TH
	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
PRE-MONSOON SURVEY (MAY 2023)										
WS1	0.89	0.996	19.42	0.18	2.732	0.162	0.039	16.326	2.563	51.32
WS2	0.195	0.055	13.909	0.061	2.344	0.109	1.067	9.728	0.947	28.19
WS3	0.822	1.002	16.986	0.139	1.526	0.102	0.262	14.705	2.047	45.15
WS4	0.789	0.77	17.119	0.139	1.57	0.095	0.353	15.005	2.242	46.70
WS5	0.782	0.962	17.95	0.142	2.113	0.151	0.291	15.317	2.135	47.04
WS6	0.559	1.005	11.451	0.101	1.314	0.091	0.108	11.953	1.452	35.83
WS7	0.457	1.056	9.666	0.109	0.929	0.105	0.352	15.005	1.052	41.80
WS8	0.705	0.846	17.119	0.127	1.426	0.09	0.605	13.747	1.542	40.68
WS9	0.819	0.278	19.422	0.127	2.221	0.123	0.533	15.426	2.508	48.85
WS10	1.255	0.347	19.893	0.14	2.737	0.158	0.52	15.699	2.459	49.33

Average	0.727	0.732	16.294	0.127	1.891	0.119	0.413	14.291	1.895	43.487
STDV	0.282	0.365	3.499	0.031	0.623	0.028	0.292	2.007	0.603	7.097
Maximum	1.255	1.056	19.893	0.180	2.737	0.162	1.067	16.326	2.563	51.320
Minimum	0.195	0.055	9.666	0.061	0.929	0.090	0.039	9.728	0.947	28.191
POST-MONSOON SURVEY (MAY 2023)										
WS1	1.282	0.677	41.538	0.235	4.3076	ND	1.011	23.986	4.737	79.40
WS2	0.143	0.448	9.740	0.063	2.584	ND	1.099	5.843	0.759	17.72
WS3	1.233	0.448	40.564	0.231	4.2202	ND	1.08	24.043	4.697	79.38
WS4	1.210	0.514	40.339	0.226	4.2616	ND	0.973	23.868	4.638	78.70
WS5	1.180	0.722	40.477	0.221	4.1653	ND	0.904	23.215	5.274	79.69
WS6	1.132	0.544	39.851	0.220	4.0555	ND	1.004	24.24	4.645	79.66
WS7	1.095	0.492	39.501	0.219	3.9539	ND	0.899	23.757	4.498	77.84
WS8	1.067	0.266	39.325	0.216	4.046	ND	1.104	22.839	5.017	77.69
WS9	1.088	0.411	37.729	0.213	4.0342	ND	1.037	22.745	4.277	74.41
WS10	1.123	0.607	37.411	0.216	4.0637	ND	0.926	22.701	4.084	73.50
Average	1.055	0.513	36.647	0.206	3.969	-	1.004	21.724	4.263	71.797
STDV	0.328	0.134	9.539	0.051	0.500	-	0.077	5.610	1.276	19.127
Maximum	1.282	0.722	41.538	0.235	4.308	-	1.104	24.240	5.274	79.686
Minimum	0.143	0.266	9.740	0.063	2.584	-	0.899	5.843	0.759	17.716

Conclusions

Water quality of the Kurichhu river in the DHPP area is of Class A quality, devoid of any significant pollution outside some organic contamination from human and animal origin. The results of analysis are compliant with NECS criteria applicable to Class A ambient water quality.

6.4 Sediment Quality and Transport

6.4.1 Sediment quality

Water quality monitoring performed under the present ESIA study involved two sampling campaigns, one pre-monsoon (May 2023) and one post-monsoon (November 2023). Sediment sampling was performed together with river water sampling along the river within the DHPP area in ten sampling stations: Two upstream of the reservoir area at Autsho (WS3) and Phawan (WS1), one in the Shungmanchu tributary stream (WS2) before its confluence at Autsho, upstream of the reservoir area, at the intake site (WS4) and dam site (WS5). Downstream dam stations comprise three stations in the future dewatered section (WS6, WS7, and WS8) and two downstream tailrace outflows (WS9 and WS10). Sampling stations are localised on Table 76 above.

Sediment Grain Size Analysis

The sediment samples collected in May exhibited an average prevalent composition of sand, constituting 74.03 ± 26.74%, followed by gravel at 13.18 ± 21.99% (Table 77). This grain size distribution was consistent across all sites, except for WS2, where the sediment exhibited a distinctive pattern, dominated by gravel (69.019%) and followed by sand (29.923%). Similarly, samples collected in November displayed a predominant sand composition of 68.31 ± 18.69%, accompanied by gravel at 18.38 ± 18.06% (Table 77**).** The uniformity in grain size distribution was observed across all sites, except for WS10, where the sediment's grain size was predominantly clay and silt (56.92%), followed by sand (41.54%).

Table 77: Sediment grain size distribution

Station	% Gravel		% Sand		% Clay & Silt	
	May	November	May	November	May	November
WS1	0.431	3.03	69.241	72.42	30.329	24.55
WS2	69.019	38.54	29.923	41.54	1.058	19.92
WS3	14.291	20.56	84.908	64.44	0.801	15.00
WS4	1.570	1.72	91.629	84.34	6.801	13.94
WS5	0.541	31.13	97.317	59.54	2.142	9.33
WS6	15.185	23.43	84.595	76.12	0.220	0.45
WS7	0.580	1.45	98.730	95.37	0.690	3.18
WS8	0.343	9.41	96.270	89.54	3.387	1.05
WS9	0.050	2.31	59.303	58.24	40.646	39.45
WS10	29.782	1.54	28.345	41.54	41.873	56.92
Average	13.18	13.31	74.03	68.31	12.79	18.38
STDV	21.99	14.00	26.79	18.69	17.49	18.06
Maximum	69.02	38.54	98.73	95.37	41.87	56.92
Minimum	0.05	1.45	28.34	41.54	0.22	0.45

Sediment Physicochemical Analysis

The average sediment pH of water for Dorjilung HPP sample sites is slightly alkaline (with 8.3719±0.168 SD).34 and 8.15±0.24 respectively in May and November, in full coherence with water pH.

The average sediment EC was 45.96±24.98 µS/cm and 79.63±32.88 µS/cm respectively in May and November, a pattern coherent with what was observed for water. The highest EC was record at WS 10 (143.90 µS/cm) in November and the lowest was recorded at WS2 (16.86 µS/cm) in May, quite regular values for non-saline and non-polluted sediments.

The average sediment redox potentials were measured at -88.30±22.61 mV in May and -85.40±19.59 mV in November. Negative values in sediment redox potential typically indicate the prevalence of reducing conditions, such as the reduction of compounds like iron or manganese, influencing the biogeochemical cycling of elements with potential effects on nutrient availability in aquatic ecosystems.

The Sediment Organic Carbon (SOC) and Total Organic Matter (TOM) content in sediment samples collected in May were respectively measured at 0.48±0.85% and 1.08±1.91%. Similarly, sediment samples from November exhibited an average OC of 0.35±0.32% and TOM of 0.79±0.73%. These values are quite low and can be explained by the granular texture of the sediment which cannot retain organic matter as observed in silty and clayey sediments.

Table 78: Sediment physical & chemical characteristics

Station	pH		EC (µS/cm)		Redox (mV)		SOC (%)		TOM (%)	
	May	Nov	May	Nov	May	Nov	May	Nov	May	Nov
WS1	8.43	8.13	43.78	97.57	-100	-94	0.03	0.27	0.07	0.62
WS2	8.18	7.92	16.86	38.98	-78	-62.5	1.54	0.35	3.44	0.79
WS3	8.68	8.43	34.56	75.98	-117	-107	0.07	0.75	0.16	1.67
WS4	8.37	8.43	36.52	52.2	-95	-86	0.03	0.24	0.07	0.53
WS5	8.11	8.19	58.51	70.45	-82	-93	0.29	0.08	0.65	0.18
WS6	8.24	8.16	34.19	39.67	-104	-89	0.06	0.04	0.14	0.09
WS7	8.2	8.14	31.96	97.74	-92	-90	0.07	0.12	0.16	0.26
WS8	8.05	8.25	45.89	107.8	-92	-96	0.02	0.04	0.05	0.09
WS9	8.24	8.265	47.73	72.01	-91	-96.5	0.20	0.86	0.44	1.93
WS10	7.35	7.6	109.6	143.9	-32	-40	2.53	0.78	5.67	1.76
Average	8.19	8.15	45.96	79.63	-88.3	-85.40	0.48	0.35	1.08	0.79
STDV	0.34	0.24	24.98	32.88	22.6	20	0.85	0.32	1.91	0.73
Maximum	8.68	8.43	109.60	143.90	-32.0	-40	2.53	0.86	5.67	1.93
Minimum	7.35	7.60	16.86	38.98	-117	-107	0.02	0.04	0.05	0.09

Conclusions

Sediments analysed from the Kurichhu river show sedimentary material mainly dominated by sand and gravel, with limited percentage of fine material. As a result, organic matter content is low, strongly reducing the organic pollution potential of the sediment. Sediment hardness was not measured, however total hardness of the water samples (see paragraph 6.3.6.3) does show values below the recommended limit. No specific measure is to be anticipated during construction for the management of such material, either for use or disposal.

6.4.2 Sediment Transport

6.4.2.1 Sediment data

A summary of observed sediment load is provided in Table 79**.** The yearly total suspended load varies from 3.18 MT to 18.37 MT.

Table 79: Summary of Total Sediment load

Year	Sediment Load (million tons)- Kurizampa	Sediment Volume-Kurizampa (MCM)	Sediment rate (mm/km2/year)
2000	15.50	11.069	1.23
2001	4.09	2.92	0.32
2002	5.19	3.70	0.41
2003	6.57	4.69	0.52
2004	11.81	8.43	0.94
2006	5.20	3.71	0.41
2007	5.66	4.04	0.45
2008	3.18	2.27	0.25
2009	18.37	13.12	1.46
2010	3.99	2.85	0.32
2011	4.28	3.054	0.34
2012	3.31	2.36	0.26
2013	3.14	2.240	0.25
Average	**6.95**	**4.96**	**0.55**

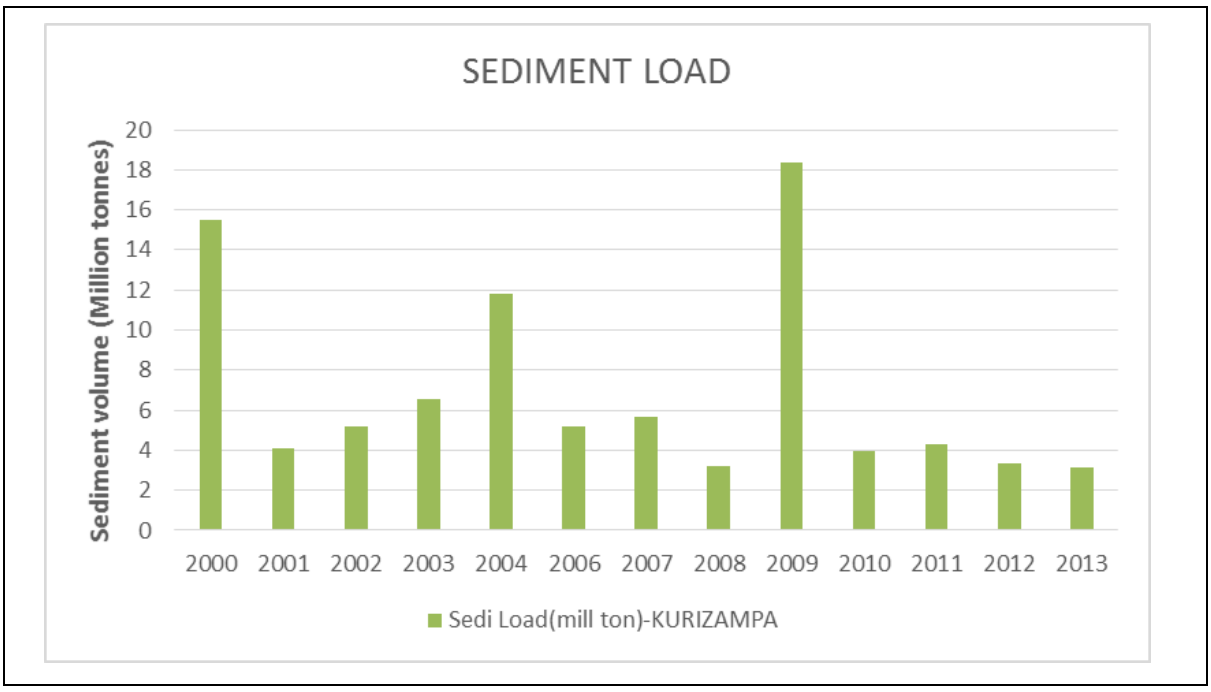


Figure 45: Plot of yearly total Suspended Load at Kurizampa

Source: DPR (2016)

Measured concentration of total suspended sediment varies from 0.35 to 6838 mg/l. The accumulated suspended sediment load is calculated by multiplying concentration of suspended sediment with measured discharge of that day and is depicted in Figure 46**.**

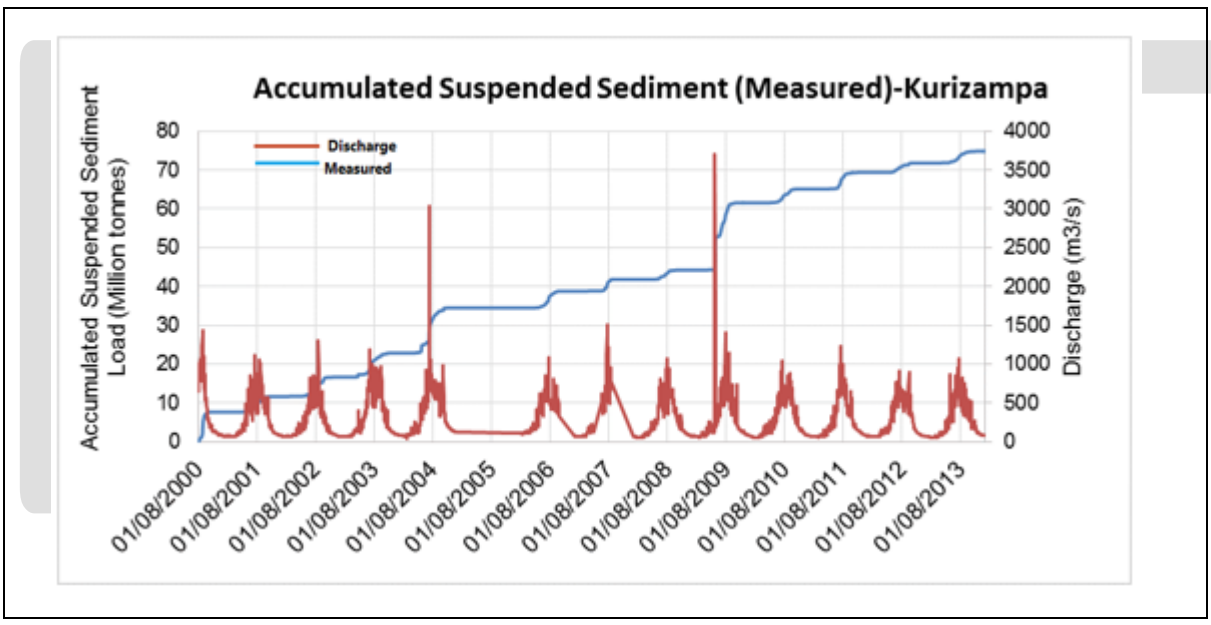


Figure 46: Accumulated suspended sediment transport from Kurizampa site, with discharge time series

Source: DPR (2016)

6.4.2.2 Bed load

For the present project at Dorjilung HPP, the Hydrology report of the DPR (2016) assumed a likely bed load of around 30%. However, after site visits by DHI professionals, it was noticed that the bed load considered in the DPR is higher. According to Turowski et al. (2010), Ref./11/., the percentage of bed load for gravel bed river generally varies from 5 to 15%. Hence, in accordance with the site visit observation as well as Ref /11/, it has been proposed to consider a bed load of 15% for the numerical simulation of the project.

6.4.2.3 Sediment transport in the reservoir

The reservoir sedimentation numerical modelling study was done using DHI's propriety software MIKE 11 and MIKE 21 C. MIKE 11 was used for 1D (one dimensional) study, whereas MIKE 21 C was used for 2D (two dimensional) study.

1D Modelling

The baseline analysis of the 1D model reveals that sediment transport remains insignificant near the intake for several decades. The transport of 0.2 mm diameter particles demonstrates varying concentrations within specific ranges based on discharge levels. Moreover, the reservoir's performance indicates its potential to function as a desilting basin, with substantial sediment settlement and a noticeable maximum velocity after an extended period of simulation.

The impact of flushing on particle sediment larger than 0.2 mm (such as coarse sand, gravel, and cobble) is relatively limited. The overall volume of sediment deposition remains consistent across scenarios, although with slight variations in distribution. This results in an evenly spread deposition pattern, slightly lower bed

levels upstream, and a prolonged progression of the sediment deposit's front within the reservoir. The effective range of flushing extends approximately 2500 m upstream from the dam axis. By applying the drawdown criteria, it becomes evident that for up to 50 years, the reservoir remains relatively free from sediment deposition for drawdown levels up to MDDL within about 700 m upstream of the dam axis.

Without flushing the reservoir attained its equilibrium condition in around 50 years and with flushing from FRL to MDDL the same is around 70 years whereas with flushing up to CL, it will take substantially more than 70 years i.e., around 90 years to attain equilibrium**.** the gross storage capacity at FRL would be lost by around 50% after 25 years with drawdown flushing to MDDL and by around 40% with drawdown up to CL whereas without flushing the gross storage capacity would be lost by around 60%. The loss of gross storage capacity at FRL without flushing, with flushing up to MDDL and up to CL after 50 years would be around 94%, 70% and 60% respectively. Thus, it is proved that drawdown up to CL would be more effective.

ZD 2D Model-MIKE 21 C

The 2D model analysis, velocity patterns were investigated for varying upstream discharges, indicating that velocities in the reservoir ranged from 0.05 to 0.25 m/s for discharges of 500 m^3/s, 800 m^3/s, and 1400 m^3/s. The intake area, located approximately 2 km upstream of the dam, exhibited velocities of 0.02 - 0.2 m/s and 0.05 - 0.3 m/s for inflows of 500 m^3/s and 800 m^3/s, respectively. Bed shear stress distributions showed values generally below 0.03 N/m^2 in the main reservoir area for 500 m^3/s, rising to 0.007 - 0.045 N/m^2 within 1 km upstream of the dam for 800 m^3/s, and 0.1 - 0.2 N/m2 for 1400 m^3/s. The critical shear stress of approximately 0.05 N/m^2 for 800 m^3/s indicated potential sediment deposition for particles larger than 0.2 mm.

Sediment transport simulations visualized the spatial variation of suspended sediment concentration. By utilizing sediment rating curves, concentrations for various particle sizes were determined. For an 800 m^3/s discharge, concentrations of 450 g/m^3 for smaller particles (<0.075 mm) and 375 g/m^3 for 0.2 mm particles were employed. The analysis of daily time series confirmed that peak discharges remained within the range of around 1400 m^3/s. To gauge the maximum safe discharge for the reservoir's desilting functionality, simulations considered a maximum discharge of 2500 m^3/s.

The findings revealed that the reservoir could function as a desilting basin for approximately 40 years with a concentration near the intake below 15 PPM for a maximum flow of around 1 400 m^3/s. However, beyond 50 years of operation, the maximum safe discharge dropped to approximately 800 m^3/s. Given the consistent yearly maximum discharge of around 1 400 m^3/s observed at the dam site in Autsho, it was determined that after roughly 50 years post-commissioning, the reservoir's desilting capabilities would diminish for discharges exceeding 800 m^3/s. After analysing both the results as described above, the safe discharge for reservoir acting like a desilting basin after different periods of reservoir operation are given in Table 80 and plotted in Figure 47**.**

Table 80: Safe Discharge for Reservoir Acting as Desilting Basin

Sl. No	Years after commissioning	Safe discharge (m^3/s)	Available water volume below MDDL (MCM)	Inflow Concentration (PPM) of Particle size of 0.2mm
1	0	2200-2400	31	3337-4028
2	10	2000-2200	24	2716-3337
3	20	1800-2000	19.5	2163-2716
4	30	1600-1800	16.2	1677-2163
5	40	1300-1500	13.2	1071-1459
6	50	800-900	9.9	484-1071

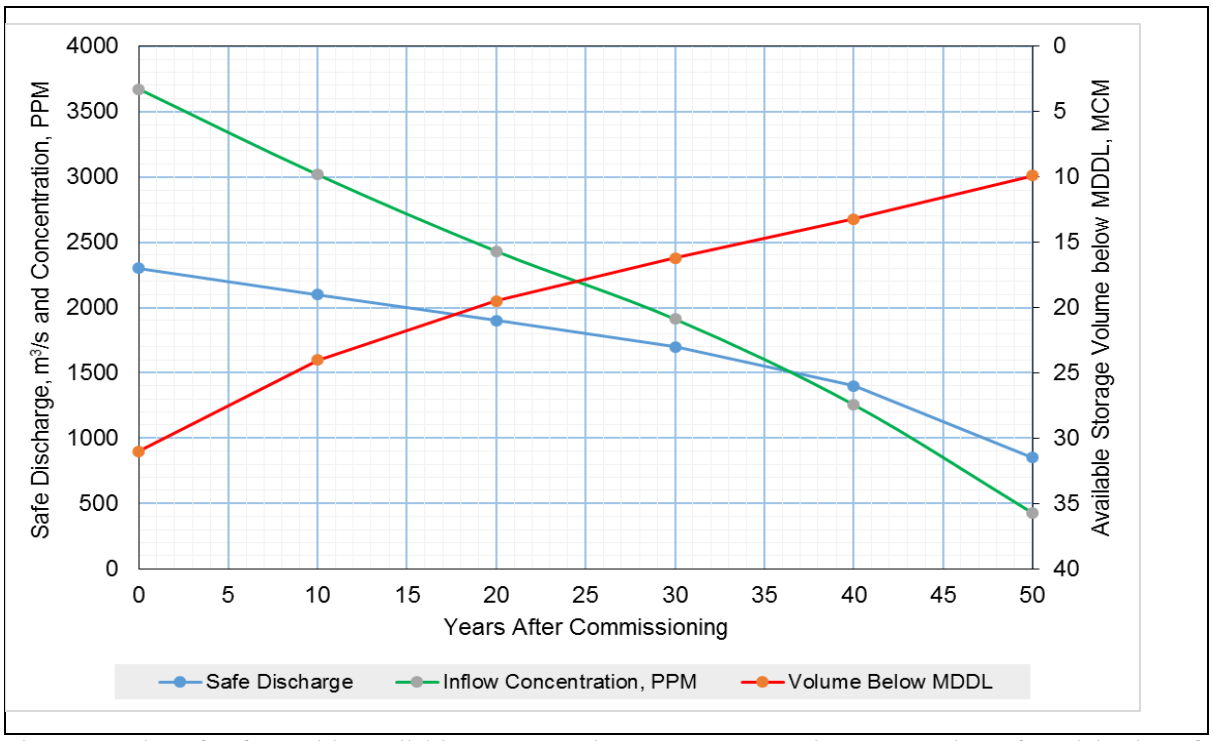


Figure 47: Plot of Safe Q with Available Storage Volume at MDDL and Concentration of Particle Size of 0.2mm at Reservoir Tip after different periods of reservoir operation

6.4.2.4 Sediment Transport

The standalone Eflow Assessment includes a qualitative assessment of the sediment transport. Key section has been duplicated here for the ESIA, but for further information the reader should consult the standalone Eflow assessment.

Water quality parameters downstream of the dam will be influenced by both the water quality of the outflow from the reservoir and modifications of hydraulics and hydro sedimentary processes occurring in the river water downstream.

6.4.2.4.1 By-Passed Reach

In principle, the water quality downstream of a dam depends on the water quality in the reservoir and on the depth of the water intake. However, the Dorjilung reservoir is expected to have a very fast turnover with daily peaking, and no stratification is expected. Additionally, the low-level opening (LLO) will be permanently open during the warm monsoon period for flushing the sediment, renewing the water in the dead volume.

During the construction phase, sediment load changes from excavation and river works can cause soil erosion of spoil heaps and other areas. Rainwater or flowing water can then mobilize this soil, suspending sediment particles in the water and transporting them downstream. This transport occurs during rain events, or natural runoff. Increased downstream sediment transport can lead to accumulation in the river.

6.4.2.4.2 Hydropeaking

During a hydropeaking event and sudden rise of the water level downstream of the dam, the risk concerning water quality is that the flow remobilizes sediments laying on the banks. This reactivation of sediments would have an impact on the water quality downstream, with potentially significant consequences for aquatic ecosystems.

The abrupt and substantial fluctuations in water flow during hydropeaking can disturb the riverbed, contributing to higher turbidity levels in the water. Since the hydropeaking occurs in the evening, fine particles are unlikely to be bound into a biofilm by micro-algae. This heightened suspension of sediment particles negatively impacts water clarity, but this is expected to abate shortly after the monsoon and would therefore follow the seasonal turbidity pattern. Additionally, the risk of lateral erosion of terraces in the valley of sub-reach 4 introduces the possibility of additional sediment entering the water. This erosion, in the most inhabited area of the whole project footprint, may introduce pollutants from the land into the water, but this remains a very minor concern. Reoxygenation at the discharge point of water that travelled down the valley in the tunnel is likely to be sufficient.

Thus, the resulting effects of hydropeaking on water quality are unlikely to have any serious repercussions on aquatic ecosystems.

6.5 Air Quality and Noise

Due to the low population density in the project area, without industries and extended forest cover, air quality is good. Particulate matter from wood burning and traffic on unsealed roads is the main source of concern. Air pollution sources are mainly related to exhaust gas from engines.

Available air quality information comes from the previous ESIA (2016). To update the available information, an air and noise survey has been organized in 5 locations in the project area in May and November 2023**.** Figure 48 show the sample site location.

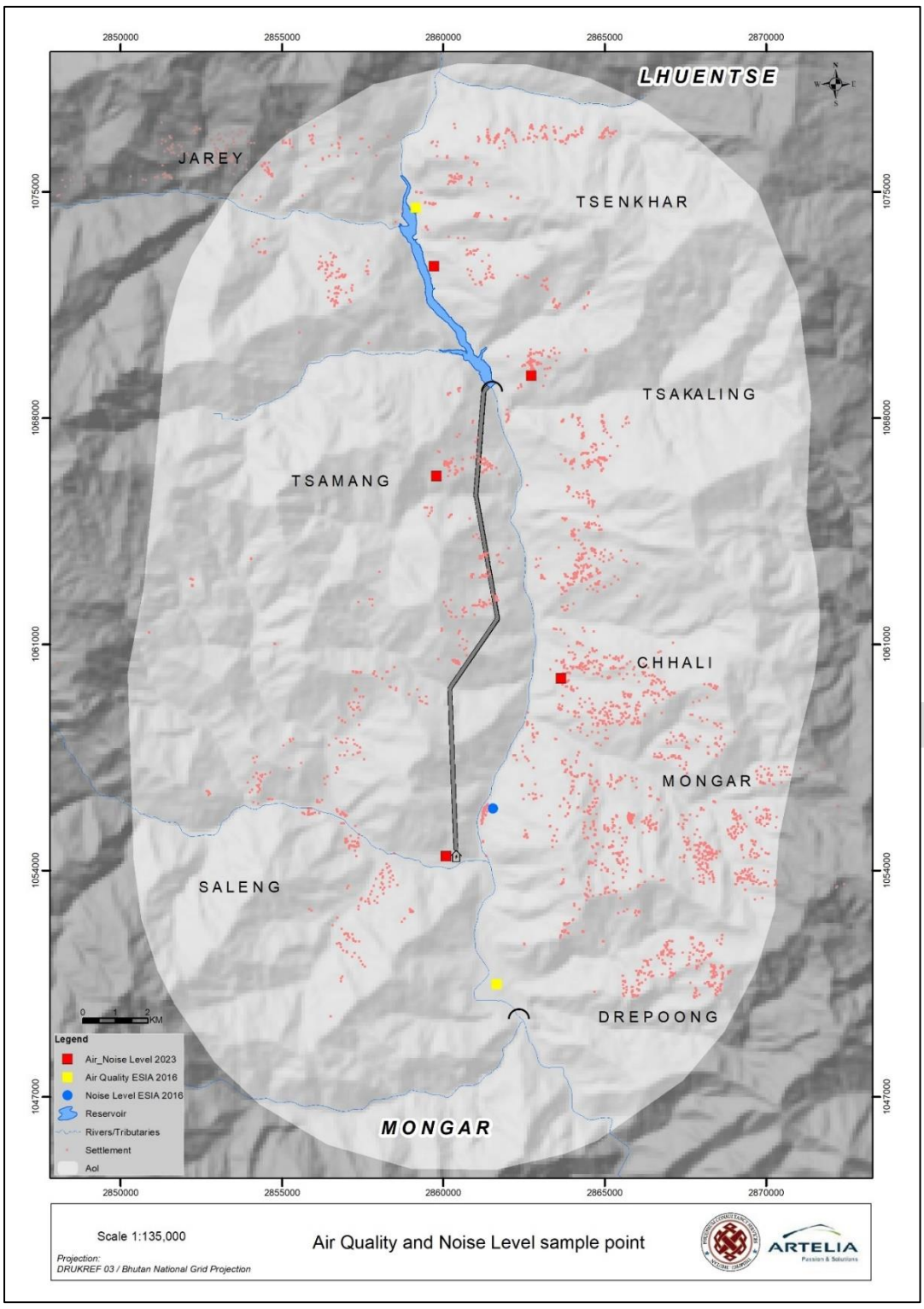


Figure 48: Sample site for air and noise survey (2023)

6.5.1 Existing air quality data

Data from ESIA (2016) are provided in the following table.

Table 81: Ambient air quality during the pre-project (2016) stage provided for four seasons

Weather	Project Sites	Coordinates of the Location	Parameter (Pre-project quality) Air (µg/m³)			
			RSPM/ PM10	Coarse SPM/>PM10	Total SPM	Air Temp. (°C)
Winter						
Sunny	Upstream of Dam Site (Autsho)	27°26'31.48"N 91°10'26.84"E	67.51	96.11	163.62	19.00
Partly Cloudy	Powerhouse Site	27°13'29.51"N 91°11'49.94"E	40.14	27.09	67.23	22.00
Autumn						

Sunny	Upstream of Dam Site (Autsho)	27°26'31.48"N 91°10'26.84"E	13.59	21.52	35.11	20.00
Sunny	Powerhouse Site	27°13'29.51"N 91°11'49.94"E	32.79	2.98	35.77	26.00
Spring						
Cloudy	Upstream of Dam Site (Autsho)	27°26'31.48"N 91°10'26.84"E	56.06	30.43	86.49	20.00
Sunny	Powerhouse Site	27°13'29.51"N 91°11'49.94"E	42.56	55.51	98.07	23.00
Summer						
Partly Sunny	Upstream of Dam Site (Autsho)	27°26'31.48"N 91°10'26.84"E	8.44	34.4	42.83	24.00
Sunny	Powerhouse Site	27°13'29.51"N 91°11'49.94"E	18.23	27.86	46.09	27.00

Source: ESLA (2016)

6.5.2 Air quality survey

In 2023 the air quality survey involved a 24-hour air sampling using (i) TS BlueSky sensor for sampling PM2.5 and (ii) S318 multi gas detector for sampling SO_2, NO_2 and CO. $PM_{2.5}$ sensor was fixed in suitable sites and was kept there for 24 hours. For SO_2, NO_2 and CO, data was manually recorded every five minutes keeping an interval of 2 hours. Representative data were collected from 8 AM till 6 PM. The table below presents results from the air quality monitoring of 2023.

Table 82: Results of air quality survey (2023)

Location	SO2 (µg/m3)	NO2 (µg/m3)	CO (µg/m3)	PM2.5 (µg/m3)
May 2023				
Banjar	0.03±0.05 –	0.19±0.49-	0.07±0.41 –	7.50±0.50 –
	0.42±0.38	0.26±0.40	2.61±2.27	17.75±0.50
Lingmithang	0.16±0.09 –	0.26±0.64 –	0.40±1.02 –	10.08±0.40 –
	0.37±0.28	0.28±0.41	3.02±4.05	18.0±1.26
Chali	0.26±0.16 –	0.02±0.08 –	0.15±0.59 –	13.0±0.40 –
	1.07±0.72	0.60±1.42	3.09±2.57	22.4±1.30
Takambi	0.16±0.10 –	0.13±0.33 –	0.06±0.38 –	4.0±0.00 –
	0.44±0.38	0.21±0.53	0.61±1.83	28.75±0.58
Namdruling	0.05±0.07 –	0.08±0.31 –	ND	3.5±0.58 –
	0.24±0.12	0.17±0.47	0.14±0.50	23.5±6.54
November 2023				
Banjar	ND	0.14±0.19-	ND	4.00±0.20-
	0.03±0.05	0.23±0.29	ND	10.58±1.45
Lingmithang	0.08±0.09-	0.08±0.16-	0.32±0.36-	3.00±0.77-
	0.23±0.11	0.30±0.37	0.46±0.65	13.75±3.23
Chali	0.03±0.06-	0.25±0.38-	0.12±0.49-	4.24±0.54-
	0.23±0.11	0.42±0.62	0.51±0.66	7.75±0.49
Takambi	0.01±0.02-	0.23±0.28-	ND	2.31±0.21-
	0.06±0.05	0.35±0.37	0.01±0.35	4.44±0.27
Namdruling	0.01±0.02-	0.17±0.19-	ND	7.13±0.34-
	0.09±0.07	0.32±0.57	ND	12.25±0.86

The result shows that the concentration of SO_2, NO_2 and CO are way below the air quality guidelines of World Health Organization (WHO) and National Environment Commission (NEC). The WHO guideline for SO_2, and NO_2 are 40 µg/m^3 and 25 µg/m3 respectively for 24-hour average, and for CO it is 4 mg/m3 for 24-hour average. NEC guidelines for SO_2, and NO_2 are 80 µg/m^3 respectively and for CO it is 2,000 µg/m3 for 8-hour average. Values during post-monsoon survey are slightly lower than those observed in May, a possible effect of the monsoon period.

The WHO guideline for $PM_{2.5}$ is 15 µg/m^3 for 24-hour average and NEC guidelines for $PM_{2.5}$ is 60 µg/m^3 for 24-hour average. The concentration of $PM_{2.5}$ in two sites is slightly higher than the WHO guidelines but much lower than NEC guidelines.

As a conclusion, the air quality of the project area is excellent, as expected.

6.5.3 Noise monitoring

Daytime noise level was measured in May and in November using EN300 Environmental Meter. Results of measurements are provided in the following table.

Table 83: Results from noise survey (2023)

Location	Noise Level (dB)	
	May 2023	November 2023
Banjar	37.6	36.14
Lingmithang	53.6	46.15
Chali	37.4	35.54
Takambi	41.7	35.01
Namdruling	43.3	39.79

The recorded noise levels consistently remain below the National Environmental Commission's (NEC) recommended guideline of 65 decibels (dB) and compliant with the World Bank Group General Environmental, Health and Safety Guidelines (55 dB for daytime noise level in residential areas). This unequivocally demonstrates that, at present, the noise levels at these study sites pose no discernible threat to human receptors.

6.6 Natural Hazards

About 70% of the country's land area (38,394 square kilometres) is under forest cover. Even though Bhutan is a net sequester of greenhouse gases (GHG), the effects of climate change and variability are becoming increasingly visible. Precarious geographical location and effects of climate variability and change have highly exposed Bhutan to a diversity of hazards, including cyclone induced storms, flash/floods, landslides, earthquakes, Glacial Lake Outburst Floods (GLOF) and droughts. Heavy seasonal monsoon rains and glacial melt are the most common cause of flooding and landslides in Bhutan. Over 70% of settlements including infrastructures and fertile agricultural lands are located along the main drainage basins, hence posing threats from flooding (Tshencho Dorji 2019).

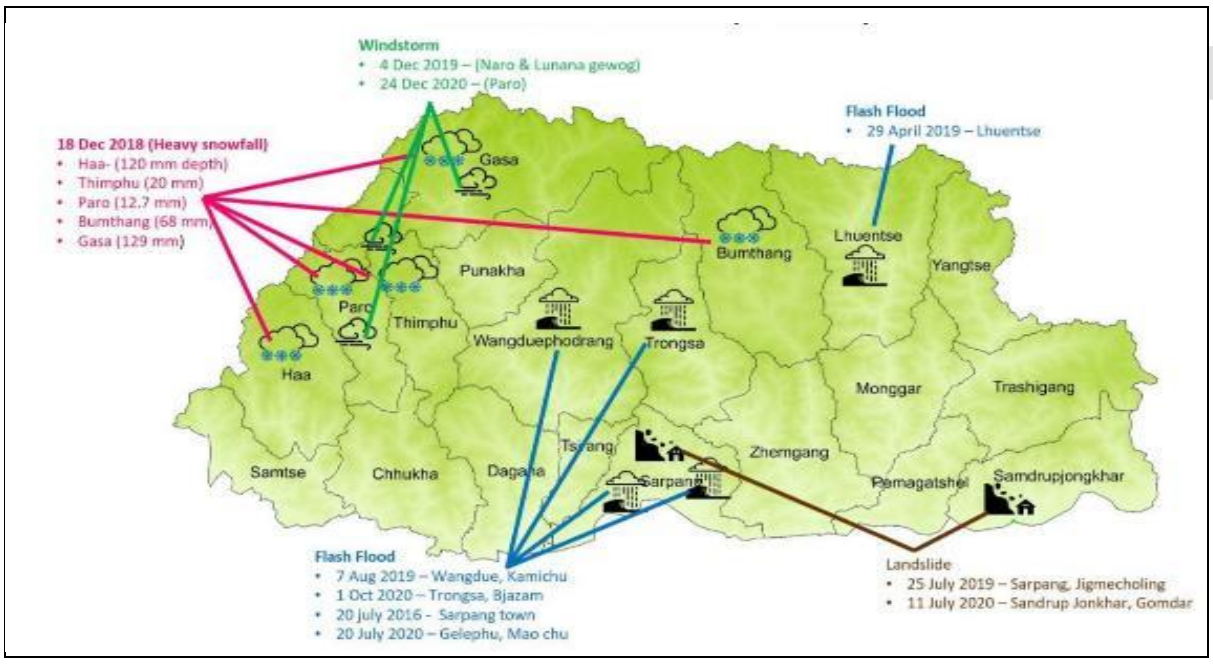


Figure 49: Weather events in Bhutan (2016-2020)

Source: (Bhutan s.d.)

6.6.1 Landslides

The global dataset of landslide hazards in the 2004–2016 period showed that almost 75% of the world's fatal landslides occurred in the Himalayan region (Froude, M. J. and Petley, D. N.: Global fatal landslide occurrence from 2004 to 2016, 2018.). Bhutan is no exception to this and is a part of one of the world's highly landslide-prone regions in the world. The damage caused by landslides in this country has led to casualties and loss of land, affecting people's livelihoods and disrupting the transportation network, which is key to the country's economy. Most of the landslides in the Bhutan Himalayas are triggered by rainfall, especially during the monsoon period (Yoshihiko KARIYA 2011).

Bhutan has 667 glaciers, 2674 glacial lakes of which 24 are flagged as potentially dangerous. Eastern and Southern foot hill belts are characterized by fractured steep terrain and soil cover on slopes provide ready bed for rain-induced landslides (SAARC 2010). The table below presents the number of landslides occurrence in Mongar and Lhuentse (Namgyal 2022).

Table 84: History of Landslides in Mongar and Lhuentse

Year	Location	Cause	Impacts
Mongar			
2017	Kengkhar, Jurmey, Narang, Drameste, Thangrong, Balam in Mongar	Landslides	Not specified
Lhuentse			
2003, 2010, 2012, 2014, 2016, 2015, 2016, 2017, 2018, 2019	Not specified	Landslides	Damage to Dzongkhag Road, Farm Road, irrigation channel, private land & crops and Infrastructure

Potential Landslide areas

The project area exhibits a certain degree of sensitivity to landslides due to the presence of existing landslide occurrences. There are seven existing landslides in the project area, most located closer to Kurichhu drainage. The two major ones are Dorjilung and the one on right bank, about 01 km downstream of Dorjilung (seven landslides estimated to cover about 23 acres (9.31ha)). The figure below present major landslide areas and shows location coordinates.

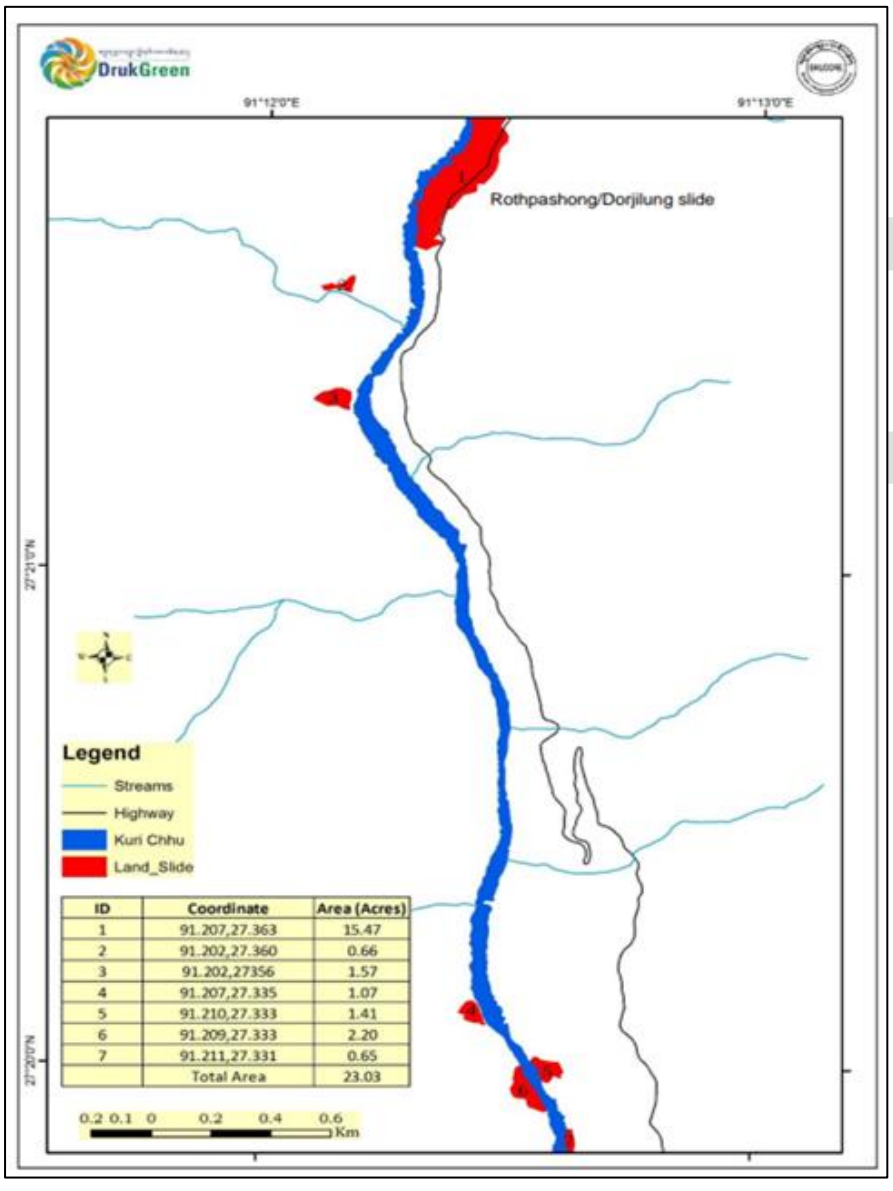


Figure 50: Areas prone to landslide

Source: DPR, 2016

6.6.2 Floods

The climate change-induced unpredictable rainfall patterns and sudden heavy monsoon rainfalls have led to an increase in the occurrence of flash floods in some of the river catchments in Bhutan. Over the years, the southern region of Bhutan has witnessed frequent flash floods and landslides due to intense and sudden heavy rainfall. These extreme weather events have caused significant damage to properties, highways, agricultural lands, irrigation channels, and water supply schemes. The frequency of floods has been on the rise since 1999, with some of the most severe floods occurring in 2000, 2004, 2009, and 2016 (Namgyal 2022).

Table 85: History of past floods in Mongar and Lhuentse

Year	Affected area	Cause	Impact
Mongar			

Year	Affected area	Cause	Impact
July 1996	Mongar-Lhuentse highway and Mongar town	Flood due to heavy rains	Washed away of the drinking water supply in Mongar town and damage to Mongar-Lhuentse highway
July 2000	Trashigang-Mongar highway	Flood due to heavy rains	Stretches of the road have been washed away
August 2000	Kengkhar, Saleng, Ngatshang, Thrangrong, Drametse and Balang gewogs	Flood due to heavy rains	Two persons from Kengkhar gewog were killed besides 15 houses that were destroyed (Five of the houses destroyed were in Kengkhar, one in Saleng, two in Ngatshang, three in Thangrong, two in Dram-etse and two in Balang)
September 2000	Thangrong and Chaskar gewogs Mongar-Lhuentse highway and Autsho	Flood due to heavy rains	The floor and walls of the Thangrong BHU building and the staff quarters of the Chaskhar BHU was damaged
July 2003	Rotpashong on the Mongar-Lhuentse highway Tsatichhu lake near Autsho, Lhuentse	Flood due to heavy rains	600m of the road at Rotpashong was washed away at the chronic landslide zone. At Autsho, the Tsatichhu lake had breached and 21shopkeepers had to be evacuated to a safer place. Loss of 4.12 acres (1.67ha) of wetland in Lhuentse
May 2009	Kurichhu hydro project Rotpashong on the Mongar-Lhuentse highway Sengor and Thrumsengla	Deposit of debris due to the heavy rainfall in the dam. Flood and landslides due to heavy rains	The Kurichhu hydro project has shut down two of its four turbines after A massive landslide in Rotpashong on the Mongar-Lhuentse highway and two others in Sengor and Thrumsengla have cut off Mongar from both Thimphu and Lhuentse. Yadi-Mongar and Mongar-Ura highways blocked. RNR centre in Mongar is covered in landslide and flood.
Lhuentse			
1995, 2004, 2005, 2006, 2011, 2014, 2016, 2018,2019,	Not specified	Flood	Damaged crops and farmland, roads& bridges, 2 people and 6 cattle lost their lives
2015, 2016, 2017, 2019	Not specified	Flash flood	Damaged farmland belonging to 45 Households, and several vehicles

The impacts of climate change are expected to intensify the monsoon rainfall in the future, leading to an increased risk of floods in certain areas. The National Integrated Water Resources Management Plan (NIWRMP) has investigated areas prone to monsoon floods using Geographic Information System (GIS) technology. The results from the investigation, depicted in the figure **below**, highlight the areas that are at higher risk of floods in terms of surface area in hectares. Upon assessment, the Dorjilung HPP project site has been identified as being situated in an area isolated from zones prone to floods during the monsoon season. This conclusion underscores the project's lower sensibility to significant flood-related risks.

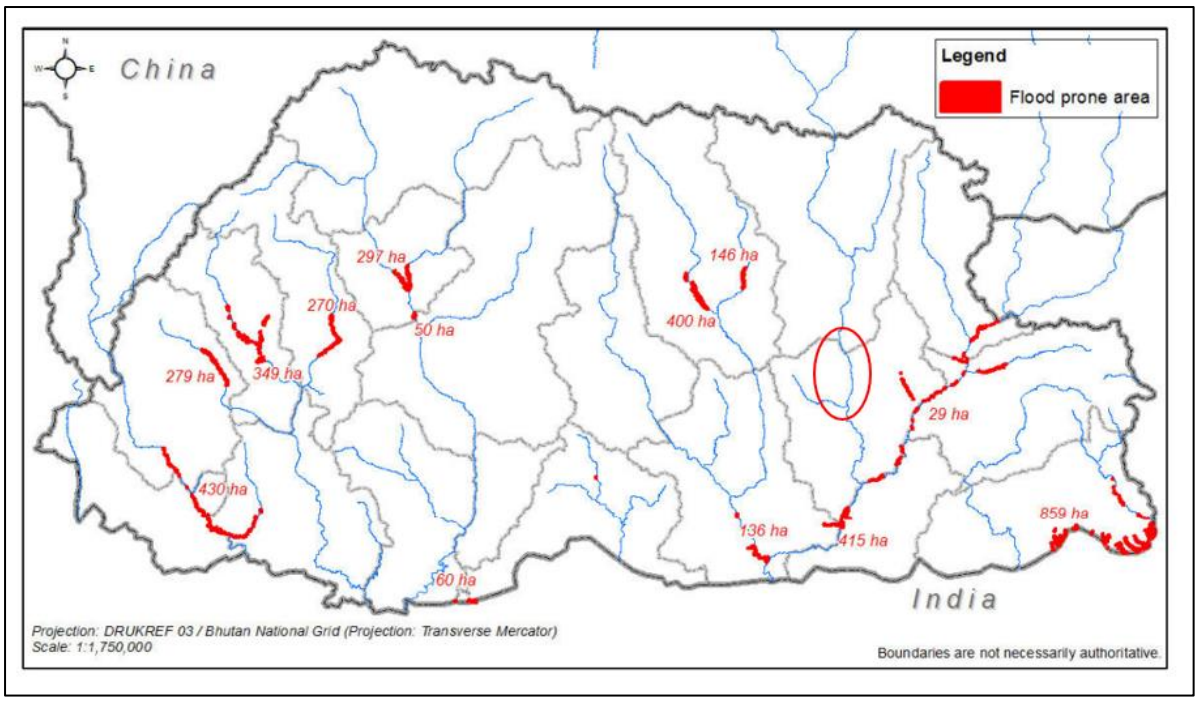


Figure 51: Map of areas prone to monsoon flooding

Source: (Muhammad Atiq 2021) - Red oval show the project area.

6.6.3 GLOF

The risk of Glacial Lake Outburst Floods (GLOFs) has also increased due to climate change, which has accelerated the melting of glaciers in the Himalayan region. However, it's worth noting that the Dorjilung HPP is not located in an area prone to GLOFs, according to the figures below showing regions at risk of GLOFs due to heavy rainfall.

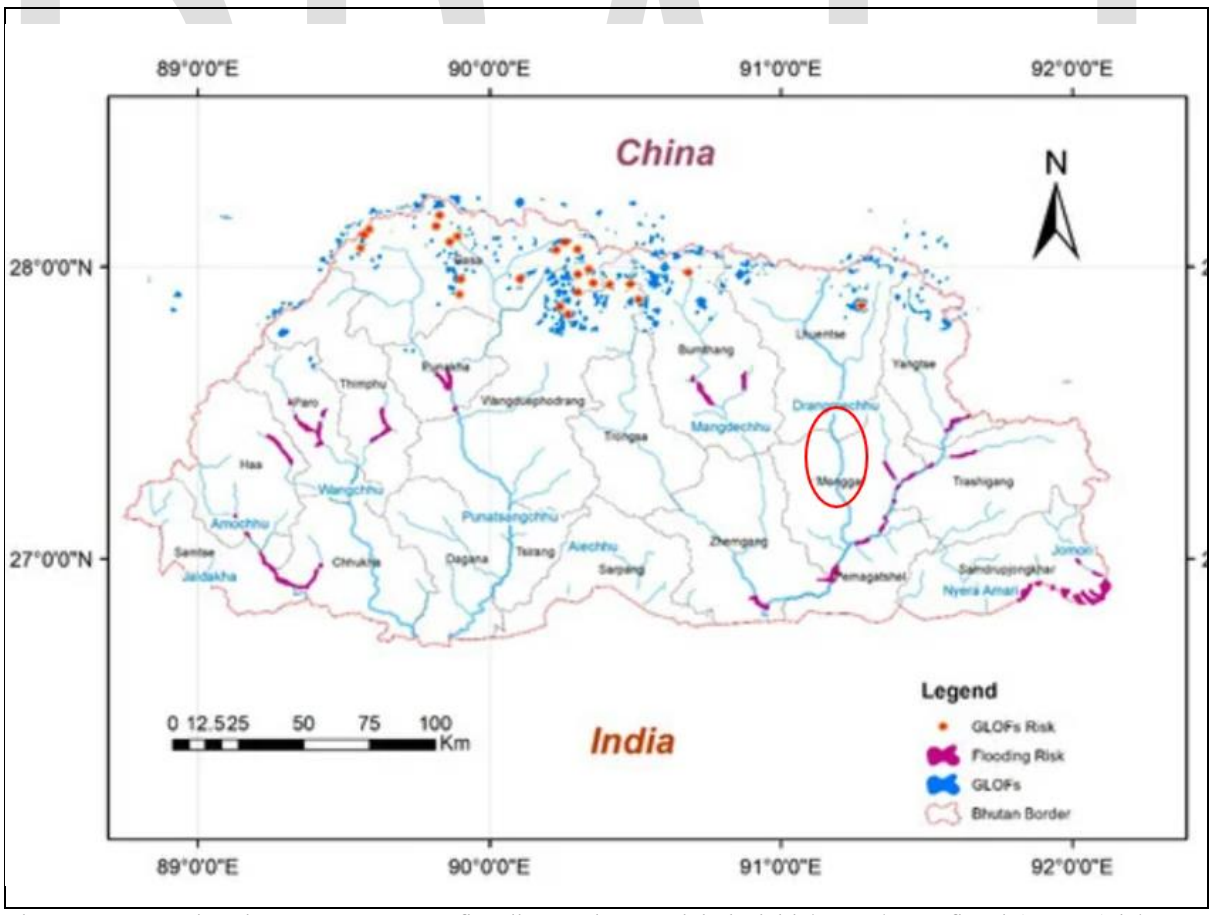


Figure 52: Map showing areas prone to flooding and potential glacial lake outburst flood (GLOF) lakes

Source: (Muhammad Atiq 2021) - Red oval show the project area.

The GLOF study conducted by Energy Infratech Private Limited India for DGPC had a primary goal of investigating and comprehending the glacial lake outburst phenomenon in the vicinity of the Dorjilung Hydropower Project (HPP) in Bhutan. The study aimed to achieve several key objectives, one of which was to identify the most critical GLOF scenario specific to the Dorjilung HPP site. This involved considering various factors that could potentially influence the magnitude and impact of a GLOF event.

To assess and simulate potential GLOF scenarios, the study utilized dam break models and hydrodynamic channel routing. These models helped to create simulations of different GLOF scenarios, including the generation of GLOF hydrographs at the project site. By doing so, the study could better understand the potential risks and impacts associated with glacial lake outburst floods in the Dorjilung HPP area.

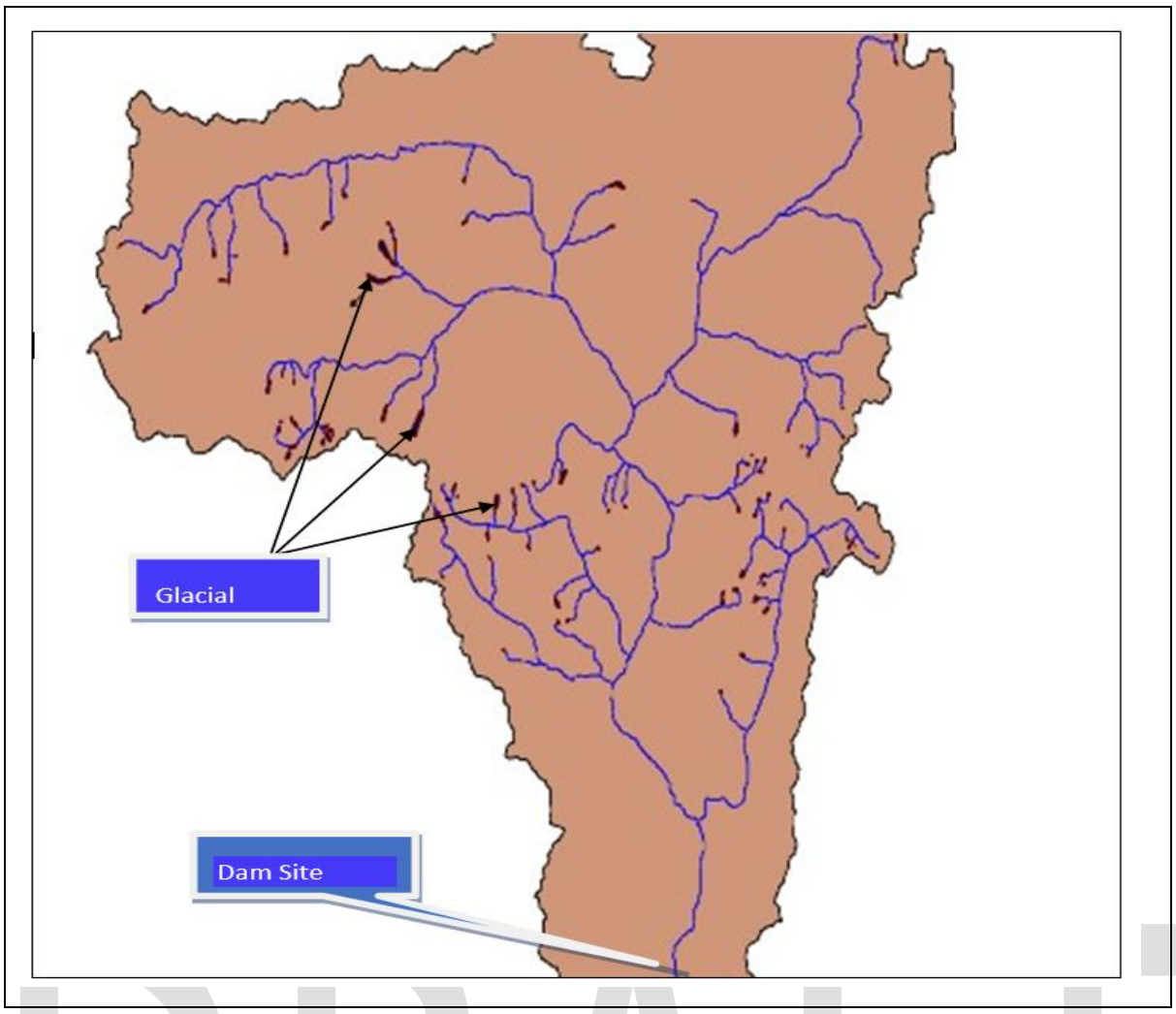


Figure 53: Dorjilung catchment model with identified glacial lakes

Source: DPR, 2016

The study revealed that the Kuri basin contained a total of 109 glacial lakes with a combined area of 20.30 km². Out of these, 17 lakes covering an area of 12.1 km² were identified as critical due to their size and geomorphologic characteristics. The study identified three types of glacial lakes in the region:

- Lakes Glacial Erosion,
- Glacial Cirque Lakes, and
- Moraine-Dammed Lakes.

Moraine dammed glacial lakes, which are still in contact or very near to the glaciers, are usually dangerous. Danger of GLOF and whether dams can withstand GLOF is included in the Dam Break Analysis carried out using HEC RAS method. It concluded that dam at the Dorjilung HPP site was assessed to be capable of withstanding potential GLOFs, providing important insights for ensuring the safety and stability of the hydropower project in the region. Hence the sensibility of the project to GLOF is low.

6.6.4 Fire

There are two types of fire, structural, that causes damage to infrastructure and forest fires. According to the National Biodiversity Strategy and Action Plan (NSB 2014) forest fire is the major factor causing habitat degradation and loss of forest cover, degrading wildlife habitat and loss of ecosystem. On average 48 fires occur annually across the country between 2009-2014, destroying 47,501 acres (19,223ha) of forest land. Over the years, while the incidence of fires has reduced, the area damaged has increased. The total loss in forest area was 8710 acres (3525ha) (40 incidents) of which 5 were in Mongar and 1 in Lhuentse. The loss in 2021 was 10374 acres (4198ha) (45 incidents) with 5 incidents in Mongar and 2 in Lhuentse (DOFPS, 2019,2021. Forest Facts and Figures).

Fires occur mostly during dry months (November to May) and spread fast due to the huge volume of fuel-load on the ground and strong wind. Ladder fuel (branches) and crown density (crown closure) combine with fuel-load to create fire risk. The rugged terrain and limited capacity and resources make it difficult to control fires efficiently and fast. Considering the historical fire events in the project area, the project's sensibility to fire outbreaks is rated as moderate. The table below presents the past five events in Mongar and Lhuentse (Namgyal 2022).

Table 86: Historic fire event in Mongar and Lhuentse

Year	Location	Cause	Impacts
Mongar			
2016	Chaskhar Gumdari, Thangrong, Kengkhar, Jurmey, Drameste, Mongar	Forest fire	Destruction to animals, plants, water structures

Year	Location	Cause	Impacts
	Konbar etc in Mongar		
Lhuentse			
2010, 2013, 2014, 2016, 2017, 2018, 2019	Not specified	Structural fire	12 Households affected and lost one live.
2000, 2011, 2014, 2015, 2016, 2017, 2018, 2019	Not specified	Forest fire	Damaged 1049 acres (425ha) of vegetation, 1 Lhakhang and its Kitchen
October 2021	Menbi gewog, Lhuentse	Forest fire	damaged more than 500 acres (202ha) of forest, mostly Chirpine trees and lemon grasses
March 2022	Maenbi gewog, Lhuentse	Forest fire	damaged more than 200 acres (81ha) of forest, mostly Chirpine trees and lemon grasses

6.6.5 Other Natural hazards

The table presents highlights instances of natural disasters in the regions of Mongar and Lhuentse. In Mongar in the year 2017, areas including Kengkhar, Thangrong, and Jurmey experienced drought, although the specific impacts were not specified. In Lhuentse, a recurring issue was windstorms affecting the area in multiple years, namely 2013, 2015, 2017, 2018, and 2019. These windstorms had a notable impact on the region, **with 129 households affected on each occasion** (Namgyal 2022).

Table 87: Historical past events of other natural hazards in Mongar and Lhuentse

Year	Affected area	Cause	Impact
Mongar			
2017	Kengkhar, Thangrong, Jurmey	Drought	Not specified
Lhuentse			
2013, 2015, 2017, 2018, 2019,	Not specified	windstorm	129 Households affected

6.7 Seismicity

6.7.1 Seismicity in Bhutan

Asia Pacific and South Asia are among the most seismically active regions globally. Bhutan spans the Himalaya, from the low-lying Brahmaputra Plain to the high Tibetan Plateau. The Main Himalayan Thrust (MHT), which covers the entire length of the Himalayan Arc, underlies most of Bhutan. Interseismic loading is mainly released by major earthquakes, as the amount of permanent aseismic deformation has been shown to be low. A recent study has shown that like the rest of the Himalayan arc, Bhutan has significant micro seismicity (Diehl et al., 2017) and is affected by large earthquakes. The country is exposed to earthquakes and has experienced twelve earthquakes, many magnitudes 7.0 in the last half century including a 2009 earthquake that generated $97 million in losses and needs (Stevens 2020).

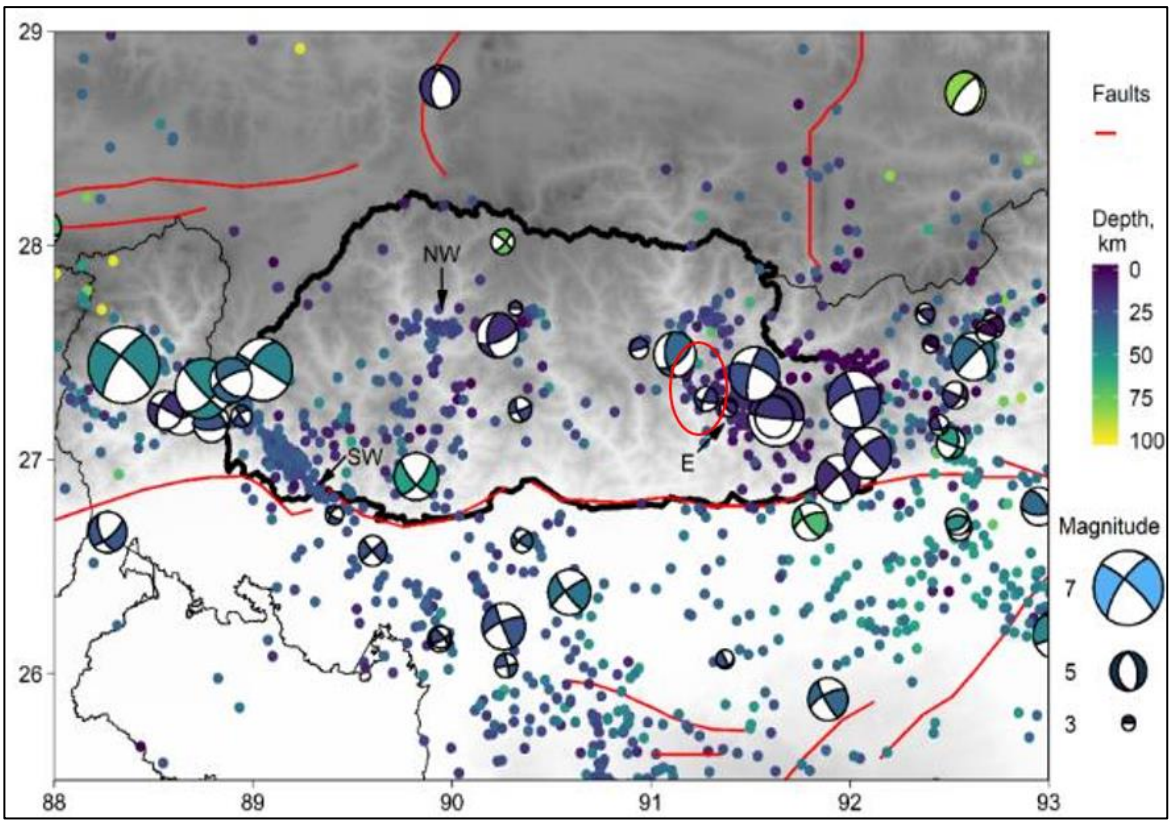


Figure 54: Geological setting of Bhutan (borders in thick line)

Source: (Stevens 2020); Earthquakes and focal mechanisms from the 116 GANSSER (Diehl et al. 2017), the CMT and ANSS catalogues. E = Eastern earthquake cluster, NW = 117 Northwestern earthquake cluster, SW = Southwestern earthquake cluster. Faults from Styron, Taylor and 118 Okoronkwo, 2010. Background shading shows elevation. Red oval shows the project area.

6.7.2 Earthquake Records

Bhutan is situated in a highly seismically active region known for experiencing earthquakes of moderate to high intensity. Several significant earthquakes with magnitudes greater than 7, including the Shillong Earthquake (1897, magnitude 8.7) and the great Assam earthquake (1950, magnitude 8.5), have occurred in the nearby north-eastern region. Additionally, the area has experienced other earthquakes of substantial magnitude, such as the Srimangal earthquake (1918, magnitude 7.6), Dubri earthquake (1930, magnitude 7.1), and Bihar-Nepal border earthquake (1934, magnitude 8.3).

Based on the records kept at the Department of Disaster Management (DoDM), MoHCA 2015, the specific project area has not encountered any significant earthquakes to date. The historical seismic activity in the region has not affected the project area, indicating a low to non-existent seismic sensitivity at this location.

According to the seismotectonic map of the Geological Survey of India (GSI), the project region has also witnessed earthquakes with magnitudes ranging from M4 to M6, occurring at shallow depths. In the eastern part of Bhutan, the maximum intensity experienced is +VIII on the Modified Mercalli (M.M) scale. The earthquake records obtained from DoDM in June 2015 are provided below in the table below.

Table 88: Bhutan's earthquake records as of May 2015

Date	Epicentre	Magnitude (Richter scale)	Impact
1897	Shillong Plateau	8.7	Destroyed Dzongs: Punakha, Lingshi, Wangdue, and Tashichodzong
1906	Bhutan China Border	6.5	No Report
1910	North of Punakha	5.7	No Report
1934	Bihar-Nepal Border	8.3	No Report
1941	West of Trashigang Bhutan-India Border	6.75	No Report
1947	Arunachal Pradesh - China Border	7.9	No Report
1950	Indo China Border	8.6	No Report
1954	China-Bhutan Border	6.4	
1960	Near Tsirang	6.5	
1980	Near Sikkim	6.3	Cracks reported in Thimphu, Phuntsholing, Gelephu, Samdrup Jongkhar, Trashigang. Phuntsholing-Thimphu Road blocked due to earthquake induced landslides
1988	Udaypur Ghari, Nepal	6.8	Landslides reported
2003	Gunitsawa	5.5	Paro landslide and minor cracks in some buildings in Thimphu
2006	Aurnachal Pradesh	5	Felt in Trashigang and neighbouring region
2006	East Sikkim	5.7	No damages reported in Bhutan
2006	Near Dewathang	5.8 and 5.5	126 houses in 9 Gewogs under Trashigang reported damage and cracks on Dzong walls
21/09/09	Narang Mongar	6.1	12 dead, 4950 Houses damaged, 117 schools, over 800 culture buildings, 29 RNR Office and 26 Gup's Office damaged. Loss of Nu. 2501 million
31/12/09	Border of Sakteng Gewog	5.6	2 minor injuries in Drametse, Mongar. Damages to homes and properties that were affected by the 21 Sept 2009 quake and most collapsed
18/09/11	Greater Sikkim	6.1	Affected Haa, Paro, Samtse, and Chukha. One dead sues to landslide, and 14 injured, 6,977 rural houses, 36 schools, 22 hospitals, 286 heritage sites, 27 RNR centers damaged. Estimated cost Nu. 1,197.63 million
25/04/15	80km northwest of Kathmandu, Nepal	7.8	Severe tremor felt in Bhutan but on official report on damages
12/05/15	Near Kathmandu	7.4	A school at Lunana was damaged while severe tremor was felt all over Bhutan

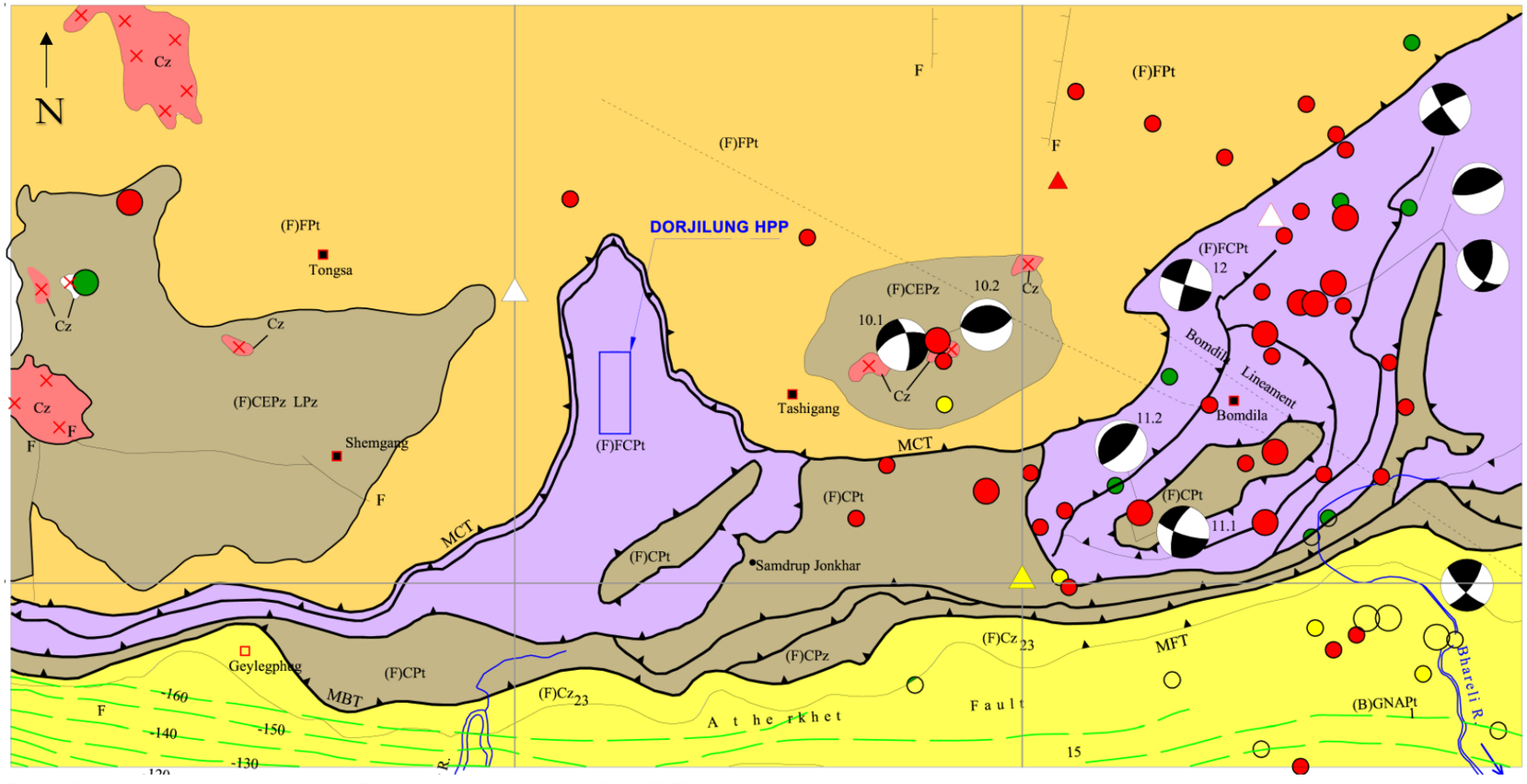


Figure 55: Seismotectonic map of the Project area (reproduced from DPR, 2016)

LEGEND

TECTONIC FRAMEWORK

Peninsular Shield

BASEMENT

(B)GN — Unclassified Gneissic Complex

PLATFORM COVER

(C)IS — Shelf facies cover in intracratonic sag

(C)E — Epiric sea / marginal overlap cover

(ef) (es) — Alluvial fill a. along foredeep b. Superposed basin

Extra Peninsular Belt

(F) F — Crystalline complex overprinted by Himalayan fold - thrust movement

(F) FC — Older folded cover sequence overprinted by Himalayan fold -thrust movement

(F) C — Older cover sequence folded during Himalayan fold - thrust movement

(F) — Cover rocks of frontal belt affected by fold -thrust movement during terminal phase of Himalayan orogeny

Accretionary Prism

MAGMATISM

a .Carbonatite
b. Mafic Pluton

a .Post tectonic granitoid
b. Pre to syntectonic granitoid

Basic Volcanics

STRUCTURAL SYMBOLS

a. Neotectonic Fault b.Fault involving cover
b. Subsurface Fault

Thrust

Gravity Fault

Shear zone

Minor Lineament

a. Antiform b. Synform

STRESS FIELD

Focal Mechanism Solution a. Normal
b. Thrust c. Strikeslip

Azimuth of insitu stress (well breakout)

OTHER FEATURES

Bouguer Gravity Anomaly contour in m Gal

Basement depth in km

DATA PERIDO 1964 - 193		
Magnitude (M) / Depth (km)	4.0 - 4.9	5.0 - 5.9
Not Determined		
0 - 40	●	●
41 - 70	●	●
71 - 150	●	

DATA PERIOD 19.1-1963				
Magnitude (M_L) / Depth (km)	4.0 - 4.9	5.0 - 5.9	6.0 - 6.9	≥ 7.0
Not Determined	△	△	△	△
0 - 40	▲	▲		▲
41 - 70		▲		
71 - 150			▲	
> 150			▲	

DATA PERIOD HISTORIC - 1900				
Magnitude (M)	Not Determined	5.0 - 5.9	6.0 - 6.9	7.0 - 7.9
Intensity (I Max) / Depth (km)	V	VI-VII	VII-IX	X-XI
Not Determined				□

7 THE BIOLOGICAL ENVIRONMENT

This section presents the ecological context of the project area. It is carried out with the objective of following the analysis and description guidelines necessary for donors to base their financing decision. The World Bank's analysis and description framework is taken as reference here (ESS6 concerning biodiversity component). This framework is itself linked to those proposed by the IUCN and the IFC. For example, the definitions of natural and modified habitats, the classification of threatened species, the criteria defining the limited distribution or endemicity and the notions of migratory species and congregation species are similar. However, significant differences exist between those frameworks and the ESS6, evet if they are based on similar criteria, especially the definition of critical habitats, the notion of Area of Analysis (AoA) and the priority given to national red lists rather than the global red list.

The section is organized as follows:

- Biogeographic context. This section presents the habitats of the project area based on land cover mapping and classifies natural and modified habitats.
- Protected and classified areas and species. This section, focusing on national regulations, maps the classified areas of Bhutan on the one hand and establishes the list of protected species on the other. This section identifies and presents the areas classified in the project's zone of influence. This section is completed by ESIA Volume 3 Appendix K - Phrumsengla National Park and Corridor #7, and various appendixes of the ESIA Volume 3 Appendix B Terrestrial Biodiversity Field Survey Report.
- Species of hight biodiversity value referenced in the IBAT (Integrated Biodiversity Assessment Tool). IBAT is a database developed by the Alliance Partners composed of IUCN (International Union for Conservation of Nature), BIRDLIFE, CI (Conservation International), UNEP (United Nation Environmental Program) and WCMC (UNEP/World Conservation Monitoring Centre). IBAT is backed by leading lenders to enable rapid screening of species and sensitive areas across the globe.
- Field survey of the terrestrial fauna and flora and Field survey of the aquatic flora and fauna. These two main sections present the field results with a focus on sensitives species occurring in the main natural and modified habitats in the project area. This survey mobilized a land and aquatic team of a total of 10 people on average over a total duration of 20 days for the aquatic team (excluding laboratory time and data processing) and 30 days for the land team with a focus on plants, mammals, birds, amphibians, and reptiles (excluding data processing time). The location of the sensitives species is also presented. This section is completed by the ESIA Volume 3 Appendix A Aquatic Biology Field Survey Report and the ESIA Volume 3 Appendix B Terrestrial Biodiversity Field Survey Report.
- The last section presents the process and results of the Critical Habitat Assessment (CHA). CHA is based on the framework of the ESS6 of the Biodiversity conservation & Sustainable management of living natural resources (WB, 2017) and the Guidance for Critical Habitat Assessment (Draft, 2023 provided by the WB). This section presents the Area of Analysis (AoA), the CHA screening and the critical habitats (CH) evidence. This section is completed by the ESIA Volume 3 Appendix L Biodiversity Assessment by CHQ Species and Other Emblematic Species.

7.1 Biogeographic context

7.1.1 Land cover

There are three eco-floristic zones in the country: the alpine zone, the temperate zone and the subtropical zone (between 150 m and 2,000m).

- The alpine zone includes alpine meadows and scrub areas above 4000masl. This zone is mainly dominated by Rhododendron scrubs, Juniper and medicinal plants and herbs such as *Aconitum, Gentiana*, Nardostachys, Delphinium, Rhodiola, Meconopsis, Osnoma, Dactylorhiza, Ophiocordyceps

sinensis, Picrorhiza and Fritillaria. Fauna typically found in these areas include Snow leopard, Lynx, Blue sheep, Himalayan marmot, Tibetan wolf, Takin and Musk deer.

- The temperate zone extends from 2000 to 4000m elevation and mostly includes Fir Forest, Mixed Conifers, Blue pine and Broadleaf mixed with confider forest at lower altitudes. Fauna typically found in this zone includes Goral, Serow, Black bear, Grey Langur, Red Panda, Assamese macaque, Leopard, Tiger, Golden cat and Clouded leopard.
- The subtropical zone extends from 150 m to 2,000m elevation with precipitation of 2,500-5,000mm. This includes the dense jungles along the foothills of the country and along riverbanks. Some of the characteristic species include Gmelina arborea, Chukrasia tabularis, Acrocarpus fraxinifolius, Ailanthus grandis, Bombax ceiba, Duabanga grandiflora, Shorea robusta, Pterospermum acerifolium, Aquilaria agallocha, etc (Forest Resources Management Division FRMD, DOFPS,2022. Forest Types of Bhutan, Maps and Statistics). Fauna typically found in this zone includes Water buffalo, Golden langur, Sambar, Tiger, Golden cat, Clouded leopard, Capped langur and Gaur.

According to the Department of Forest and Park Services (DoFPS), there are 11 types of forest following an elevation gradient (Table 89). The Project area largely falls in broadleaf and Chirpine forest.

Table 89: Forest cover in Mongar and Lhuentse Dzongkhags

Forest type	Mongar		Lhuentse	
	Area	Percentage	Area	Percentage
Subtropical Forest	4,245.56	2.20	0.00	0
Warm Broadleaved Forest	53,284.83	27.68	5,840.03	2.06
Chirpine Forest	18,017.64	9.36	6,385.89	2.26
Cool Broadleaved Forest	46,939.96	24.28	56,975.49	20.13
Evergreen Oak Forest	23,266.08	12.08	32,540.31	11.49
Blue Pine Forest	2,557.33	1.33	7,260.21	2.56
Spruce Forest	494.07	0.26	1,956.61	0.69
Hemlock Forest	12,539.80	6.51	15,972.17	5.64
Fir Forest	13.713.40	7.12	45,811.39	16.18
Juniper Rhododendron Scrub	532.83	0.28	10,795.00	3.81
Dry Alpine Scrub	61.20	0.03	11,360.35	4.01

Source: FRMD, DOFPS,2022. Forest Types of Bhutan, Maps and Statistics

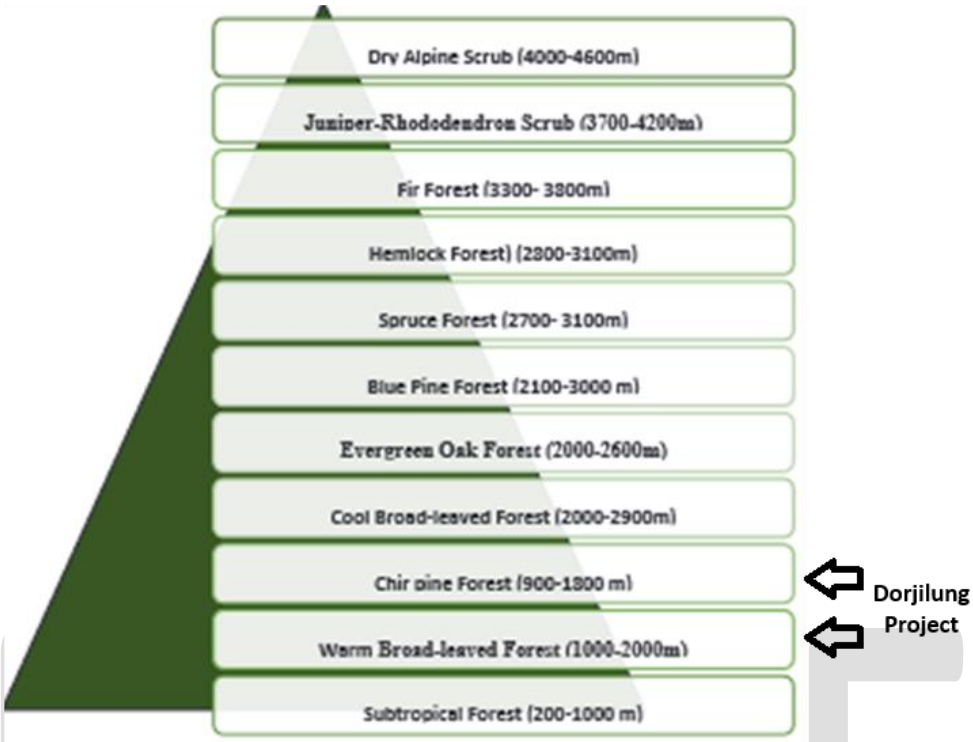


Figure 56: Types of forest as per the elevational gradient

Source, DOFPS, 2019. Forest facts and figures

The Land Use and Land Cover of Bhutan (LULC; Forest Resources Management Division, 2016), describes 13 types of land classes in the country including:

- **Forest:** Land with trees spanning more than 1.23 acres with trees higher than 5 meters and a canopy cover of more than 10 percent. It does not include land that is predominantly under agricultural or urban land use (National Forest Policy of Bhutan, 2011). This includes:

o Blue Pine Forest - Pure or dominant stands of blue pine, between 1500 m and 3200 m asl.
o Chirpine Forest - Pure stands of Chirpine, between 700m and 2000 m asl in relatively dry areas.
o Mixed Conifer Forest - Mixed stands of spruce, hemlock, juniper, fir, larch, taxus and blue pine, between 2500m and 3500 m asl
o Fir Forest - Largely pure stands of fir or few stands of other species such as junipers, taxus and larch occurring above 3000masl.
o Broadleaf Forest - Dominantly broadleaf trees below 3000 m asl

- **Alpine scrub** – predominantly includes dwarf rhododendrons and junipers at elevations above 3500 m asl.
- **Shrubs:** Areas with persistent and woody stem with height less than 5 meters. It also includes abandoned agricultural fields with overgrown bushes and other regeneration in disturbed areas
- **Meadows:** More common at higher elevations. These areas are dominated by grasses or any herbaceous plant without or with few scattered trees or shrubs on it.
- Cultivated land
- Built-up areas
- Non-built-up areas
- Water bodies
- Snow and glaciers
- Moraines

- Scree
- Landslide
- Rocky outcrops

The coverage of the various updated land cover subclass within the project area of influence (5 km radius) is provided in the tables and figures below. The current national land cover classification does not include riparian forests.

Table 90: Vegetation subclass land cover in Mongar Dzongkhag

Sl.No.	Land Cover Sub Class	Area (ha) in Dzongkhag	Area (ha) in 5km Radius	% Coverage in 5km radius
1	Broadleaf	131209.55	11265.05	8.59
2	Built up	256.20	88.86	34.68
3	Chhuzhing	690.62	302.17	43.75
4	Chirpine	26334.80	7140.12	27.11
5	Kamzhing	5858.28	1107.47	18.90
6	Landslides	364.32	8.51	2.34
7	Meadows	735.03	3.5	0.48
8	Non Builtup	7.86	1.7	21.62
9	Orchards	10.02	8.88	88.67
10	Rivers	893.87	238.21	26.65
11	Shrubs	7797.20	1174.04	15.06
	TOTAL	174157.75	21338.51	12.25

Table 91: Vegetation subclass land cover in Lhuentse Dzongkhag

SN	Land Cover Sub Class	Area (Ha) in Dzongkhag	Area (Ha) in 5km Radius	% Coverage in 5km radius
1	Broadleaf	112022.02	708.917	0.63
2	Builtup	162.29	9.262	5.71
3	Chhuzhing	1736.53	4.63	0.27
4	Chirpine	7871.83	583.85	7.42
5	Kamzhing	1981.14	72.44	3.66
6	Landslides	103.99	9.64	9.27
7	Meadows	3245.66	13.34	0.41
8	Rivers	597.82	21.3	3.56
9	Shrubs	26464.62	98.33	0.37
	TOTAL	**154185.91**	**1521.71**	**31.30**

7.1.2 Natural habitats and modified habitats

The table and map below show the updated land use area by subclass within a 10 km radius of the Kurichhu river (AoI), from the upstream part of the reservoir to the downstream discharge point.

Table 92: Land cover subclass in the AoA

Habitat type	Subclass	Area (Ha)	Area (Acres)	Area (%)	Area (Ha)	Area (Acres)	Area (%)
Natural habitats	Riparian forest	359.8	889.2	0.48	70 743.8	174 811.6	93.41
	Broadleaf	49 862.4	123 212.5	65.84			
	Chirpine	15 563.6	38 458.6	20.55			
	Fir	15.7	38.9	0.02			
	Mixed conifer	1 470.0	3 632.5	1.94			
	Shrubs	2 717.5	6 715.0	3.59			

Habitat type	Subclass	Area (Ha)	Area (Acres)	Area (%)	Area (Ha)	Area (Acres)	Area (%)
	Rivers	526.0	1 299.9	0.69			
	Meadows	127.5	315.0	0.17			
	Landslides	101.2	250.1	0.13			
Modified habitats	Chhuzhing	537.6	1 328.5	0.71	4 988.4	12 326.5	6.59
	Kamzhing	2 777.5	6 863.3	3.67			
	Orchards	7.2	17.9	0.01			
	Non-Built up	4.9	12.2	0.01			
	Built up	162.2	400.9	0.21			
	Road and track with buffer	1 498.8	3 703.7	1.98			
Total		75 732.19	187 138.14	100.00	75 732.19	187 138.14	100.00

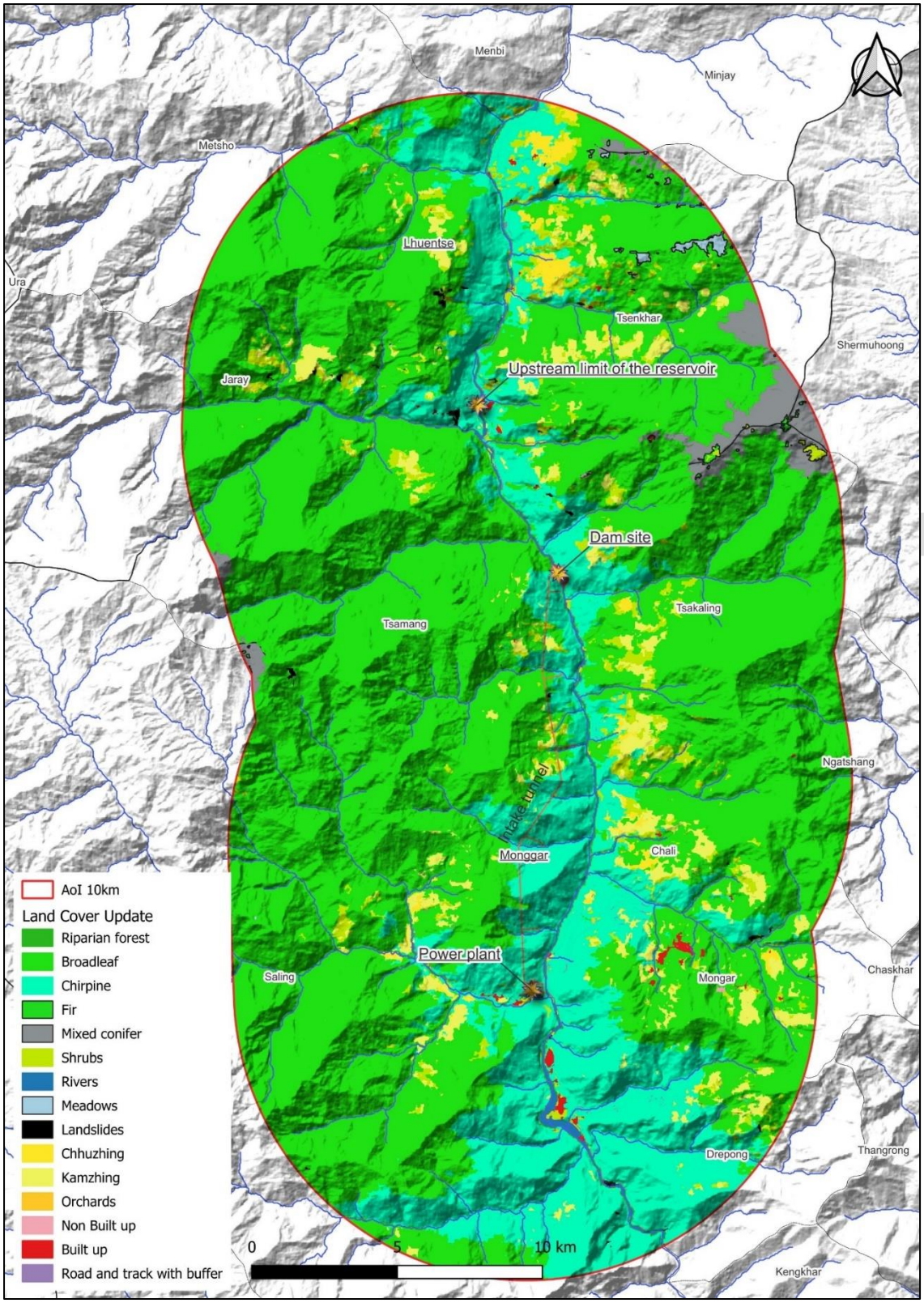


Figure 57: Vegetation subclass and cover in the area of analysis

Source: Land Use Land Cover (LULC); Forest Resources Management Division

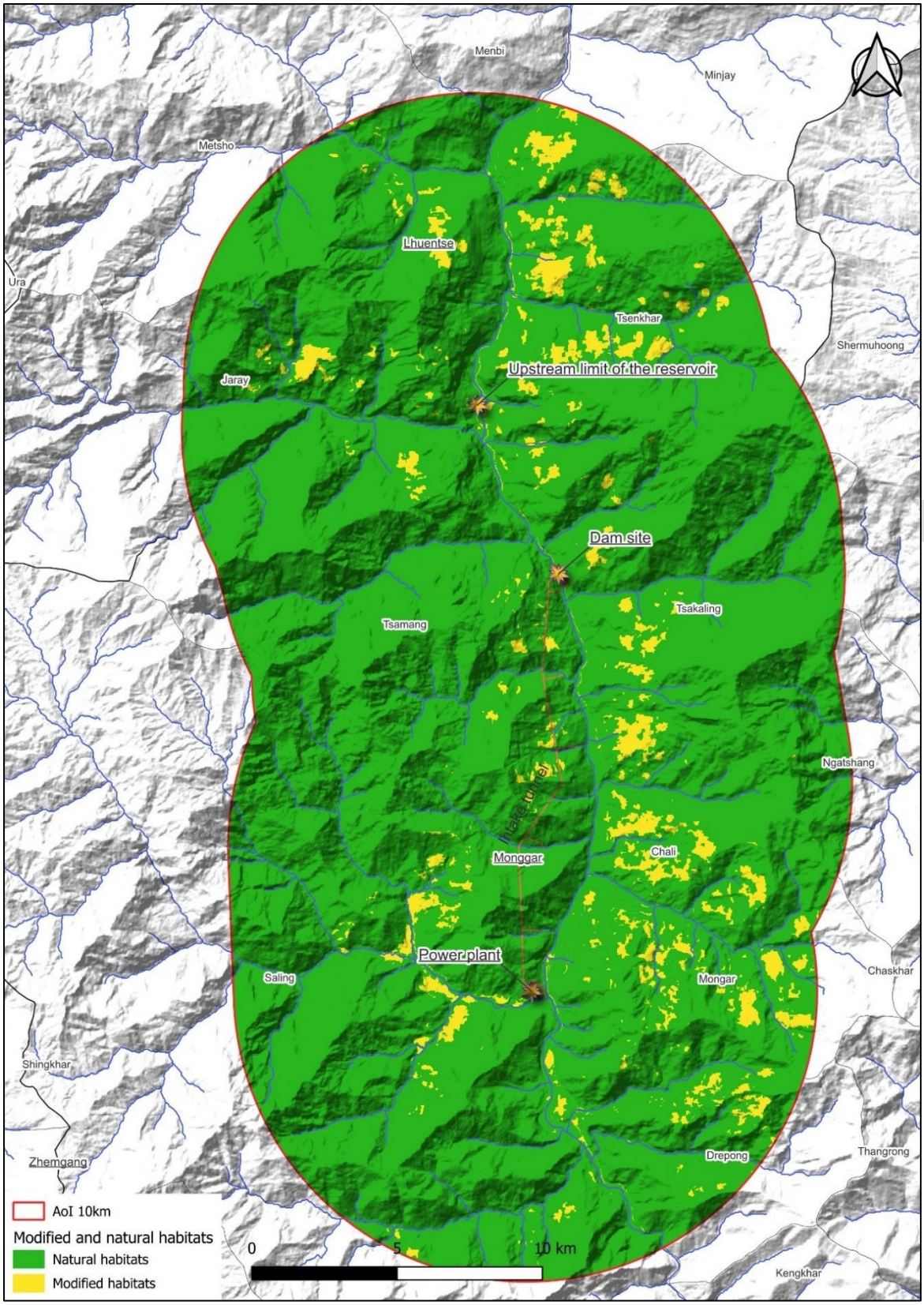
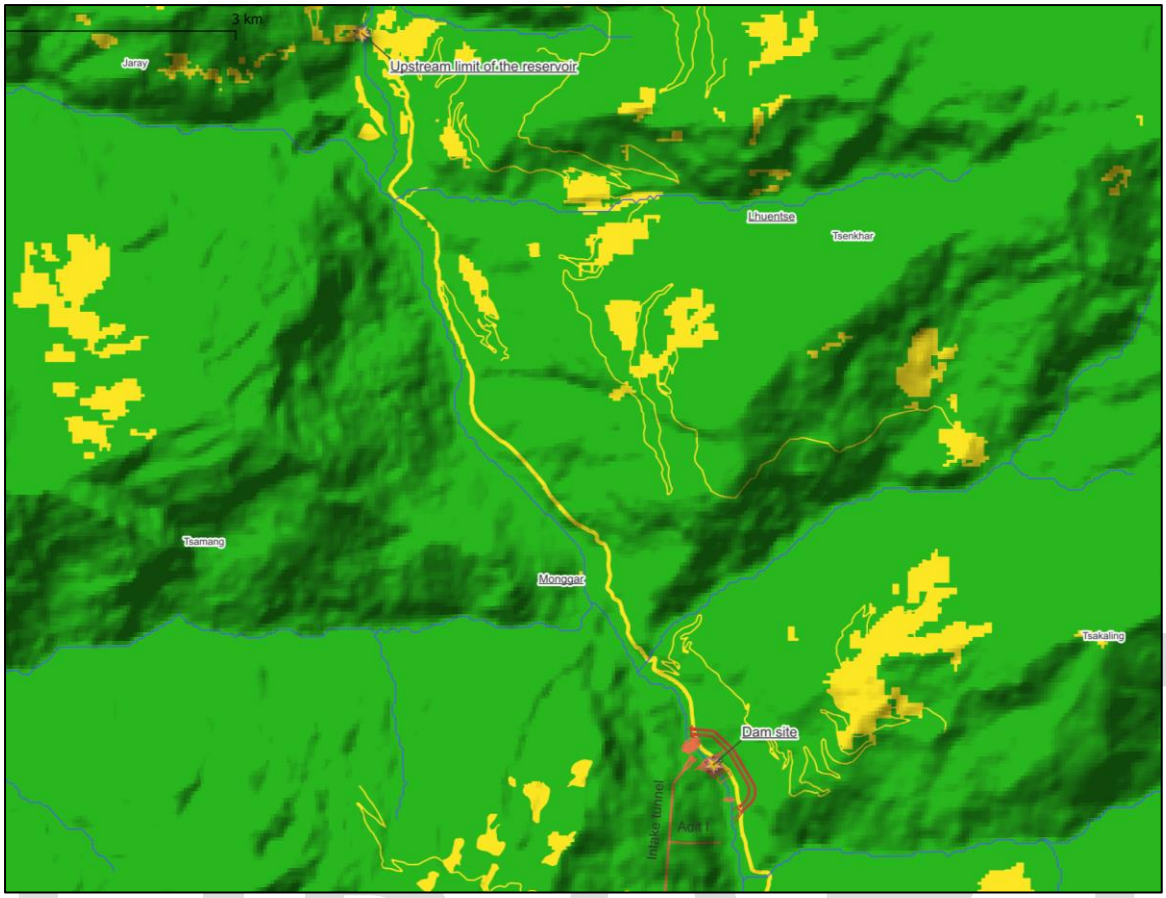


Figure 58: Modified habitats and natural habitats in the AoA

Source: Land Use Land Cover (LULC); Forest Resources Management Division, 2016



Zoom in project reservoir and dam site

The project is set in a well conserved area with 96% of natural habitat, represented by 10 subclasses of habitat, presented above. As per ESS6, implementing a project in this area will need to prescribe the appropriate measure to aim the no net loss and, where feasible, preferably a net gain of biodiversity over long term.

7.1.3 Deforestation in the AoI of the project

As almost all natural habitats are forests, an assessment of the loss of forest cover is an important element of the initial state of the project's area of influence. The tools available on the Global Forest Watch (GFW) website make it possible to produce statistical reports on forest losses and gains in the project area, by satellite data interpretation. The statistics presented below are generated using available tools and datasets (https://www.globalforestwatch.org/).

Tree cover loss in Dorjilung Lhuentse district and Mongar district.

From 2001 to 2022, Dorjilung Lhuentse district and Mongar district lost 803 ha of tree cover, equivalent to a 1.3% decrease in tree cover since 2000. After GFW, the tree cover loss includes the loss of trees of a minimum of 5 metres high in any kind of habitat (natural or modified). The loss can be caused by mechanical felling, fire, disease or storm damage. As such, "loss" does not equate to deforestation.

Primary forest loss in Dorjilung Lhuentse district and Mongar district.

From 2002 to 2022, Dorjilung Lhuentse district and Mongar district lost 216 ha of humid primary forest which represents a decreased by 0.58% in this period. This loss of primary forest represents making up 27% of its total tree cover loss in the same period. After GFW definition, primary forests are qualified as

"mature natural tropical rainforest cover that has not been completely cleared and reforested in recent history".

Tree cover gain in Dorjilung Lhuentse district and Mongar district.

From 2000 to 2020, Dorjilung Lhuentse district and Mongar district gained 313 ha of tree cover equal to 0.41% is its total extent.

Even if losses of primary forest and forest cover are highlighted, these remain low and can be explained by the low population of Bhutan and the particularly high slopes which make all agricultural development and logging difficult.

7.2 Protected and classified areas and Species

7.2.1 Legally Protected Areas of Bhutan

Bhutan is a country favourable to the preservation of biodiversity with a low population, agricultural practices that are not very mechanized and require few inputs, and above all a topography that is not conducive to economic development with steep slopes and high altitudes.

Forest covers 70,5% of the country. The Constitution limits the country's forest cover to at least 60%, while 51.44% of the country's area is already protected by a network of national parks and reserves. This includes 5 National Parks, 4 Wildlife Sanctuaries, 1 Strict Nature Reserve (43.48%), 1 Royal Botanic Park (0.24%) and 8 Biological Corridors (7.73%)

The ratio of natural surfaces to modified surfaces, the 100% low carbon hydropower electricity mix (low carbon) and a low level of vehicle equipment explain why Bhutan is the only country in the world to have a negative carbon balance. The table and the map below list and locate the protected area in Bhutan.

Table 93: Legally Protected Areas of Bhutan (Areas in bold are near the Project)

ID No.	Name of Area	Type	Area (Km^2)	Year Notified	Year Estab-lished	Districts
BWS	**Bumdeling (BWS)**	**Wildlife Sanctuary**	**1534.24**	**1993**	**1998**	**Mongar, Lhuentse, Trashi Yangtse**
JDNP	Jigme Dorji (JDNP)	National Park	4374.06	1993	1995	Gasa, Paro, Thimphu, Punakha
JKSNR	Jigme Khesar (JKSNR)	Strict Nature Reserve	784.22	1993	2010	Ha, Samtse
JSWNP	Jigme Singye Wangchuk (JSWNP)	National Park	1730.06	1993	1995	Sarpang, Trongsa, Tsirang, Wangduephodrang, Zhemgang
JWS	Jomotsangkha (JWS)	Wildlife Sanctuary	362.49	1993	1993	Samdrup Jongkhar
PNP	**Phrumsengla (PNP)**	**National Park**	**906.65**	**1993**	**2000**	**Bumthang, Lhuentse, Mongar, Zhemgang**
PWS	Phibsoo (PWS)	Wildlife Sanctuary	286.83	1974	1993	Sarpang, Dagana
RMNP	Royal Manas (RMMNP)	National Park	1057.40	1993	1996	Pema Gatshel, Sarpang, Zhemgang
SWS	Sakteng (SWS)	Wildlife Sanctuary	742.46	1993	2003	Trashigang

ID No.	Name of Area	Type	Area (Km²)	Year Notified	Year Estab-lished	Districts
WCNP	Wangchuk Centennial (WCNP)	National Park	4914.65	2008	2008	Bumthang, Lhuentse, Wangduephodrang, Gasa, Trongsa
RBP	Royal Botanic Park (RBP)		91.20		2004	Thimphu, Punakha

Source: DOFPS, Annual Forestry Statistics, 2021

Table 94: Biological corridors in Bhutan

Num-ber	Name of Area	Location	Area (Km2)	Year Notified	Year Estab-lished	Organization
1	BC 1	JDNP-JKSNR BC	255.55	1999	2007	Ha, Paro
2	BC 2	RBP-JSWNP BC	291.76	1999	2007	Wangduephodrang
3	BC 3	JSWNP-PWS-RMNP	407.70	1999	2007	Sarpang, Tsirang
4	BC 4	JSWNP-PNP-RMNP	594.65	1999	2007	Trongsa, Zhemgang
5	BC 5	JWS-RMNP	205.84	1999	2007	Pema Gatshel, Samdrup Jongkhar
6	BC 6	JWS-SWS	232.77	1999	2007	Samdrup Jongkhar, Trashigang
7	BC 7	BWS-PNP-WCNP	419.66	1999	2007	Mongar, Lhuentse
8	BC 8	JSWNP-WCNP	558.60	1999	2007	Trongsa, Wangduephodrang
			19750.79			

Source: DOFPS, Annual Forestry Statistics, 2021

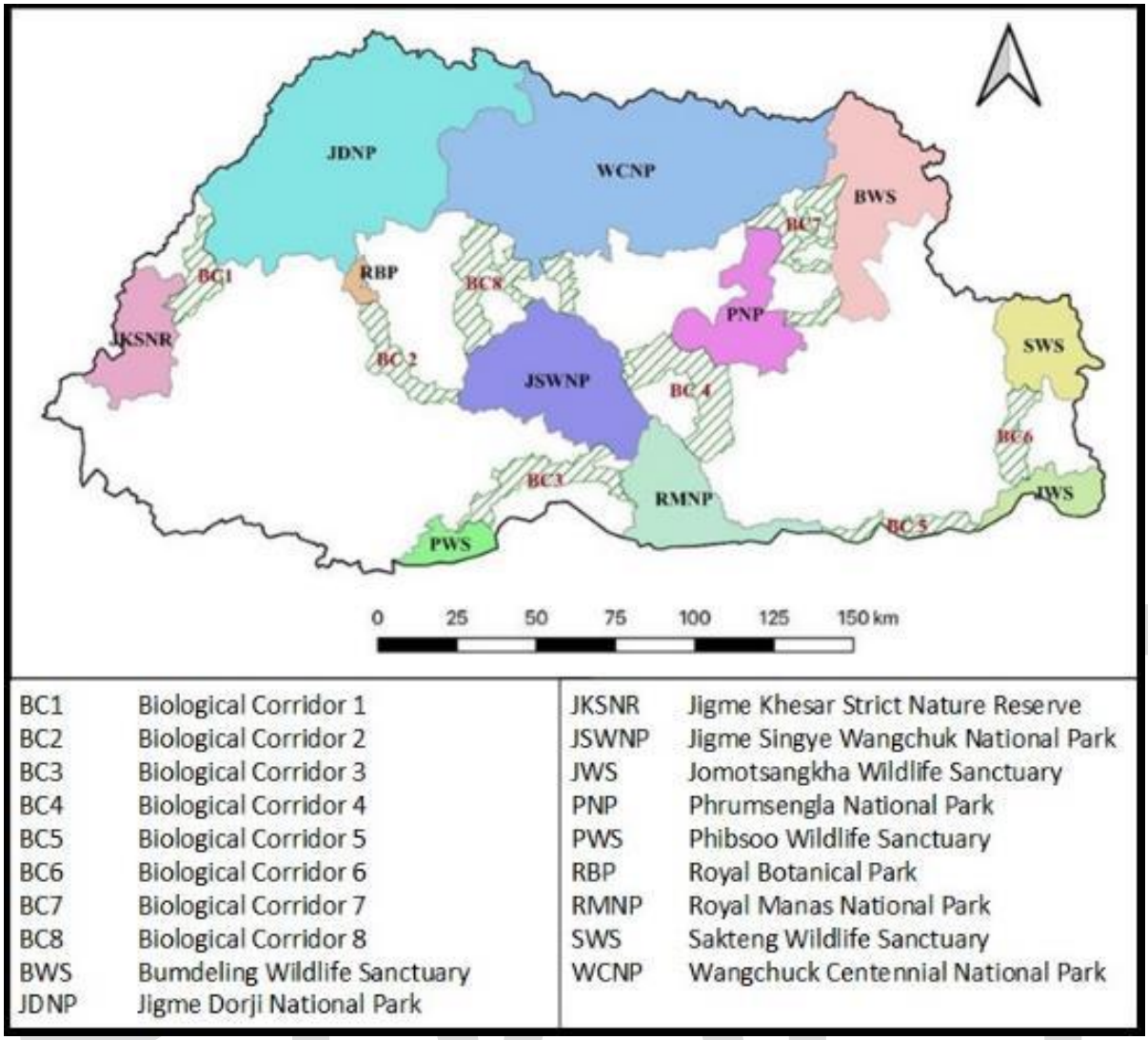


Figure 59: Legally Protected Areas of Bhutan

Source: Nature Conservation Division, DOFPS, 2022

The project is located close to some classified areas including:

- The Phrumsengla National Park
- The Bumdeling Wildlife Sanctuary
- The Biological corridor 7 (BC#7)

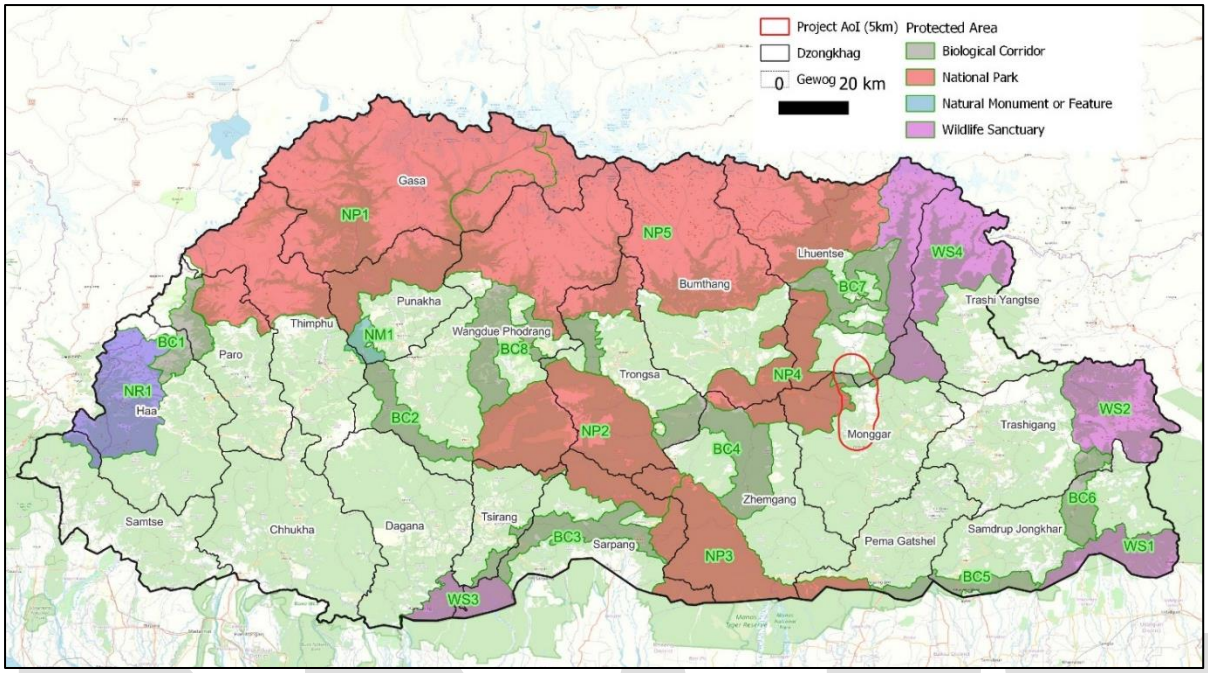


Figure 60: Project location and nationally classified areas

Source: Nature Conservation Division, DOFPS, 2022

NM1: Royal Botanical Park. Natural Monument ; NP1: Jigme Dorji National Park ; NP2: Jigme Singye Wangchuck National Park; NP3: Royal Manas National Park; NP4: Phrumsengla National Park; NP5: Wangchuck Centennial National Park; NR1: Jigme Khesar Strict Nature Reserve; WS1: Jomotsangkha Wildlife Sanctuary; WS2: Sakteng Wildlife Sanctuary; WS3: Phibsoo Wildlife Sanctuary; WS4: Bumdeling Wildlife Sanctuary; BC1: Biological Corridor 1; BC2: Biological Corridor 2; BC3: Biological Corridor 3; BC4: Biological Corridor 4; BC5: Biological Corridor 5; BC6: Biological Corridor 6; BC7: Biological Corridor 7; BC8: Biological Corridor 8

The 3 protected areas located close or within the project area of influence are described below.

7.2.1.1 Phrumsengla National Park

In 2014, Phrumsengla National Park (PNP) encompassed 906.65 km2. The park was created to conserve the temperate ecosystem of central regions and is linked to four other protected areas - Jigme Singye Wangchuck National Park (JSWNP), Royal Manas National Park (RMNP), Bumdeling Wildlife Sanctuary (BWS), and Wangchuck Centennial National Park (WCNP) - through Biological Corridors.

PNP comprises sub-tropical broadleaved to alpine ecosystems and the park is home to diverse flora and fauna including 1,000 plant species (154 with medicinal value, 21 endemics to Bhutan), 70 mammal species (4 endangered: the Tiger, the Red Panda, the Musk Deer and the Wild dog, 4 vulnerable: the Takin, the Himalayan Black Bear, the Asian small-clawed otter, 1 near threatened, the Asiatic Golden cat), 364 bird species (3 vulnerable: the Chestnut-breasted partridge, the Rufous-necked hornbill and the Beautiful nuthatch, 6 near threatened, 8 restricted range), 3 amphibian species, 12 reptile species, 4 lizard species, 7 fish species, and 55 butterfly species. The figure below presents the location of Phrumsengla National Park (PNP).

The ESIA Volume 3 Appendix K provides additional information concerning the Phrumsengla National (PNP).

The project components are not located within the park as shown in the figure below, but a small part is in the 5 km AoI buffer zone.

Figure 61: The Phrumsengla National Park

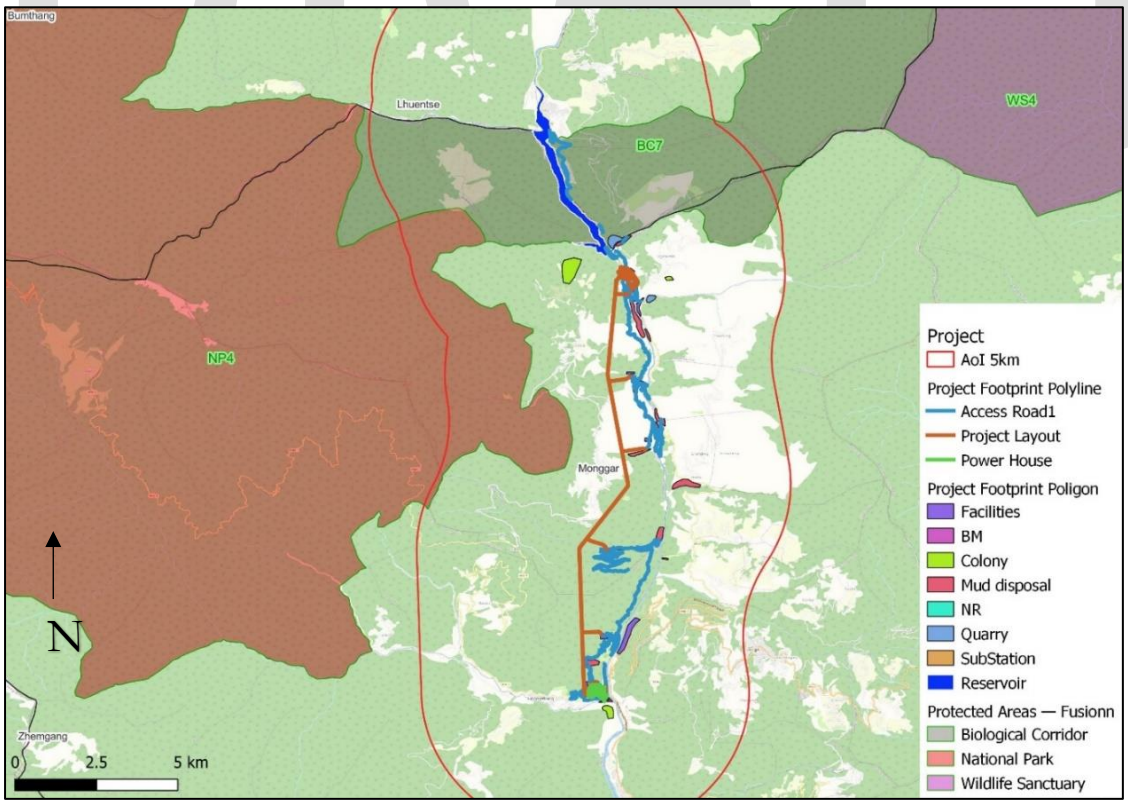


Figure 62: The Phrumsengla National Park (NP4) in relation to the project components

7.2.1.2 Bumdeling Wildlife Sanctuary

The Bumdeling Wildlife Sanctuary (BWS) covers an area of 1,534.24 km² and is outside the 5 km buffer zone around the project. The Sanctuary was created to conserve protect ecological zones of the mid and high-altitude ecosystems of the eastern parts of Bhutan and comprises warm broadleaved forest to Alpine scrubs and lakes. It is connected to the 2 other protected areas (Phrumsengla National Park / NP4 and Wangchuck Centennial National Park), by Biological Corridor # 7 as shown in Map 1.

So far, 966 species of plants (Blue poppy, Chinese Caterpillar, and Himalayan yew), 52 species of mammals (which include 4 endangered, 5 vulnerable and 2 near threatened species), 356 species of birds (1 endangered, 3 vulnerable, 6 near-threatened species), 3 species of amphibians, 18 species of snakes, 3 lizards, 7 native fish species and 200 species of butterflies have been recorded in the Sanctuary (Bumdeling Wildlife Sanctuary, DOFPS, 2020. Conservation Management Plan (June 2020 - June 2030). Endangered species include Tiger, Red Panda, Musk Deer and Wild Dog; Vulnerable species include Snow Leopard, Himalayan Black Bear, Capped Langur, Clouded Leopard and Common Leopard, and Near threatened species include Marbled Cat and Himalayan Serow. Endangered species include Steppe Eagle, Vulnerable species include Rufous-necked hornbill, Chestnut-breasted Partridge and Wood Snipe and Near threatened species include the Black-Necked Crane, Satyr Tragopan, Ferruginous Poachard, Yellow-yumped Honeyguide, Ward's Trogon and River Lapwing.

The Sanctuary is unique because it contains the national butterfly, Ludlows Bhutan Glory (Bhutanitis ludlowi), which is endemic to Trashi Yangtse and, which was rediscovered in 2009 (Trashi Yangtse Dzongkhag. http://www.trashiyangtse.gov.bt/tourism/ludlows-bhutan-glory).

The Sanctuary only includes villages within Khoma, Sherimuhung, Bumdeling gewogs in Trashi Yangtse Dzongkhag.

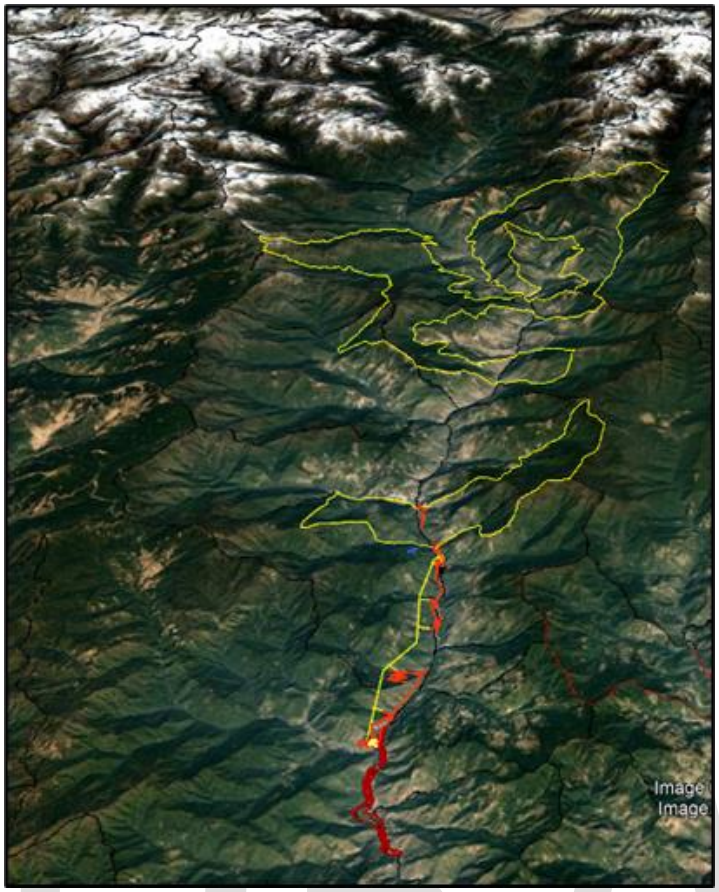
7.2.1.3 Biological corridor (BC#7)

BCs were created to provide secure migratory habitats and routes for species between protected areas. The PNP and BWS are connected by a Biological Corridor (BC#7) which covers 79 km² (Bhutan for Life, ESMP document).

BC 7 was created to support focal species like Tiger, Red Panda and Musk Deer. BC 7 runs through Tsamang gewogs in Mongar and Tsenkhar gewog in Lhuentse. Although some parts of BC 7 falls in the jurisdiction of Mongar Division, the activities such as biodiversity survey, management plan writing etc. are taken care by Bumthang Division. The recent biodiversity survey in BC 7 recorded 21 species of mammals, 162 species of birds (Bhutan for Life,2020. Environmental and Social Management Plan for Biological Corridor 7).

Endangered species include Tiger, Red Panda, Musk Deer, Wild Dog; Vulnerable species include Takin, Himalayan Black Bear, Asian Small-clawed Otter, and Clouded Leopard and Near threatened species includes Asiatic Golden Cat. Vulnerable species include Chestnut-breasted partridge, Rufous-necked hornbill, and Beautiful Nuthatch.

The project cuts in two the lower section of Biological Corridor (BC#7) because of the reservoir footprint which widens the river about 200 m while the actual width is about 50 m (See figure below).



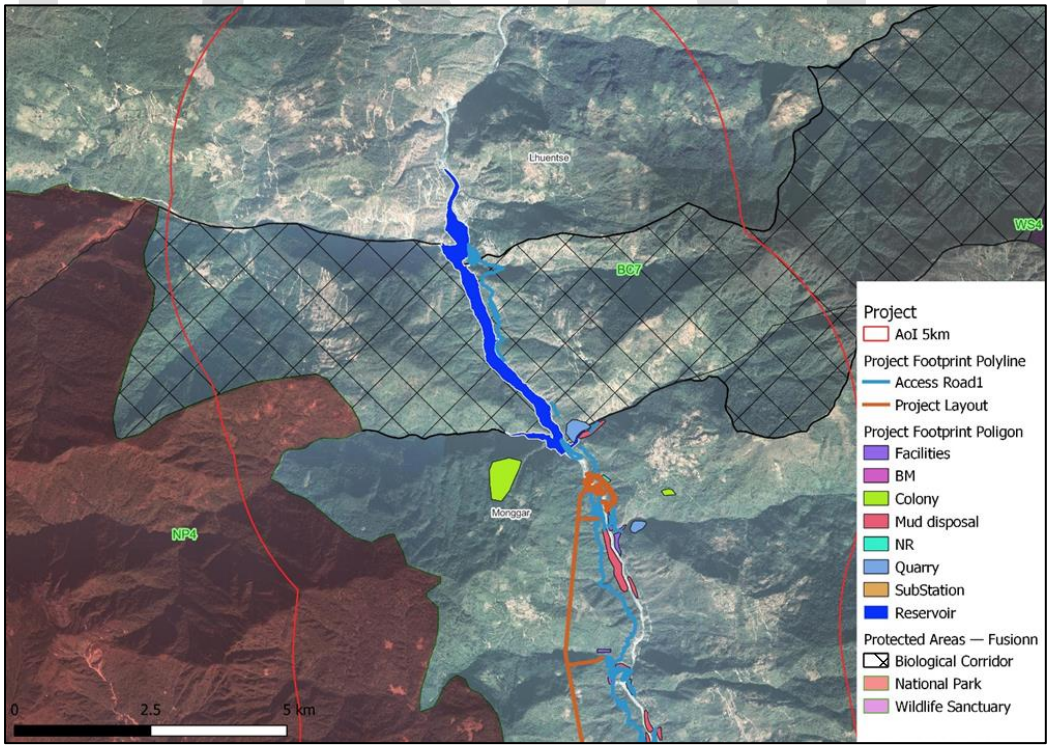


Figure 63: Biological Corridor # 7 in relation to the project components

Source: The Conservation Management Plan for Biological Corridor (2022 Draft available at Divisional Forest Office, Mongar, Department of Forests and Park Services).

7.2.2 Internationally Recognised Areas of High Biodiversity

7.2.2.1 Ramsar Convention (1971)

The International Convention on Wetlands of International Importance (RAMSAR), promotes the conservation of wetlands, aims to halt their degradation or disappearance, by recognizing their ecological functions as well as their economic, cultural, scientific and recreational value.

RAMSAR areas play an important role in the conservation of birds and aquatic species. There are 3 RAMSAR sites in Bhutan:

- The Gangtey-Phobji site designated in 2014 with an area of 10km²
- The Bumdeling site designated in 2012 with an area of 1.42 km²
- The Khotokha site was designated in 2012 with an area of 1.14 km²

All these sites are out of the area of influence of the project, the closest one, the Bumdeling sites being about 50 km away.

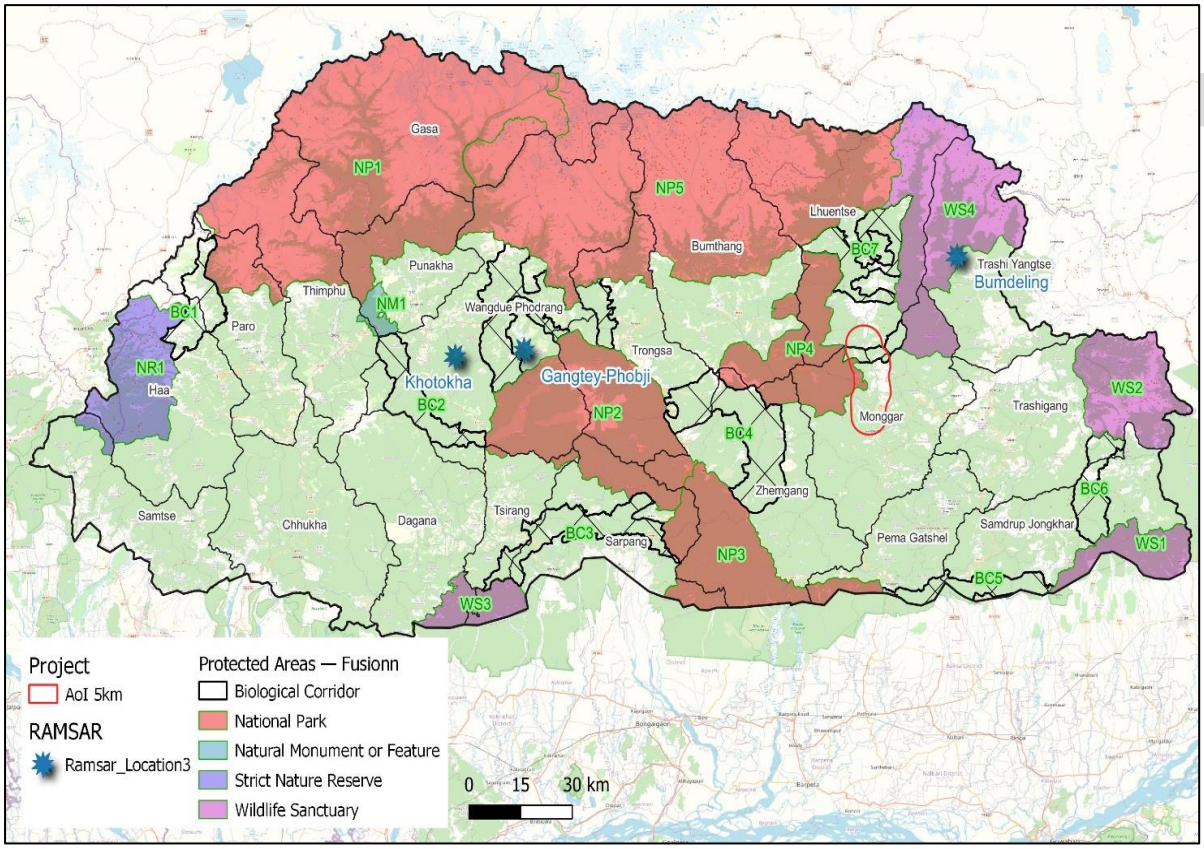


Figure 64: Ramsar sites in Bhutan

7.2.2.2 EBA, KBA/IBA of Birdlife

7.2.2.2.1 Endemic bird areas (EBA)

EBAs are area designated by BirdLife when a landscape contains large population and numerous endemic bird species all over the world. The project area of influence is entirely inside the Eastern Himalaya area.

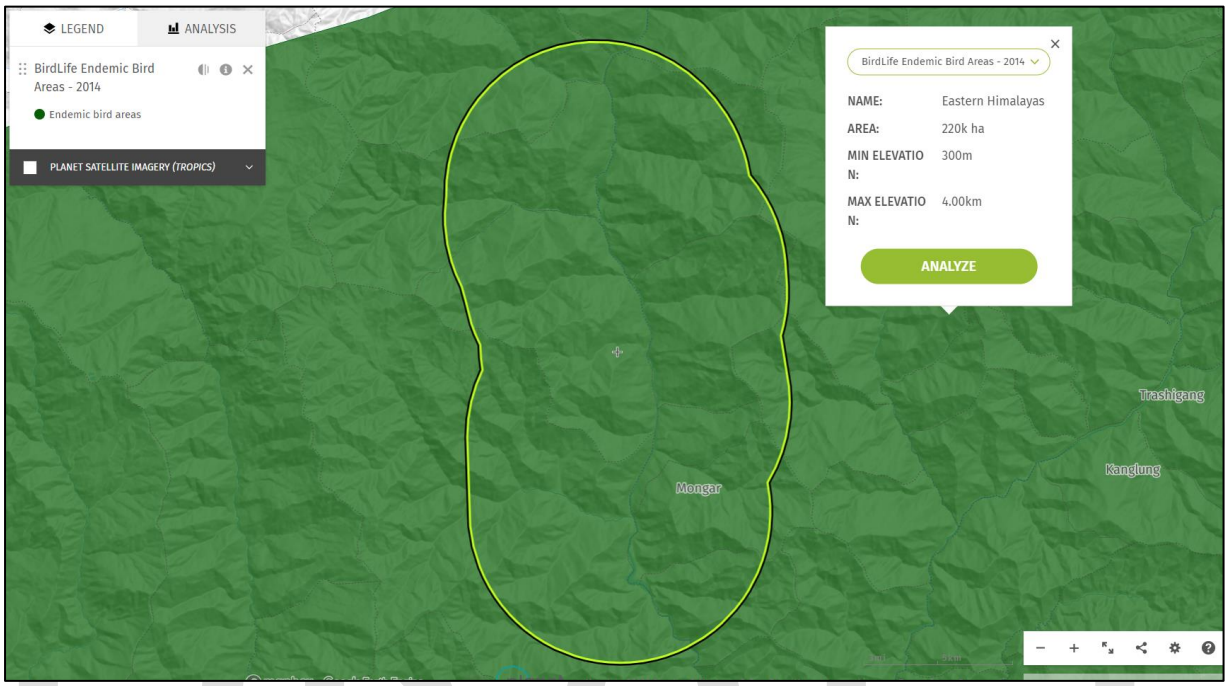


Figure 65: Eastern Himalaya endemic birds' area

Source: BirdLife with GFW website - https://www.globalforestwatch.org/ma

BirdLife defines the location of this area as "This EBA follows the Himalayan range east from the Arun-Kosi valley of eastern Nepal, through Bhutan, north-east India (Sikkim, northern West Bengal and Arunachal Pradesh), south-east Tibet autonomous region and north-east Myanmar to south-west China (north-west Yunnan province). It also includes the mountain ranges to the south of the Brahmaputra River, which extend through north-east India (Nagaland, Manipur, southern Assam, Meghalaya and Mizoram) to the Chin hills in western Myanmar, and the Chittagong hills in south-east Bangladesh." The main threat reported are deforestation and forest degradation.

23 endemic species including 1 EN, 5 VU and 6 NT species are reported in this EBA.

In Bhutan, 12 IBAs are included in this EBA (See next section on KBAs/IBAs)

7.2.2.2.2 Key Biodiversity Areas

Key Biodiversity Areas 'Focus on safeguarding global biodiversity and are recognised as vital land, freshwater, and marine sites for threatened plants and animals… Key Biodiversity Areas (KBAs) are sites of global significance for the conservation of biodiversity, […]. Currently there are 15,524 KBAs acknowledged worldwide, and more are continuing to be identified nationally using simple, globally standardised criteria and thresholds, based on biodiversity requiring safeguards at the site scale. (source: BirdLife http://datazone.birdlife.org/sowb/casestudy/what-are-key-biodiversity-areas).

Note that IBA focus on Birds and KBA concern all taxa so that all IBAs are KBAs. Two Key Biodiversity Areas (KBA) are located within the 10 km and five more in the wider 50 km.

Note that Alliance for Zero Extinction sites are not acceptable for financing, with the exception of projects specifically designed to contribute to the conservation of the area. The presence of this kind of area is systematically checked out.

Table 95: Key Biodiversity Areas in the vicinity

Area name	IBAT search boundary	IBA	Alliance for Zero Extinction
Kori La	10 km	Yes	No
Thrumsing La National Park (now known as Phrumsengla National Park)	10 km	Yes	No
Bumdeling Wildlife Sanctuary	50 km	Yes	No
Bumthang wetlands	50 km	Yes	No
Deothang/Narphang / SamdrupJongkhar	50 km	Yes	No
Kanglung wetlands	50 km	Yes	No
Menji wetland	50 km	Yes	No

Source: IBAT report, 2023

- **Kori La KBA** is approximately 5 km east of the Project. This KBA was listed for its important Bird Areas and triggered due to its values for one IBA threatened species (Rufous-necked Hornbill *Aceros nipalensis*).
- **Thrumsing La National Park KBA** is approximately 5 km west of the Project. This KBA was listed for its important Bird Areas and ornithological importance and triggered due to its values for 4 IBA threatened species which are the Rufous-necked Hornbill (Aceros nipalensis), the Chestnut-breasted Patridge (Arborophila mandellii), the Grey-crowned Prinia (Prinia cinereocapilla) and the Beautiful Nthatch (Sitta Formosa).
- **In addition, a proposed KBA dedicated to the Pallas fish eagle** is also in the southern part of the AoI of the project, this KBA for the Pallas extends from below the Kurigapa bridge to below the Kurichhu Dam as shown in figure below. The DOFPS is currently preparing the conservation plan for this area.

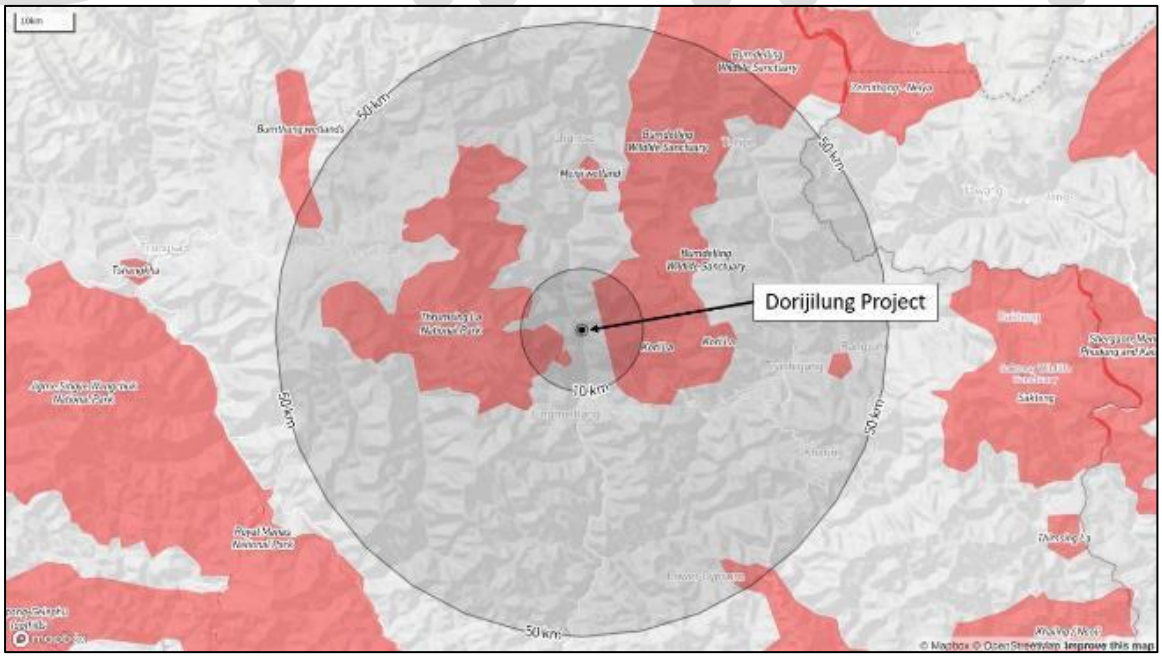


Figure 66: KBA close to the project

Source: IBAT report, 2023

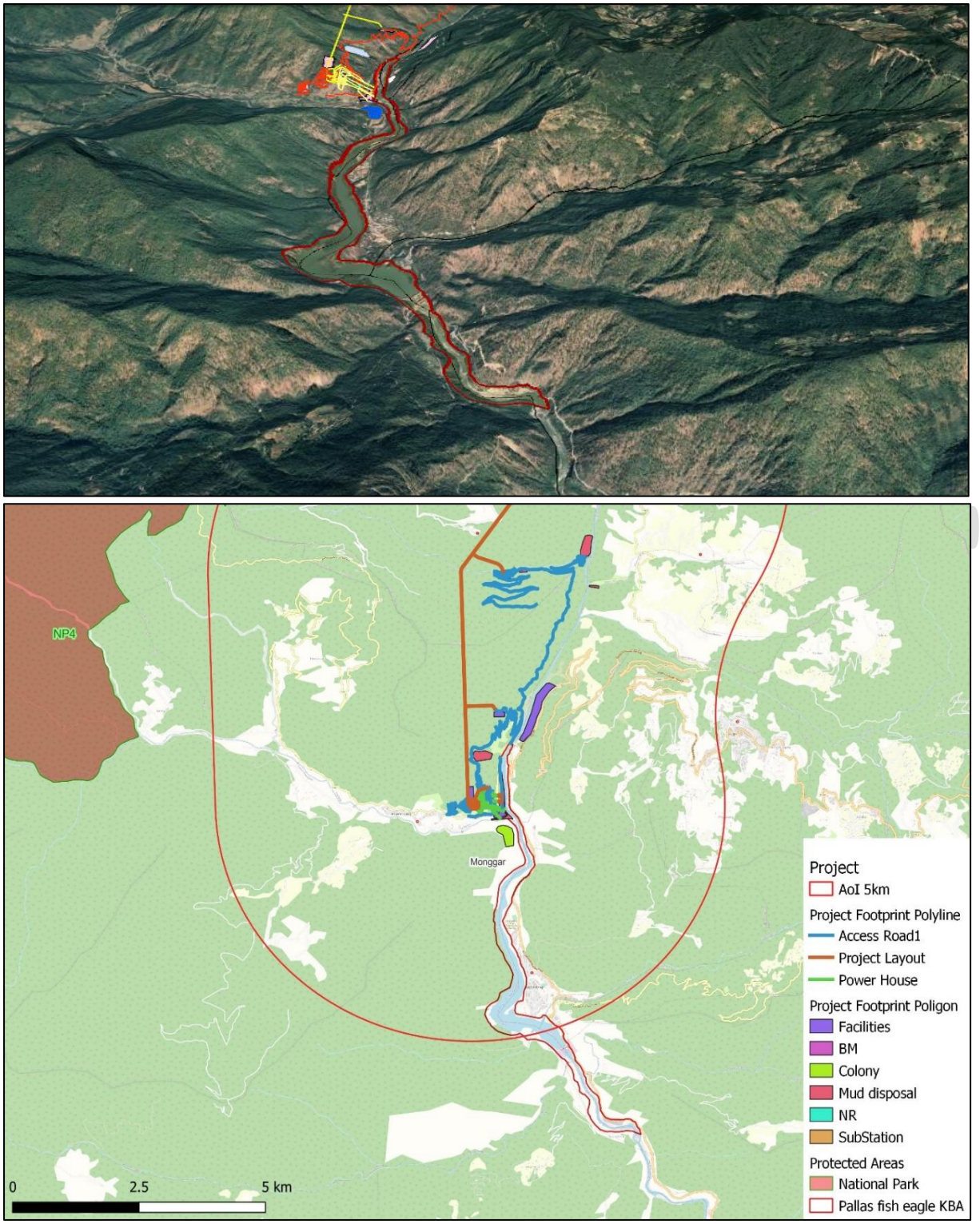


Figure 67: Key Biodiversity area for the Pallas fish eagle

7.2.2.3 Tiger conservation landscape of WWF and Resolve

The AoI of the project is entirely inside the Tiger conservation landscape set up by WWF and RESOLVE in 2007. The large Landscape is defined with the following assumption "Tiger Conservation Landscapes (TCLs) are large blocks of contiguous or connected area of suitable tiger habitat that can support at least five adult tigers and where tiger presence has been confirmed in the past 10 years. The data set was created by mapping tiger distribution, determined by land cover type, forest extent, and prey base, against a human influence index." In the Bhutan section of the Landscape, it is also assumed, by WWF and Resolve, that the wild tiger population could double through proper conservation and management by 2020.

Other studies, such as the National Tiger Survey, have been led to record the number of tigers in the country. In 2014-2015, 103 tigers were recorded. The study is conducted every five years in Bhutan and the results of the 2020-2021 session are pretty encouraging with an increase of 27% (131 individuals), approaching the expected results. Concerning the project area itself, no tigers were recorded during the 2020-2021national survey in PNP.

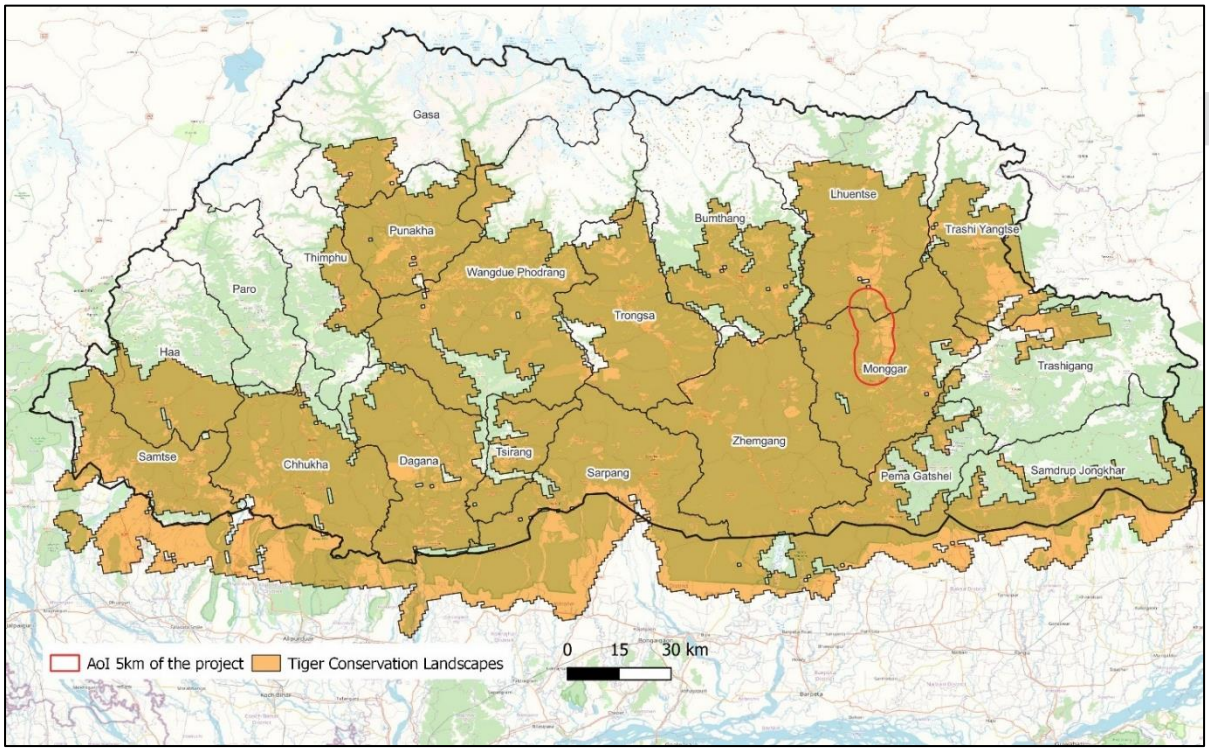


Figure 68: Tiger conservation landscape

Source Dataset: WWF/RESOLVE by GFW website (https://www.globalforestwatch.org/map)

7.2.3 Protected species and species of concern

7.2.3.1 Species of Bhutan in the IUCN Red List

The National Environment Commission (NESCS) have published in 2021 the Bhutan Biodiversity User List also known as the "National Red List species of Bhutan" as the NESCS is the National Focal Agency to the United Nation Convention on Biological Diversity and all the document classification has been done following the IUCN Red List categories.

The report contains numerous information with:

- The list of wild species is protected by national legislation, CITES listing and IUCN Red List Status (National status which may be different than the world status available on the IUCN Red List

website). This list is provided in the Appendix A: National Red List Species of the ESIA Volume 3 Appendix B Terrestrial Biodiversity Field Survey Report.

- The list of invasive species recorded from Bhutan.
- The national list of notified/released kinds or varieties of agricultural crops and fodder.
- The list of permitted ornamental plants in Bhutan.
- The list of native livestock and poultry breeds of Bhutan.

The following figures in the table below come from the list of wild species on 7 taxon groups**.**

Table 96: Number of species by taxon groups and IUCN status (national redlist)

Taxon groups	CR	EN	VU	NT	LC	Total
Bird	4	1	13	0	0	37
Mammal	2	11	17	0	0	40
Plant	13	20	16	0	0	53
Amphibians and reptiles	2	5	11	0	0	19
Fish	0	3	8	0	0	11
Butterfly	0	1	0	0	0	1
Fungi	0	0	1	0	0	1
Total	21	41	66	0	0	162

In this document, the three threatened categories have been defined as: VU: Vulnerable: Species facing high risk of extinction in the wild with number of mature individuals less than 10,000 and their geographic range extent of occurrence and occupancy is less than 20,000 km2 and 2000 km2 respectively. EN: Endangered: Species are facing very high risk of extinction in the wild with the number of mature individuals less than 2500 and its geographic range extent of occurrence and occupancy is less than 5000km2 and 500km respectively. CR: Critically Endangered: Species facing extremely high risk of extinction in the wild with the number of mature individuals less than 250 and their geographic range extent of occurrence and occupancy is less than 100km2 and 10km2 respectively.

7.2.3.2 Protected species of Bhutan

The list of protected species refers to the FNCA (Forest and Nature Conservation Act list (FNCA -2023) and Forest and Nature Conservation Rules and Regulations list (FNCRR - 2017). The full list of protected species is provided in Appendix B PROTECTED SPECIES OF BHUTAN of the ESIA Volume VIIIB, Appendix B: TERRESTRIAL BIOLOGY FIELD SURVEY REPORT.

Table 97: Number of species by taxon groups and schedule of the FNCA -2023

Taxon	SCHEDULE I	SCHEDULE II	SCHEDULE III	Total
Plants	3	48	96	147
Mammals	10	31	32	73
Birds	3	35	189	227
Amphibians	0	2	0	2
Tortoise and turtles	0	4	0	4
Reptiles	0	8	6	14
Insects	0	3	4	7
Fish	0	4	16	20
Total	16	135	343	494

Source: FOREST AND NATURE CONSERVATION ACT OF BHUTAN 2023

The FNCA classifies the species in the three schedules with the following rules*:*

*"Any wild flora listed in **Schedule I** of this Act shall not be collected, possessed, or traded except, for scientific research and population management including conservation breeding or plantation on the recommendation of the Scientific Authority. Any wild fauna listed in **Schedule I** of this Act shall not be killed, injured, or destroyed except in defense against attack, imminent threat to human life or for population management as recommended by the Scientific Authority.*

*Any wild fauna listed in **Schedule I** of this Act shall not be captured, collected, possessed, bred, raised or traded except for scientific research or population management including conservation breeding as recommended by the Scientific Authority.*

*The Department shall allow cultivation, collection, or trade of any wild flora listed in **Schedule II and III** of this Act as per the procedure prescribed in the Rules.*

*Any wild fauna listed in **Schedule II and III** of this Act is also protected and may not be killed, injured, destroyed, captured, collected, possessed, bred, raised, or traded except for approved fishing, scientific research, population management, defence against attack or imminent threat on human life or livestock, damage to crop or other private property."*

7.3 Species of high biodiversity value referenced in the IBAT database

The IBAT database generates a generic area of influence for a project based on a standard 50km radius, which is used to extract species from the IUCN Red List of Threatened Species. In the project area, the extraction of the data has been done. 1214 species are reported in the database as summarised in the table below. The database is provided in the ESIA Volume VIIIN, Appendix B: terrestrial biology field survey report.

Table 98: Number of species by taxon groups in the IBAT database

Taxon groups	CR	EN	VU	NT OR LR/NT	LC OR LR/LC	DD	Total	Including restricted range	Including migra-tories
AVES	4	2	10	26	522	0	**564**	5	305
REPTILIA	0	3	3	4	54	1	**65**		
MAMMALIA	1	10	11	10	67	2	**101**	2	4
ACTINOPTERYGII	0	1	2	6	53	4	**66**	7	20
AMPHIBIA	0	0	0	1	28	0	**29**	2	
MALACOSTRACA	0	0	0	2	13	3	**18**	1	3
INSECTA	0	1	0	1	97	2	**101**	2	7
GASTROPODA	0	0	0	0	42	6	**48**	2	
BIVALVIA	0	0	0	0	29	4	**33**	2	
POLYPODIOPSIDA	0	0	0	0	3	0	**3**		
MAGNOLIOPSIDA	1	4	3	4	88	8	**108**		
LILIOPSIDA	1	3	4	1	62	2	**73**		
SORDARIOMYCETES	0	0	1	0	0	0	**1**		0
AGARICOMYCETES	0	0	0	0	1	0	**1**		
ARACHNIDA	0	0	0	0	3	0	**3**		
TOTAL	**7**	**24**	**34**	**55**	**1062**	**32**	**1214**	**23**	**339**

7.4 Field survey of the Terrestrial fauna and flora in the study area

7.4.1 Location and representativity of the stations

The strategy to assess flora and fauna was informed by an initial desktop analysis of the project footprint and land use, followed by site visits to specific stations to ground the truth data. The criteria used for selection of the stations were a balance consideration between:

- (i) the project footprint (2023 version) and their anticipated impacts. Note that project footprints of the 2024 version have significant changes as most of the MD, CCF; SY and access are on the right bank.
- (ii) to be representative of the main natural habitats of the project area. The main natural habitats within the project area are the riparian forest, broadleaf forest and Chirpine forest.
- (iii) consideration of access constraint limited by feasibility of access (such as impassable steep and high slopes), the time needed to access and the safety of the surveyors.

The location of the 47 stations for fauna (Mammal, Birds, opportunistic observations) are show in Table 99. These locations represent mainly formation of Riparian Forest, Broadleaf Forest and Chirpine Forest. These stations also provide understanding of the environment within different aspects of the project footprint. Table 100 shows the 12 stations dedicated to the herpetofauna survey assessed at the end of monsoon below provide a summary of each station surveyed including the habitats status and type.

Table 99: Stations assessed during the two surveys pre-monsoon (from May 15th to May 30th, 2023) and post-monsoon survey (from October 20th to November 1st, 2023)

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
ST01 Pre-monsoon	27.45927	91.17133	880	Natural riverine broadleaf forest closed to the road upstream the reservoir.	Left bank. The station is representative of the RES2 aquatic survey for EFlow. Direct observation of otters and macaques. Completed by RECESS for fauna and flora.	Natural	Riverine (Kurichhu) broadleaf forest
ST02 Pre-monsoon	27.43655	91.16849	886	Natural riverine broadleaf forest is close to the footbridge in the upper section of the reservoir.	Right bank of a main tributary which is on the right side of the Kurichhu river. Completed by RECESS for fauna and flora and cliff observations. Trace of conversion because of the track and the construction of the footbridge. Small riverine forest, mainly shrubs with numerous cliffs. One orchid, pellet of 2 dear species, butterfly...	Natural	Riverine (Chhudigang chhu) broadleaf forest
ST03 Pre-monsoon	27.41902	91.17887	865	Natural riverine broadleaf forest close to the road to	Left bank. The station will be flooded by the reservoir. Completed by RECESS for fauna and flora. Hoya buthanica herbs with	Natural	Riverine (Kurichhu) broadleaf forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
				be flooded by the reservoir	flowers and pellets of deer. Trace of degradation, one Chirpine cut for timber and some waste from the road.		
ST04 Pre-monsoon	27.43462	91.17547	921	Chirpine forest to be impacted by new highway	Representative of a Chirpine forest mixed with shrub in average slope. Some trace of degradation is not far from Autsho. Dear signs, Cobra royal	Natural	Chirpine forest
ST05 Pre-monsoon	27.43271	91.17869	967	Riverine forest of a small tributary to be impacted by the new highway	Representative of a riverine forest in an average slope. Some trace of degradation is not far from Autsho. Numerous dear signs.	Natural	Riverine (Trib LB) broadleaf forest
ST06 Pre-monsoon	27.38545	91.2001	778	Fully degraded. Modified habitat	Station on SY-1	Modified	Pioneer herbaceous plants
ST07 Pre-monsoon	27.39305	91.19782	791	Natural riverine broadleaf forest closed to the road at the dam site	Human impact, cave use by human, quite degraded	Natural	Riverine (Kurichhu) broadleaf forest
ST08 Pre-monsoon	27.40263	91.195869	848	Natural riverine broadleaf forest impacted by MD1 and KaR3 sites in tributary.	Some human traces cutting timber naturally fallen in the stream.	Natural	Riverine (Trib LB) broadleaf forest
ST09 Pre-monsoon	27.346519	91.209598	780	Transition chirping to riparian	Natural habitat. Mainly shrubs	Natural	Transition chirping to riparian
ST10 Pre-monsoon	27.355261	91.20424	714	Natural riverine broadleaf forest	Possible to reach the river. Well natural	Natural	Riverine (Kurichhu) broadleaf forest
ST11 Pre-monsoon	27.359023	91.202686	726	Natural riverine broadleaf forest to be impacted by	Natural habitat with natural and anthropic modifications. Big erosion process of a cliff. Some human signs.	Natural	Riverine (Pheldang chhu) broadleaf forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
				MD4 and Office			
ST12 Pre-monsoon	27.35651	91.199822	908	Natural broadleaf forest	Close assess road, Manly shrubs in rooky substratum. Some anthropogenic pressures	Natural	Broadleaf forest
ST13 Pre-monsoon	27.338153	91.199696	1104	Natural Chirpine with one big timber cut.	Chirpine Cliff, closed to Adit 3	Natural	Chirpine forest
ST14 Pre-monsoon	27.39167	91.21099	1293	Natural Chirpine in rocky and wet area	Many orchids and many species	Natural	Chirpine forest
ST15 Pre-monsoon	27.35715	91.20313	733	Natural broadleaf forest	Not many species, many shrubs and rocks	Natural	Broadleaf forest
ST16 Pre-monsoon	27.27932	91.19772	590	Natural Chirpine with power line	Closed to the mini hydropower	Natural	Chirpine forest
ST17 Pre-monsoon	27.29495	91.20582	593	Natural riparian forest	Old human traces	Natural	Riverine (Kurichhu) broadleaf forest
ST18 Pre-monsoon	27.2496	91.19603	550	Modified habitat with remnant riparian vegetation	Station on relictual riparian vegetation, severe degradation by nearby crushing activities. This station corresponds to the REV1 aquatic ecology station immediately downstream of the restitution.	Modified	Remnant riverine (Kurichhu) vegetation
ST19 Pre-monsoon	27.30137	91.19505	1142	Natural Chirpine	Selective logging with a small number of trees cut per acre. Natural regeneration is in progress. The station is 150 m below the logging road.	Natural	Chirpine forest
ST20 Pre-monsoon	27.3908166	91.1794833	1616	Natural broadleaf forest	Below the village about 1000mts into the forest, disturbed area	Natural	Broadleaf forest
ST21 Pre-monsoon	27.2621166	91.1816833	691	Natural Chirpine forest	Dumpyard site above the highway of Lingmethang. Natural with antropic	Natural	Chirpine forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
					perturbation. Closed to modified area		
ST22 Pre-monsoon	27.2620959	91.1849555	689	Natural Chirpine forest	Natural with antropic perturbation. Closed to modified area	Natural	Chirpine forest
ST23 Pre-monsoon	27.2725166	91.1910833	602	Natural Chirpine forest	Natural with antropic perturbation. Closed to modified area	Natural	Chirpine forest
ST24 Pre-monsoon	27.2643166	91.19155	560	Natural Chirpine forest	Natural with antropic perturbation. Closed to modified area	Natural	Chirpine forest
ST25 Post-monsoon	27.4518947	91.1699285	869	Natural riverine broadleaf forest closed to the road upstream the reservoir.	Left bank. The station is representative of the RES2 aquatic survey for Eflow. Some human signs and cows. Completed by RECESS for fauna and flora.	Natural	Riverine (Kurichhu) broadleaf forest
ST26 Post-monsoon	27.447982	91.1714575	868	Natural riverine Chirpine forest closed to the road upstream the reservoir	Right bank, partially flooded by reservoir. Many waste. Barking deer pellets	Natural	Mixed Chirpine broadleaf riverine (Kurichhu) forest
ST27 Post-monsoon	27.4355409	91.1748135	893	Chirpine forest to be impacted by new highway	Representative of a Chirpine forest mixed with shrub in average slope. Some trace of degradation is not far from Autsho. Barking deer and Gora signs	Natural	Chirpine forest
ST28 Post-monsoon	27.4326801	91.1795870	990	Broadleaf forest to be impacted by the new highway	Right bank with a small tributary and human signs with drinking water access. Barking deer and Monkey signs. Will be impact by new Atshua access.	Natural	Broadleaf forest
ST29 Post-monsoon	27.4351602	91.1718097	846	Riverine young Chirpine clear forest in a rocky accumulation plateau created by	Right bank, to be flooded by reservoir. Banjing deer and Sambar signs. It is a large cone of rock accumulation brought by the watercourse with recent colonization of vegetation. The Chirpines	Natural	Riverine (Chhudigang chhu) young Chirpine clear forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
				one strong flood event. Will be flooded by reservoir	are young at less than 8 m and the herbaceous and shrub layer is made up of pioneer species. The area forms a plateau dotted with metric blocks. See the photo of the hotel which gives the date without vegetation. Downstream, we can also note on the right bank a secondary bed recently covered with vegetation during the same period.		
ST30 Post-monsoon	27.4218477	91.1781333	850	Riverine station closed to the road in the middle of the reservoir	Left bank. The station will be flooded by the reservoir, some waste from the road. Barking deer pellets and direct observation. Station of *Hoya Buthanica* not far, confirmed, no flower.	Natural	Riverine (Kurichhu) broadleaf forest
ST31 Post-monsoon	27.4245479	91.1793676	973	Chirpine forest to be impacted by new highway	Chirpine station on the right bank.	Natural	Chirpine forest
ST32 Post-monsoon	27.4007694	91.1939579	877	Riverine broadleaf station was impacted by quarry 3	Quarry KaR3 site close to tributary. Foot of the cliff. The station is in a riverine broadleaf forest. Human signs of timber exploitation by villagers. Quarry middle and highest cliff is cover by a clear Chirpines forest.	Natural	Riverine (Trib LB) broadleaf forest
ST33 Post-monsoon	27.3857627	91.2047623	840	broadleaf station impacted by quarry 4	Quarry site KaR4 is closed to a tributary (Rewan chhu). Foot of the cliff. Station and quarry are in broadleaf forest. Numerous signs of Sambar, pellets and resting area.	Natural	Riverine (Rewan chhu) broadleaf forest
ST34 Post-monsoon	27.3738399	91.2049801	801	Broadleaf forest closed to the road impacted by MD3	Sambar signs which come down in winter for water.	Natural	Broadleaf forest
ST35 Post-	27.3911286	91.2109821	1262	Broadleaf forest in mixed	Numerous barking deer. Monkey signs (macaque). Wild pig signs and resting	Natural	Broadleaf forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
monsoon				Chirpine broadleaf area	area. Capped langur observation. Wild dog signs (piece of skin) Numerous orchids. big rocks		
ST36 Post-monsoon	27.3482717	91.2078478	706	Broadleaf forest	Broadleaf forest. Barking deer and wild pig signas.	Natural	Broadleaf forest
ST37 Post-monsoon	27.3471389	91.2076653	674	Riverine broadleaf forest	Down ST36 on riverbed. Spair with ST38. Representative of riverine forest first vegetation up the river. Goral observation on the left bank.	Natural	Riverine (Kurichhu) broadleaf forest
ST38 Post-monsoon	27.3484256	91.2070169	670	Riverine broadleaf forest	Down ST36 on riverbed. Spair with ST37. Representative of riverine forest first vegetation up the river. Goral observation on the left bank.	Natural	Riverine (Kurichhu) broadleaf forest
ST39 Post-monsoon	27.2546798	91.1964681	501	Modified habitat with remnant riparian. Fully degraded.	Station on a remnant part of the riparian vegetation, nearby Desuung camp and Gyalsung guest house. Great Cormorants observed near the station. Assamese macaques observed on the right bank of Kurichhu river opposite to the station.	Modified	Remnant riverine (Kurichhu) vegetation
ST40 Post-monsoon	27.2627147	91.1927555	507	Modified habitat with remnant riparian vegetation.	Modified habitat with remnant riparian vegetation. Station on a remnant part of the riparian vegetation, severe degradation by nearby crushing activities. Footprints of Small Clawed Otter observed in the station and 2 Yellow Throated Martens observed on the right bank of Kurichhu opposite to the station.	Modified	Remnant riverine (Kurichhu) vegetation
ST41 Post-	27.2706170	91.1895042	675	Modified habitat with	Modified habitat with remnant riparian Fully	Modified	Remnant riverine

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
mons oon				remnant riparian	degraded. Modified habitation. Goral observed.		(Kurichhu) vegetation
ST42 Post-mons oon	27.2776 607	91.1953 13	547	Chirpine forest	Disturbed area, accessible through existing foot trail	Natural	Chirpine forest
ST43 Post-mons oon	27.9322 891	91.1812 374	1510	Broadleaf forest	Natural broadleaf forest, for Dam base camp. A group of Capped Langurs observed, scats of Common Leopard and Himalayan Yellow Throated Marten and pellets of Barking Deer observed.	Natural	Broadleaf forest
ST44 Post-mons oon	27.3927 449	91.1793 941	1520	Broadleaf forest	Natural broadleaf forest, for Dam colony. A group of Capped langurs observed, scats of Common Leopard and Himalayan Yellow Throated Marten and pellets of Barking Deer observed. The dung of Wild Pig, pellets of Barking Deer & Sambar scratch on tree.	Natural	Broadleaf forest
ST45 Post-mons oon	27.3032 946	91.1959 948	1020	Chirpine forest	Natural Chirpine. Selective logging with a small number of trees cut per acre. Natural regeneration is in progress. Station 300 m below the Natural Chirpine. Meant for access road. A group of Capped Langurs and one Barking Deer observed along Lingmethang -Yongkala highway and burrows of Wild pig observed in the station.	Natural	Chirpine forest
ST46 Post-mons oon	27.2987 593	91.1914 267	1223	Chirpine forest	Natural Chirpine forest for access road. Pellets of Barking Deer observed.	Natural	Chirpine forest
ST47 Post-	27.2619 571	91.1818 591	655	Chirpine forest	Natural Chirpine forest for DP yard	Natural	Chirpine forest

Ref-Station	Lat DD	Long DD	Alt (m)	Name and description	Other notes	Natural / Modified	Habitat
monsoon							

Table 100 - Station dedicated to herpetofauna survey assessed end of monsoon (from September 11th to September 19th 2023).

Ref-Station	Lat DD	Long DD	Name and description of the station	Natural / Modified	Habitat
HST1 end-monsoon	27.436723	91.169906	Riverine young Chirpine clear forest in a rocky accumulation plateau created by flood event. Will be flooded by reservoir	Natural	Riverine (Chhudigangchhu) young Chirpine clear forest
HST10 end-monsoon	27.295186	91.207290	Natural broadleaf forest	Natural	Riverine (Khalangzichhu LB) broadleaf forest
HST11 end-monsoon	27.246726	91.194916	Small and fragmented natural broadleaf forest	Natural	Broadleaf forest
HST12 end-monsoon	27.224136	91.198541	Remnant broadleaf vegetation in Gyelpozhing town	Modified	Remnant broadleaf vegetation
HST2 end-monsoon	27.432722	91.176619	Riverine forest of a small tributary to be impacted by the new highway	Natural	Riverine (Autshochhu LB) broadleaf forest
HST3 end-monsoon	27.428980	91.176047	Riverine broadleaf forest to be flooded by reservoir	Natural	River Kurichhu
HST4 end-monsoon	27.402002	91.196279	Natural riparian forest impacted by MD1 site in tributary.	Natural	Riverine (Trib LB) broadleaf forest
HST5 end-monsoon	27.384100	91.201918	Riverine broadleaf forest is close to the existing road to be impacted by CCF-2, CCF-5	Natural	Riverine (Rewanchhu) broadleaf forest
HST6 end-monsoon	27.358971	91.202690	Natural riverine broadleaf forest to be impacted by MD4	Natural	Riverine (Pheldangchhu) broadleaf forest
HST7 end-monsoon	27.354142	91.204539	Natural riverine broadleaf forest to be impacted by MD4	Natural	Riverine (Kurichhu) broadleaf forest

Ref-Station	Lat DD	Long DD	Name and description of the station	Natural / Modified	Habitat
HST8 end-monsoon	27.353996	91.205572	Natural riverine broadleaf forest	Natural	Riverine (Trib LB) broadleaf forest
HST9 end-monsoon	27.321107	91.225195	Natural riverine broadleaf forest closed to the road	Natural	Riverine (Trib LB) broadleaf forest

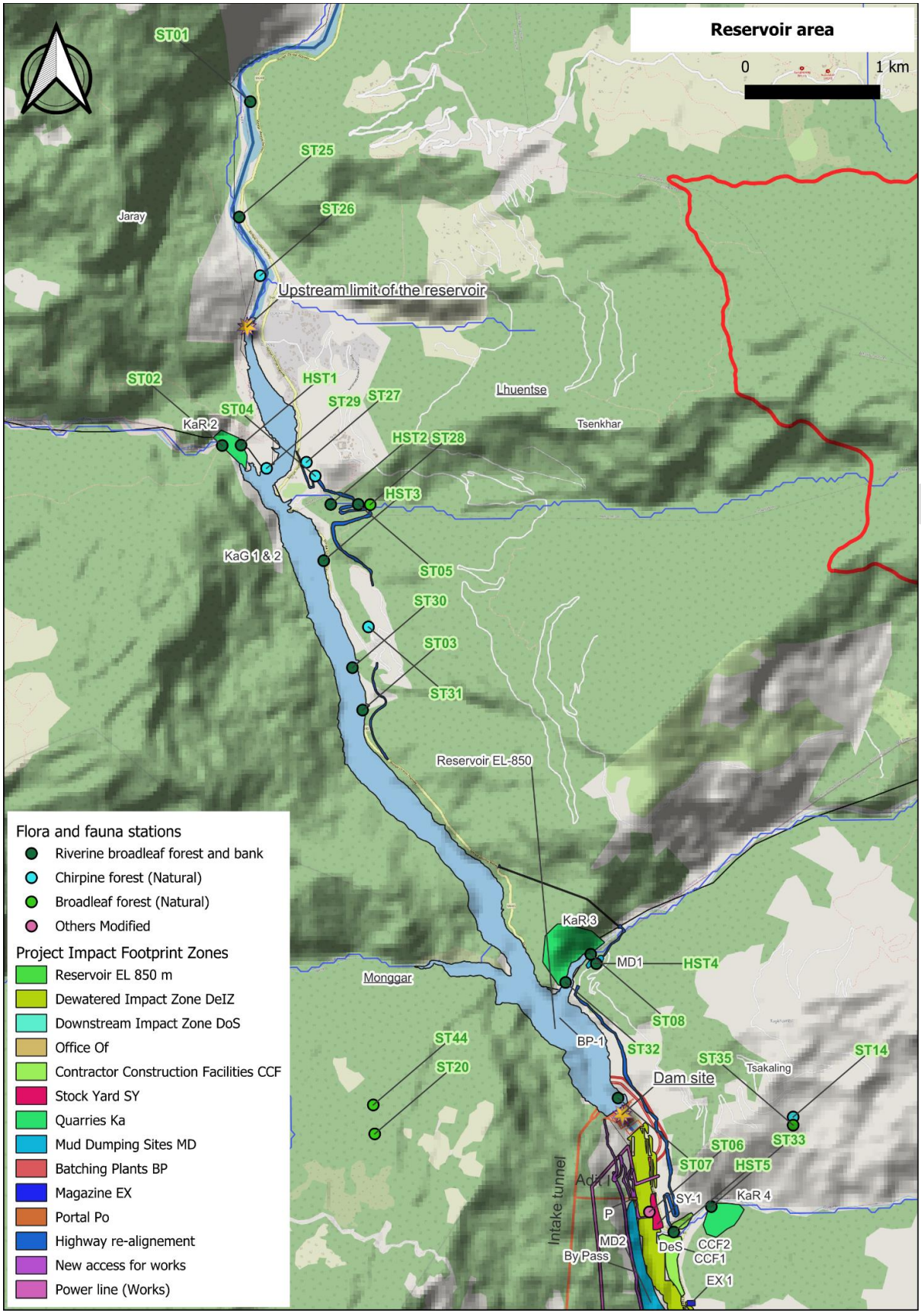


Figure 69: Location of the stations and project footprints (Reservoir area)

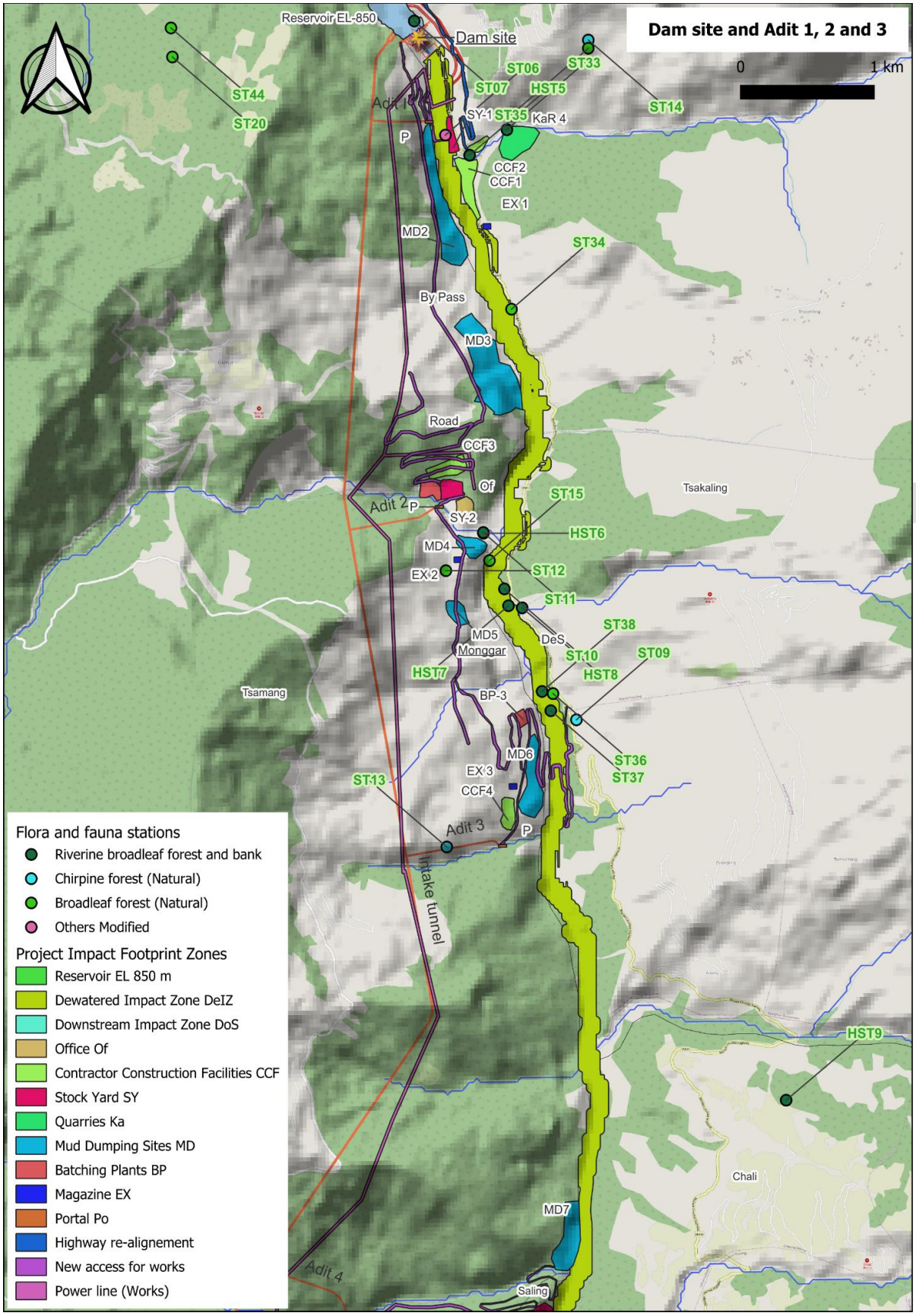


Figure 70: Location of the stations and project footprints (Dam site and Adit 1, 2 and 3)

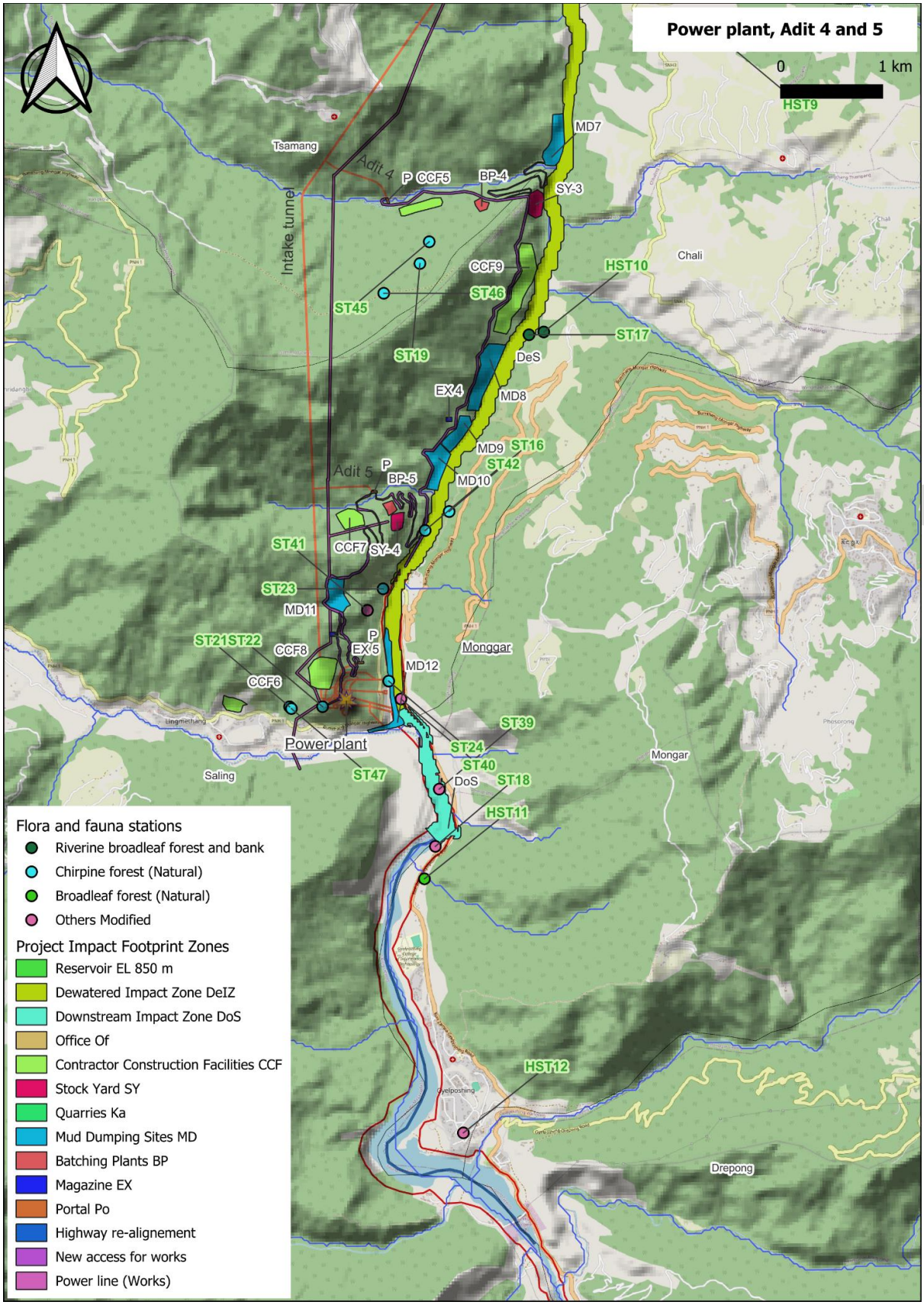


Figure 71: Location of the stations and project footprints (Power plant adit 4 and 5)

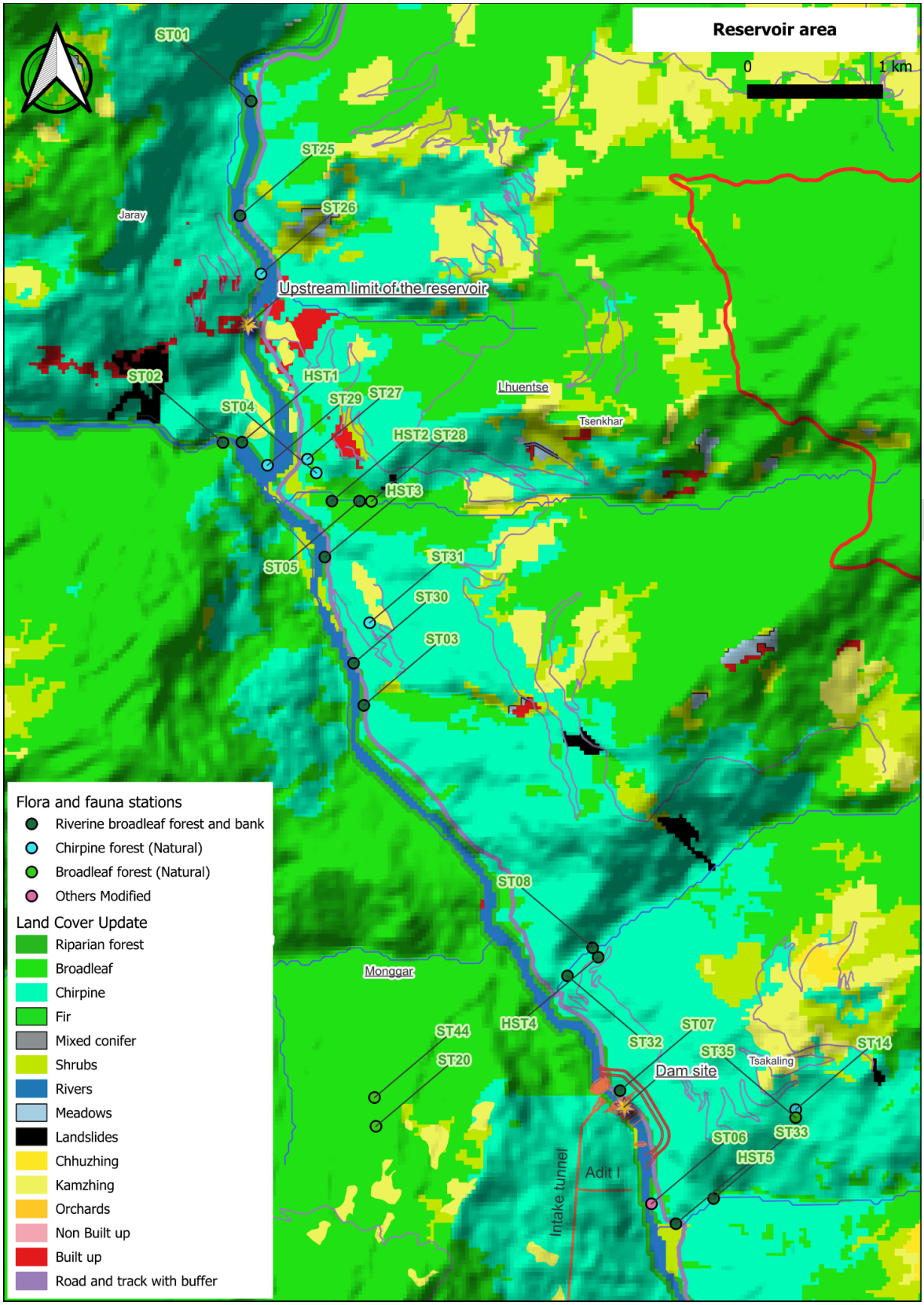


Figure 72: Location of the stations and land cover (Reservoir area)

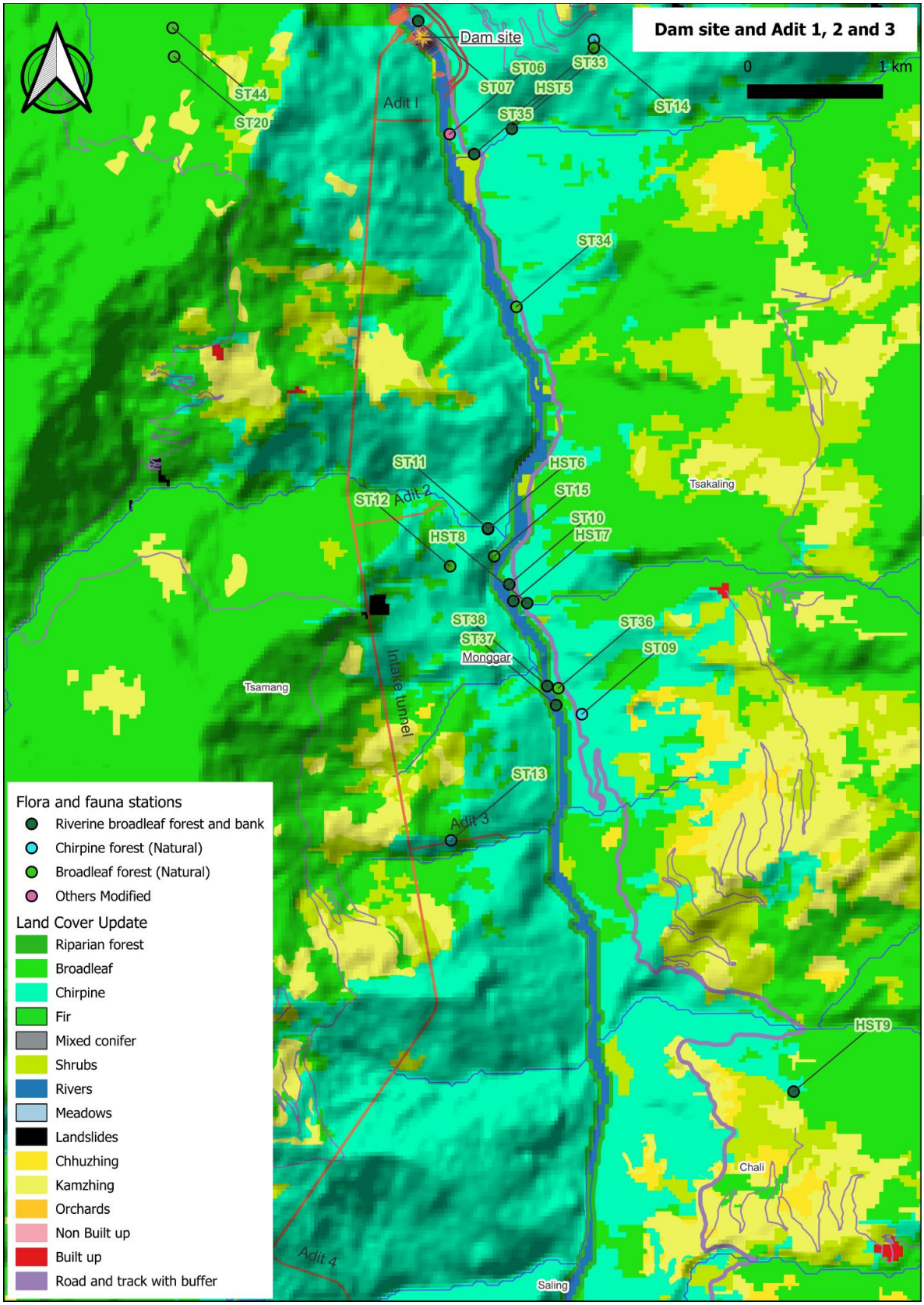


Figure 73: Location of the stations and land cover (Dam site and Adit 1, 2 and 3)

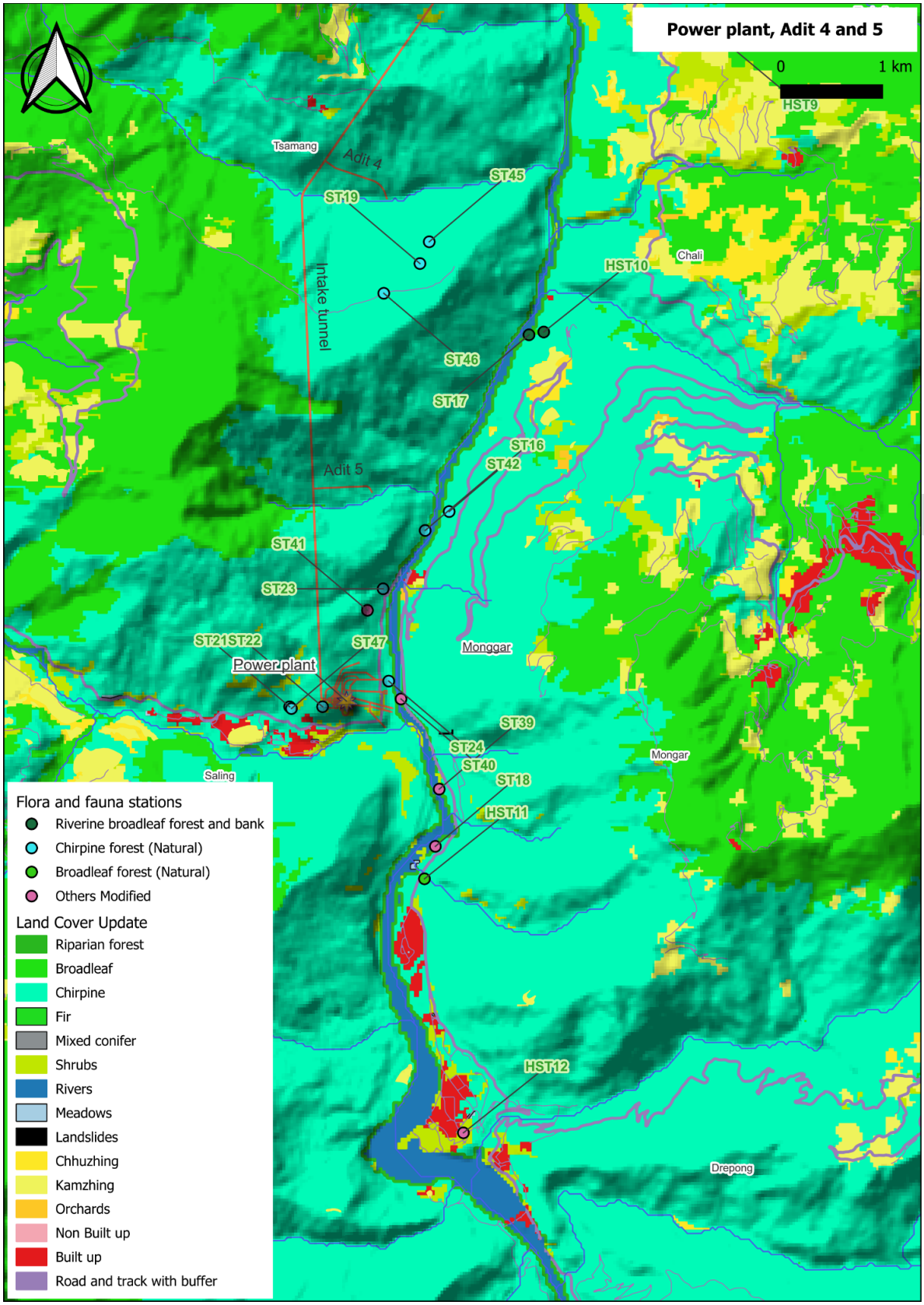


Figure 74: Location of the stations and land cover (Power plant adit 4 and 5)

7.4.2 Methodology

The sampling methodology is detailed in the ESIA Volume VIIIB, Appendix B Terrestrial Biodiversity Field survey report which contain also bibliographic data such as regulation, National Red List, List of the protected species in Bhutan.

7.4.3 Flora

7.4.3.1 Main results of the field survey

This section presents the flora result by main type of habitat with:

- The broadleaf riverine forest. This forest is mainly a subtropical broadleaf forest occurring at the bank of Kurichhu and its tributaries between 500 m to 1000m. The broadleaf riverine forest has been split into 4 subcategories with:

o Riverine bank of Kurichhu when the stations include the bank vegetation of the Kurichhu.
o Riverine slope Kurichhu when the stations are just above the bank in the first slopes above the river and do not include the riverbank vegetation.
o Riverine tributary when the stations are not near the Kurichhu, but representative of a forest close to tributaries of the Kurichhu.

- The Chirpine forest is low altitude xerophytic forests occurring between 500-1300m.
- The broadleaf forest is occurring between 700-1600 m.
- The modified habitat including remnant riverine bank when the stations are located on the Kurichhu bank in a modified habitat by human activities

The results are detailed in the ESIA Volume VIIIB, Appendix B Terrestrial Biodiversity Field survey report which includes the full list of the identified species by station.

Table 101 and Figure 75 below present the number of species by habitat.

Table 101: Number of species by habitat type

Habitat	Tree	Shrub	Herb	Orchid	Total species	Total species LC	Total species EN
Broadleaf forest (9 stations)	24	42	32	10	109	24	0
Chirpine forest (18 stations)	41	56	60	7	164	44	1
Riverine bank Kurichhu (5 stations)	24	25	21	2	72	19	0
Riverine slope Kurichhu (4 stations)	18	25	19	3	65	24	1
Riverine tributary (6 stations)	28	22	43	4	97	27	0
Remnant riverine bank (4 stations)	18	18	21	1	58	16	0
Pioneer herbaceous plants (1 stations)	6	6	6	0	18	5	0

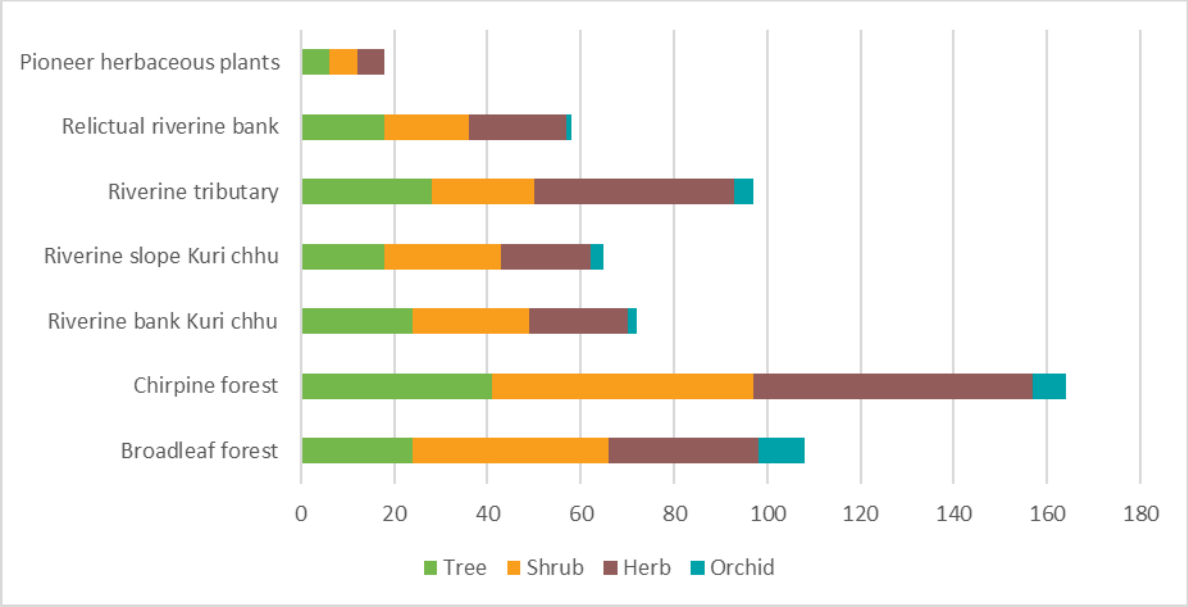


Figure 75: Number of species by habitat

The same species can be shrub or tree depending on its level of development. Aggregating species by station, in case or one species is shrub or tree, the species has been considered as a tree.

Table 102 and Figure 76 below present the number of species by habitat with all the riverine habitat subcategories merged.

Table 102: Number of species by habitat type (Riverine habitat merged)

Habitat	Tree	Shrub	Herb	Orchid	Total species	Total species LC	Total species EN
Riverine broadleaf forest (15 stations)	42	48	58	7	155	43	1
Broadleaf forest (9 stations)	24	42	32	10	109	24	0
Chirpine forest (18 stations)	37	51	58	7	153	41	1
Other modified (5 stations)	22	22	26	1	71	19	0

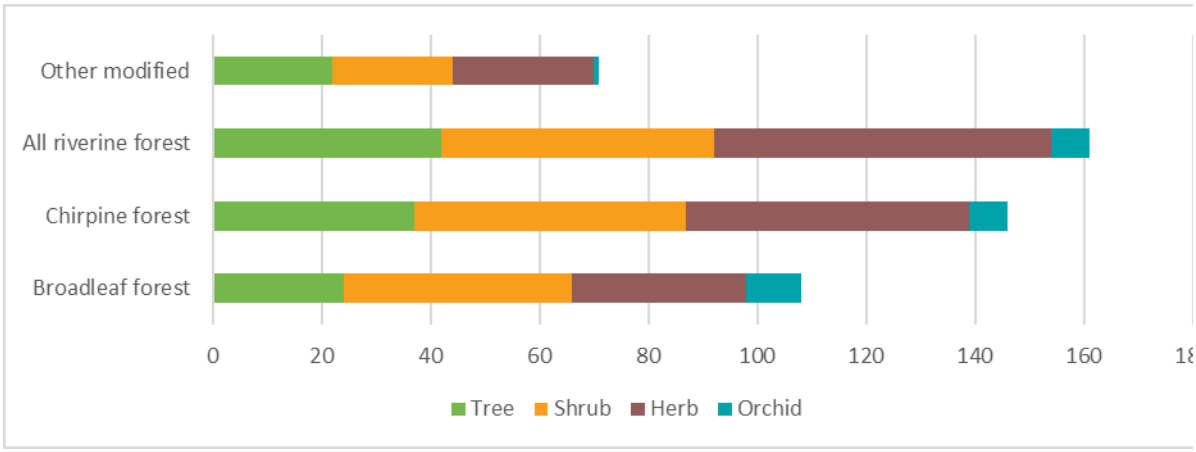


Figure 76: Number of species by habitat (Riverine habitat merged)

The same species can be shrub or tree depending on its level of development. Aggregating species by station, in case or one species is shrub or tree, the species has been considered as a tree.

The whole survey has identified 286 plant species of 93 families. This high number of family and species highlights the rich biodiversity of the area.

The main families are: Orchidaceae (20 species), *Asteraceae* (19 species), *Fabaceae* (19 species), *Phyllanthaceae* (11 species), *Malvaceae* (10 species), *Euphorbiaceae* (9 species), *Urticaceae* (9 species), *Moraceae* (8 species), *Poaceae* (8 species), *Rutaceae* (8 species), *Lamiaceae* (7 species), *Fagaceae* (6 species), *Araceae* (5 species), *Rosaceae* (5 species).

7.4.3.2 Riverine Broadleaf Forest

The station IDs in this habitat are ST01, ST02, ST03, ST05, ST07, ST08, ST09, ST10, ST11, ST17, ST25, ST30, ST32, ST33, ST37, ST38 (15 Stations). The riverine Broadleaf Forest (RBF) represents 3 different types.

- Riverine bank of Kurichhu when the stations include the bank vegetation.
- Riverine slope Kurichhu when the stations are just above the bank in the first slopes above the river and do not include the riverbank vegetation
- Riverine tributary when the stations are not near the Kurichhu but representative of Kurichhu tributaries.

The Riverine Bank of Kurichhu (RBK) is characterised by the presence of 27 tree species and 27 shrub species with *Bauhinia variegate*, *Casearia glomerata*, *Mallotus philippensis* and *Syzygium cumini* which are not (or in much lower number) in the other riverine stations. Note that in one station, one species may be counted as tree and/or shrub depending on the number of species. In this section, the number of tree species plus the number of shrub species is not equal to the aggregated number of tree and shub species because of some double counting. However, *Bauhinia variegate* is only present in ST30 while *Syzygium c*umini, *Casearia glomerata*, *Mallotus philippensis* and *Ficus semicordata* are present is most of the station. These last 4 tree/shrub species may be considered as the most indicative of RBK.

The Riverine Tributary (RT) is characterised by the presence of 31 tree species and 31 shrub species. *Bauhinia purpurea*, *Duabanga grandiflora*, *Fleuggea virosa*, *Pterospermum acerifolium* and *Sapium insigne* are the trees found in a great number of stations. These species can be considered as indicative, but they are also present in other habitats. Seven plants of *Garuga pinnata* are found in only one station (ST33).

The main difference between RT and RBK / RSK is the number of herbs/Orchid species with 43 species compared with the 19 and 21 species respectively for RSK and RBK. RT has the highest diversity with 97

species to be compared with the 65 and 72 respectively for RSK and RBK. *Calanthe triplicata* (orchid), *Mikania micrantha* (invasive plant), *Callicarpa arborea* (LC), *Solanum* viarum (LC) and Urena lobata identified in RT are not identified in RBK and RSK. No herb species is present in all RT stations even if *Mikania micrantha* (invasive plant) is identified in 4 stations indicating that RT is far from being pristine habitat. Tributaries have been observed as good access to construction materials.

The Riverine Slope Kurichhu present a low number of species, maybe linked to the slope and the fact that some stations are closed to the road. However, these riverine stations are significantly different with a lower biodiversity than the two previous riverine stations (RT and RBK). Most of the species have been observed in one station and some in two. There is no indicative tree species for these stations. *Murraya koenigii* (Curry tree) is found in all stations but this species is also found in all other habitats.

A total of 155 species have been found in this habitat with 42 trees, 48 shrubs, 58 herbs and 7 orchids. There are 43 LC species and one EN species. *Hoya bhutanica, the EN species,* is an herb found in ST03 in the RSK habitat in the middle of the reservoir.

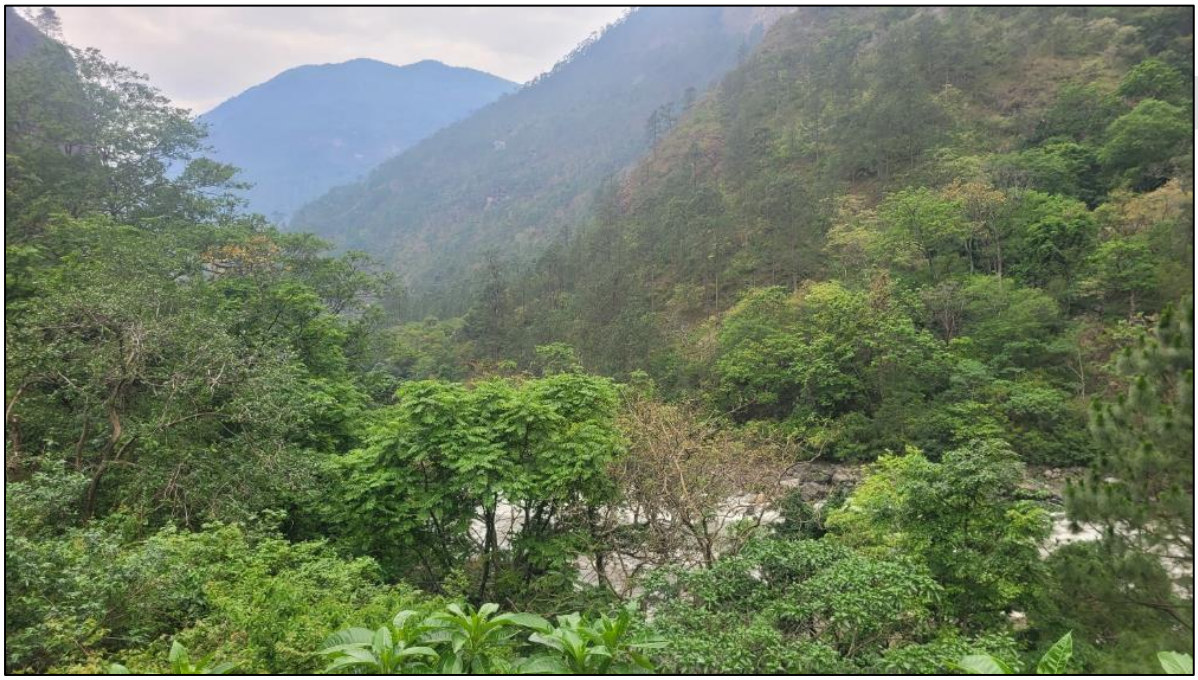


Figure 77: Stations of the Riverine Broadleaf Forest - Riverine bank of Kurichhu – ST1

Figure 78: Riverine bank of Kurichhu – ST17

Figure 79: Riverine tributary – ST8

Figure 80: Riverine bank of Kurichhu – ST38

7.4.3.3 Chirpine forest

The station IDs in this habitat are ST04, ST13, ST14, ST16, ST19, ST21, ST22, ST23, ST24, ST26, ST27, ST29, ST31, ST42, ST45, ST46, ST47.

In Chirpine forest the most abundant tree species is *Pinus roxburghii* found in 17 stations with 95 plants count in the various plots. For other trees (50 species), they are found in 1 to 4 stations indicating a high diversity. Note that in one station, one species may be counted as tree and/or shrub depending on the number of species. In this section, the number of tree species plus the number of shrub species is not equal to the aggregated number of tree and shub species because of some double counting. The most abundant shrubs (59 species) are *Rhus paniculate* (14 stations); *Desmodium confertum* (10 stations), *Phyllanthus emblica* (9 staions), *Flueggea virosa* (8 stations), *Mallotus philippensis* (6 stations) and *Caseria graveolens* (6 stations).

On the 68 herbs species, the most abundant herbs are Chromolaena odorata, Adiantum spp and Nephrolepis cordiflolia but these other species are also found in various other habitats so that there is no indicative herbs species.

A total of 164 species have been found in this habitat with 41 trees, 56 shrubs, 60 herbs and 7 orchids. There are 44 LC species and one EN species. *Tectona grandis (Teak), the EN species,* is a tree that is not native to the area (planted) and therefore does not qualify for CHA. It is found in ST47 in Chirpine forest to be impacted by project access road.

Figure 81: Stations of the Chirpine Forest – ST14

Figure 82: Stations of the Chirpine Forest - ST19

7.4.3.4 Broadleaf forest

The station IDs in this habitat are ST12, ST15, ST20, ST28, ST34, ST35, ST36, ST43 and ST44.

The most abundant tree species in Broadleaf Forest (BF) are *Mallotus philippensis*, *Castonopsis hystrix*, *Quercus griffithii* and *Xanthoxylem armatum*. *Mallotus philippensis* has been found in 6 stations and *Sapium insigne* in 5 stations, while other species are found in a lower number of stations with *Castonopsis hystrix* in 3 stations, the other species are less represented. *Mallotus philippensis* and *Sapium insigne* are found in most habitat types

while *Castonopsis hystrix* is only found in Broadleaf Forest and *Quercus griffithii* is mainly found in BF. These two last species seem to be the most indicative of BF tree species.

Osplimenus hirstellus identified in BF in 5 stations seems to be an herbs species indicative of BF as this species seem to be less represented in the other habitats.

A total of 109 species have been found in this habitat with 24 trees, 42 shrubs, 32 herbs and 10 orchids. There are 24 LC species.

Figure 83: Stations of the Broadleaf Forest

ST15

ST34

7.4.3.5 Modified area in the project area

ST06 is cultivated on private land in the past. It is on CCF1 and representative of CCF2 and CCF3. The indicative tree species in modified habitat are *Albizzia odarotissima, Sapium insigne, Bauhinia purpurea, Melia azedarach, Rhus chinensis, Daubanga grandiflora and Engelhardia spicata*.

The indicative shrub species in the modified habitat are *Murraya koenigii, Murraya koenigii, Sapium insigne, Zanthoxylem armatum, Rhus paniculata* and *Buddleja paniculata*. The indicative herb species in the modified habitat are *Artemesia vulgaris, Mikania micrantha, Cannabis sativa, Adiantum spp, Chromolaena odorata* and *Caesalpinia cullata.*

For reconnaissance survey in the reservoir from Autsho to ST02 crossing some modified areas, the indicative tree species are *Sterculia villosa, Pinus roxburghii, Ficus semicordata* and *Chukrasia tubularis*; the indicative shrub species are *Indigofera dosua, Jasminium grandiflorum, Rhus paniculata, Woodfordia fructicosa, Rubus ellipticus* and *Clerodendrum spp* and the indicative herbs are *Cannabis sativa, Artemesia vulgaris, Polygonatum spp* and *Thalictrum spp.*

For remnant bank vegetation in modified habitat (ST18, ST39, ST40 and ST41), there is no indicative tree or herbs species. For shrubs, *Rhus paniculate* is found in each station and *Indigofera dosua* and *Osyris lanceolata* are also well represented. However, these species are also well present in many other habitats and are not indicative for riverine stations.

There were no Red List species/other restricted range species identified in theses modified habitat.

Figure 84: Stations of the modified habitat

ST06 Young fallow

ST18 Riverine modified habitat

7.4.3.6 Sensitive Flora Species Identified

The main result considering the sensitivities of the species is that there is no CR species, two EN species, one VU, one NT, no DD and 66 LC species. The threatened species (IUCN red list) are the following:

- *Hoya bhutanica* (*Apocynaceae*), EN at global and national level and considered as protected in Bhutan by national legislation
- *Tectonis grandis* (*Lamiaceae*), EN at global IUCN level but not listed in the national red list species and considered as protected in Bhutan by national legislation
- *Piper pedicallatum* (*Piperaceae*), VU at global IUCN level but not listed in the national red list species
- *Eucalyptus obliqua* (*Myrtaceae*), NT at global IUCN level but not listed in the national red list species

Considering the Forest and Nature Conservation Act (2023), 27 occurring species are classified as SCHEDULE II and 7 occurring species SCHEDULE III. On the 27 SCHEDULE II species, 20 are orchids (all Bhutanese orchids are SCHEDULE II). No plant species are classified as SCHEDULE I.

Table 103: Protected plant species identified on site.

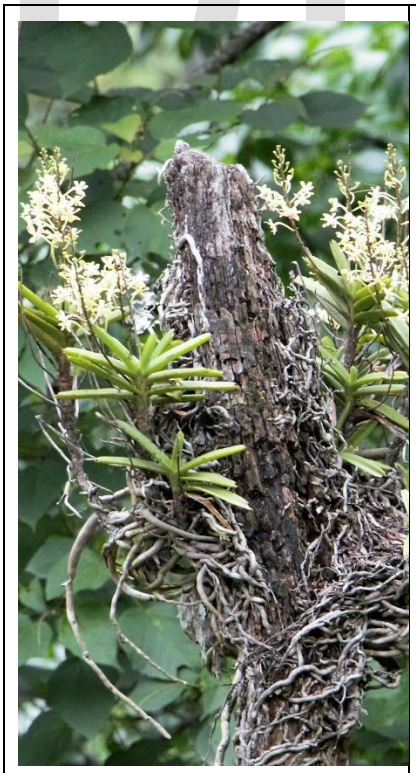
ID	Type	Family	Genus species	Common Name	IUCN (Global)	National Protection (2023)
12	Tree	Combretaceae	Terminalia myriocarpa	East Indian Almond	LC	SCHEDULE II
36	Tree	Juglandaceae	Toona ciliata	Toon Tree	LC	SCHEDULE II
39	Tree	Lamiaceae	Tectona grandis	Teak	EN (not native)	SCHEDULE II
44	Tree	Lythraceae	Duabanga grandiflora		LC	SCHEDULE II
46	Tree	Magnoliaceae	Michelia champaca	Champ	LC	SCHEDULE II
85	Tree	Verbenaceae	Gmelina arborea	White Teak	LC	SCHEDULE II
47	Tree	Malvaceae	Bombax ceiba	Cotton tree	LC	SCHEDULE III

ID	Type	Family	Genus species	Common Name	IUCN (Global)	National Protection (2023)
48	Tree	Malvaceae	Pterospermum acerifolium	Bayur Tree	LC	SCHEDULE III
65	Tree	Phyllanthaceae	Bischofia javanica	Javanese Bishopwood	LC	SCHEDULE III
70	Tree	Pinaceae	Pinus roxburghii	Chirpine	LC	SCHEDULE III
84	Tree	Theaceae	Schima wallichii	Oak	LC	SCHEDULE III
158	Orchid	Orchidaceae	Aerides odorata	Orchid	LC	SCHEDULE II
159	Orchid	Orchidaceae	Agrostophyllum callosum	Orchid	LC	SCHEDULE II
160	Orchid	Orchidaceae	Calanthe spp	Orchid	LC	SCHEDULE II
161	Orchid	Orchidaceae	Calanthe triplicata	Orchid	LC	SCHEDULE II
162	Orchid	Orchidaceae	Cleisostoma williamsonii	Orchid	LC	SCHEDULE II
163	Orchid	Orchidaceae	Crepidium khasianum	Orchid	LC	SCHEDULE II
164	Orchid	Orchidaceae	cymbidium aliofolium	Orchid	LC	SCHEDULE II
165	Orchid	Orchidaceae	Cymbidium bicolor	Orchid	LC	SCHEDULE II
166	Orchid	Orchidaceae	Cymbidium erythraeum	Olotshe	LC	SCHEDULE II
167	Orchid	Orchidaceae	Cymbidium lancifolium	Orchid	LC	SCHEDULE II
168	Orchid	Orchidaceae	Cymbidium triplicata	Orhicd	LC	SCHEDULE II
169	Orchid	Orchidaceae	Dendrobium aphyllum	Orchid	LC	SCHEDULE II
170	Orchid	Orchidaceae	Dendrobium densiflorum	Orchid	LC	SCHEDULE II
171	Orchid	Orchidaceae	Eria spicata	Orchid	LC	SCHEDULE II
172	Orchid	Orchidaceae	Eulophia zollingeri	Carrion orchid	VU	SCHEDULE I
173	Orchid	Orchidaceae	Herpysma longicaulis	Orchid	LC	SCHEDULE II
174	Orchid	Orchidaceae	Rhyncostylis retusa	Foxtail Orchid	EN	SCHEDULE I
175	Orchid	Orchidaceae	Vanda alpina	Montane Vanda	LC	SCHEDULE II
176	Orchid	Orchidaceae	Vanda bicolor	Bicolor Vanda	VU	SCHEDULE I
177	Orchid	Orchidaceae	Vanda cristata	Comb Vanda	VU	SCHEDULE I
239	Herb	Juglandiaceae	Juglans regia	Walnut	LC	SCHEDULE II
187	Herb	Apocynaceae	Hoya bhutanica	Climber	EN	SCHEDULE I
273	Herb	Urticaceae	Boehmeria rugulosa	Chinese Grass, Ramie	LC	SCHEDULE III

Cleisostoma williamsonii

Crepidium khasianum

Cymbidium erythraeum



Vanda alpine

Calanthe triplicata

Rhyncostylis retusa

Figure 85: Some of the 20 orchids identified during the survey

7.4.3.7 Plant use

Most of the species (240) are used by the population for various application like construction, energy, medicinal purposes, etc. The list of these species is provided in ESIA Volume 3 Appendix B TERRESTRIAL BIODIVERSITY FIELD SURVEY REPORT.

7.4.3.8 Invasive species

The overall survey carried out in the 47 stations also allowed the identification of invasive species. In this context, invasive species are defined as species with a high proliferation potential and can be associated as pests. Alien species are the exogenous species of the country, they can be considered as invasive because of the proliferation potential but are not pests. The results of this assessment have been summarised in the following Table 104 invasive species including 11 alien species.

Table 104: List of Invasive species identified in field

ID	Scientific Name	Common Name	Remarks
1	Achyranthes aspera	Chaff-flower	Alien to Bhutan
2	Adiantum spp	Maidenhair Fern	Native
3	Ageratum conyziodes	Billy goat weed	Alien to Bhutan
4	Artemesia vulgaris	Mugwort	Native
5	Barleria cristata	Phillipine Violet	Native
6	Bidens Pilosa	Blackjack	Alien to Bhutan
7	Cannabis sativa	Hemp	Alien to Bhutan
8	Carex spp	Sedges	Natvie
9	Chromolaena odorata	Siam weed	Alien to Bhutan
10	Colocasia spp	Elephant Ear	Native
11	Coriaria nepalensis	Masuri berry	Natvie
12	Crassocephalum crepidiodes	Ebolo thickhead	Native
14	Cynoglosum furcatum	Forked forget-me-not	Native
15	Eupatorium adenophora	Black weed	Alien to Bhutan
16	Euphorbia hirta	Asthma-Plant	Native
17	Euphorbia royleana	Sullu Spurge	Native
18	Eupotorium adenophora	Black weed	Alien to Bhutan
19	Galingsoga conyzoides	Potato weed	Alien to Bhutan
20	Galingsoga parviflora		Alien to Bhutan
21	Geranium nepalensis	Nepal geranium	Native
22	Hedychium spp	Perfume Ginger	Native
23	Herpysma longicaulis	Orchid	Native
24	Lantana camara	West Indian lantana	Alien to Bhutan
25	Mikania micrantha	Mile a-minute	Alien to Bhutan
26	Osplimenus hirstellus	Basket Grass	Alien to Bhutan
27	Parthenium hysterophorus	Congress grass	Alien to Bhutan
28	Persicaria spp	Purple fantasy	Alien to Bhutan
29	Plantago erosa	Plaintain	Nativee
30	Pteridium aquilinum	Common fern	Native
31	Sida acuta	Wireweed	Alien to Bhutan
32	Sida rhombifolia	Arrowleaf Sida	Alien to Bhutan
33	Solanum viarum	Soda Apple	Alien to Bhutan
34	Sonchus spp	Sowthistle	Alien to Bhutan
35	Strobilanthus spp	Pecah, Kaca	Native
36	Tagetes minuta	Mexican marigold	Alien to Bhutan
37	Urena lobate	Caesarweed	Alien to Bhutan
38	Urtica dioca	Common Nettle	Native

7.4.4 Mammals

7.4.4.1 Terrestrial mammals

7.4.4.1.1 Field survey

Eleven mammal species were identified either through direct observation, sound or scats, pellets, dungs and burrows during the field surveys. Barking deer is the most common and observed in many stations. Sambar and Goral are less observed during pre-monsoon survey but are more frequent during the post monsoon survey as they come down to the valley for food. Wild pigs have been observed during the pre-monsoon survey. Twenty species were identified either through camera traps in the AoI. Dhole (Wild Dog), Capped Langur, Tiger, Red Panda are the EN species evidenced in the AoI of the project. Note that the red panda is generally located between 2500 and 3500 m altitude, i.e. above the project's area of influence.

Assamese macaque and Capped Langur are also seen in various places in the AoI and reported in many villages thanks to the interviews conducted. These species are easy to observe, indicating well-established populations in the AoI.

Table 105: Sensitive mammals species identified from field survey

Family name	Scientific name	Common name	FNCA Act (2023)	CITES listing	IUCN Red list	National Red list
Mustelidae	*Aonyx cinereus*	Asian Small-clawed Otter	SCHEDULE II	I	VU	VU
Canidae	*Cuon alpinus*	Dhole (Wild Dog)	SCHEDULE II	II	EN	EN
Cercopithecidae	*Macaca assamensis*	Assamese macaque	SCHEDULE III		NT	
Mustelidae	*Martes flavigula*	Himalayan Yellow Throated Marten	SCHEDULE III	III	LC	
Cervidae	*Muntiacus muntjak*	Barking Deer	SCHEDULE III		LC	
Bovidae	*Naemorhedus goral*	Goral	SCHEDULE II	I	NT	NT
Felidae	*Panthera pardus*	Common Leopard	SCHEDULE II	I	VU	VU
Felidae	*Prionailurus bengalensis*	Leopard Cat	SCHEDULE II	I	VU	LC
Cervidae	*Rusa unicolor*	Sambar	SCHEDULE II		VU	VU
Suidae	*Sus scrofa*	Wild Pig	SCHEDULE III		LC	
Cercopithecidae	*Trachypithecus pileatus tenebricus*	Capped Langur	SCHEDULE II	I	EN	VU

Table 106: Sensitive mammals species identified from camera trap survey.

Family name	Scientific name	Common name	Ind events	No. Of camera	National Red list
Felidae	*Panthera tigris*	Tiger	1	1	EN
Felidae	*Neofelis nebulosa*	Clouded Leopard	2	2	VU
Felidae	*Panthera pardus*	Common Leopard	32	14	VU
Felidae	*Prionailurus bengalensis*	Leopard Cat	38	8	LC
Felidae	*Pardofelis marmorata*	Marbled Cat	16	4	VU
Felidae	*Catopuma temminckii*	Asiatic Golden Cat	39	13	NT
Ursidae	*Ursus thibetanus*	Asiatic Black Bear	12	3	VU
Canidae	*Cuon alpinus*	Asiatic Wild Dogs	37	12	EN
Viverridae	*Paguma larvata*	Masked Palm Civet	7	3	LC
Ailuridae	*Ailurus fulgens*	Red Panda	7	4	EN
Mustelidae	*Martes flavigula*	Yellow-throated Marten	37	13	LC
Cercopithecidae	*Macaca assamensis*	Assamese Macaque	11	8	LC
Cercopithecidae	*Trachypithecus pileatus*	Capped Langur	11	2	VU
Suidae	*Sus scrofa*	Wild pig	187	16	LC
Cervidae	*Muntiacus muntjak*	Barking Deer	205	20	LC
Bovidae	*Naemorhaedus goral*	Himalayan Goral	11	3	LC
Cervidae	*Sambar Deer*	Rusa unicolor	275	23	VU
Hystricidae	*Hysterix brachyura*	Himalayan Crestless Porcupine	56	13	LC
Bovidae	*Capricornis sumatraensis*	Serow	36	9	NT
Sciuridae	*Dremomys lokriah*	Orange-bellied Himalayan Squirrel	29	6	LC

Table 107 - Sensitive mammals species identified by interviewees.

Order	Family	Scientific Name	Common Name	National legislation	CITES	IUCN Red List
Carnivora	Felidae	*Catopuma temminckii*	Asiatic Golden Cat		I	NT
Carnivora	Felidae	*Panthera pardus*	Black Panther	FNCA &FNCRR	I	VU
Carnivora	Felidae	*Pardofelis marmorata*	Marbled Cat		I	NT
Carnivora	Felidae	*Felis chaus*	Jungle Cat		II	LC
Carnivora	Mustelidae	*Lutrogale perspicillata*	Smooth-coated otter		II	VU
Feliformia	Viverridae	*Paradoxuxus hermaphroditus*	Himalayan Palm Civet			LC
Rodentia	Hystricidae	*Hystrix bracyhura*	Himalayan Crestless Porcupine			LC

Order	Family	Scientific Name	Common Name	National legislation	CITES	IUCN Red List
Rodentia	Sciuridae	*Hylopetes alboniger*	Flying Squirrel	FNCRR		LC

Figure 86: Plate of species (mammals)

Asian Small clawed Otter (ST01)

Assamese macaque (Various locations)

Capped langur (Various locations)

Common leopard scats

Sambar (female)

Himalayan Yellow throated Marten

7.4.4.1.2 Camera Trap – National Tiger Survey

Separate to the activities let by Artelia, the National Tiger Survey in Phrumsengla National Park was carried out with effect from 4th October 2021 to 4th November 2022. During this survey, some camera traps were set within the different zones of influence in the proposed Dorjilung Hydropower plant project. The result

shows that 21 species of wildlife were captured in six camera trap stations located inside the Direct Area of Influence, 21 species of wildlife were captured in 7 camera trap stations in the Indirect Area of Influence and 13 species of wildlife species captured in 3 camera trap stations in the Cumulative Area of Influence.

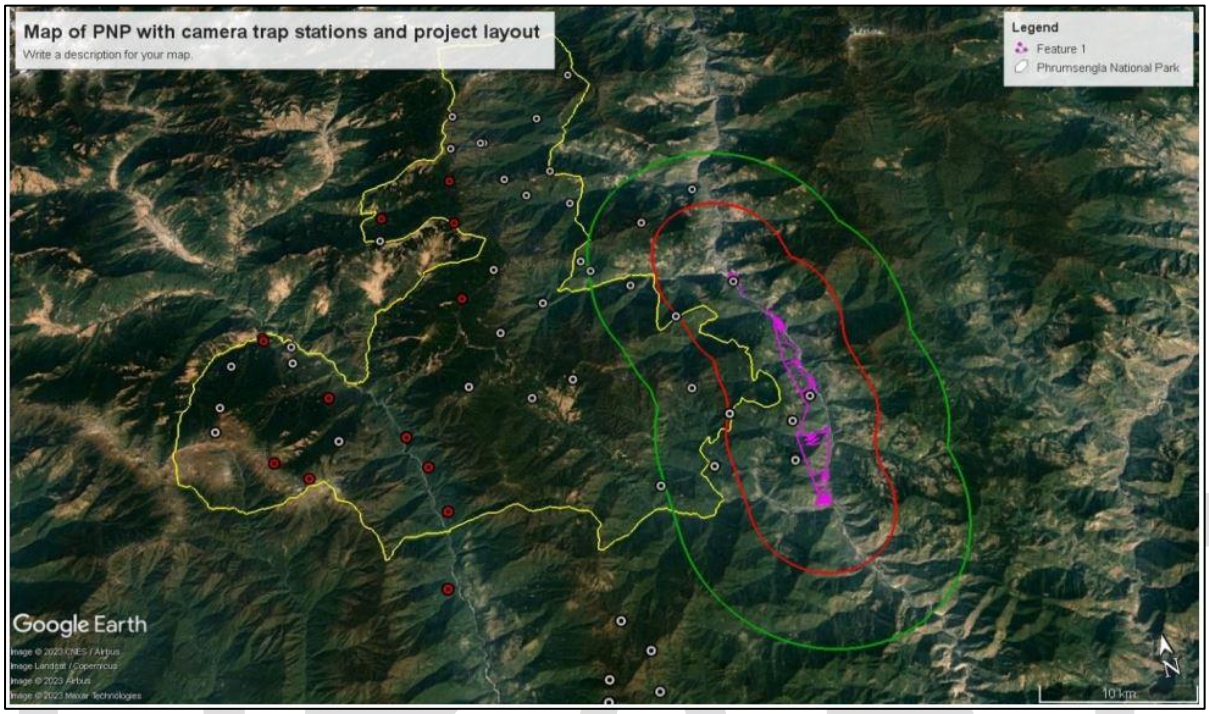


Figure 87: location of the camera trap from NTS inside Dorjilung HPP area of influence (direct, indirect, cumulative) *National Tiger Survey Report of Phrumsengla National Park (2021-2022).*

Among all the species caught on camera, none of them were new record.

7.4.4.1.3 Camera Trap – Department of Forest and Park Services

Separate to the activities let by Artelia, camera trap investigations were carried out by the Nature Conservation Division, Department of Forests and Park Services of the Ministry of Energy and Natural Resources. Observations took place between December 2023 and mid-February 2024. The sampling effort totalled 1549 camera trap days, resulting in the identification of 23 species of mammals, including an unidentified rodent, and 15 species of birds.

The investigative work has been published on July 1st, 2024 (Supplementary Baseline Survey of Mammals, Birds and Fish of the Dorjilung Hydropower Project, Nature Conservation Division, Department of Forests and Park Services, April 2024).

These camera trap activities have been reported in the ESIA Volume VIIIB Appendices, Appendix B. The following mammal species of interest (EN, VU, NT) are here reported:

Table 108: Mammals species of interest evidenced by CT

SPECIES	COMMON NAME	FAMI-LY	CONSERVATION STATUS	RAI	NAÏVE OCCUPANCY	MEAN ELEVATION (MASL)	**RANGE (MASL)**	**MEAN DISTANCE FROM DAM FOOTPRINT (KM)**	**RANGE (DISTANCE FROM THE DAM FOOTPRINT IN KM)**
Panthera tigris	Tiger	*Felidae*	EN	0.06	0.034	1998	nd	6.1	nd
Neofelis nebulosa	Clouded Leopard	*Felidae*	VU	0.13	0.069	2321	2172 - 2469	8.3	6.58 - 10
Panthera pardus	Common Leopard	*Felidae*	VU	2.07	0.483	2032.3	1024 - 2935	7.4	2.34 - 15.57
Pardofelis marmorata	Marbled Cat	*Felidae*	VU	1.03	0.138	2461.5	1998 - 2935	7	2.39 - 11.31
Catopuma temminckii	Asiatic Golden Cat	*Felidae*	NT	2.52	0.448	2391.2	1685 - 2935	8	3.92 - 12.86
Ursus thibetanus	Asiatic Black Bear	*Ursidae*	VU	0.77	0.103	2263.3	1885 - 2470	8	6.58 - 9.04
Cuon alpinus	Asiatic Wild Dogs	*Canidae*	EN	2.39	0.414	2364.5	1998 - 2935	7.3	2.57 - 15.32
Ailurus fulgens	Red Panda	*Ailuridae*	EN	0.45	0.138	2869.8	2470 - 3402	8.4	4.23 - 12.77
Trachypithecus pileatus	Capped Langur	*Cercopithecidae*	VU	0.71	0.069	1528.6	1172 - 1885	8.8	8.21- 9.04
Rusa unicolor	Sambar Deer	*Cervidae*	VU	17.75	0.793	2181.3	983 - 3402	7.2	2.34 - 12.86
Capricornis sumatraensis	Serow	*Bovidae*	NT	2.32	0.310	2134.5	983 - 3402	8.7	2.57 - 15.32

Nd: not determined, only one observation

"Naïve occupancy" determined by dividing the number of camera trap locations where each species was detected by the total number of camera trap locations. "RAI" Relative Abundance Index determined for each species by dividing the number of captures by the total number of sampling days, and then multiplying by 100.

7.4.4.2 Chiroptera

Concerning the chiroptera group, no field surveys were led. Indeed, the IBAT database records the potential presence of 21 differents species and they are all listed as LC, exept one NT. This group does not show issues. The species are presented below.

Table 109: Chiroptera species listed in IBAT database

Family	Scientific Name	Common nam	IUCN Red List
PTEROPODIDAE	*Rousettus leschenaultii*	Leschenault's Rousette	NT OR LR/NT
PTEROPODIDAE	*Cynopterus brachyotis*	Lesser Dog-faced Fruit Bat	LC OR LR/LC
PTEROPODIDAE	*Cynopterus sphinx*	Greater Shortnosed Fruit Bat	LC OR LR/LC
HIPPOSIDERIDAE	*Hipposideros cineraceus*	Least Leaf-nosed Bat	LC OR LR/LC
MEGADERMATIDAE	*Lyroderma lyra*	Greater False Vampire	LC OR LR/LC
PTEROPODIDAE	*Megaerops niphanae*	Ratanaworabhan's Fruit Bat	LC OR LR/LC
VESPERTILIONIDAE	*Pipistrellus coromandra*	Coromandel Pipistrelle	LC OR LR/LC
VESPERTILIONIDAE	*Pipistrellus javanicus*	Javan Pipistrelle	LC OR LR/LC
PTEROPODIDAE	*Pteropus giganteus*	Indian Flying Fox	LC OR LR/LC
RHINOLOPHIDAE	*Rhinolophus ferrumequinum*	Greater Horseshoe Bat	LC OR LR/LC
RHINOLOPHIDAE	*Rhinolophus affinis*	Intermediate Horseshoe Bat	LC OR LR/LC
RHINOLOPHIDAE	*Rhinolophus macrotis*	Big-eared Horseshoe Bat	LC OR LR/LC
VESPERTILIONIDAE	*Scotomanes ornatus*	Harlequin Bat	LC OR LR/LC
VESPERTILIONIDAE	*Scotophilus heathii*	Greater Asiatic Yellow House Bat	LC OR LR/LC
PTEROPODIDAE	*Sphaerias blanfordi*	Blandford's Fruit Bat	LC OR LR/LC
VESPERTILIONIDAE	*Myotis laniger*	Chinese Water Myotis	LC OR LR/LC
VESPERTILIONIDAE	*Myotis nipalensis*	Nepal Myotis	LC OR LR/LC
VESPERTILIONIDAE	*Barbastella leucomelas*	Eastern Barbastelle	LC OR LR/LC
VESPERTILIONIDAE	*Barbastella darjelingensis*	Eastern Barbastelle	LC OR LR/LC
VESPERTILIONIDAE	*Eptesicus serotinus*	Serotine	LC OR LR/LC
HIPPOSIDERIDAE	*Hipposideros gentilis*	Andersen's Roundleaf Bat	LC OR LR/LC

7.4.5 Avifauna

A total of 198 bird species were identified in field surveys through direct sighting, sound, feather and droppings. Pallas Fish Eagle (Haliaeetus leucocryphus) which is listed in FNCRR and EN in IUCN Red list, has habitat near the reservoir of Kurchhu Hydroelectric Plant which is 5km away from Dorjilung Hydropower restitution area.

Great Hornbill (Buceros bicornis) which is listed in FNCRR, CITES Appendix II and VU in IUCN Red list and Rufous-necked Hornbill (Aceros nipalensis) which is listed in FNCA and FNCRR, CITES Appendix II and VU in IUCN Red list are identified through calls in Chirpine forest above ST21 (MD14). Megaceryle lugubris and Spilornis cheela two other FNCA species are also observed.

15 other species classified as Schedule III in the FNCA (2023) have been also observed.

Table 110: Sensitive birds species identified from field survey.

Family name	Scientific name	Common name	FNCA (2023) Act	IUCN Red list	National Red list
BIRDS					
Bucerotidae	*Aceros nipalensis*	Rufus necked hornbill	SCHEDULE II	VU	VU
Phasianidae	*Arborophila torqueola*	Hill Partridge	SCHEDULE III	LC	
Podargidae	*Batrachostomus hodgsoni*	Hodgson's Frogmouth	SCHEDULE III	LC	
Bucerotidae	*Buceros bicornis*	Great hornbill	SCHEDULE II	VU	VU
Cuculidae	*Cacomantis merulinus*	Plantive cuckoo	SCHEDULE III	LC	
Columbidae	*Chalcophaps indica*	Emerald dove	SCHEDULE III	LC	

Family name	Scientific name	Common name	FNCA Act (2023)	IUCN Red list	National Red list
Corvidae	*Corvus macrorhynchos*	Larged-beilled crow	SCHEDULE III	LC	
Cuculidae	*Cuculus micropterus*	Indian cuckoo	SCHEDULE III	LC	
Cuculidae	*Cuculus poliocephalus*	Lesser cuckoo	SCHEDULE III	LC	
Falconidae	*Falco subbuteo*	Eurasian hobby	SCHEDULE III	LC	
Falconidae	*Falco tinnunculus*	Common Kestrel	SCHEDULE III	LC	
Alcedinidae	*Halcyon smyrnensis*	White-throated-kingfisher	SCHEDULE III	LC	
Accipitridae	*Haliaeetus leucoryphus*	Pallas's Fish Eagle	SCHEDULE II	EN	EN
Cuculidae	*Hierococcyx sparverioides*	Large hawk cuckoo	SCHEDULE III	LC	
Phasianidae	*Lophura leucomelanos*	Kalij pheasant	SCHEDULE III	LC	
Phasianidae	*Lophura leucomelanus*	Kalij pheasant	SCHEDULE III	LC	
Alcedinidae	*Megaceryle lugubris*	Crested Kingfisher	SCHEDULE II	LC	
Phalacrocoracidae	*Phalacrocorax carbo*	Great Cormorant	SCHEDULE III	LC	
Accipitridae	*Spilornis cheela*	Crested Serpent-Eagle	SCHEDULE II	LC	
Strigidae	*Taenioptynx brodiei*	Collared Owlet	SCHEDULE III	LC	

Table 111: Sensitive birds species identified from camera trap survey

Family name	Scientific name	Common name	Ind events	No. Of camera	Conservation statuts
Turacoenidae	*Turacoena fasciata*	Barred Cuckoo Dove	7	1	LC
Muscicapidae	*Phoenicurus frontalis*	Blue-fronted Redstart	2	1	LC
Turdidae	*Myophonus caeruleus*	Blue-whistling Thrush	36	8	LC
Corvidae	*Urocissa flavirostris*	Yellow-billed Blue Magpie	2	2	LC
Muscicapidae	*Tarsiger indicus*	White-browed Bush Robin	11	3	LC
Leiothrichidae	*Garrulax leucolophus*	White-crested Laughing Thrush	5	3	LC
Leiothrichidae	*Garrulax albogularis*	White-throated Laughing Thrush	31	6	LC
Leiothrichidae	*Grammatoptila striata*	Striated Laughing Thrush	3	1	LC
Muscicapidae	*Tarsiger cyanurus*	Orange-flanked Bush Robin	1	1	LC
Phasianidae	*Tragopan satyra*	Satyr Tragopan	24	3	VU
Leiothrichidae	*Trochalopteron subunicolor*	Scaly Laughing Thrush	28	3	LC
Leiothrichidae	*Garrulax caudatus*	Long-tailed Laughing Thrush	20	6	LC
Phasianidae	*Lophura leucomelanos*	Kalij Pheasant	78	14	LC
Picidae	*Picus canus*	Gray-headed Woodpecker	1	1	LC
Phasianidae	*Hill Patridge*	Arborophila torqueola	8	5	NT

Additional sensitive species identified by interviewees which may be also considered are listed in the table below.

Table 112: Sensitive birds species identified by interviewees.

Sl. No.	Common Name	Scientific Name	National Legislation	CITES Listing	IUCN Status
1	Beautiful Nuthatch	*Sitta formosa*	VU, FNCRR		VU
2	Blyth's Tragopan	*Tragopan blythii*	VU, FNCRR	I	VU
3	*Chestnut-breasted Partridge*	*Arborophila mandellii*	VU, FNCRR		VU
4	Eastern Imperial Eagle	*Aquilla heliaca*			VU
5	Great Slaty Woodpecker	*Mulleripicus pulverulentus*	VU, FNCRR		VU
6	Greater **Spotted Eagle**	*Clana clanga*	VU, FNCRR		VU
7	Grey-crowned Prinia	*Prinia cinereocapilla*	VU, FNCRR		VU
8	Hodgson's Bushchat	*Saxicola insignis*	VU, FNCRR		VU
9	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	EN, FNCRR		EN

The images below depict bird species present in the project area (direct observation / photos from the Project area)

Grey treepie (Dendrocitta formosae)

Red-vented bulbul (Pycnonotus cafer)

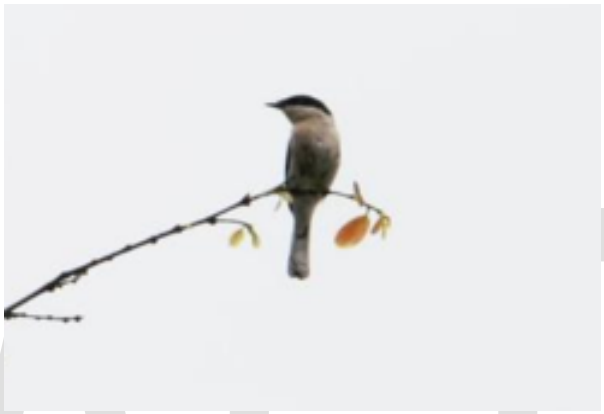
Oriental white eye (Zosterops palpebrosus)

Large-billed crow (Corvus macrorhychos)

Oriental turtle dove (Streptopelia orientalis)

Blue throated barbet (Megalaima asiatica)

Verditer flycatcher (Eumyias thalassina)



Grey buschat (Saxicola ferra)

Spangled drongo (Dicrurus hottentottus)

Rusty cheeked scimitar babbler (Pomatorhinus erythrogenys)

Crimson sunbird (Aethopyga siparaja)

Kalij pheasant (Lophura leucomelanous)

Black drongo (Dicrurus macrocercus)

White crested laughingthrush (Garrulax leucolophus)

Figure 88: Plate of Species (birds)

7.4.6 Herpetofauna

A total of 24 herpetofauna species were identified in the field of 22 reptiles and 2 amphibians. Out of these species, none are listed CR, EN or restricted range. Only the King Cobra (*Ophiophagus hannah*) which is listed in CITES Appendix II and vulnerable in IUCN Red List was sighted near ST04 in the new road construction area.

Eastern Trinket (Elaphe cantoris)

Collared Black-headed Snake (Sibynophis collaris)

White-banded Wolf Snake (Lycodon septentrionalis)

Oranged-collared Keelback (Rhabdophis himalayanus)

Amolops sp

King Cobra
(Ophiophagus hannah)

Himalayan Ground Skink (Ablepharus himalayanus)

Himalayan Little Skink (Sphenomorphus indicus)

Figure 89: Plates of species (Herpetofauna)

7.5 Field survey of the Aquatic Flora and Fauna in the project area

The aquatic baseline was established using available literature and two field missions in May and October 2023, respectively. It includes information on aquatic ecosystems, aquatic plants, macroinvertebrates, and fish. Field investigations were carried out to guarantee that all project components, including the upstream reservoir, future reservoir, downstream of the dam (dewatered section), downstream of the water restitution point, and downstream of the Kurichhu Dam, were covered (See **Figure below**). This field survey included tributaries and mainstream rivers.

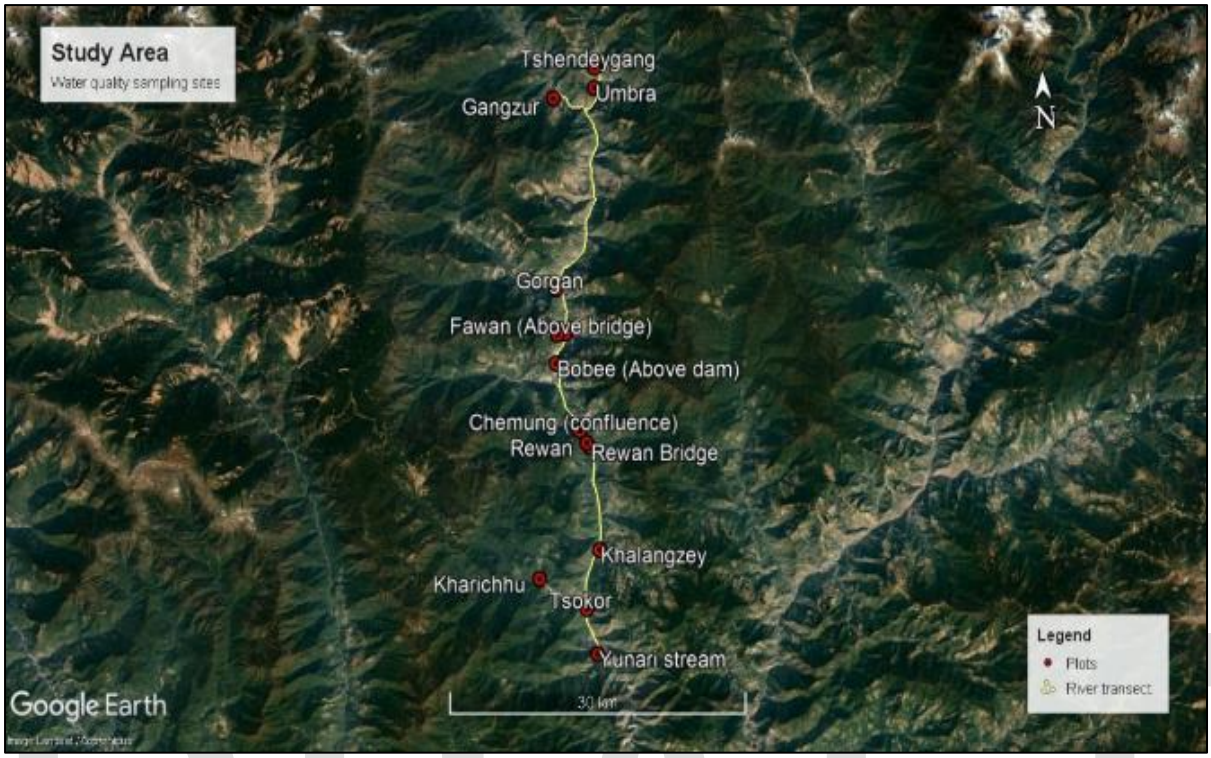


Figure 90: Aquatic Survey, May 2023

7.5.1 Aquatic Habitat

The Dorjilung dam is located on the Kurichhu River which was qualified as a river with pristine water quality state without tendency of eutrophic period (DPR, 2016). Therefore, this initial state indicated that the Kurichhu river is a natural habitat.

The aquatic system samples during the field mission were of 2 types:

- Kurichhu mainstream
- Tributaries

7.5.1.1 Kurichhu mainstream

The mainstream habitat can be described as following:

- River width above 50 m.
- Fast flowing water current (0.4m/s for one area to 4 m/s registered during the field mission)
- The river substratum is mineral. It is mainly composed of medium size gravels, rocks, and boulders. Only a few sand patches were observed.

Upstream station (Bobee)

Upstream station (Bobee)

Downstream of the dam (Rewan station)

Downstream of the restitution (Tsokor station)

Figure 91: Pictures of the general habitat of Kurichhu River in the project area (May 2023)

7.5.1.2 Tributaries

The tributaries habitat can be described as following:

- River width from 5 m to 8.5 m
- Tributaries with fast flowing water current (0.2 m/s for one station and other stations 1.1 m/s to 3.6 m/s)
- The riverbed is mineral composed of natural stones and blocks (diameters > 250 mm) with a few sand patches.
- The tributaries show the largest range of aquatic habitat.:
- Khalangzey (dewatered section), with a width varying from 2m to 4m, shows large blocks and sandy areas, fast flooding waters and a pool. The stream was under the riparian vegetation shadow.
- Kharicchu (tributary downstream of the restitution), with a width varying from 6m to 10m.
- Rewan Bridge (tributary downstream of the dam – dewatered section), with a width of around 8.5m, the tributary show fast flooding waters with a substratum composed by large boulders and rocks. The tributary is surrounded by riparian vegetation.
- Fawan (upstream tributary), with a width of around 8m, with fast current and pool. The station presents a substratum mainly composed of rocks and boulders.

Khalangzey

Kharicchu

Rewan Bridge

Fawan

Figure 92: Fish Ladder observation

Based on field observation (first campaign) and species found, the sensitivity of habitat is defined as medium. Indeed, tributaries present a higher diversity of habitats with a close riparian forest playing an important role for the river system (insects…). Compared to the mainstream river, the tributaries are narrower (max 8.5m vs above 50m for the mainstream river) and shallower and with lower velocity. Furthermore, the tributaries present the highest habitat complexity in terms of substrate composition (various mineral substratum and the presence of riparian vegetation). Field investigation also underlined some human activities close to the tributaries. Anthropogenic modification of the riverbed itself and riverbank were not observed. Therefore, the aquatic habitat could be qualified as natural habitat.

7.5.2 Fish

7.5.2.1 Baseline method

To assess accurately the fish biodiversity and associated biological characteristics (size, weight, presence of eggs/sperm…), a fish survey was conducted at the end of the dry season end of April – early May 2023 and in October 2023. This data were completed by a survey performed end of December 2019.

In the campaign May 2023 (pre-monsoon), stations were located to ensure to cover the future upstream reservoir area, reservoir area, downstream of the dam (dewatered section) and downstream of the restitution (downstream of the Powerhouse). No fish sampling was done in the mainstem river downstream of the Kurichhu dam due to difficult access to the river close to the dam and river condition. The location of the sampling points within the Area of Influence (AoI) is presented in the following map. The same stations were investigated for the second mission in October 2023 (post monsoon).

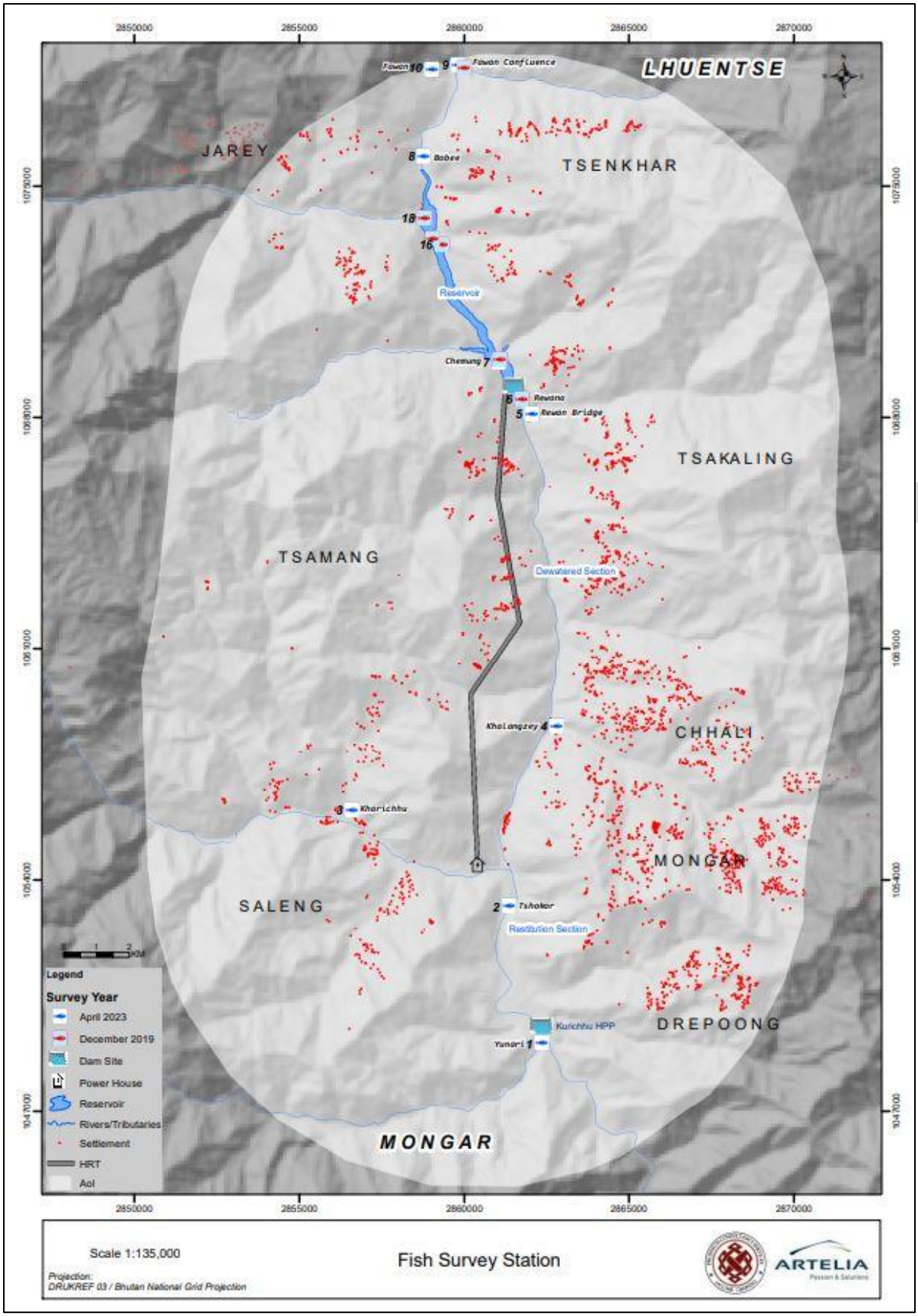


Figure 93: Fish survey station

The same method was applied in 2023 compared to the 2019 mission. Catch and release method was conducted. Electro-shockers along supported by mosquito nets in lieu of seine net, cast nets of 3 metres radius, and scoop net were used to capture fish (Figure 94). Fish were identified on site, measured (total length) and weighed. After measurement, fish were released into the river. Some specimens were put in an aquarium with fresh water for photography. Fish specimens of each species were collected and preserved using 10% formalin for fixation and 70% ethyl alcohol for preservation. Fin clips of few species were collected in 100% ethyl alcohol vials for DNA analysis to confirm their taxa Figure 95.

- No official fishermen were found in the area which underlines that local people do not rely significantly on the river for fishing.

Figure 94: Electric fishing and cast net methods by CNR and Forestry members

Figure 95: Morphometric measurement of fish and DNA samples

7.5.2.2 Results

A total of 13 fish species were recorded in the project area that includes the main River, confluence and tributaries of Kurichhu (Table 113) during the two surveys.

Table 113: List of species recorded during the two field missions and the stations

	Status	October 2023											May 2023														December 2019					
Species		1	2	3	4	5	6	7	8	9	10	11	1	2a	3	4	5	6a	7	8	9	10	11a	12	13	1	2	3	4	5	6
Garra annandalei	LC	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Garra lissorhynchus	LC	-	-	+	+	-	-	-	-	-	-	-	+		+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Garra quadratirostris	NE	+	-	+	+	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Glyptothorax sp.	?	-	-	+	-	+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Neolissochilus hexagonolepis	NT	+	-	+	-	-	-	-	-	-	-	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Parachiloglanis bhutanensis	End.	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
Pseudecheneis sulcata	LC	-	-	+	-	+	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-
Psilorhynchus homaloptera	LC	+	-	+	-	-	-	-	-	-	-	+	+	-	+	-	-	-	+	-	-	+	+	-	-	-	-	-	-	+	
Schistura sp.	?	+	-	+	-	-	-	+	+	-	+	+	+	-	+	-	-	+	+	-	+	+	-	-	-	-	+	-	-	-	+
Schizothorax richardsonii	VU	+	+	+	-	-	-	-	+	-	+	-	-	+	+	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+
Schizothorax sp.	?	-	+	-	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Creteuchiloglanis bumdelingensis	End.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+
Parachiloglanis dangmechuensis	End.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-

Note: * outside project area (above and below project area), [a]River,

Stations: 1=Yunari (downstream of Kurichhu Dam), 2=Tshokor, 3=Kharichhu, 4=Khalangzey, 5=Rewan bridge, 6=Rewana, 7=Chemung, 8=Bobee, 9=Fawan confluence, 10=Fawan, 11=Gorgan, 12=Tshendeygang,

13=Gangzur.

Abbreviation: VU. -Vulnerable, NE- Not Evaluated, NT- Near Threatened, End. - Endemic, LC- Least Concerned, ?-Unknown.

On mainstream Kurichhu River, a total of 7 species were collected during the pre-monsoon season (see Figure below). Fish populations are mainly composed by the torrent stone carp (*Psilorhynchus homaloptera*, 16 ind.), the Buduna (*Garra quadritrirostris*, 14 ind. and *Garra* sp. certainly *quadritrirostris*, 8 ind.), the copper masheer (*Neolissochilus hexagonolepsis*, 21 ind.), *Gadera* (*Schistura* sp., 14 ind.), Khasi garra (*Garra lissorhynchus*, 9 ind.), the snow trout (*Schizothorax* sp., 20 ind.), the Sucker throat catfish (*Pseudecheneis sulcata*, 1 ind.).

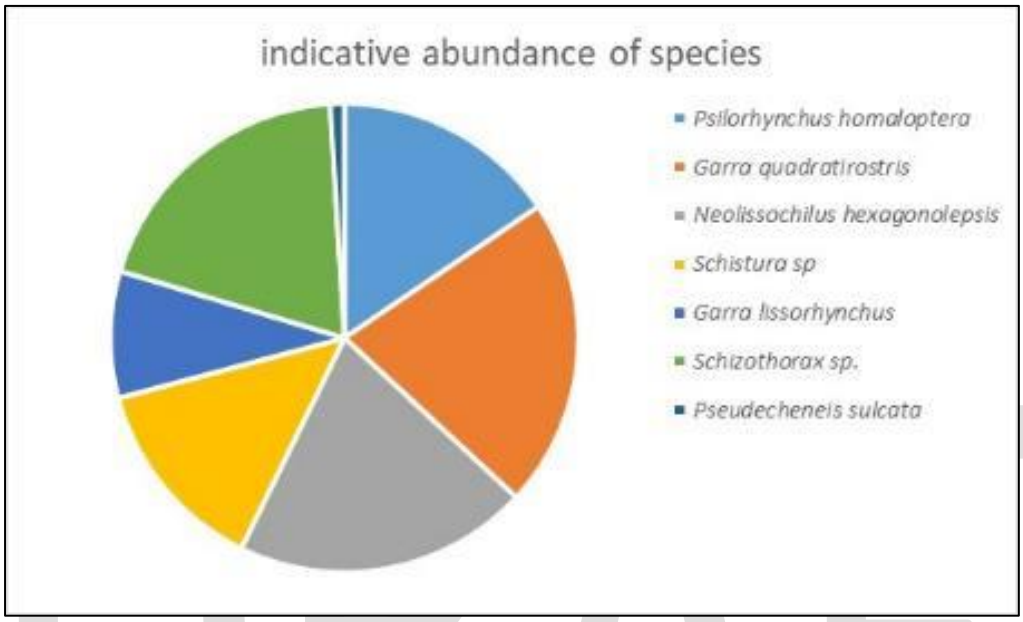


Figure 96: Indicative abundance of species in the mainstream river (May 2023)

In the tributaries, the species found are similar with some more species found. Indeed, a total of 9 species were collected (see Figure below).

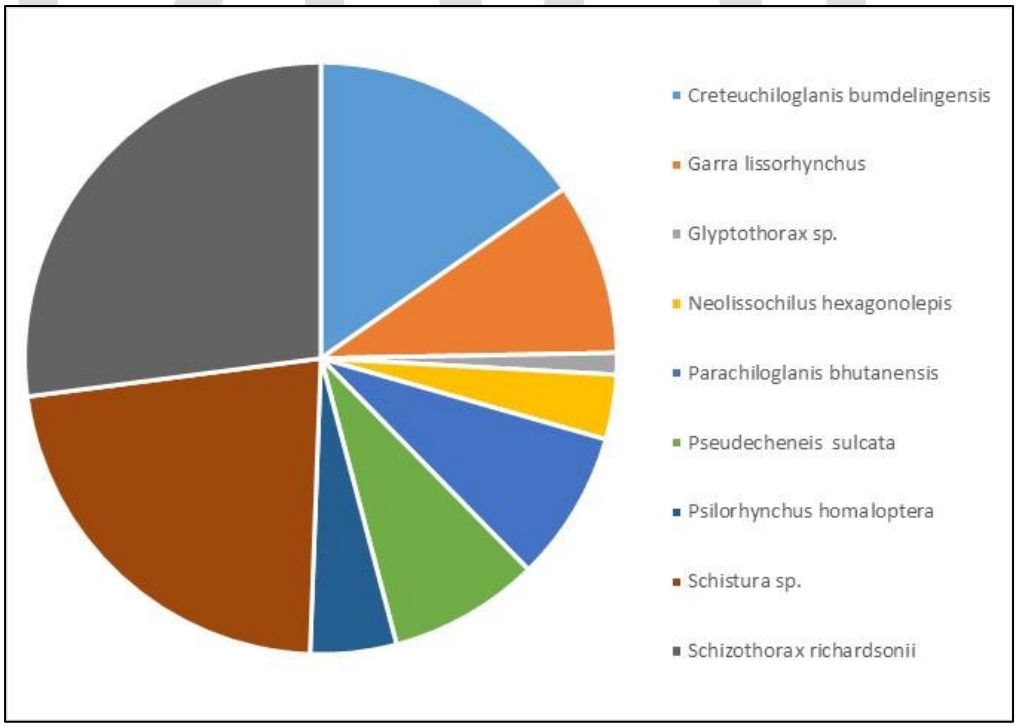


Figure 97: Indicative abundance of species in the tributaries (May 2023)

Schizothorax richardsonii (the snow trout) is a common demersal species found in the Himalayan region, inhabiting mountain stream and rivers. It is known to live among rocks (Fishbase).

Neolissochilus hexagonolepis (Chocolate mahseer/copper mahseer) is widespread in Asia (FishBase 2023). Adults are known to inhabit fast flowing streams and rivers with rocky bottom. They are omnivorous.

Few species of torrent catfish were collected in the project area. These species are:

- *Creteuchiloglanis bumdelingensis* (a torrent catfish) is an endemic species. It is adapted to a high-flow environment. Recent studies investigation highlights that the species prefers cold to moderately warm water in medium to high flow environments. The species might prefer rock substrates and feed on benthic invertebrates (Thoni and Gurung, 2018).
- *Parachiloglanis dangmechuensis* is an endemic species of Bhutan. This species was found in mid to high elevation tributaries of the Dangmechhu River. Specimens were also recorded in Kuktorgangchhu stream in Trashiyangtse, Gamrichhu River Trashigang, Sherichhu River Mongar, and Lingmethangchhu River Mongar. The species is adapted to high flow environments; having striations on the leading rays of the paired fins aiding in adhesion to the substrate, as well as a mouth fit for scraping invertebrates from rocks (Thoni and Gurung, 2018).
- *Parachiloglanis bhutanensis* (Khaling torrent catfish). These species are known in Bhutan to inhabit mid to high elevation tributaries of the Dangmechhu River. Specimens collected from Kuktorgangchhu stream in Trashiyangtse, Gamrichhu River Trashigang, Sherichhu River Mongar, and Lingmethangchhu River Mongar. The species is mainly found adhering to rocks, in riffles and torrents rather than pools. It is adapted to high flow environments; having striations on the leading rays of the paired fins aiding in adhesion to the substrate, as well as a mouth fit for scraping invertebrates from rocks (e.g. plecoptera or ephemeroptera) (Thoni and Gurung, 2018).

Pseudecheneis sulcata (sucker throat catfish) is known as to inhabit freshwater rivers from Bangladesh, Bhutan, India or Nepal.

Psilorhynchus homaloptera (torrent stone carp) is a demersal species is found in high-gradient streams with rocky bottom (Fishbase) and commonly found in Asia (India, Myanmar, or Nepal – source: iucnredlist.org).

Garra sp. are known to be found in very shallow, slow-flowing, crystal-clear, and oxygen-rich streams, small pools, and rivers. Garra is one of the most diverse genera of Himalayan Cyprinidae. In Bhutan, Northeastern India and Nepal, a total of 30 species area recorded and described. During the survey 2 species were recorded. These are *Garra quadritrirostris* (Buduna) and *Garra lissorynchus* (Khasi Garra). The last one is a common species encountered in streams and rivers of central and eastern Bhutan. Specimens were collected in tributaries of the Mangdechhu, Kurichhu, and Bodachhu Rivers, with the Mangdechhu being the westernmost extent of its range in Bhutan. It was always found in clear, fast flowing water with boulders and cobble substrate (Thoni et al. 2016).

Schizothorax richardsonii

Creteuchiloglanis bumdelingensis

Parachiloglanis dangmechuensis

Psilorhynchus homaloptera

Pseudecheneis sulcata

Parachiloglanis bhutanensis

Neolissochilus hexagonolepis

Garra quadritrirostris

Garra lissorynchus

Figure 98: Plate of fish species

Finally, 2 species were collected and under species confirmation by DNA analysis. These species are:

Glyptothorax sp. (Catfish) found in Kharichhu. The morphological characteristics are a Dark coloured skin with a distinct light-coloured lateral line, and a posterior margin of all fins outlined in lighter shade and thoracic adhesive apparatus with a median depression on the ventral part of the body (**Figure below**). This identification must not be considered as a result as analysis is still on-going and might therefore change the sensitivity of the aquatic ecosystem result.

Figure 99: Glyptothorax sp.

Schistura sp. (Gadera) are a species with large and highly diverse group of fish with complicated taxonomy due to limited morphological data and genetic data for majority of the species. The total length of the specimen ranged from 6-11.5 cm and were found dwelling under rocks with stagnant water nearby a stream as well as in the shallow streams (**following figure**).

Figure 100: Glyptothorax sp.

7.5.2.3 Spawning behaviour of species

Spawning behaviour of species is mentioned in the following table. However, some species missed scientific data on spawning behaviour. Therefore, spawning habits were defined based on existing knowledge of congeners and knowledge from the national fish expert.

Table 114: Spawning behaviour of species

Species	Spawning period	Spawning habitat
Schizothorax richardsonii	April/May. Presence of small fingerlings during September and December 2019 was recorded which indicated that the species continues to spawn until late autumn (September-October)	Shallow gravelly riverbanks of larger river water with low water current or in the smaller stream reaches.
Creteuchiloglanis bumdelingensis	Unknown	unknown
Parachiloglanis dangmechhuensis	Spawning habit is likely to be like other congeners	Spawning habit is likely to be like other congeners*
Psilorhynchus homaloptera	This species spends most of its wintertime in larger water bodies and migrates short distance upstream during summer, June-July	Gravelly water courses among smaller streams.
Pseudecheneis sulcata	Unknown	unknown
Glyptothorax sp.	Spawning habit is likely to be like other congeners	Spawning habit is likely to be like other congeners*
Schistura sp.		Members of loaches are noted to spawn before the onset of monsoon in shallow water, securing eggs under stones or among gravels
Parachiloglanis bhutanensis	unknown but it is reported that females caught in February 2019 and May 2023 had mature eggs	To be defined

Species	Spawning period	Spawning habitat
Neolissochilus hexagonolepis	from April to October with a peak during monsoon	Stones and gravels.
Garra quadritrirostris	during monsoon	
Garra lissorynchus	during monsoon	

** Congener refers to a species expected to have the same habits of other species of the same genus*

7.5.2.4 eDNA survey

The Nature Conservation Division, Department of Forests and Park Services of the Ministry of Energy and Natural Resources has conducted eDNA sampling in the project area (See appendix B). Observations took place between December 2023 and mid-February 2024. Environmental DNA (eDNA) sampling was conducted at 14 sites along the Kuri Chhu River and its main tributaries.

The results are reported on the table below and complement the fish capture field activities.

Table 115: eDNA results for fish in the Kuri Chhu River and its major tributaries

SCIENTIFIC NAME	COMMON NAME	IUCN STATUS	FNCA 2023 STATUS	NO. OF SITES	SITE TYPE
Anguilla bengalensis	Indian mottled eel	NT	Schedule III	1	Tributary
Creteuchiloglanis spp	Torrent Catfishes	-	Schedule III	11	Main river, Tributary
Cyprinus spp	Carp species	-	Schedule III	1	Main river
Garra spp		-	-	9	Main river, Tributary
Glyptothorax annandalei	Sisoroid catfishes	LC		11	Main river, Tributary
Labeo rohita	Rohu	LC	-	4	Main river, Tributary
Neolissochilus hexagonolepis	Copper mahseer	NT	-	5	Main river, Tributary
Parachiloglanis spp	Sisoroid catfishes	Not Evaluated	Schedule II	10	Main river, Tributary
Pseudecheneis sulcata	Suckerthroat Catfish	LC	-	14	Main river, Tributary
Salmo spp	Trout	-	-	1	Tributary
Schistura spp	Stone loach	-	Schedule III	1	Tributary
Schizothorax spp	Snow trout	VU	-	12	Main river, Tributary
Tachysurus spp	Catfish species	-	-	1	Main river
Triplophysa spp	Loach species	-	-	5	Main river

This resilt confirm the absence of Golder Masheer (Tor putitora) in the project area.

A consolidated list of species is proposed below merging fish capture and field activities.

Table 116: Consolidated list of fish species

Scientific name	Common name	IUCN status (or RR status)
Anguilla bengalensis	Indian mottled eel	NT
Creteuchiloglanis bumdelingensis	Torrent Catfishes	End
Cyprinus spp	Carp species	-
Garra annandalei		LC

Scientific name	Common name	IUCN status (or RR status)
Garra lissorhynchus		LC
Garra quadratirostris		NE
Glyptothorax annandalei	Sisoroid catfishes	*LC*
Labeo rohita	Rohu	LC
Neolissochilus hexagonolepis	Copper mahseer	NT
Parachiloglanis bhutanensis	Torrent Catfishes	End
Parachiloglanis dangmechuensis	Torrent Catfishes	End
Pseudecheneis sulcata	Suckerthroat Catfish	LC
Salmo trutta	Trout	-
Psilorhynchus homaloptera		LC
Schistura sp.	Stone loach	?
Schizothorax richardsonii	Snow trout	VU
Schizothorax sp.	Snow trout	?
Tachysurus spp	Catfish species	*? (No CR, EN, VU) may be LC, NT or DD*
Triplophysa spp	Loach species	*?*

Abbreviation: VU. -Vulnerable, NE- Not Evaluated, NT- Near Threatened, End. - Endemic (RR: Restricted range), LC- Least Concerned? -Unknown

7.5.2.5 Fish observation

7.5.2.5.1 The fish Ladder observation – Kurichhu HPP

The fish ladder was visited on the 29th of May 2023. The fish ladder functions manually Figure 101. It was not possible to observe fish directly on the fish ladder or to get information as there is no monitoring or data captured on the fish ladder (except real time readings of the flow passed through the ladder) and there is no information on the fish species that may use it. There is also no information on the design parameters used to determine the fish ladder (noting that it is a very tall / long structure with high flow velocities and limited resting spots). Therefore, the Golden Mahseer is unlikely to use the ladder, and it was not found upstream of the ladder.

However, around 100m downstream of the dam (near the confluence of the tributary downstream), Golder Masheer (*Tor putitora*) at the OBS 1 point (see following figure on the top right and map). Individuals were observed on the riverbank, close to rocks and low current. These groups were composed of around 10 individuals (see picture on the top right below). The Golden masheer, qualified as endangered species, was not collected in samples in the upstream area of the Kurichhu Dam that might be a barrier for further migration upstream.

Figure 101: Fish Ladder observation

7.5.2.5.2 Fish use

No fishers were observed to fish in the river or tributary. Indeed, fish license/permit are required.

Observation in the market at Autsho was done. Some dried fish were observed (see following figure). However, these fish are not from local fish activities and were reported to be imported from India and Thailand.

Furthermore, during social investigation (see chapter "Uses of the Kurichhu River") the river was not mentioned as important for the resource for the communities. For the 8 Gewog community interviews, only one interview raised a bit of fishing even though this activity is known to be forbidden. This reflects insignificant fishing pressure in the area and the use of this natural resource.

Figure 102: Dried imported fish (Autsho market)

Based on the results of the first survey, the sensitivity of fish is moderate to high (tributaries area)

7.5.3 Aquatic Flora

The aquatic habitat (riverbed) is mainly mineral as described in the previous chapter. Strict aquatic flora was not observed in the project area (mainstream and tributaries). Only one tributary downstream of the future restitution point presents a little development of bryophytes on a few rocks. Only one semi-aquatic plant was observed in the mainstream river: *Persicaria capitata.*

Observations were made on the more terrestrial riparian flora (located on riverbank). Main species identified are presented in the following table.

Table 117: List of observed plants during aquatic survey

Name of the species	IUCN status	Location	Comment
Persicaria capitate	Unknown (other *Persicaria* spp. in southeast Asia are LC)	River mainstream	Semi-aquatic
Ageratina Adenophora	LC	Riparian mainstream and tributaries	Introduced species terrestrial
Asclepias sp.	unknown	Riparian	Terrestrial
Anaphalis sp.	unknown	Riparian	Terrestrial plant
Drymaria cordata	LC	Riparian	Terrestrial

Name of the species	IUCN status	Location	Comment
			Known as a medicinal plant
Mikenia micrantha	NE	Riparian	Terrestrial Invasive species

Source: Bhutan Biodiversity Portal

Persicaria capitate (Kurichhu mainstream)

Ageratina adenophora (Kurichhu mainstream)

Asclepias sp. (Kurichhu mainstream)

Anaphalis sp. (Kurichhu mainstream)

Figure 103: Plate of Aquatic Flora

Species found near the main river or tributaries are widespread in the area and are not threatened species. Some of the riparian plants found during the baseline survey are known to be invasive species such as *Mikenia micrantha.*

Finally, some periphyton was observed during the first campaign. Indeed, the periphyton and algae are an important component (see picture below). Periphyton on rocks were observed in some tributary's stations (station 3, Kharichhu station). Phytoplankton was also sampled (see chapter 7.5.5.2.2).

Figure 104: Rocks with periphyton

Based on field observation (first campaign) and species found, the sensitivity of aquatic flora and riparian plants is defined as low.

7.5.4 Aquatic Invertebrates

7.5.4.1 Baseline method

Aquatic invertebrates are recognized to be an important component of freshwater systems as they are important food resources for fish. They also are a good indicator of the aquatic system. Indeed, assessment of benthic aquatic-invertebrates provide useful information on the pollution and habitats (Giri and Singh, 2012). At each sampling station, rock flip and kick sampling method were used. Substratum at each station was disturbed by hand. Aquatic invertebrates were collected by a net. All individuals were placed in a white container for identification (main families only) and pictures were taken.

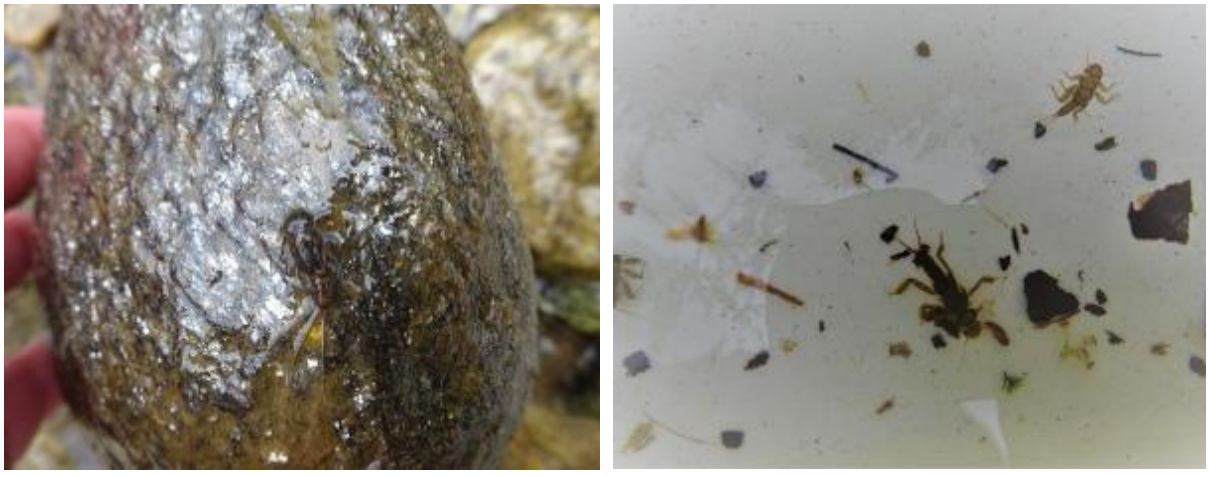


Figure 105: Macroinvertebrates sampling

The objective of the baseline was to provide an overall image of the aquatic macroinvertebrate's families of the river and streams in the project area. This includes the diversity (until the genus level) and the sensibility of the genus to the environment.

A literature review of available documentation in the project area was conducted to complete the field data.

7.5.4.2 Results

A high diversity of macroinvertebrates belonging to 18 orders and 89 families are found in Bhutan (Dorji & Gurung, 2017). However, the team encountered only 9 types of macroinvertebrates in the main River, confluence and tributaries of Kurichhu. The list of species by sampling point (presence/absence) is provided in the table and in the following map. Some of sampling areas did not allow aquatic invertebrates observation (high water level and velocity).

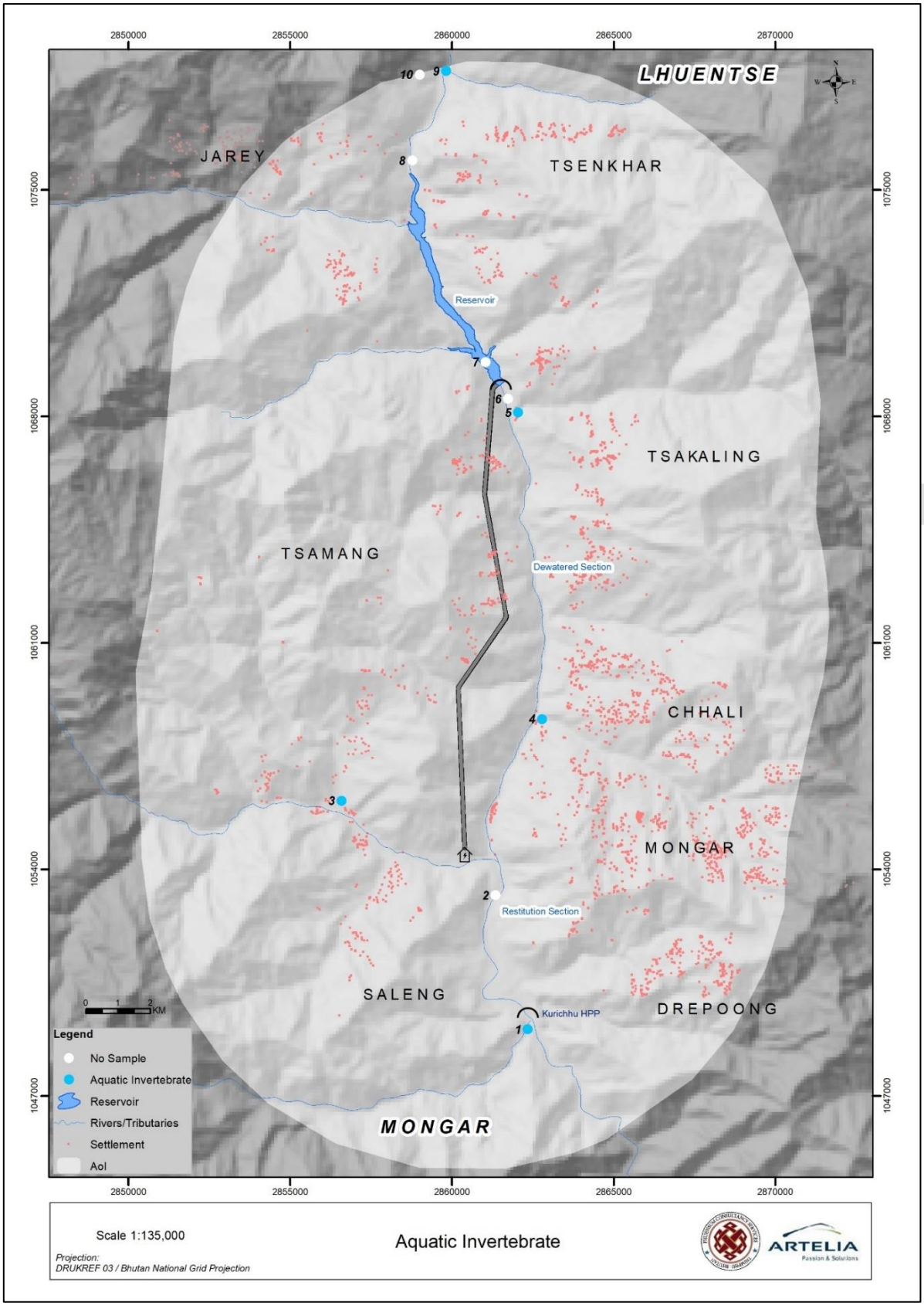


Figure 106: Aquatic Invertebrate observation

Table 118: List of macroinvertebrates found during the pre-monsoon field mission

Order	Family	Genus	Common name	Habitat	1	2[a]	3	4	5	6[a]	7	8	9	10	11[a]	12	13
Megaloptera	Corydalidae	*Corydalus*	Dobsonflies	Riffle	+		+		+				+			+	
Ephemeroptera	Heptageniidae	*Epeorus*	Flat-headed Mayflies	Riffle	+				+							+	
Odonata	Gomphidae	*Gomphus*	Club-tailed dragonflies	Riffle	+			+								+	+
Plecoptera	Perlidae	*Acroneuria*	Common stonefly	Run					+							+	
Trichoptera	Hydropsychidae	*Arctopsyche*	Net spinning caddisfly	Run					+							+	
Hemiptera	Aphelocheridae	*Aphelocheirus*	Creeping water bug	Run					+								
Ephemeroptera	Baetidae	*Baetis*	Blue-winged olive	Run					+								
Trichoptera	Brachycentridae	*Brachycentrus*	Humpless casemaker caddisfly	Cascade												+	
Trichoptera	Leptoceridae	Unknown	Case-building caddisfly	Cascade												+	

Note: * Outside project area (above and below project area), [a]River, 1=Yunari, 2=Tshokor, 3=Kharichhu, 4=Khalangzey, 5=Rewan bridge, 6=Rewan, 7=Chemung, 8=Bobee, 9=Fawan confluence, 10=Fawan, 11=Gorgan, 12=Tshendeygang, 13=Gangzur

Number of identified species varies amongst the sampling station with a highest diversity recorded at Rewan Bridge and Tshendeygang (upstream area). All other sampling stations show low diversity.

For the overall area, a total of 65 individuals were identified. Megaloptera are dominant followed by Ephemeroptera and Plecoptera

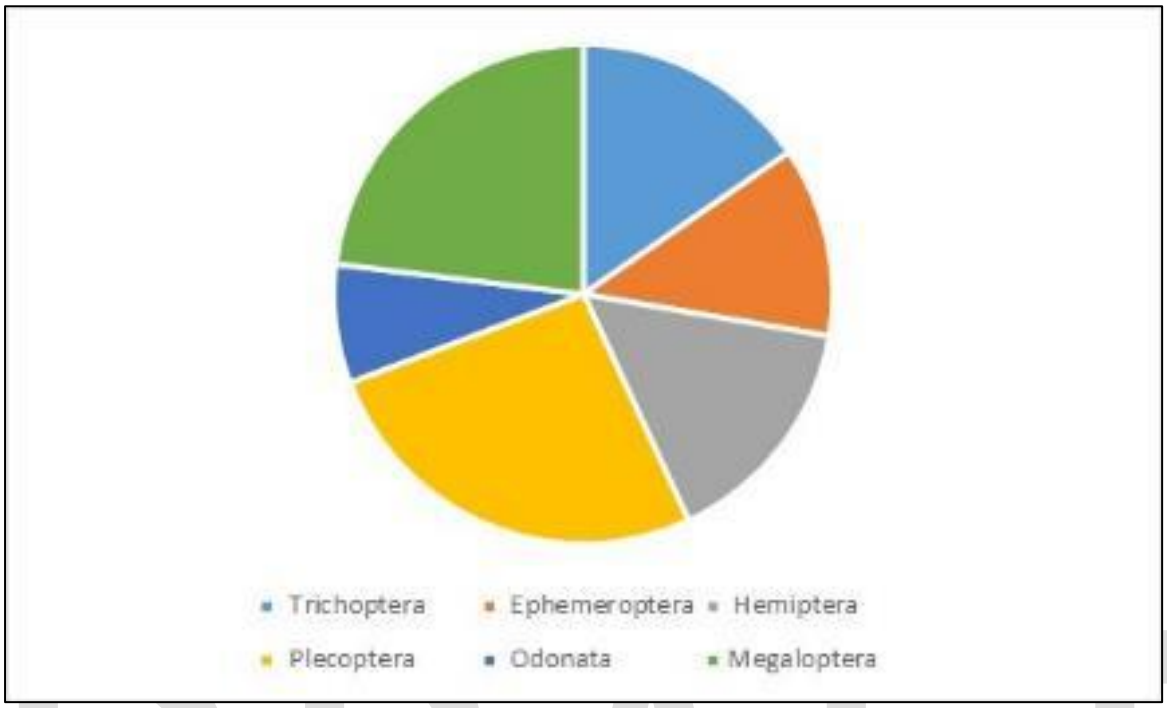


Figure 107: Indicative abundances of macroinvertebrates in the project area in May 2023

The presence of sensitive benthic macroinvertebrates families (Ephemeroptera, Plecoptera, and Trichoptera) highlights a good water quality. No molluscs were observed (high variation of temperature during the year, low conductivity might be limiting factors).

A macroinvertebrate investigation was conducted in 2015 in the Kurichhu Dam area (Department of Water Resources, UWICE, 2015). This study includes a sampling point upstream of the reservoir (on the Kurichhu River) which correspond to the downstream restitution area. The survey included quantitative assessment over a 3km distance. Samples were collected in various habitats including riffle, run, cascade and pool.

Figure 108: Sampling site 2018 – Downstream of the restitution point

Source: Department of Water Resources, UWICE, 2015

The 2015 study underlined (Figure 109):

- A diversity of 37 species (including tadpole and 2 fish) and density (28 ind/30cm² area) compared to the downstream area of the Kurichhu dam.
- Dominance of Ephemeroptera.

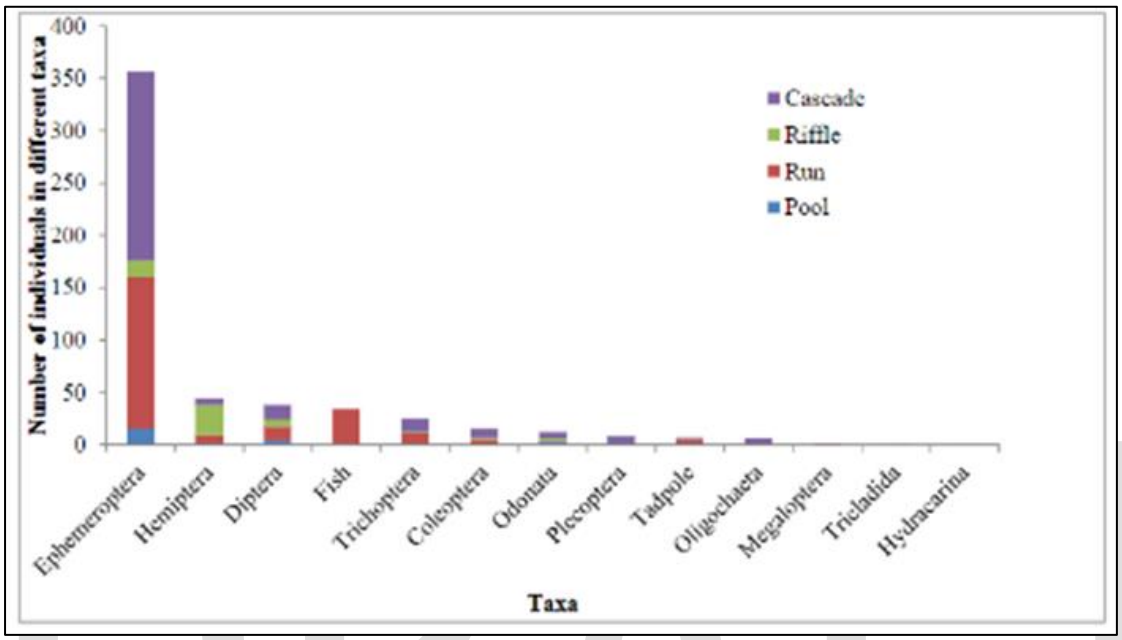


Figure 109: Abundance of taxonomical group per habitat

Source: Department of Water Resources, UWICE, 2015

Based on field observation (first campaign) and species found, the sensitivity of aquatic invertebrates is low to medium (for the future reservoir area).

7.5.5 Freshwater plankton assessment

As plankton plays a vital role in the structure and function of an aquatic ecosystem, influencing the food webs, nutrient cycles, biogeochemical cycles, and the overall health of the water bodies (Ganoni et al., 2018), an assessment was performed in the project area to complete the aquatic baseline. The objective of the study was to identify the plankton to family and genus level and assess the plankton biomass and diversity (richness index and diversity index). The study report is provided in ESIA Volume 3 Appendix C - Dorjilung HPP Freshwater Plankton Assessment Final Report.

7.5.5.1 Baseline method

The study included records of samples taken from 16 sampling sites on Kurichhu river and its tributaries located in Mongar and Lhuentse Dzongkhag. The analysis included a total of 64 samples of phytoplankton, and 64 samples of zooplankton, for one post-monsoon season for December 2023. A team of five members from Sherubtse College, Kanglung was involved in sample collection from December 2, 2023, to December 9, 2023.

Water parameters were analysed for all sampling sites including pH, electrical conductivity (EC), dissolved oxygen (DO), temperature (T) and turbidity.

The detailed method is provided in the Freshwater Plankton Assessment report (ESIA Volume 3 Appendix C - Dorjilung HPP Freshwater Plankton Assessment Final Report)

The sampling stations are presented in the following figure.

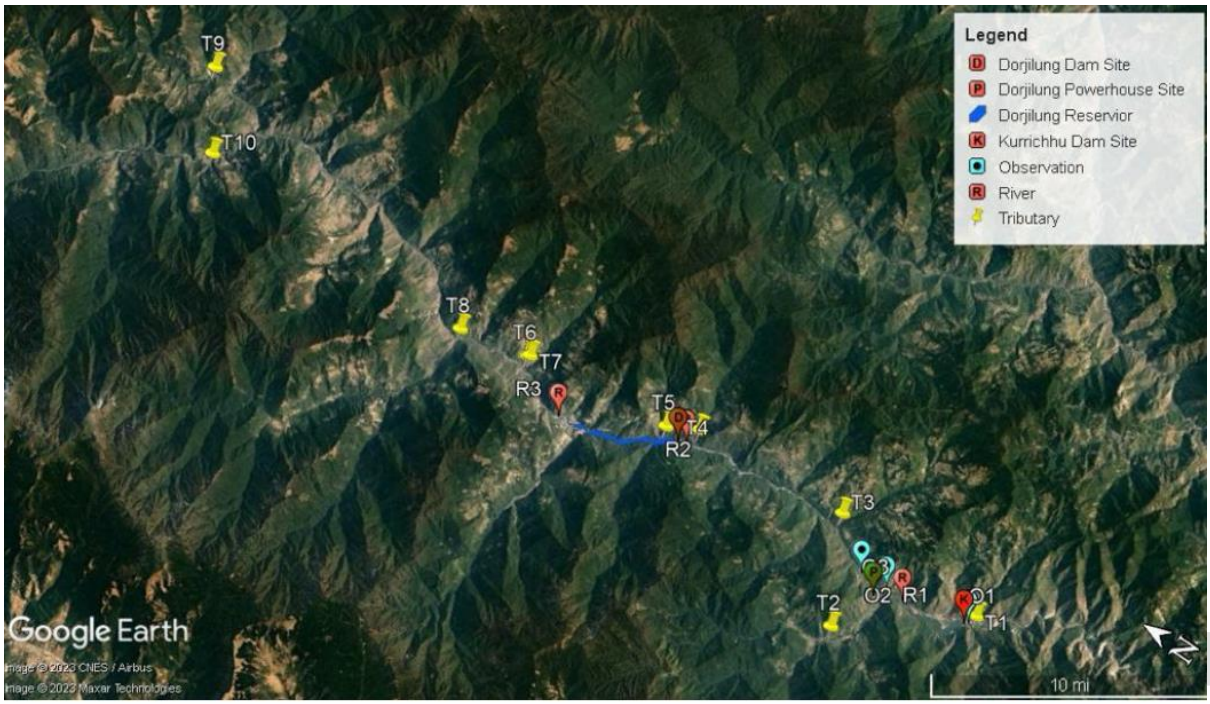


Figure 110: Freshwater sampling location - Plankton

7.5.5.2 Results

7.5.5.2.1 Zooplankton

A total of 14 zooplanktons were found from the tributaries, rivers and observation points. Out of the 14 zooplanktons, 10 were traced to species, 2 to order, and 2 to family level of classifications.

Table 119: Diversity of zooplankton with classification to Phylum, class, order, genus, and species level from the study sites

Phylum	Class	Order	Family	Genus	Species
Annelida	Clitellata	Tubificida	Naididae	-	-
Arthropoda	Copepoda	Cyclopoida	Cyclopoidae	*Cyclops*	*Cyclops sp.*
		Harpactidcoida	-	-	-
	Ostracoda	Podocopida	Cyprididae	*Tanycypris*	*Tanycypris sp.*
		Podocopida	Cyprididae	*Dolerocypris*	*Dolerocypris sinensis*
		Podocopida	Cyprididae	*Cypretta*	*Cypretta sp.*
Ciliophora	Oligohymenophora	Peniculida	Parameciidae	*Paramecium*	*Paramecium sp.*
Nematoda	Enoplea	Dorylinida	Dorylinidae	-	-
		Triplonchida	-	-	-
	Adenophorea	Monhysterida	Monhysteridae	*Monhystrella sp.*	*Monhystrella sp.*
Rotifera	Eurotatoria	Philodinavida	Philodinavidae	*Henoceros*	*Henoceros faclcata*
	Bdelloidea	Bdelloida	Philonidae	*Philonida*	*Philonida sp.*
	Monogononta	Ploima	Gastropodidae	*Ascomorpha*	*Ascomorpha sp.*
		Collothecaceae	Collothecidae	*Collotheca*	*Collotheca sp.*

In terms of abundance, the most represented zooplankton classes during the assessment were Ostracoda (21.4%), Copepoda (14.3%), and Enoplea (14.3%). The other classes each represented 7.1% of the zooplankton. OBS3 was the sampling site with the lowest zooplankton abundance (406 m^{-3}), while the highest abundance was represented at site R1 (3859 m^{-3}) (Figure 111).

The analysis of species richness using diversity indexes (Shannon-Weaver, Menhinicks, and Simpson) revealed a variation in zooplankton species richness depending on the sampling sites.

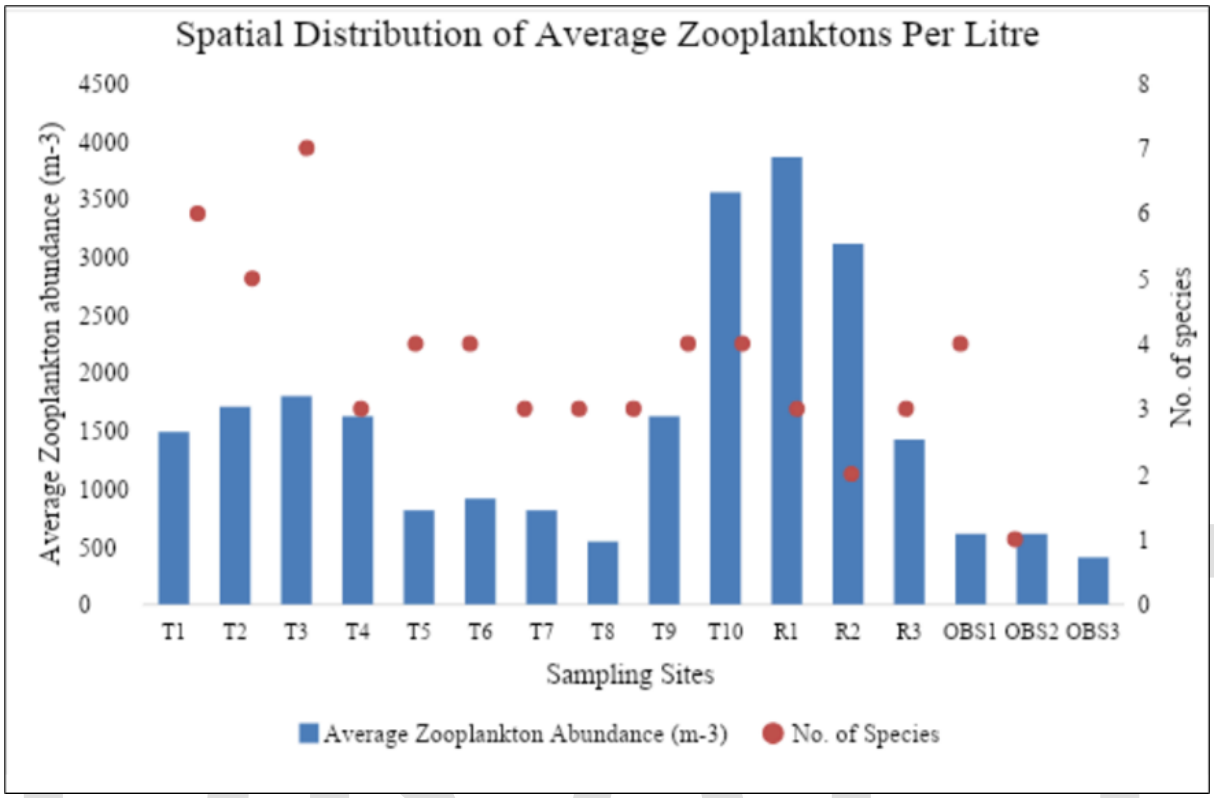


Figure 111: Average zooplankton abundance and number of species of 16 sampling sites

Statistical tests (Pearson correlation test) were conducted to investigate potential correlations between the three diversity indexes and the physiochemical parameters. According to the test results, the Shannon index (species diversity) showed a significantly positive correlation with water temperature ($r = 0.59$, p-value = 0.02). Additionally, the Evenness index had a significant positive correlation with water turbidity ($r = 0.61$, p-value = 0.01), suggesting that species are evenly distributed as water turbidity increases. However, there were no significant correlations to the rest of the results.

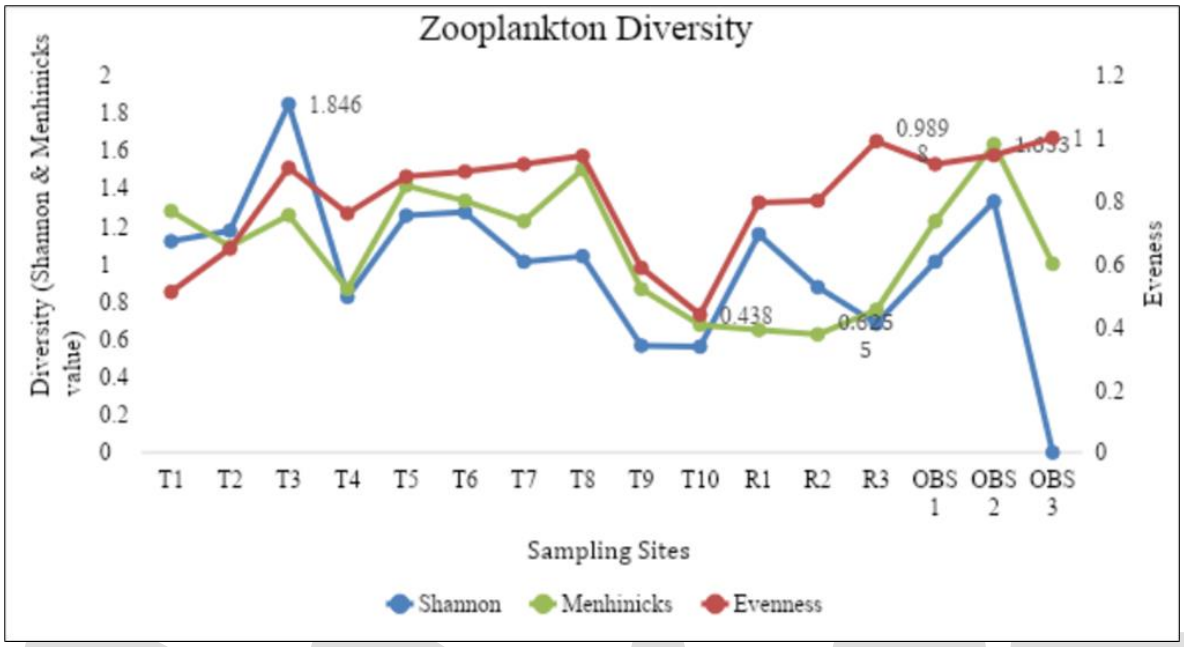


Figure 112: Diversity indices of total zooplankton recorded at different sites

7.5.5.2.2 Phytoplankton

A total of 32 genera, spanning 29 families, were identified across all sampling sites. Among these, 14 genera were found in at least three sites, while 18 were recorded in three or fewer sites. *Navicula, Pinnularia*, and *Synedra* remained commonly distributed phytoplankton from the study area, while *Oscilatoria, Diploneis*, and *Diatoma* were less abundant but widespread. Additionally, over half of the genera were found in three or fewer sampling points, with *Microsystic* being the most abundant and *Scenedesmus* and *Eunotia* recorded only once each.

Table 120: The total phytoplankton genus recorded from all the sampling points

Number represents total count of each genus from each sampling point.

SN	Phylum	Class	Order	Family	Genus
1	Bacillario-phyceae	Bacillario-phyceae	Achnanthales	Cocconeidaceae	*Cocconeis*
2			Bacillariales	Bacillariaceae	*Nitzschia*
3			Cymbellales	Cymbellaceae	*Cymbella*
4					*Didymosphenia*
5				Gomphonemataceae	*Gomphonema*
6				Rhoicospheniaceae	*Rhoicosphenia*
7			Eunotiales	Eunotiaceae	*Eunotia*
8			Fragilariales	Fragilariaceae	*Diatoma*
9					*Fragillaria*
10					*Synedra*
11			Melosirales	Melosiraceae	*Melosira*
12			Naviculales	Diploneidaceae	*Diploneis*
13				Pleurosigmataceae	*Gyrosigma*
14				Naviculaceae	*Navicula*
15				Pinnulariaceae	*Pinnularia*
16			Surirellales	Surrellaceae	*Surirella*
18			Tabellariales	Tabellariaceae	*Tabellaria*
17	Fragilariophyceae	Fragilario-phyceae	Thalassiosirales	Stenphanodiscaceae	*Cyclotella*

SN	Phylum	Class	Order	Family	Genus
19	Zygnemato phyceae	Zygnemato-phyceae	Desmidiales	Closteriaceae	*Closterium*
20				Desmidiaceae	*Cosmarium*
21			Zygnematales	Zygnemataceae	*Spirogyra*
22	Chlorophy ceae	Chlorophyceae	Chlamydomonadales	Haematococcaceae	*Haematococcus*
23				Scenedesmaceae	*Scenedesmus*
24			Oedogoniales	Oedogoniaceae	*Oedogonium*
25			Sphaeropleales	Scenedesmaceae	*Tetrastrum*
26			Chladophorales	Cladophoraceae	*Cladophora*
27	Trebouxio phyceae	Trebouxio-phyceae	Chlorellales	Oocystaceae	*Selenastrum*
28	Ulvo-phyceae	Ulvophyceae	Ulvales	Ulvaceae	*Ulva*
29			Ulotrichales	Ulothrichaceae	*Ulothrix*
30	Cyano-phyceae	Cyanophyceae	Chroococcales	Microcystaceae	*Microsystis*
31			Oscillatoriales	Oscillatoriaceae	*Oscitollaria*
32	Euglen-oidea	Euglenoidea	Euglenida	Euglenidae	*Euglena*

When phytoplankton genera are grouped into classes, Baccilariophyceae contributes 53.13% (17 genera) of the reported phytoplankton diversity, followed by Chlorophyceae (5 genera). Zynematophyceae is represented by 3 genera, Ulvophyceae and Cynophyceae are each represented by 2 genera, while Trebouxiophyceae, Frágilariophyceae, and Euglenoidea are each represented by 1 genus.

Using the Shannon-Weaver and Menhinick indexes to assess phytoplankton diversity, the results indicated a globally low diversity of phytoplankton in the study sites.

Tributary 6 (T6) downstream in Fawan-Lhuntse showed the highest diversity, whereas Tributary 8 (T8) in Yungichu, Gorgan, demonstrated the lowest diversity. T8 showed low diversity but high abundance, particularly marked by the presence of the genus Navicula. This indicates that the distribution of phytoplankton diversity across sampling sites is uneven (Figure 113).

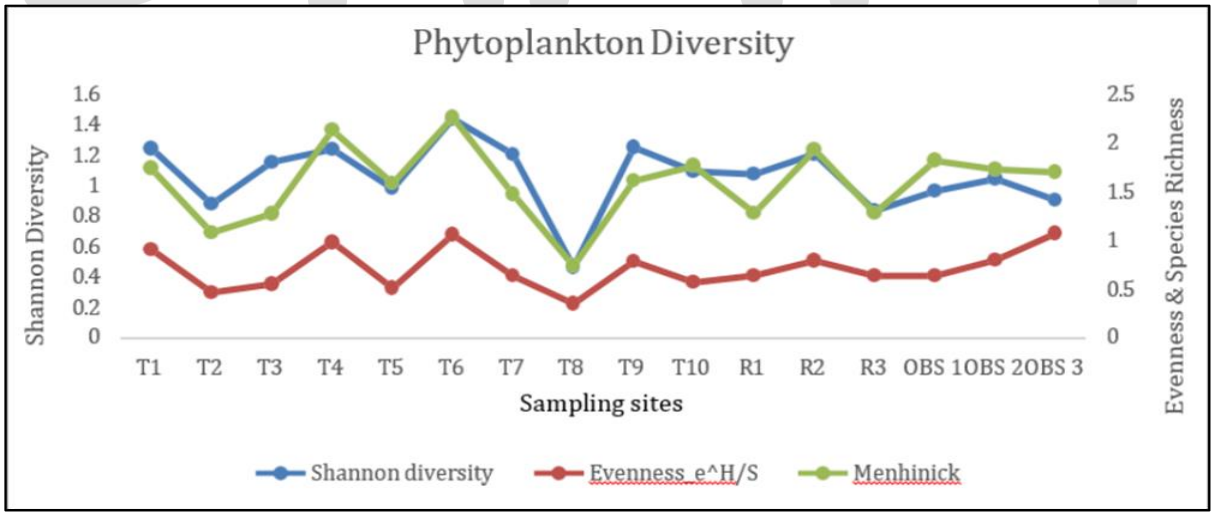


Figure 113: Phytoplankton genus diversity from the study area

Pearson correlation tests were conducted to explore potential correlations between physiochemical parameters and the specific richness of phytoplankton (via the three diversity indices), like those performed for zooplankton. However, no significant correlations were observed.

Globally, the highest number of zooplankton species was recorded at site T3 (7 species), while the lowest was observed at OBS 3 (1 species). Similarly, the highest number of phytoplankton species was found at sites T3 and T7 (16 species each), whereas the lowest was recorded at OBS 3 (6 species).

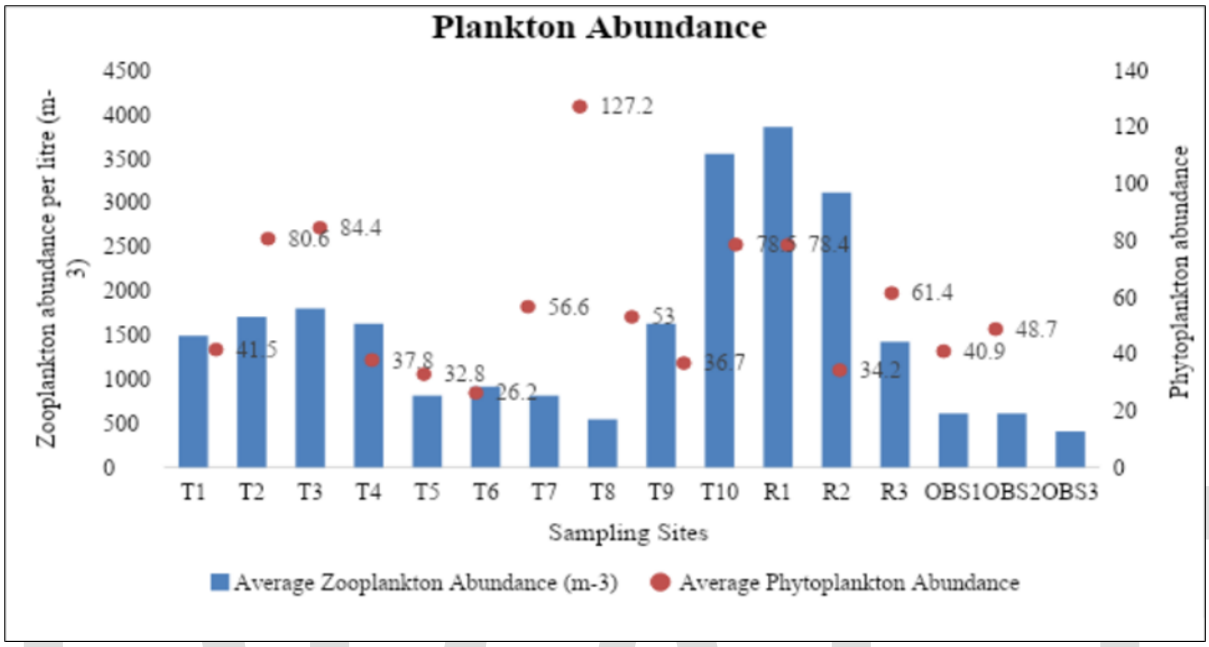


Figure 114: Average Plankton Abundance from sampling sites

The average zooplankton abundance per litre was recorded highest at R1 (3859 m^3) and lowest from OBS3 (406 m^3). Contrastingly, the highest average phytoplankton abundance was recorded from T8 (127.2) and lowest from T6 (26.2) (Figure 114).

7.5.5.3 Discussion

The report aimed to identify phytoplankton and assess plankton biomass and diversity using various diversity indices, across 16 sampling sites along the Kurichhu River. Additionally, an analysis of water physicochemical parameters was conducted to determine potential correlation with diversity indexes.

Regarding zooplankton, the most represented class was Ostracoda (21.4%), followed by Copepoda Monogonata and Enoplea (14.3% each). Four different species of rotifers*, Henoceros faclcata, Philonida sp., Ascomorpha sp.*, and *Collotheca sp.*, were observed. Most rotifer species are opportunistic feeders, exhibiting high tolerance to environmental conditions, making them the most diverse group in aquatic ecosystems (Segers 2006) & (Verma, Ahmad et Bajpai 2014). The lowest number of species (one species) was recorded at site OBS3, likely due to strong water currents (Paterson, et al. 2019). Conversely, the highest number of species was recorded at site T3 (seven species), followed by T1 (six species), possibly attributed to their undisturbed nature and low population density.

Concerning the phytoplankton, the highest number of genera was recorded at the T3 and T7, with 16 genera each, due to their isolation from human activities and minimal disturbances. The low diversity of phytoplankton observed in T8 is likely caused by recent flash floods that washed away sediments, resulting in the removal of benthic habitats, as noted by (Biggs et Smith 2002). Sampling points along rivers, including observation points, exhibited lower generic diversity of phytoplankton compared to tributaries, due to strong water flow and frequent water level fluctuations causing disturbances.

Correlation analysis between water parameters and diversity indices for zooplankton revealed a significant positive correlation between Shannon index (species diversity) and water temperature, as well as between zooplankton evenness and water turbidity, which plays a vital role in influencing aquatic biota and ecological

conditions. However, for phytoplankton, no significant correlation was established between physical water parameters and diversity indices, as phytoplankton diversity responds more directly to factors such as light and nutrient availability (John, Whitton et Brook 2002) & (Svensson, Lindegarth et Pavia 2009).

7.6 Location of Key biodiversity Values (Field data)

The following maps locate sensitive species presented in previous sections and evidenced by field activities. The most sensitive species are also presented in detail in the ESIA Volume 3 Appendix L Biodiversity Assessment by CHQ Species and Other Emblematic Species.

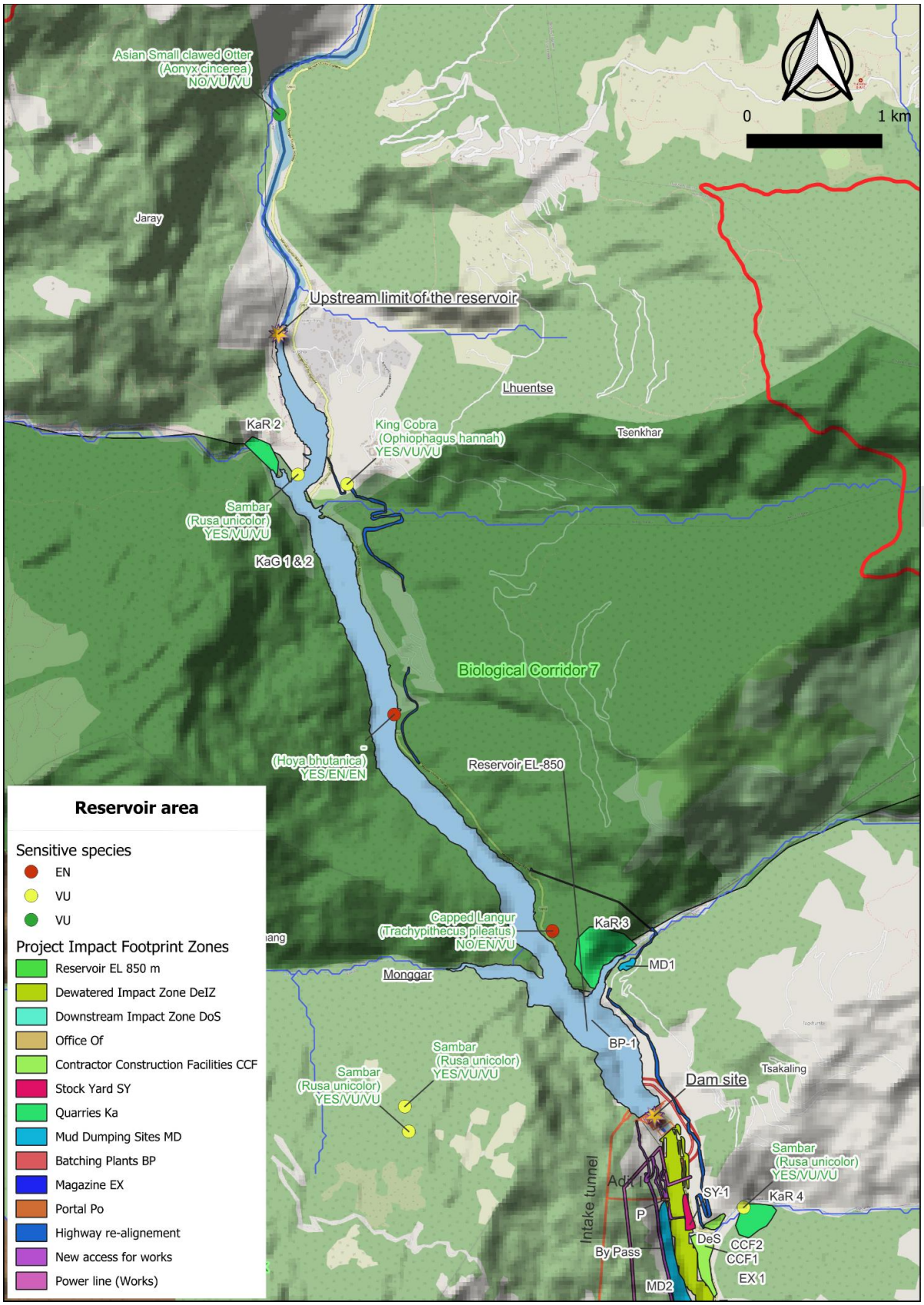


Figure 115: Sensitive terrestrial species identified in field (Reservoir area)

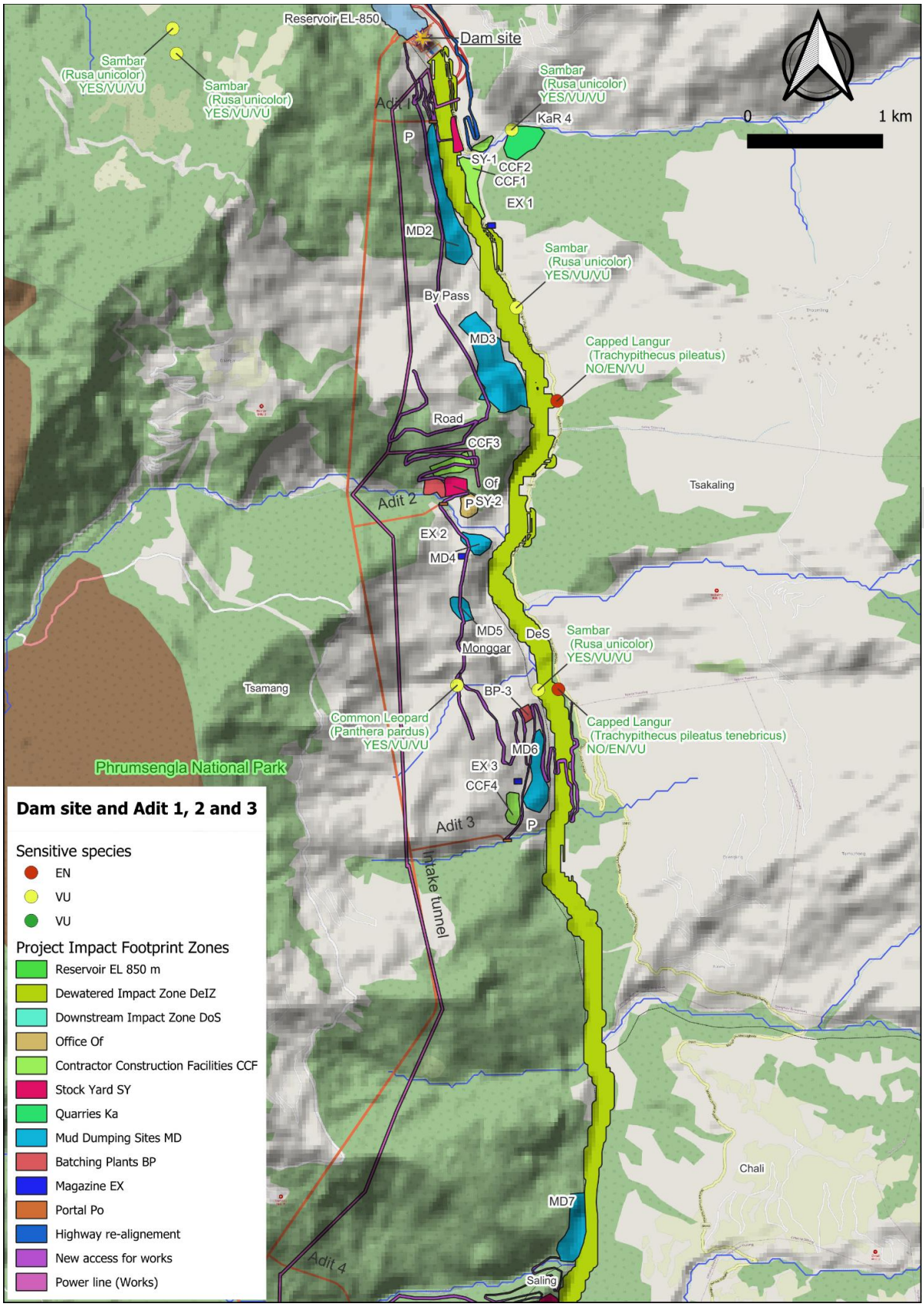


Figure 116: Sensitive species identified in field (Dam site, Adit 1, 2 and 3)

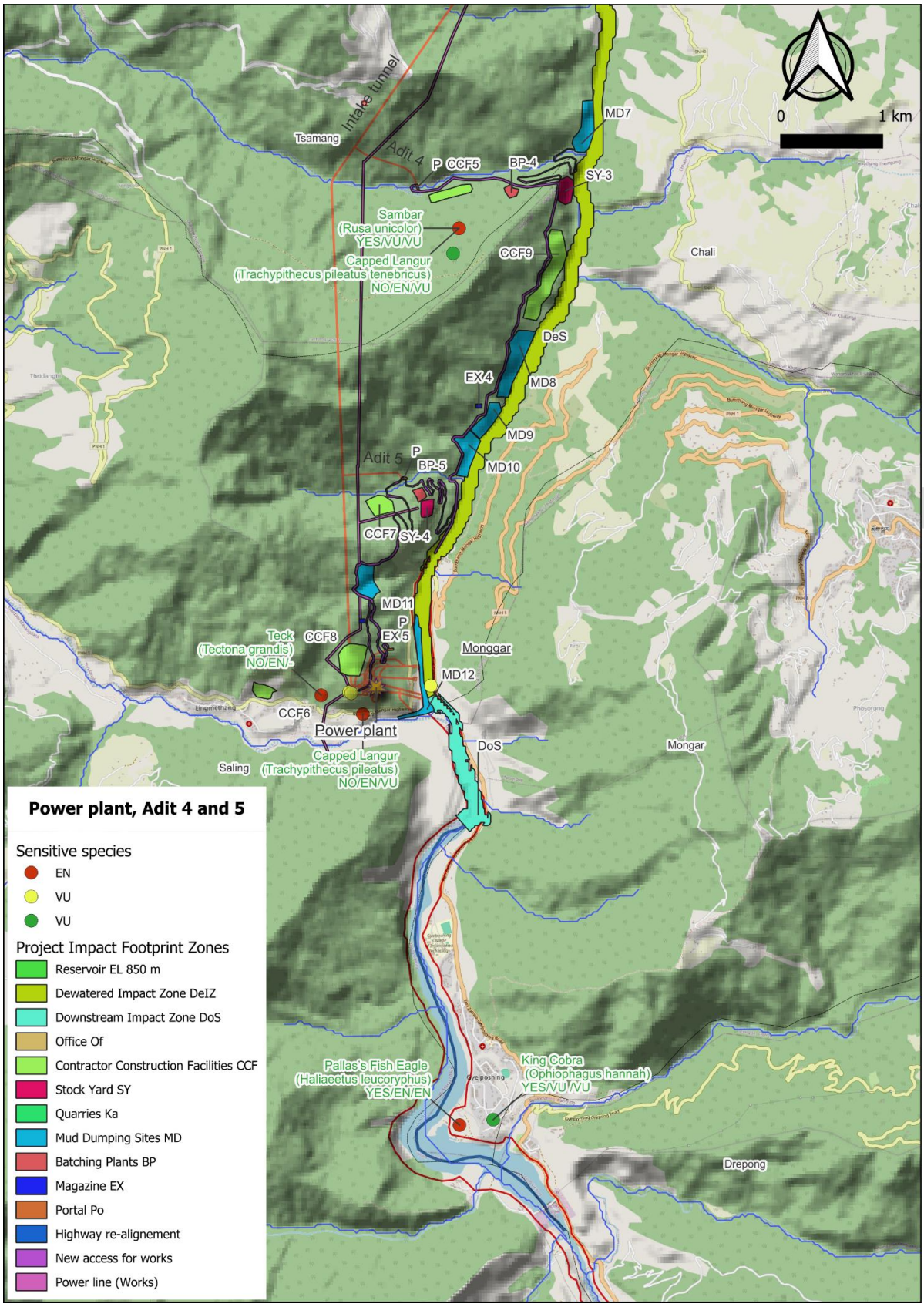


Figure 117: Sensitive species identified in field (Power plant, Adit 4 and 5)

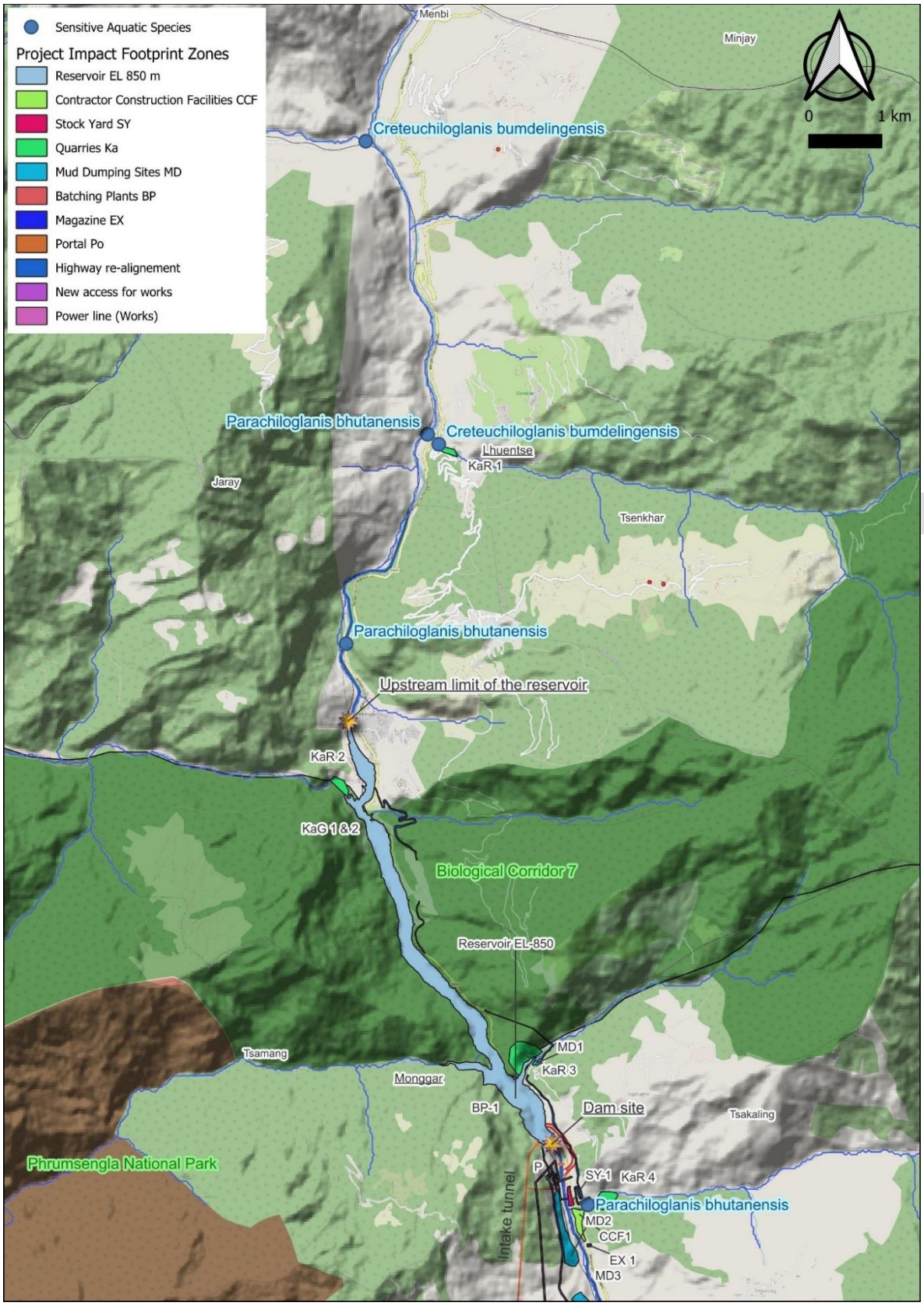
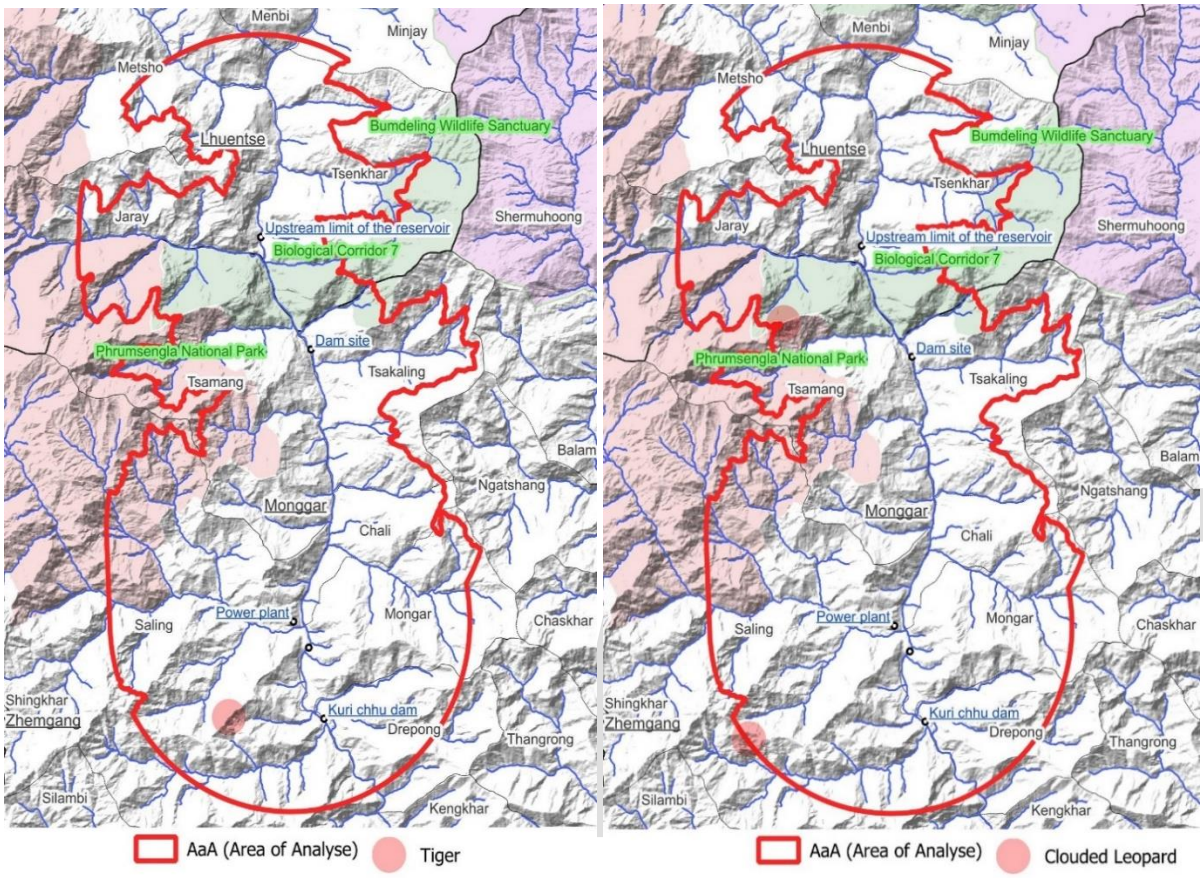


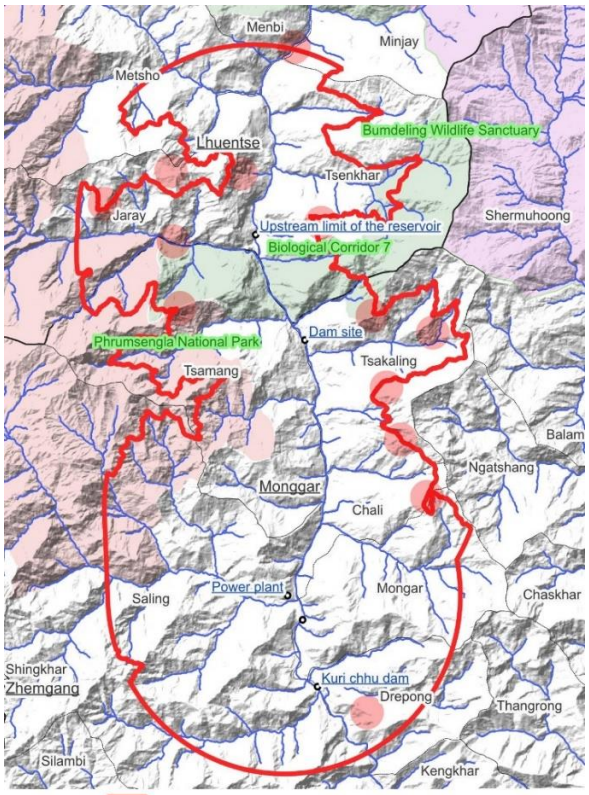
Figure 118: Sensitive aquatic species identied in the field (RR species only in the northern half).

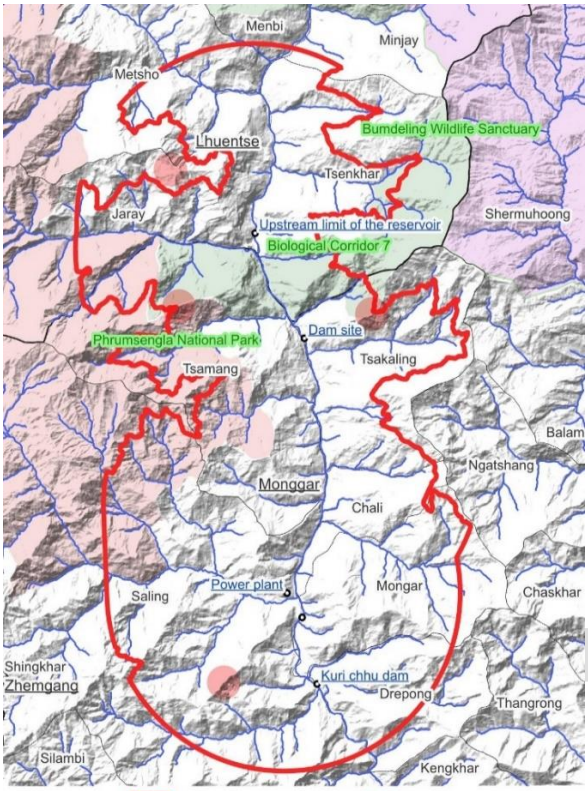
The CT activities of the Nature Conservation Division allow also to present some distribution data for sensitive species such as Red Panda, Tiger, Wild dog and also for some Tiger prey such as Sambar which

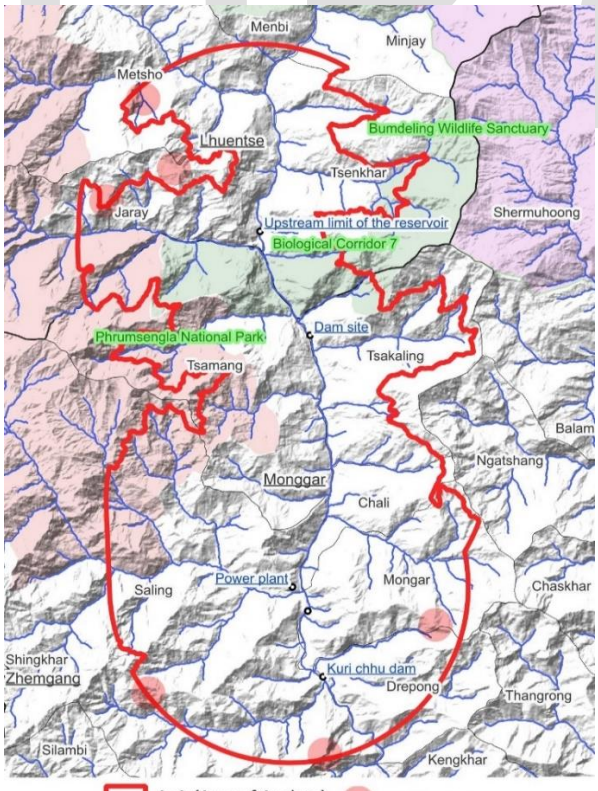
have been used to discuss the likelihood of occurrence in the AoA of the project during the CHA screening. Some maps are provided below.

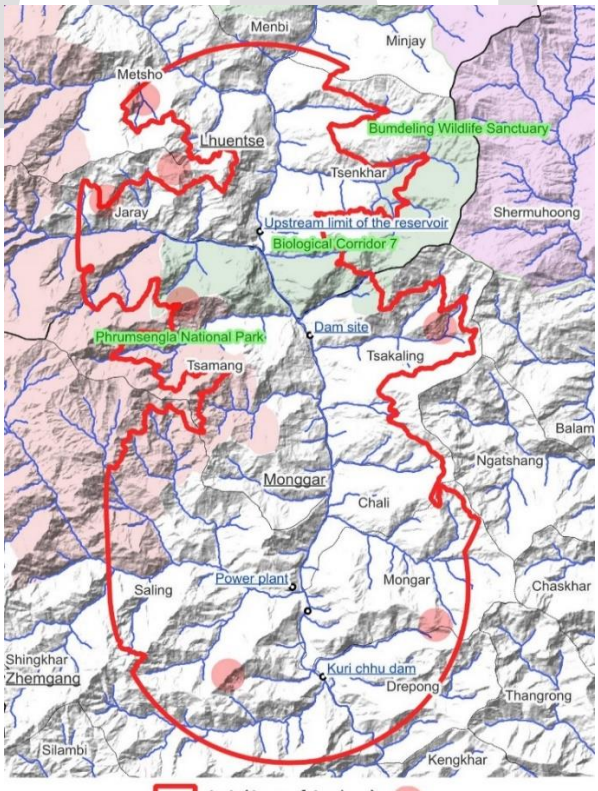
Figure 119: Location of some sensitive mammal species

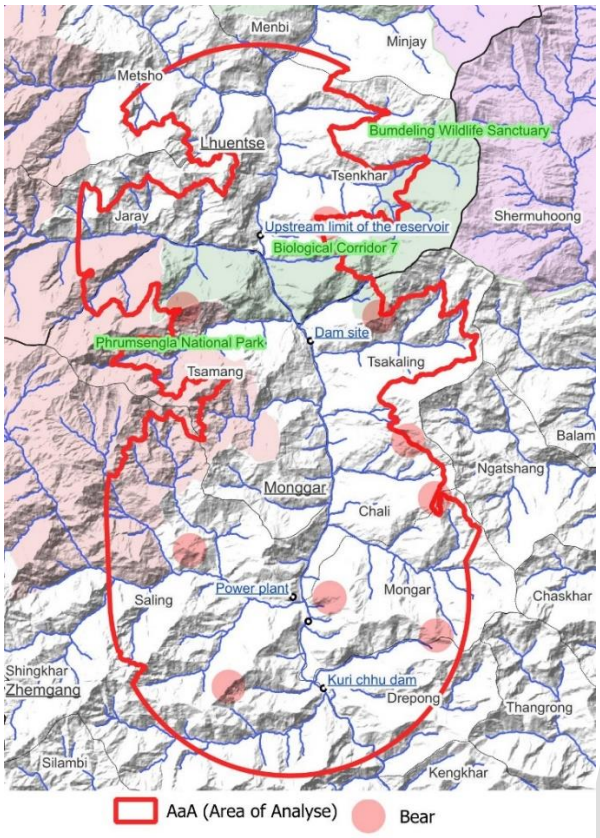


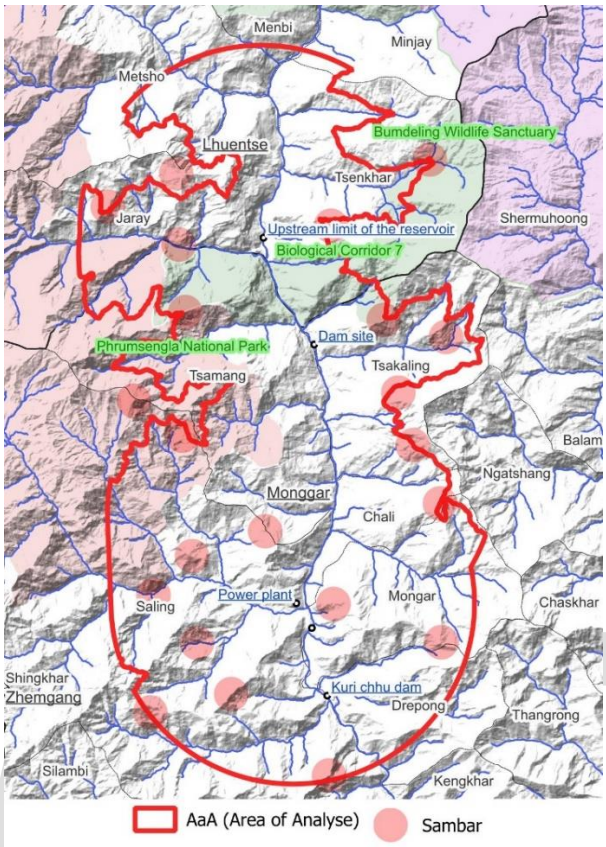

Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Shermuhoong
Upstream limit of the reservoir
Biological Corridor 7
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Common Leopard

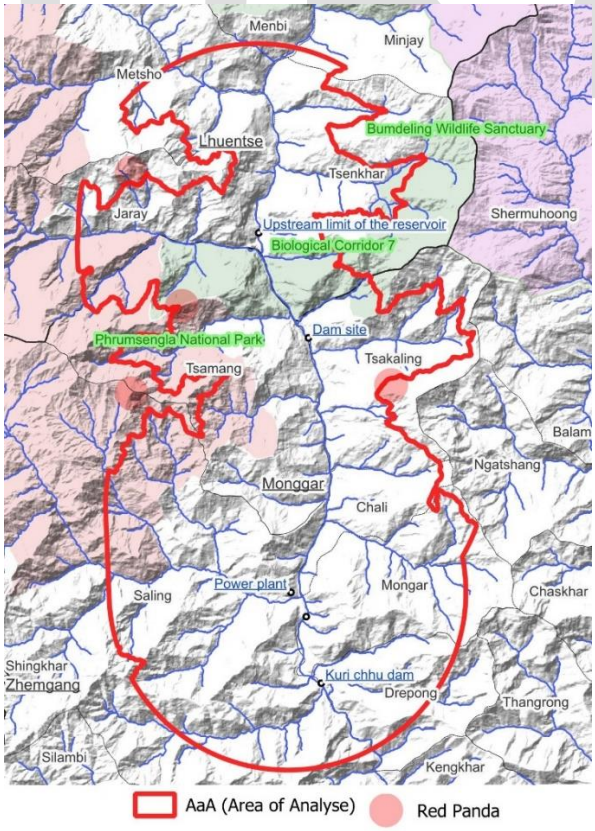

Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Shermuhoong
Upstream limit of the reservoir
Biological Corridor 7
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Marbled Cat

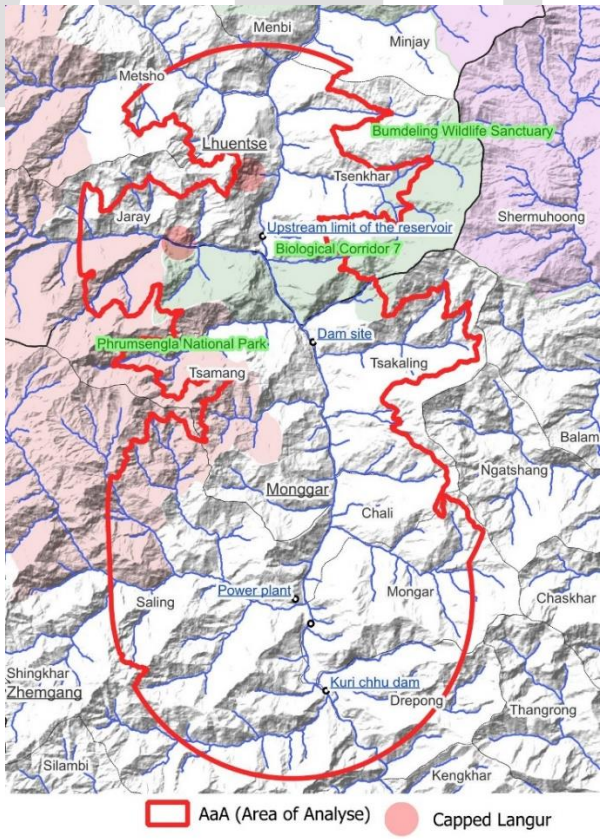

Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Shermuhoong
Upstream limit of the reservoir
Biological Corridor 7
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Golden Cat


Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Shermuhoong
Upstream limit of the reservoir
Biological Corridor 7
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Wild Dogs


Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Upstream limit of the reservoir
Biological Corridor 7
Shermuhoong
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Bear


Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Upstream limit of the reservoir
Biological Corridor 7
Shermuhoong
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Sambar


Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Upstream limit of the reservoir
Biological Corridor 7
Shermuhoong
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Red Panda


Menbi
Minjay
Metsho
Lhuentse
Bumdeling Wildlife Sanctuary
Tsenkhar
Jaray
Upstream limit of the reservoir
Biological Corridor 7
Shermuhoong
Phrumsengla National Park
Dam site
Tsakaling
Tsamang
Balam
Ngatshang
Monggar
Chali
Saling
Power plant
Mongar
Chaskhar
Shingkhar
Zhemgang
Kuri chhu dam
Drepong
Thangrong
Silambi
Kengkhar
AaA (Area of Analyse)
Capped Langur

Source of CT data: Supplementary Baseline Survey of Mammals, Birds and Fish of the Dorjilung Hydropower Project (07/2024), Nature Conservation Division, Department of Forests and Park Services, Ministry of Energy and Natural Resources

7.7 Critical Habitat Assessment

7.7.1 General methodology

ESS6 of the Biodiversity conservation & Sustainable management of living natural resources (WB, 2017) aims to analyse biodiversity to classify habitats into three main categories: modified habitats, natural habitats and critical habitats which can be natural or modified. This classification aims to establish the level of requirements for biodiversity management. Description of the three main categories provided in ESS6 as:

- Modified habitats are areas that may contain a large proportion of plant and/or animal species of non-native origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include, for example, areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands."
- Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition."
- Critical habitat is defined as areas with high biodiversity importance or value, including: (a) Habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches. (b) Habitat of significant importance to endemic or restricted-range species, (c) Habitat supporting globally or nationally significant concentrations of migratory or congregatory species, (d) Highly threatened or unique ecosystems and (e) Ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d).

For non-critical modified habitats, the general requirements of ESS1 namely to avoid and to minimize impacts on such biodiversity and implement mitigation measures as appropriate.

For non-critical natural habitat, it is required to demonstrate that no technically and economically viable alternative is possible in modified habitats. For projects for which natural habitats cannot be avoided, appropriate mitigation measures must be put in place, in accordance with the mitigation hierarchy, to achieve no net loss and, where feasible, preferably a net gain of biodiversity over the long term.

For critical habitats, the requirements of the World Bank are particularly high and are:

- (a) No other viable alternatives within the region exist for development of the project in habitats of lesser biodiversity value.
- (b) All due process required under international obligations or national law that is a prerequisite to a country granting approval for project activities in or adjacent to a critical habitat has been complied with.
- (c) The potential adverse impacts, or likelihood of such, on the habitat will not lead to measurable net reduction or negative change in those biodiversity values for which the critical habitat was designated.
- (d) The project is not anticipated to lead to a net reduction in the population of any Critically Endangered, Endangered, or restricted-range species, over a reasonable period.
- (e) The project will not involve significant conversion or significant degradation of critical habitats. In circumstances where the project involves new or renewed forestry or agricultural plantations, it will not convert or degrade any critical habitat.
- (f) The project's mitigation strategy will be designed to achieve net gains of those biodiversity values for which the critical habitat was designated; and

- (g) A robust and appropriately designed, long-term biodiversity monitoring and evaluation program aimed at assessing the status of the critical habitat is integrated into the Borrower's management program.

For Natural and modified habitats, when residual impacts remain despite avoid and reduce strategy, mitigation measures may include biodiversity offsets adhering to the principle of "no net loss" for natural habitat and "net gain" for critical habitat.

Although similar, the methodologies of the WB, IFC and IUCN for the assessment of critical habitats have significant differences. The Guidance for Critical Habitat Assessment (Draft, 2023 provided by the WB) and will be taken here as a reference.

The approach is the following:

- STEP 0. Define an AoA. As a large project, the AoA will be the AoI that includes direct, indirect impact and cumulative impact.

o For terrestrial biodiversity it is considered that the AoI and thus the AoA could be also limited in altitude at a secure level of 2500 m. It is very unlikely that the project may have an influence at this altitude considering the dam and reservoir level and the highest communities that may be affected by social influx during the construction and operation phase. For aquatic habitat, in addition to the AoA of terrestrial habitat, the river downstream Kuricchu Dam is also taken into consideration (down to Panbang at the confluence with Mangde river, near India border), as a cumulative area of impact (ACoI).
o The downstream area of influence (AoI) is limited downstream by the existing Kurichhu hydropower plant and dam. It is supposed that the existing Kurichhu hydropower plant will work as a demodulation dam during low flow an in run of the river operation during high flow. It is unlikely that the project may have an influence downstream in addition to the influence of the existing Kurichhu hydropower plant. However, for aquatic habitat CHA, it is also considered a downstream stretch of the Kurichhu river to reach the confluence with the Mangdechhu river just downstream Pangang.

- STEP 1. Generate a list of species using primary and secondary data.
- STEP 2. Screen features based on relevance and Likelihood of Occurrence.
- STEP 3. Ecological assessment to determine CH status. Ecological assessment of each species based on six guidelines with:

o Protected areas and the reasons they are designated can provide important indicators of potential CH.
o ESS6 footnote states for species with global (IUCN) and national/regional red lists, assessment will be based on the national/regional population. The national Red List database will be used to determine criteria (a) and criteria (b). (a: threatened species CR and EN, b: restricted range species)
o If a Critically Endangered species population is present, it qualifies as CH under ESS6 Criterion (a). Where a significant proportion of a species is likely within the AoA, it qualifies for CH. ± 1% will be used for significance when piloting, but to be adjusted for project conditions.
o A restricted-range species can qualify for CH where the AoA overlaps a significant proportion of its distribution.
o ESS6 Criteria (d) and (e) are assessed on a case-by-case basis using specialist input and reliable data.

- STEP 4: Identify CH features that are impacted and require Net Gain outcomes and its feasibility. (See ESIA Volume 3 Appendix L Biodiversity Assessment by Chq Species and Other Emblematic Species.

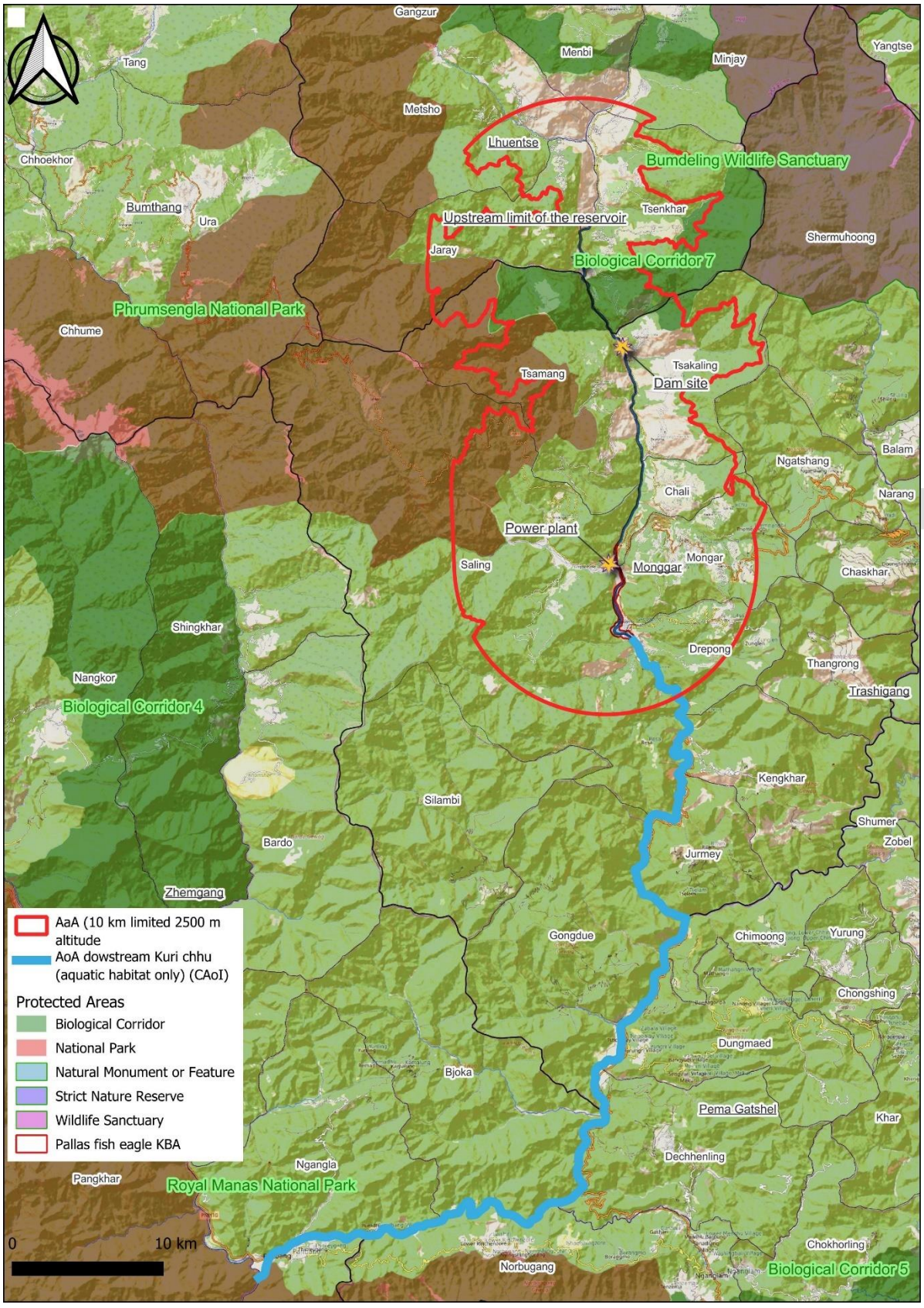


Figure 120: Area of Analysis (AoA)

The CHA uses various primary and secondary data as the following:

Primary data. In carrying out the field flora and fauna surveys, several techniques were implemented to collect primary data including:

- Phytosociological flora survey by station of 20 x 40 m for tree and shrubs and 3 plots of 2 x 2 m for herbs.
- Measurement of height and diameter of trees: sampling for estimating the number impacted tree.
- Reconnaissance route around the station for additional identification of plant species (specific attention on protected and national red list species).
- Search (Two seasons) for evidence of the presence of fauna on the approach routes of the flora stations, in the flora stations and on the reconnaissance routes around the station.
- Dedicated aquatic survey for herpetofauna.
- Dedicated aquatic survey (Two seasons) for fish with various techniques in the mainstream and some tributaries.
- Dedicated aquatic survey (Two seasons) for macroinvertebrates in some fish stations.
- Interview for wildlife occurrence with image book with resource people (focus on mammals and birds).
- Camera trap survey of about 1550 j/camera in the AoI
- See section 7 The Biological Environment, ESIA Volume 3 Appendix A Aquatic Biology Field Survey Report and ESIA Volume 3 Appendix B Terrestrial Biodiversity Field Survey Report for details.

The main **secondary data** used during the assessment are:

- Land cover classification of the country
- Classified and protected area in Bhutan
- The national red list species
- The protected species
- The IBAT database
- Various satellite image datasets
- IUCN Redlist database (https://www.iucnredlist.org/)
- Various field guides (Birds, Mammals, Plants)

7.7.2 Screening potential Critical Habitat Qualificative (CHQ) species (Criteria a and b)

Habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of Threatened Species or equivalent national approaches (Ca)

Habitat of significant importance to endemic or restricted-range species (Cb)

STEP 1. A full list of species is aggregated merging (i) the IBAT database, (ii) the National Red List of Bhutan, (iii) the field assessments and (iv) the interview. The screening list is generated with global or national IUCN status as CR or EN or RR (Restricted range).

For each species it is noted:

- If species is evidence by field (direct observation) or interview (Indirect observation)
- **STEP 2. Likelihood of Occurrence (LOO)** with (i) Present is the species is reported by field activities or by interviews of informed stakeholders and (ii) Likely or (ii) Unlikely or (iv) not present following examination of species data regarding its distribution and availability of suitable habitats (Information from the IUCN Red List website).
- **STEP 3. CH status.** If LOO is "Present" or "Likely", then the CH status is assessed with YES, Likely or Unlikely with the following rules:

- CR species occurring in the AoA is considered as CH.
- EN or RR species are considered CH if a significant part of their stations (flora) or Estimated Extent of Occurrence (EOO) overlap the AoA. By significant, it is considered the threshold of 1% of stations or EOO in the AoA
- If National IUCN status and Global IUCN status are not similar, the National IUCN status is used.

The Screening table for the criteria a and b is provided in the ESIA Volume 3 Appendix I CHA screening table criteria and b. This table also gives reasons why some EN or RR species were not considered as CHQ because their habitat, distribution area, and altitudinal zone allows us to consider that the population is not in the AoA or that it is very unlikely that more than 1% of the world population is in the AoA.

Table 121: Database merging bibliography sources, field activities, camera trap and interview

Taxon	Number of species in the database	Criteria a (CR or EN Global)	Criteria a (CR or EN National)	Criteria b Restricted range	Number of species evidenced during field survey	Number of species reported by interview
Herpetofauna	120	13	7	2	24	0
Actinopterygii	92	3	3	10	19	0
Aves	634	2	7	6	145	10
Bivalvia	34	0	0	2	0	0
Flora	487	25	17	7	282	1
Fungi	3	0	0	0	0	0
Gastropoda	48	0	0	2	0	0
Insecta	104	1	1	2	0	0
Malacostraca	18	0	0	1	0	0
Mammalia	124	18	12	3	11	8
Total	1664	62	47	34	473	19

The screening table focusing on CR, EN and RR species from the database includes 83 species with the following taxon.

Table 122: Screening database

Taxon	Number of species in the database	Criteria a (CR or EN Global)	Criteria a (CR or EN National)	Criteria b Restricted range	Number of species evidenced during field survey	Number of species reported by interview
Herpetofauna	14	13	7	2	0	0
Actinopterygii	12	3	2	10	3	0
Aves	11	2	7	6	1	2
Bivalvia	2	0	0	2	0	0
Flora	22	25	17	7	2	0
Fungi	0	0	0	0	0	0
Gastropoda	2	0	0	2	0	0
Insecta	3	1	1	2	0	0
Malacostraca	1	0	0	1	0	0
Mammalia	18	18	12	3	4	3
Total	85	62	47	34	10	5

Considering the criteria a and b, the screening concludes to 13 species that are likely CH qualificative species with 4 fishes, 4 birds, 3 mammals, 1 plant, 1 insect.

Table 123: CH qualificative species from the screening table criteria a and b

Species Name	Common Name	Taxonomic Group	N_Ca	G_Ca	N_Ca OR G_Ca	Protected in Bhutan	Cb	Cc	Field	Inter-view	Add Biblio	LOO	Note LOO	CHA status	Note CHA status
Creteuchiloglanis bumdelingensis		ACTINOPTERYGII	0	0	0	0	1	0	1	0	0	Present		Likely	This species is considered as new species in the FishBase data and is not well documented. It is considered as a RR species
Parachiloglanis bhutanensis		ACTINOPTERYGII	0	0	0	0	1	0	1	0	0	Present		Likely	This species is considered as new species in the FishBase data and is not well documented. It is considered as a RR species
Parachiloglanis dangmechuensis		ACTINOPTERYGII	0	0	0	0	1	0	1	0	0	Present		Likely	This species is considered as new species in the FishBase data and is not well documented. It is considered as a RR species

Tor putitora	Golden Mahseer	ACTINOPTERYGII	1	1	1	1	0	1	0	0	1	Likely	This species is reported in the project area in 2015. In 2019 and 2023 field survey, this species was not observed upstream the Kurichhu HPP. Based on local expert knowledge and eDNA survey, *Tor puttitora* is unlikely present upstream of the Kurichhu Dam (pers. Comm.). The data confirm the extant of the EOO in the Bhutan	Likely	As the AoA is limited downstream by the Kurichhu HPP, it is unlikely that the AoI of the project contain more than 1% of the population of this species. However, if an additional reach downstream of the Kurichhu is considered because of potential cumulative impact (CAoI) there are possibilities that the AoA contains more than 1% of the population of this species. By precautionary principle and considering this species is emblematic, it will be considered as a CHQ species

Apus acuticauda	Dark-rumped Swift	AVES	0	0	0	1	1	1	0	0	1	Likely	The known EOO overlaps with the AoA in this south part and have adequate habitats. This species breeds colonially in the crevices of rocky cliffs and deep gorges, at 200-1,350 m, generally in the vicinity of forest.	Likely	Considering the small EOO it is likely that the project may contain more than 1% of the population
Gyps bengalensis	White-rumped Vulture	AVES	1	0	1	1	0	0	0	0	1	Likely	The EOO of this vulture is large and cover several countries. This species may cover a vast territory	Likely	As a CR species it considered that the area around nest must be considered as CH. However, no nest is known in the project area but there is a lack of information at this scale.
Haliaeetus leucoryphus	Pallas's Fish-eagle	AVES	1	1	1	1	0	1	1	1	0	Present	See also the IBA dedicated to this species to designated downstream part of the AoA	Likely	For such species, nesting location must be considered CH whatever de population ratio. The IBA to be designated will be considered as a CH.

Sarcogyps calvus	Red-headed Vulture	AVES	1	0	1	1	0	0	0	0	1	Likely	The EOO of this vulture is large and cover several countries. This species may cover a vast territory	Likely	As a CR species it considered that the area around nest must be considered as CH. However, no nest is known in the project area but there is a lack of information at this scale.
Hoya bhutanica		FLORA	1	1	1	1	0	0	1	0	0	Present	Only two stations are reported. This species grows in dense subtropical forests. It is a succulent epiphytic climbing herb (Apocynaceae).	YES	The station a new one to be add to the 2 existing.
Bhutanitis ludlowi	Bhutan Swallowtail	INSECTA	1	1	1	1	0	0	0	0	1	Likely	The AoA overlap de EOO. The main foodplant (Aristolochia griffithii) is found between 1800 and 3000 m and elevation occupied by this species exhibits alpine conditions.	Likely	Taking in consideration the EOO (46800 km2) and the AoA the population inside the project area may be more than 1% but less than 5%.

Manis pentadactyla	Chinese Pangolin	MAMMALIA	1	1	1	1	0	0	0	0	1	Likely	The AoA present suitable habitat for this species which have a large distribution including the AoA of the project. However, known locations in Bhutan are outside the project area (South Esat and Southwest) and the species prefer clair forest (25% to 50%)	Likely	Considering the EOO and the AoA and the fact that this iconic species is not indicated by informed stakeholders, it is unlikely that more than 1% of the population occur in the AoA of the project area. However, as the species is CR the CH is considered
Trachypithecus pileatus tenebricus	Tenebrous Capped Langur	MAMMALIA	0	1	1	1	1	0	1	1		Present	Field and interview with numerous evidence	Likely	Considering the limited EOO of this species and the population in the project AoI of the project it is possible that more than 1% of the population occur in the AoA

Panthera tigris	Tiger	MAMMALIA	1	1	1	1	0	0	0	1	0	Likely	AoA contains potentially habitats for Tiger. Theorical distribution show that the habitat is at the edge of the AoA, mainly in altitude. However, the tiger can travel great distances to find its prey.	Likely	Considering the EOO and the distribution of the species (2018. Bhutan tiger action plan 2018-2023), it is unlikely that more than 1% of the global population occur in the AoA of the project area. However, it is likely that more than 1% of the national population occur in the AoA. By precautionary principle and also considering this species is emblematic, it will be considered as a CHQ species

7.7.3 CHA species for criteria c (STEP 3)

Habitat supporting globally or nationally significant concentrations of migratory or congregatory species (Cc)

Criterion c, gregarious and migratory species, is evaluated by taxon according to the following process:

- Screening of all migratory species in the database
- If the migratory species are only LC, it is considered unlikely that more than 1% of the species' population could live or depend on the AoA.
- For NT and VU species, a dedicated analysis is carried out using available information on distribution, population status, threats, and ecology to assess whether more than 1% of the population may be dependent on the AoA.

The screening table, with all migratory species with global IUCN status CR, EN, VU and NT, is presented at the ESIA Volume VIIIB I CHA screening table criteria c. There are 6 fishes, 3 mammals and 21 birds which have been considered for screening.

7.7.3.1 Insects

There are 7 migratory insects in the database, all LC, and thus a **CH is unlikely for this taxon**.

7.7.3.2 Crustacea

There are 3 migratory crustacea in the database, all LC, and thus a **CH is unlikely for this taxon**.

7.7.3.3 Avifauna

There are 305 migratory bird species in the database with 2 EN (1 for national red list), 7 VU (5 national red list), 13 NT (5 national red list and 283 LC (7 national red list). Four have already been assessed for CH for criteria a and b. On the 19-remaining species, no other CH qualifying species for criteria c.

The assessment of these 21 species (EN, VU and NT) **doesn't evidence new CH qualifying species for criteria c**.

7.7.3.4 Mammals

There are 4 migratory mammal species in the database with 2 EN (1 for national red list) and 1 VU (1 national red list) and 1 LC (No LC in the national red list).

Two have already been assessed for CH for criteria a and b. The assessment of these 3 species (EN, VU and NT) **doesn't evidence new CH qualifying species for criteria c**.

7.7.3.5 Ichthyofauna

There are 21 migratory fish species in the database with 2 EN, 1 VU, 3 NT and 15 LC. Two have already been assessed for CH for criteria a and b. There is **no other CH qualifying species for criteria c**.

7.7.4 CHA for criteria d (STEP 3)

Highly threatened or unique ecosystems (Cd)

These criteria refer to diverse situations including internationally threatened habitat defined by relevant experts sur as IUCN, National Museum or Herbarium and some other experimented NGO. This criterion (d) can also provide useful arguments recognizing the special status of protected areas and other classified areas.

To date, there is no Bhutanese ecosystem in the Red List of Ecosystems of IUCN (https://assessments.iucnrle.org/)

However, part of the AoA matches with the Tiger Conservation Landscapes of WWF and RESOLVE, with the Thrumsing La and Kori La KBA of BirdLife. Note that the Thrumsing La and Kori La KBA as similar location that the Phrumsengla National Park (PNP). The Thrumsing La KBA / PNP is considering

triggering KBA criteria because of two EN mammals (Red Panda and Tiger), 5 other VU mammals and 4 other birds' species. A small part of the Phrumsengla National Park (PNP) is in the AoA even if it is in the highest part of the AoA.
Considering the number threatened and restricted range taxa and the number of iconic species such as the Tiger and the Red Panda, forest, shrubland and grassland of **the Phrumsengla National park will be considered as a critical habitat**. This critical habitat status is augmented by the KBA classification of NPN area by BirdLife.

7.7.5 CHA species for criteria e (STEP 3)

Ecological functions or characteristics needed to maintain the viability of the biodiversity values described above in (a) to (d) (Ce)

Various ecological functions may be considered assessing this criterion with, as suggested in the WorldBank draft Guidance for Critical Habitat Assessment, the following:

- *"Species diversity functions (including species composition and viable assemblages of key species).*
- *Habitat structure functions (including population stability, recruitment and biological macro-habitat structural providers).*
- *Habitat maintenance functions (including biological water purifiers, biological erosion control agents, ecosystem engineers and burrowers and hole-makers / micro-habitat creators).*
- *Habitat development functions (including pollination agents, biological dispersal agents and disease control agents).*
- *Nutrient transfer (food chain) functions which comprise ecologically balanced combinations of primary producers, herbivores, insectivores, predators, scavengers, parasites and decomposers.*
- *Movement and refugees (including migration, breeding colonies and species congregations and wide-ranging species dependencies).*
- *Succession process functions for the natural development/recovery of vegetation (but can be adversely influenced by the presence of invasive alien species)."*

"However, there is limited guidance that can be provided for recognizing critical habitats under this criterion, and each situation needs to be assessed on its own merits using expert opinion and substantiated with appropriate data and ecological justification".
All forest and aquatic habitats provide all types of ecological functions listed in the guideline. However, these type of habitats (ie Subtropical Forest/warm broadleaf forest (riverine broadleaf forest and broadleaf forest), and Chirpine forest) are quite common in Bhutan below 2000 m of elevation.
As identified in the analysis of criterion a, the tiger is considered as likely to be critical. The projet is intersecting corridor 7, which as the purpose of maintaining the viability of its prey. Even if the section of C7 intersecting the AoA is not known as a hunting area for the tiger, it can indeed be considered as an area fulfilling the role of *transfer (food chain) functions which comprise ecologically balanced combinations of primary producers, herbivores, insectivores, predators,* for a critical species.
Corridor 7 can be qualified as triggering criterion e. However, the project area does not present a specific ecological function that would not be found in other areas occupied by some forest habitats in other locations in Bhutan.

7.7.6 Preliminary impact examination of the CH and feasibility of the offsetting (STEP 4)

The examination of the potential impact, residual impact and offsetting feasibility is part of the WB CHA process. The table below gives an overview of the assessment. The detailed assessment is provided in the ESIA Volume VIIIB Appendix L Biodiversity Assessment by CHQ Species and Other Emblematic Species.
For offsetting feasibility, the ranking system is defined as follows:

- **Offset easy to implement:** This means the measures are easy to organize, implement and have a good chance of having positive results after the first years of monitoring.
- **Offset with medium difficulties to implement:** These offsets present more challenges in their implementation. It is possible to prescribe such measures, but more effort will have to be deployed

to have the best chance of results. These measures are often supported by additional assessment on long term period.

- **Offset difficult to implement:** Such measure can be considered as a red flag because the chance of success is low.

Table 124: Impact and feasibility of the offsetting examination of the critical habitats and protected areas

Red: Moderate to Major, Yellow: Minor to moderate and Green: Insignificant to Minor

Note that in addition to CH offsetting, a no net loss will be reached thanks to offsetting program for forest natural habitat mainly composed of reforestation measures in riparian, Chirpine and broadleaf forest. The afforestation program is feasible.

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Creteuchiloglanis bumdelingensis	Torrent catfish	ACTINOPTERYGII	These torrent catfish species are restricted range and have been found in tributaries of the AoA. No evidence of their occurrence in the Kurichhu river is done. Potential impact concerns the flow pattern changes in the reservoir and the dewatered sections which will reduce the hydraulic continuity with the tributaries. Erosion, with a change in sediment, is also a potential impact that might affect Torrent catfish. Note that the project does not impact the tributary (except some manageable impacts of the works). It is not certain if these species use or not the Kurichhu river habitat at some stages of their development and if tributaries/Kurichhu hydraulic continuities are critical of not for these species. It is considered that mixing population between tributaries is an important factor for the long-term preservation of these species.	Mitigation measures included in the ESMP and EFMP during works phase avoiding impact on tributaries with control of the water discharges, erosion, and hydraulic continuities. With adequate flow management, residual impacts can be minor to moderate. The EFlow should allow adequate lateral connectivity with the tributaries and minimum flow to maintain minimum water depth and velocity, as well as hydraulic continuities of the Kurichhu River in rapid areas. Even if EFlow significantly reduces the impact of the project, it is difficult to demonstrate an insignificant to minor residual impact without adequate monitoring. These species can be expected to persist in their tributaries with adequate EFlow with similar biomass if adequate lateral connectivity is preserved.	Long term management plan dedicated these 3 species including: -Additional investigations before the project in other watersheds to assess the distribution of these species and validate its status as a restricted range species (Cb) -Additional assessments to understand the lateral movements of these species and the relationship with main river down the tributaries to complete all life cycle and to preserve genetic diversity. -Dedicated monitoring to demonstrate the population level in the tributaries and validate that the residual impact remains insignificant to minor. -Additional assessments to define preservation strategy of the upper watershed and recommendation for hydropower project to preserve lateral connectivity (in EFMP). If the residual impact is demonstrated to be moderate or even major after monitoring, the net gain in biodiversity may be difficult to obtain
Parachiloglanis bhutanensis	Torrent catfish	ACTINOPTERYGII			
Parachiloglanis dangmechuensis	Torrent catfish	ACTINOPTERYGII			

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Tor putitora	Golden Mahseer	ACTINOPTERYGII	Low risk of impact on the Golden Masheer population because the distribution of this species does not correspond to the project's zone of influence (AoI) limited downstream by the existing Kurichhu dam. No additional impact of the project is expected downstream of the Kurichhu dam. No additional impacts on hydrology, hydraulics, sedimentology, morphology and water quality compared to those already caused by the existing Kurichhu dam.	No residual impact anticipated *Note: EDNA monitoring will be realized and adaptive management measures will be design according to the results.*	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge on this species financing a research program with Universities or the DOFPS including monitoring of the species
Haliaeetus leucoryphus	Pallas's Fish-eagle	AVES	Low risk of impact on nests because of project footprint (no nest identified on field). The known nesting area is located closed to the lake of the Kurichhu dam. Low risk of fishing success loss due to project footprint thanks to its capacity to target various terrestrial and aquatic species in various aquatic. For this species, the most important feeding success occurs in lake and wetland and with a lesser importance in river and stream. Risk of loss of availability of prey due to the dewatered segment and water level variation in the lake	Additional survey before work checking the presence of nests in and near the structures (100 m). If there are nests, optimize the footprint as much as possible to avoid the proximity of works less than 100 m away. In all cases, it will be prohibited to cut down a tree containing a nest. This will be protected by a marked prohibition zone of 20 m around, without clearing the vegetation. Adequate EFlow and implementation of the EFMP will maintain a stream instead of a river, thereby reducing the loss of fishing opportunities.	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge on this species financing a research program with Universities or the DOFPS including monitoring of the species. Contribution to the management of the KBA and associated program"

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Gyps bengalensis	White-rumped Vulture	AVES	Low risk of impact on nests due to the project's footprint (no nests identified on the ground). Vultures do not like to build their nests at the bottom of valleys but they are high up. Low risk of loss of favourable habitats and feeding success due to the impact of the project given the size of the flight range of this species.	Additional survey before work checking the presence of nests in and near the structures (100 m). If there are nests, optimize the footprint as much as possible to avoid the proximity of works less than 100 m away. In all cases, it will be prohibited to cut down a tree containing a nest. This will be protected by a marked prohibition zone of 20 m around, without clearing the vegetation.	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge on this species financing a research program with Universities or the DOFPS including monitoring of the species. Raising awareness about the preservation of biodiversity for this species social consultation to assess human/wildlife conflicts with working groups to find solutions
Sarcogyps calvus	Red-headed Vulture	AVES			
Apus acuticauda	Dark-rumped Swift	AVES	Loss of habitat (Quarries, Dam sites). Blasting There is a low risk of finding this species in the potential favourable habitats such as quarries and cliffs.	Insignificant or Low considering the loss of favourable habitat and the occurrence (No identified-on site in May 2023. Low level of risk but to be checked with: Additional investigation before works in quarry areas (cliff) and blasting zone during migratory period (March to May) Micro adjustment of quarries if possible if nest is found and delineation of protection area around nests. Works schedule considering nesting and migratory periods (avoid March to May)	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge on this species financing a research program with Universities or the DOFPS including monitoring of the species

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Hoya bhutanica		FLORA	The identified station will be flooded by the reservoir. Only 3 stations are known so that the impact is Major	Major. It is not possible to avoid or reduce the loss of the station. The residual impact still stays Major. However, knowledge of the cultivation of this herb suggests that the multiplication of the plant could be attempted in a nursery for possible introductions into the natural environment. The station has 2 configurations, one climbs on an old stump 3 to 4 m high, and the other close to the ground. However, it seems that this species is epiphyte. Additional investigation before works in the project footprint to identify these herbs. If new stations are evidenced: -Adjust as possible project footprint 100 m away from the station. -Prohibition zone and protection of plants	Good potential with a good level of confidence as several documented testimonies show the feasibility of propagating this species in nurseries (See https://plantophiles.com/plant-care/hoya-bhutanica/). X10 gain seems easy to reach. The existing station needs to be protected before works and put in nursery at the best period. Fund to identify other stations and other reintroduction sites. Conservation measure contributions to the other stations.
Bhutanitis ludlowi	Bhutan Swallowtail	INSECTA	Considering the altitude ranges of this species impact may be Insignificant. No direct impact. Low risk of indirect impact during work and by social influx No impact on the host plant in the range of altitude of this species	No residual impact anticipated. No measure dedicated to this species. To be included in the sensibilisation program for sensitive species	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge of this species financing a research program with Universities or the DOFPS including monitoring of the species

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Manis pentadactyla	Pangolin	MAMMALIA	Low impact due to habitat loss by project footprint in forest habitats. Known locations in Bhutan are outside the AoA (Southeast and Southwest) Significant loss may be associated with the worker during work increasing poaching in the project area. However, the population level of this species seems to be very low in the AoA resulting in a low impact. The increase in poaching and bush hunting could also put additional pressure on this species. The primary threat is indiscriminate hunting and poaching for local and international use (demand in China), and the species is subject to very heavy collection pressure across much of its range (See Red list form https://www.iucnredlist.org/species/12764/168392151).	Insignificant or Low considering the loss of favourable habitat and the occurrence. Insignificant or low considering social influx during works if effective management is implemented with: Funding and implementation of a conservation program dedicated to this species including monitoring of the action is required during work phase. Raising awareness among all workers about the preservation of biodiversity and the implementation of impact management measures Provision of balanced meals so as not to supplement protein needs. Provision to be included in the employment contract: -Ban on consumption of bush meat -Prohibition on detention, capture and killing of all wild animal species -Prohibition of use, possession, importation of hunting weapons, traps or any other device aimed at capturing or killing wild fauna. -Prohibition of illegal trade	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge of this species financing a research program with Universities or the DOFPS including monitoring of the species

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Panthera tigris	Tiger	MAMMALIA	Low impact due to habitat loss due to project footprint. Indirect impact on the availability of the prayer because of works disturbance. Main known locations in Bhutan are outside the AoA. The NTS PNP survey led in 2021-2022 did not record any images of the Tiger in the areas os influence of the project. However, one interview and one camera trap image demonstrate its occurrence in the AoI Low/positive impact on the continuity of biodiversity. It is likely that the Tiger will cross the Kurichhu river more easily after the project (dry segment and low water speed in the reservoir)	Same as for Pangolin. Insignificant or Low considering the loss of favourable habitat and the occurrence. Insignificant or Minor considering social influx during works if effective management is implemented with: -Prohibition on detention, capture and killing of all wild animal species -Prohibition of use, possession, importation of hunting weapons, traps or any other device aimed at capturing or killing wild fauna. -Prohibition of illegal trade	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain. Program to improve knowledge of this species financing a research program with Universities or the DOFPS including monitoring of the species

Species Name	Common Name	Taxonomic Group	Potential impact factor	Residual impact	Offsetting feasibility
Trachypithecus pileatus ssp. Tenebricus	Capped Langur	MAMMALIA	Moderate to significant impact on its forest habitat (footprint). Moderate to significant impact because of population disturbance and risk of accident during work However, there is an available forest habitat in which the species will be moved during work and operation. Worksforce presents also a risk of poaching and bushmeat consumption	Low to moderate considering the loss of favourable habitat and the workforce Main mitigation measures are: Eflow to preserve riverine forest in the dewatered reach Restauration of the temporary footprint after works Social influx management plan with: -Prohibition on detention, capture and killing of all wild animal species -Prohibition of use, possession, importation of hunting weapons, traps or any other device aimed at capturing or killing wild fauna. -Prohibition of illegal trade	Moderate risk of residual impacts, such as the implementation of a conservation program for this species with improvement of the knowledge of the ecology of this species, funding for research and monitoring program with University and DOFPS in the project area, taxon management in relation to the main threats.

Protected area	Potential impact factor	Residual impact	Offsetting feasibility

Phrumsengla National Park and critical habitat by criterium d	Insignificant to minor. There is no direct impact on the NP outside on the project footprint but 83 km2 of the NP is inside the AoA (9%). Indirect impacts of the social influx are unlikely and, if there are, they will be very limited because of the altitude of the PNP in comparison to the altitude of the works sites and work camps.	General measures to limit social influx and several measures during the construction phase could be effective in avoiding the risk of an increased pressure on the forest habitats and associated sensitive species of the PNP.	Contribute to the conservation in the NP by funds and associated program.
Corridor #7. critical habitat considering Tiger species	The question for the indirect impact of the reservoir on corridor 7 is if the connectivity with Bumdeling WS will be significantly affected or not, for mammals. The impact seems to be limited. The increase in depth and width of the river transformed into a long reservoir as well as the drop in current may affect the use of corridor #7 in its southern branch only. While it is certain that during high water the reservoir will be easier to cross than the river, during low water, the reservoir may be more difficult to cross for some species.	Extend corridor 7 south of the reservoir by approximately 4 km in the bypassed section. The terrestrials' habitats are similar on a few kms downstream. This will allow us to restore the connectivity between the eastern and western parts of the corridor. This will include the same type of habitat present in C7 and it will offer a new section possible to be crossed by animals.	Low risk of residual impacts, such that general conservation measures for preserving the habitat of this species are acceptable to generate a net gain

8 THE HUMAN ENVIRONMENT

8.1 Methodology

8.1.1 Introduction

To ensure accuracy and reliability, the gathering of official information formed an integral part of the baseline assessment. Official documents, reports, and records were carefully reviewed and analysed to obtain a solid foundation of data about the community. This information served as a starting point, providing key context and background details for the subsequent stages of data collection.

The assessment process began with a **consultative approach prior to the planning stages** based on the stakeholders identified in the SEP. Consultations and guidance were sought from key interested parties such as the National Statistics Bureau (NSB), the Water Resources Division, Department of Environment and Climate Change (DoECC), Department of Forest and Park Services under the Ministry of Energy & Natural Resources (MoENR) and the Department of Culture and Dzongkha Development, Ministry of Home Affairs.

Approvals were sought to conduct consultations with Health Care centres, and schools in the project area from the Ministry of Education and Ministry of Health.

To gain a comprehensive understanding of the social dynamics and potential impacts within the area of influence of the project, a **field mission to address social aspects** was conducted in May 2023. This assessment employed a multi-dimensional approach, using a range of data collection methods to gather valuable information. The baseline assessment incorporated the gathering of official information, Key Informant Interviews (KII), Livelihoods and Gender Focus Group Discussions (FGD), Community Mappings, and Seasonal Calendars. Additionally, the assessment aimed to further enrich the community information through the implementation of a comprehensive household survey.

8.1.2 Description of field activities

During the field visit, presentations and discussions were held with the District Administration in Mongar and Lhuentse wherein the project background, objective, layout, components, and potential impacts were shared, and concerns and view of the Dzongkhag was recorded. These details of these meetings are documented in the public consultation report for the first field survey.

In the field, the consultative approach at the gewog level included stakeholder mapping and the incorporation of relevant agencies in the stakeholder engagement plan. Subsequently, consultations were conducted with the identified agencies and communities to ensure their involvement and input. This inclusive approach aims to foster collaboration and gather diverse perspectives throughout the assessment process. The details of the consultations are presented in the first field survey report.

In addition to the consultative process, **Key Informant Interviews** (KII) were conducted to gather qualitative data from individuals who possessed extensive knowledge and expertise regarding the community under study. The KII participants, including community leaders, representatives from local organizations, and knowledgeable individuals, provided valuable insights into various social dimensions, local traditions, cultural practices, and community dynamics. These interviews served to deepen the understanding of the social fabric and complexities within the community.

Livelihood Focus Group Discussions were also conducted as part of the assessment. These discussions brought together community members representing different occupations and livelihoods, providing a platform for them to share their perspectives, experiences, and challenges related to their livelihoods, as well as their expectations regarding the project. Through these open dialogues, the assessment aimed to

gain insight into the social and economic factors influencing the community's capacity to generate revenue and improve their overall well-being.

To incorporate spatial and temporal dimensions into the assessment, **community mapping** exercises and the creation of a **seasonal calendar** were undertaken. Community mapping visually represented the physical and social landscapes of the community, highlighting significant landmarks, infrastructure, and resource distribution. The seasonal calendar documented important events, practices, and activities throughout the year, shedding light on the community's cultural practices, rituals, and seasonal variations that shape their daily lives. These exercises provided a comprehensive understanding of the community's context, enabling a more holistic analysis of the social impact assessment. These activities also helped the social team to have dynamic and open discussions about key elements of the community livelihood system, governance, organisation, relations and dependencies, etc.

To augment the richness of social community information, a comprehensive **household survey** was designed and implemented. This survey aimed to capture detailed data on household demographics, socio-economic status, education, health, access to services, and other pertinent factors. By directly collecting data from households, the survey facilitated a nuanced understanding of individual experiences, aspirations, and challenges within the community, thereby strengthening the assessment's findings and recommendations.

Overall, the assessment employed a consultative and participatory approach, incorporating Key Informant Interviews, Livelihood Focus Group Discussions, Gender Focus Group discussions (women only), community mapping, and a seasonal calendar. The comprehensive household survey further contributed to the depth and breadth of the social community information, ensuring a robust baseline for the assessment, and informing the future impact evaluation.

Following the field visits, consultations were conducted with parent departments and ministries to brief about the project, the findings of the field visit and to seek input into the ESIA documentation and ESMP preparation process.

These include CSOs and NGOs (Ability Bhutan Society, Disabled People's Organization of Bhutan, Respect, Educate, Nurture and Empower Women and Tarayana Foundation), Competition & Consumer Affairs Authority (CCAA), Ministry of Industry, Commerce and Employment, National Biodiversity Centre, Ministry of Agriculture and Livestock (MoAL), Department of Culture and Dzongkha Development, Ministry of Home Affairs (MoHA), Culture Officer, Mongar Dzongkhag Administration, Waste Division, Department of Environment and Climate Change, Ministry of Energy and Natural Resources (MoENR), Electric Regulatory Authority, Ministry of Energy and Natural Resources (MoENR) and the Ministry of Education.

Table 125: Description of the field activities

Activity	Purpose	Participants
Community mapping	Visualize community resources, infrastructure, and spatial relationships.	A few (2-4) knowledgeable villagers (both men and women)
Seasonal calendar	Capture seasonal variations and cultural practices to understand community dynamics.	Women and men totalling 5-10 participants
Livelihood FGD	Gather diverse perspectives on livelihoods for comprehensive social baseline assessment.	Women and men totalling 10-15 participants
Gender FGD	Capture gender-related insights for inclusive social baseline assessment.	Only women participants ranging from 5-10 women
HH Surveys	Gather household information and data on demography, socio-economy and perspectives on the project from households from villages located in the	A total of 508 HH were interviewed from chiwogs falling in project area

Activity	Purpose	Participants
	project area along both the left and right banks of Kurichhu river	located in Mongar and Lhuentse districts

The map Figure 121 show the major settlements where the household surveys were conducted. It was decided to call people of several villages to a common meeting place to conduct the interviews. This was done to ensure maximum coverage of interviews. In view of this arrangement, the map below shows the major villages where interviews with people from nearby villages were also conducted.

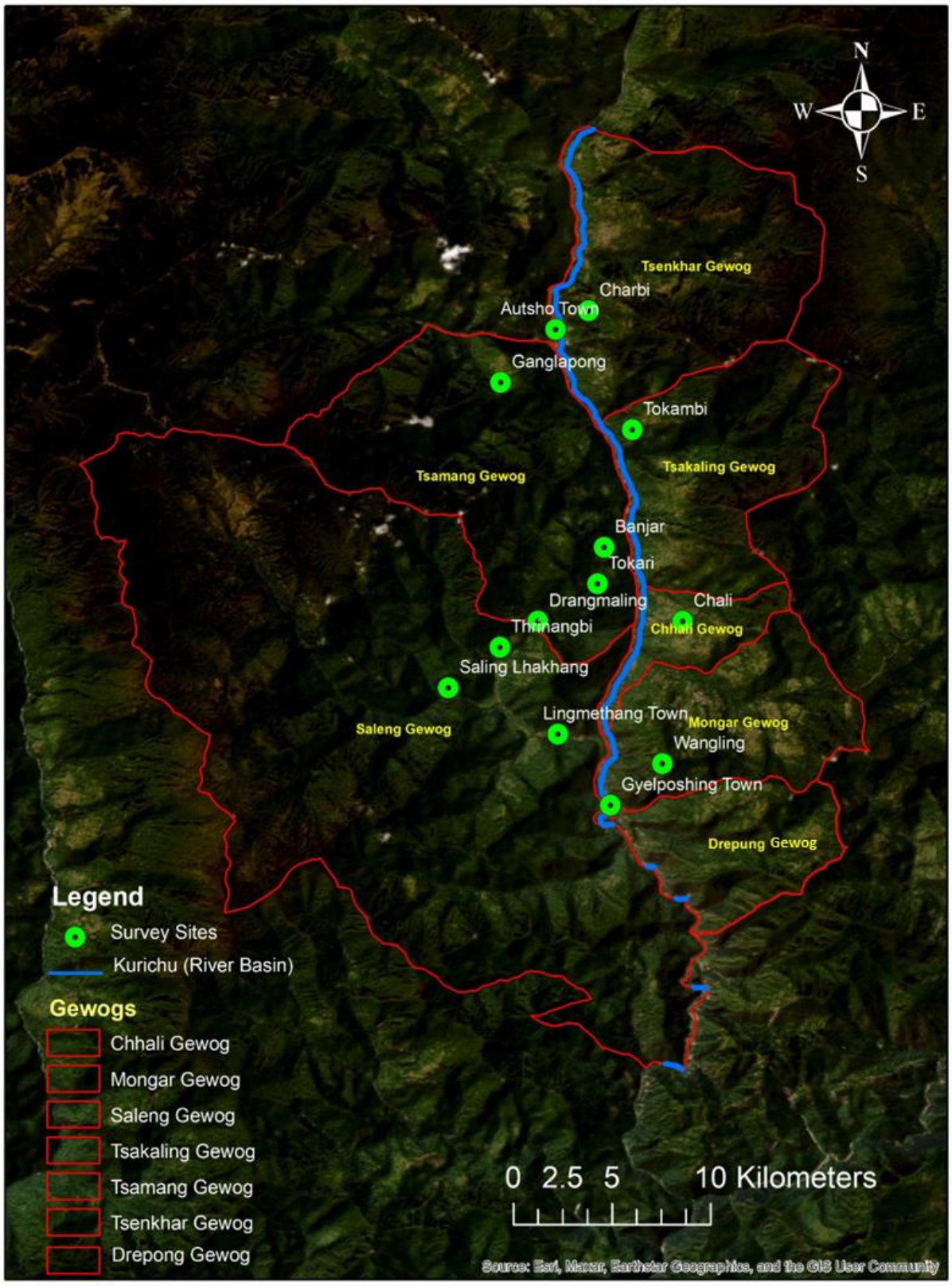


Figure 121: Social Survey sites

8.1.3 Synthesis of the coverage of the social survey

A mix of qualitative and quantitative societal tools were used to gather information about the survey area.

The baseline first field mission **quantitative household questionnaire** was conducted in May 2023. Our proposed sampling plan involved conducting approximately 500 interviews, ensuring coverage of approximately 33% of the estimated total population (around 7,000 individuals) within the area of influence. These interviews were distributed across different localities based on their respective population weights. Overall, a total of 508 households were surveyed, encompassing 1,907 people. Out of the surveyed households, 44% were in rural areas, while the remaining 56% were situated in urban areas. The following graph shows the number of households surveyed for each Gewog.

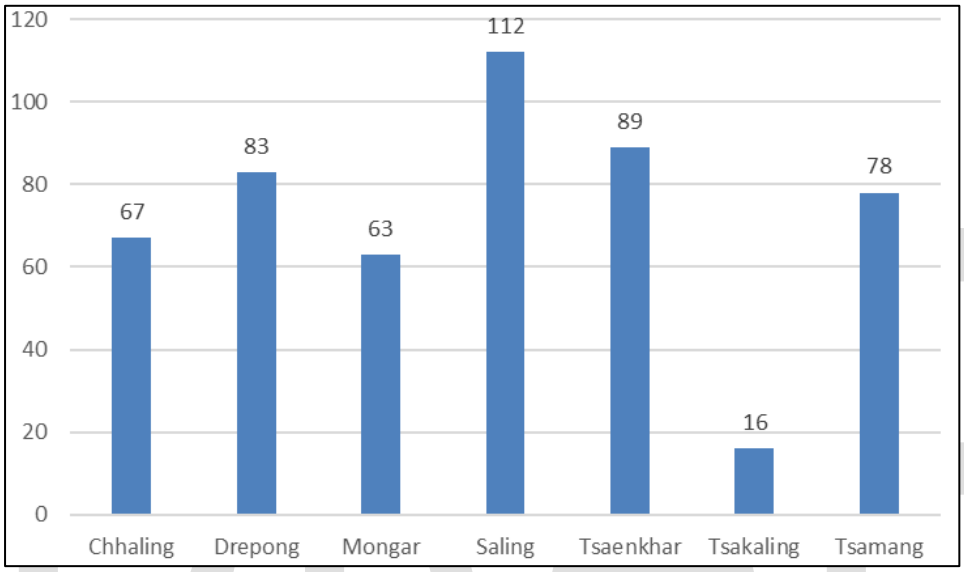


Figure 122: Number of households surveyed, by Gewog

For the gathering of **qualitative data**, the following tools were used:

- 8 community mappings
- 8 seasonal calendars
- 18 focus groups discussions (FGDs), namely:
  - 9 livelihoods related FGDs
  - 9 genders based FGDs
- 5 KII with health centres.

A list of Primary Health Care Centres (PHC) and Hospitals in the project area was shortlisted for surveys and consultation. The primary objective was to understand the baseline scenario, in terms of current capacities, constraints and future of the existing Primary Health Care centres in the gewogs and the Hospitals, as well as seek the views of these stakeholders.

Figure 123: Seasonal calendar, Autsho

Figure 124: Focus group discussion with businesses, Autsho

Figure 125: Community mapping, Chhali

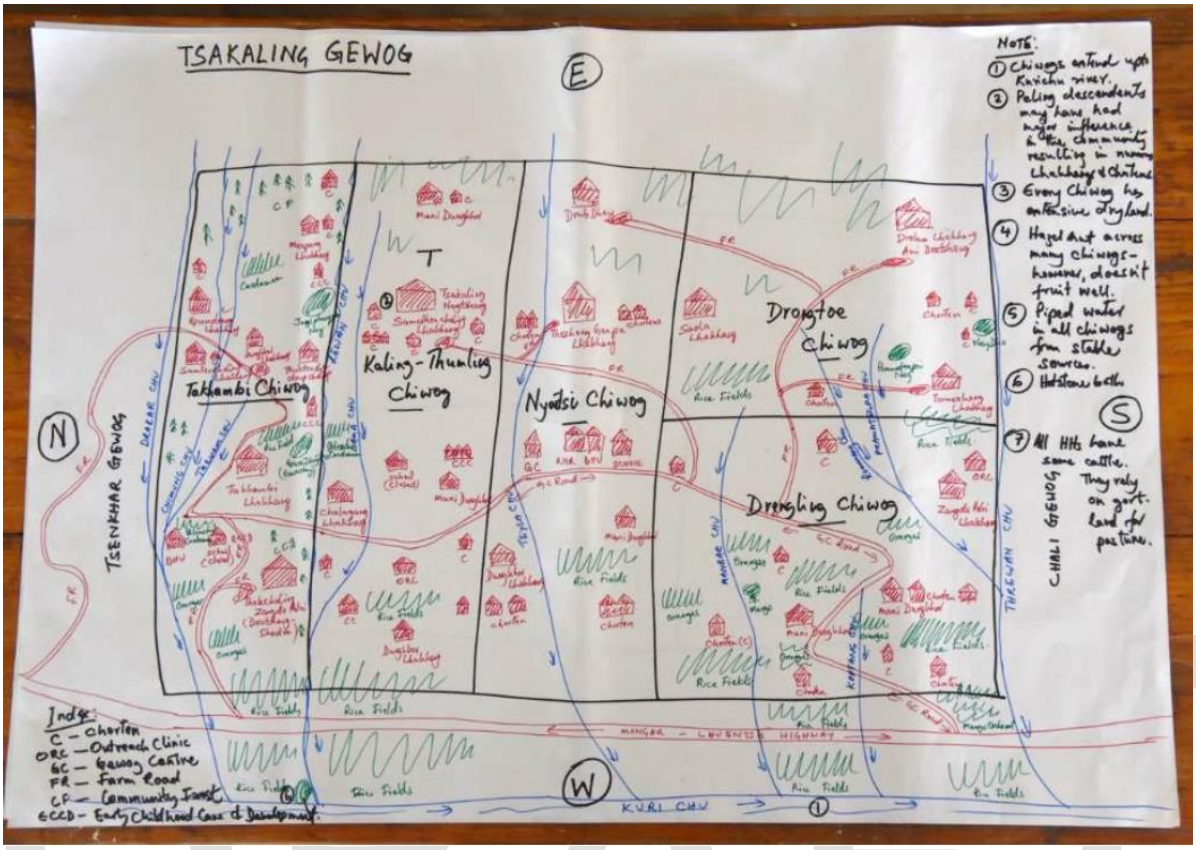


Figure 126: Community mapping, Tsakaling

8.1.4 Team composition

The household survey team was composed of 10 enumerators, two supervisors and the National Social Expert who divided his time between supervision of the household surveys and the social focus group discussion teams.

The social focus group discussion was composed of the International Social Expert and one translator with occasional assistance from the National Gender Expert. The National Social Expert accompanied the team to some sites.

Likewise, the Gender Focus Groups Discussion team was composed of the International Gender Consultant, one translator and the National Gender Expert.

8.2 Socio-Economic Baseline

8.2.1 Administrative areas and governance

Key points related to administrative areas and governance

Dorjilung Hydropower Project is located on Kurichhu, 3 – 20 km upstream of the existing Kurichhu Hydropower Plant. All the construction activities are in the **Mongar Dzongkhag** except some parts of the reservoir stretching into **Lhuentse Dzongkhag**.

The project's area of influence comprises 2 Dzongkhags, 7 Gewogs, 42 Chiwogs, and 69 villages.
Bhutan became a Democratic Constitutional Monarchy in 2008 and has three arms: the legislative, executive and judiciary powers.
The Executive power comprises of the **Central Government** composed of 9 Ministries and their Departments, and autonomous services; and the **Local Government is** composed of the Local Government Council at the district level/District Assembly named *Dzongkhag Tshogdu*, the Local Government Council at the Gewog level/Gewog Assembly called *Gewog Tshogde* and the Municipal Council called *Thromde Tshogde* Municipal Council. They are governed by the Local Government Act 2009.
More details about administrative areas and governance are given below.

The governance structure of Bhutan is illustrated in Figure 127, which maps out the administrative hierarchy starting from the district level known as 'Dzongkhag'. At the head of each Dzongkhag is the 'Dzongdag', the district's chief executive. The 'Dzongkhag Tshogdu' serves as the local government body for the Dzongkhag. Below the Dzongkhags are subdivisions called 'Gewogs', which are blocks consisting of multiple villages, each led by a 'Gup'. The 'Gewog/Thromde Tsogde' functions as the local assembly for these blocks. At the most fundamental level are the 'Chiwogs', the smallest administrative units that include groups of villages, also under the administration of a Gup. This hierarchical structure ensures an organized approach to governance across the varied territorial areas of Bhutan.

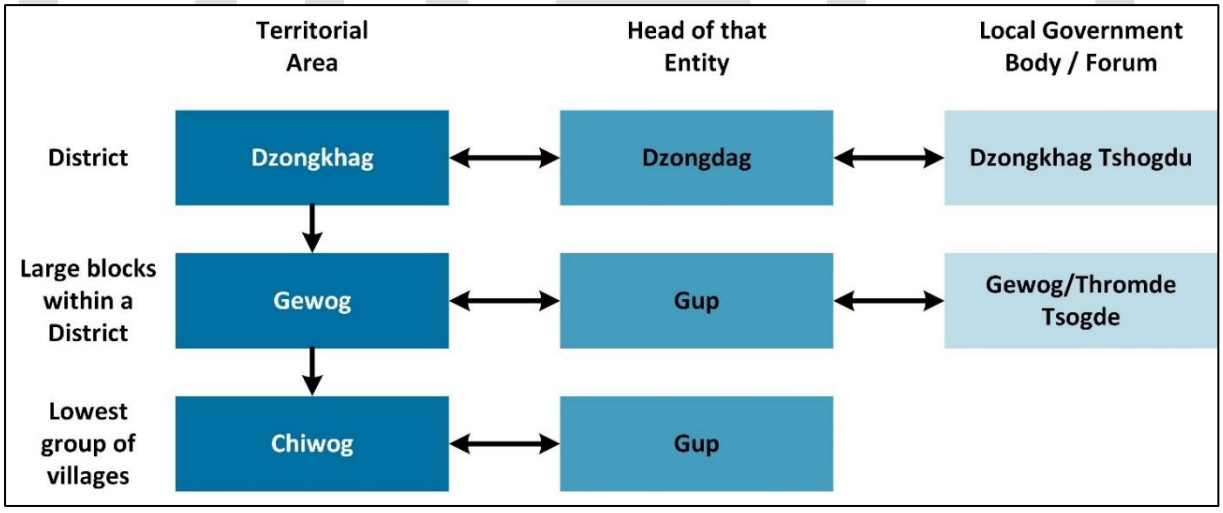
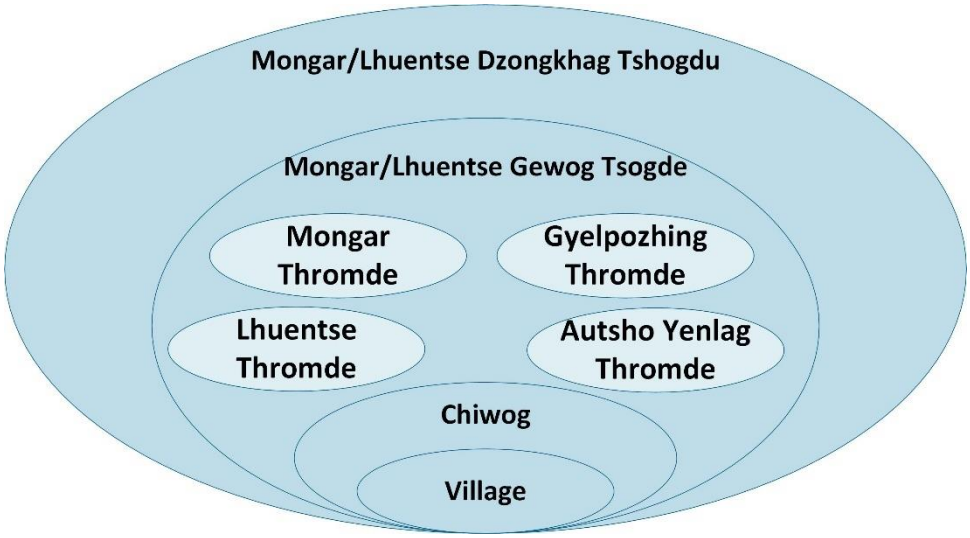


Figure 127: Illustrative governance diagram

Bhutan is divided into 20 Dzongkhags, with each Dzongkhag headed by a 'Dzongdag', or Governor, who is supported by civil servants. A Dzongkhag includes several 'Gewogs', which are local constituencies for electing Gups and Mangmis to the Gewog Tshogde, as well as 'Chiwogs', which are the lowest territorial constituencies made up of village groups for electing Tshogpas to the Gewog Tshogde. Additionally, the Dzongkhags contain villages and towns classified as 'Thromdes', which are categorized based on resident population size, area, and reliance on non-primary activities. Notable Thromdes within the Dzongkhags include Mongar, Lhuentse, Gyelpozhing, and Autsho Yenlag.

Figure 128: Local governance diagram



The project's direct area of influence covers 56 villages in 7 gewogs, as shown in the Table 126 presents the villages in relation to the project area.

Table 126: Chiwogs (in urban and rural areas) that constitute the Project´s directly influenced area

Gewog	Villages	Plotting on Map
Chhaling Gewog	Chali	Yes
	Charzhong	Not found
	Dolophung	Not found
	Domangla	Not found
	Kardungma	Not found
	Khoijongla	Not found
	Kurizampa	Yes
	Lingchu	Not found
	Lungkang	Not found
	Pangjakpa	Yes
	Sokpaling	Yes (Sokpasin)
	Tangdarpi	Not found
	Tashi Poktor	Yes
	Wangmakhar	Yes (Wangmokha)
	Yangthang	Yes
Drepong Gewog	GCIT colony	Yes
	KHPC Colony Gyelposhing	Yes
	Tashi Poktor	Yes
	Yongri Gyelposhing	Yes
Mongar Gewog	Chali	Yes
	GCIT colony	Yes
	Gyalposhing Town	Yes
	Khairi	Yes (Kheri)
	Khaling (resides in Gyalposhing)	Not found
	KHPC	Yes
	Pemathang Gyelposhing	Not found
	Tashi Poktor	Yes
	Wamling	Yes
Saling Gewog	Jangdung	Yes
	Lingmithang	Yes

Gewog	Villages	Plotting on Map
	Mengchugang	Yes
	Saling	Yes
	Thrinangbi	Yes
Tsaenkhar Gewog	Autsho Town	Yes
	Chalibadeb	Yes
	Charbi	Yes
	Dolophung	Yes
	Dongthrum	Yes
	Luengtsa	Not found
	Nye	Yes
	Peladraphu	Yes
	Thocholung	Yes (Tshosilung)
	Thongphung	Yes
	Tsenkhar	Yes (Tsenkhar Gewog Office)
	Tshokem	Yes (Tshochen)
	Yangla	Yes
Tsakaling Gewog	Takhambi	Yes
Tsamang Gewog	Banjar	Yes
	Drangmaling_ngar	Yes
	Ganglapong	Yes
	Ganglapong Khuling	Yes
	Ganglapongmaed	Yes
	Ganglapongtoed	Yes
	Thengbung	Yes (Tenpung)
	Thengmo	Not found
	Tokari	Yes

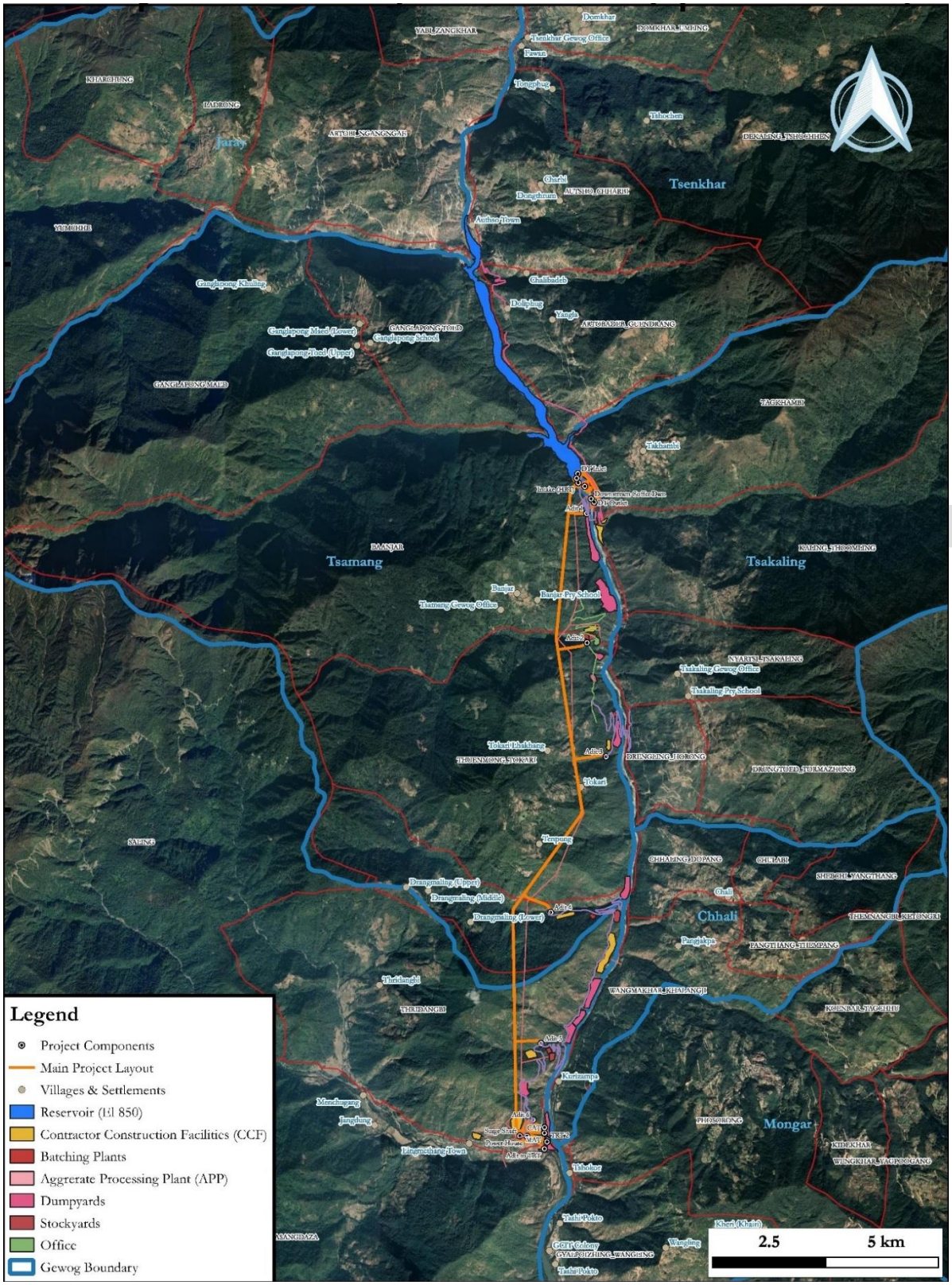


Figure 129: Villages & Settlements

8.2.1.1 Governance system

Bhutan's political organization, as depicted in the organogram of the Royal Government of Bhutan post the constitutional enactment of 2009, is structured around the central figure of His Majesty, the King, who stands at the top of the hierarchy. The executive branch, known as the Lhengye Zhungtshog, consists of

ministers and is led by the Prime Minister. This branch is supported by various ministries and autonomous bodies responsible for the country's administration.

The legislative branch is bicameral, comprising the National Assembly, which is the elected lower house, and the National Council, which is the upper house and functions as a house of review. These two bodies together are responsible for law-making processes in the country.

The judiciary branch is independent and consists of the Supreme Court at its pinnacle, followed by the High Court, with the Dzongkhag Courts and Dungkhag Courts operating at the district and sub-district levels, respectively. This hierarchy ensures the rule of law and legal uniformity across the nation.

The defence sector is a standalone entity, highlighting its distinct role in national security.

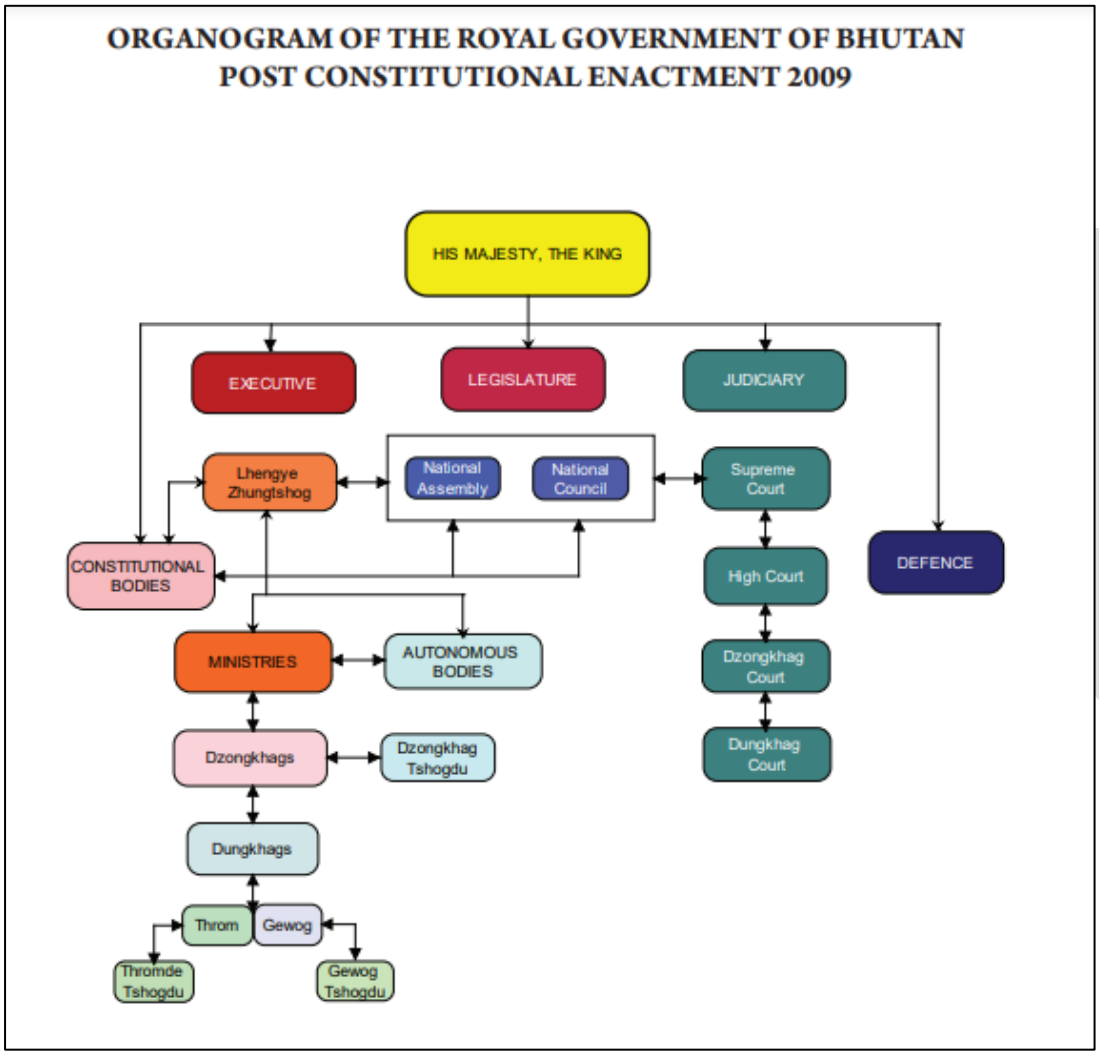


Figure 130: Organogram of the Royal government of Bhutan post constitutional enactment 2009

Source: NSB, 2022

8.2.1.2 Judiciary

The Judicial system in Bhutan comprises of the following hierarchy with the Supreme Court as the highest jurisdiction/organisation.

- The Supreme Court of Bhutan- extends to the whole country.
- The High Court- extends to the whole country.
- The Dzongkhag Courts- extends to the district level only.

- The Dungkhag Courts- extends to the dungkhag level only.

Other institutional actors with different constitutional and statutory mandates in the administration of justice. The Royal Bhutan Police (RBP) and the Anti-Corruption Commission (ACC) serve as the investigating agencies; the Office of the Attorney General (OAG) as the prosecuting agency; and the Bar, regulated by the Bar Council of Bhutan (BCB), represents litigants in civil and criminal proceedings (Royal Court of Justice, 2021. Judiciary Strategic Plan 2022-2032).

8.2.1.3 Legislative

The Parliament of Bhutan, as established by the Constitution, consists of the Druk Gyalpo (King of Bhutan) and a bicameral legislature, comprising the National Council and the National Assembly. Each house has distinct roles and responsibilities within the legislative process.

National Council

The National Council, the upper house, is composed of 25 members: 20 elected from each of the 20 Dzongkhags (districts) of Bhutan and 5 eminent members appointed by the King. It operates under the National Council Act of 2008 and has the following key functions:

- Legislative Role: Participates in the legislative process but cannot introduce financial bills, which are the sole responsibility of the National Assembly.
- Review and Oversight: Acts as a reviewing body for legislation passed by the National Assembly, ensuring governmental compliance with laws and policies.
- Representation: Represents the interests of the Dzongkhags at the national level.

National Assembly

The National Assembly, the lower house, consists of 47 members elected from single-member constituencies through a two-round electoral system. Its primary responsibilities include:

- Legislation: The main legislative body, responsible for introducing and passing bills, including financial and budget-related bills.
- Government Formation: The majority party in the National Assembly forms the government, with its leader typically appointed as Prime Minister.
- Oversight of the Executive: Oversees the executive branch's actions, with powers to conduct inquiries and hearings.
- Public Engagement: Represents and engages with the public on various national issues.

Both houses collaborate on certain issues like constitutional amendments and other critical national matters (National Assembly of Bhutan, 2018. Strategic Development Plan, 2009-2023).

8.2.1.4 Executive

The Executive arm comprises of the **Central Government** and **Local Government**.

8.2.1.4.1 Central Government

The central government is made of Ministries, Departments and Autonomous bodies (Election Commission, Royal Audit Authority, Anti-Corruption Commission and the Royal Civil Service Commission).

Up till 2022, there were 10 Ministries. In 2022, with the new Civil Service Reform Act, the 10 ministries were reorganized with the objective of enhancing governance. The Ministries of Labour and Human Resources, Information and Communications and Economic Affairs have been merged to form the Ministry of Industry, Commerce and Employment (MoICE).

The executive organization with previous and new Ministries and the Departments composition is presented below.

Table 127: Executive organization

Previous Ministry	New Ministry	Reorganization in Departments/Divisions
Ministry of Agriculture and Forests	Ministry of Agriculture and Livestock (MoAL)	Department of Forest separated under Ministry of Energy and Natural Resources (MoENR)
Ministry of Education	Ministry of Education and Skills Development (MoESD)	National Commission for Women and Children Secretariat has been absorbed into MoESD. MoESD's Quality Assurance and Accreditation Division, Higher Education and Planning Division, Engineering Council of Bhutan, Bhutan Medical and Health Council, and Bhutan Board for Certified Counsellors (BBCC) absorbed into the newly established Bhutan Qualification and Professional Certification Authority (BQPCA)
Ministry of Economic Affairs	Ministry of Energy and Natural Resources (MoENR)	Department of Energy Department of Geology and Mines Department of Forests and Park Services Department of Water The National Environment Commission Secretariat (NECS) renamed as the Department of Environment & Climate Change Bhutan Electricity Authority is renamed the Electricity Regulatory Authority (ERA)
Ministry of Foreign Affairs	Foreign Affairs and External Trade (MoFAET)	Same as before
Ministry of Health (MoH)	Ministry of Health (MoH)	Same as before
The Ministry of Home and Cultural Affairs	Ministry of Home Affairs (MoHA)	The Department of Culture has been renamed as Department of Culture and Dzongkha Development after subsuming Dzongkha Development Commission (DDC). The Department of Local Governance and Department of Disaster Management have been merged to form the new Department of Local Governance and Disaster Management.
Ministry of Economic Affairs	Ministry of Industry, Commerce and Employment (MoICE)	Department of Industry and Department of Trade The Department of Employment and Entrepreneurship and the Department of Labour The Department of Information and Media has been merged with the Department of Intellectual Property, and renamed the Department of Media, Creative Industry and Intellectual Property. Tourism Council of Bhutan renamed Department of Tourism The Office of Consumer Protection renamed the Competition and Consumer Affairs Authority Bhutan Standards Bureau renamed the Bureau and the Media Council of Bhutan. National Film Commission has been merged with the Bhutan InfoComm and Media Authority (BICMA)
Ministry of Works and Human Settlements	Ministry of Infrastructure	Road Safety and Transport Authority and the Department of Roads merged as the Department of Surface Transport.

Previous Ministry	New Ministry	Reorganization in Departments/Divisions
	and Transport (MoIT)	Regulatory functions under the Department of Roads, Road Safety and Transport Authority, and Construction Development Board have been subsumed under the new Bhutan Construction and Transport Authority (BCTA).
Ministry of Information and Communications	Government Technology Agency	The Department of Information Technology and Telecommunications under the former has been reconstituted as the Government Technology Agency

Source: https://kuenselonline.com/civil-service-reform-bill-proposes-reducing-ministries-to-9.

8.2.1.4.2 Local government

Each Dzongkhag in Bhutan is equipped with a Local Government system established under the Local Government Act of 2009. The local governance structure comprises the Dzongkhag Tshogdu, which is the Local Government Council at the district level, also referred to as the District Assembly. Within the Dzongkhags, there are further subdivisions known as Gewogs, which are blocks or clusters of villages, each managed by a Gewog Tshogde, the Local Government Council at the Gewog level. Additionally, urban areas within the Dzongkhags are organized into Thromdes, or towns, each with its own Thromde Tshogde, also known as the Municipal Council. These local administrative bodies are integral to managing local governance and addressing the development needs within their respective jurisdictions.

The administrative organogram detailing the local governance structures of Mongar and Lhuentse is included in the ESIA Volume 3 Appendix E Social 1st Field Report.

8.2.1.4.3 Social links and organisation

Well established and recognised administrations- especially the gewog, or village, serving as the primary administrative and social unit in rural Bhutan- also support traditions and culture, which plays a crucial role in fostering a sense of belonging, mutual support, and collective identity among community members. The following social links are important in Bhutanese population:

- **Extended Family Networks**: In Bhutanese rural communities, extended families often live in proximity, forming the backbone of social support networks. These networks provide emotional, financial, and practical assistance to family members in times of need. The extended family system also reinforces intergenerational bonds and ensures the continuity of cultural traditions and values.
- **Gewog (Village) Communities**: Within gewog communities, residents collaborate on various communal activities such as agricultural work, religious ceremonies, and social gatherings. This fosters a strong sense of solidarity and cooperation among villagers, who often come together to address common challenges and celebrate shared achievements.
- **Community Rituals and Festivals**: Rituals and festivals are integral parts of Bhutanese rural life, providing occasions for community members to come together, socialize, and reinforce cultural bonds.
- **Traditional Forms of Governance**: In many rural areas of Bhutan, traditional forms of governance, such as the system of chathrim (village councils) and the institution of gup (village headman), continue to play a significant role in community decision-making and conflict resolution. These institutions facilitate grassroots participation in local governance and ensure that community interests are represented and protected.
- **Religious Institutions**: Buddhism plays a central role in Bhutanese society, and rural communities are often centered around monasteries, temples, and stupas. These religious institutions serve not only as places of worship but also as hubs for community activities, education, and social welfare. Monks and lamas play important roles as spiritual leaders and mentors, providing guidance and support to villagers.

- **Traditional Arts and Crafts**: In rural Bhutan, traditional arts and crafts are not only expressions of cultural identity but also sources of livelihood and social cohesion. Activities such as weaving, pottery, painting, and wood carving are often passed down through generations within families and communities, strengthening bonds and preserving cultural heritage.
- (also refer to 8.2 and 8.3)

8.2.2 Socio-demographic characteristics

Key points from socio-demographic characteristics

Demography and migration

With 19 inhabitants per km², Mongar is one of the more densely populated Gewogs compared to the national average (which stands at 14 inhabitants per km²), while Lhuentse is one of the least densely populated, with 5 inhabitants per km². The age group the most represented in the study area in between 25 and 45 years old.

Rural exodus is an issue in the study area for economic reasons and can lead to a situation of economic vulnerability for the households.

Languages and religions

Language disparities could lead to some challenges during Project implementation. Some local community members do not use Dzongkha fluently and communication also needs to be provided in multiple local dialects. This component has been considered in the Project's communication elements.

More details about the socio-economic characteristics are given below.

8.2.2.1 Demography

8.2.2.1.1 National level

8.2.2.1.1.1 Population

In 2022, the Bhutan Living Standards Survey selected a sample size of 13,416 households nationally using a stratified two-stage sampling design. This comprehensive approach was informed by the 2017 demographic Census and subsequent official projections, which estimated Bhutan's 2022 population at 763,249. However, the 2022 survey revealed a total population of 650,118 individuals across 164,331 households, differing from the forecast of 763,249. This discrepancy underscores Bhutan's dynamic demographic and socio-economic landscape. In Mongar and Lhuentse, the sample sizes were 624 and 516 households, respectively, reflecting our survey's robust and representative methodology. Table 128 details the demographic split between urban (39% of the population) and rural areas (61%), highlighting differences in household compositions and the proportion of female-headed households in these regions.

It should be noted that in Bhutan, as women are traditionally the owners and heirs to land and property, they are more likely to be the head of households. They declare themselves and are registered as such.

Table 128: Demography of the Bhutanese Population

	National level	Urban areas	Rural areas
Total Population	650,118.00	251,070.00 (39%)	399,049.00 (61%)
Total households	164,332	66,243 (40%)	98,089 (60%)
Average household size	4	3.8	4.1
Female headed households	33% of Households	29 % of households	35 % of households

Source: NSB, 2022. Bhutan Living Standard Survey Report

Overall, household size tends to decline with increasing per capita household revenues (from an average of 5.1 for the poorest quantity to 2.7 for the richest).

8.2.2.1.1.2 Age structure

The share of the young generation in the population began to decline approximately 25 years ago due to falling fertility rates. To date, the current national population growth rate is 0.9 per year (NSB. 2017, Population and Housing Census of Bhutan). However, the age pyramid below still shows an eminently young society.

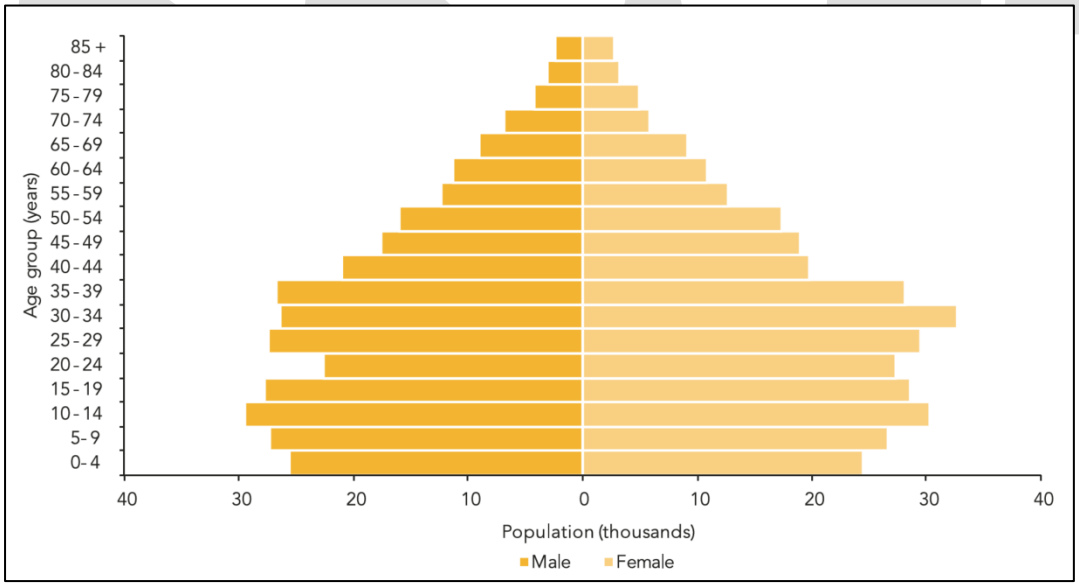


Figure 131: Age pyramid

Source: NSB, 2022. Bhutan Living Standard Survey Report (BLSS, 2022)

The largest segment, comprising 66.9% of the population, is the working-age group, defined as individuals aged between 15 and 64 years. Notably, there's a higher concentration of working-age individuals in urban areas (70.2%) compared to rural areas (64.9%), indicating a possible trend of younger populations moving towards urban centres for opportunities such as employment, education, and modern amenities (BLSSR, 2022).

The other two age groups, children (0-14 years) and the elderly (65+ years), make up 25.2% and 7.9% of the population, respectively. The proportion of children is nearly equal in both urban and rural areas, suggesting a balanced distribution of young populations across the country. In contrast, the elderly population tends to reside more in rural areas. This rural-urban disparity in the distribution of the elderly might be attributed to traditional living arrangements or the migration of younger individuals to urban areas, leaving behind an older demographic in rural regions.

The age and sex distribution of Bhutan's population, as shown in the provided population pyramid, illustrates a demographic that skews younger, with a notable concentration in the 10-14 and 30-34 age brackets. The gender analysis within these age groups shows a balanced representation between males and females.

8.2.2.1.2 District level

According to the BLSS 2022 estimates the districts of Lhuentse and Mongar are populated by 14,031 and 34,948 people respectively, with an average household size of 4.4 and 4.3 people per household respectively, which is slightly higher than the national average (that stands at 4 people per household) (see Table 129**)**.

Table 129: Population size at national and district level

Description	National level (BLSS 2022)	Lhuentse (PHCB 2017) (Male / Female)	Mongar (PHCB 2017) (Male / Female)
Total Population	650,118.00	14,031 (BLSS, 2022)	34,948 (BLSS, 2022)
0-14 years	163,670	4,263	11,399
15-64 years	435,072	9,006	23,108
65 years and over	51,377	1,168	2,643
Total households	164,331	3,193 (BLSS, 2022)	8,132 (BLSS, 2022)
Average household size	4	4.4 (BLSS, 2022)	4.3 (BLSS, 2022)
Female headed households	33%	57% (BLSS, 2022)	46% (BLSS, 2022)

Source: NSB. 2017. Population and Housing Census of Bhutan and NSB, 2022. Bhutan Living Standards Survey Report

With 19 inhabitants per km², Mongar is one of the more densely populated Gewogs compared to the national average (which stands at 14 inhabitants per km²), while Lhuentse is one of the least densely populated, with 5 inhabitants per km². Lhuentse also has the distinction of having a higher rate of female-headed households than the national average, with 56.8% of households headed by women, compared with 33% for the national average and 46% for Mongar district.

8.2.2.1.3 Local level

In the directly affected Gewogs, the population is distributed as follows:

Table 130: Population, by Gewog

Dzong-khag	Gewog	Area (km²)	# chiwogs	# villages	H# households	# Male	# Female	Total Population	Population density per km²
Mongar	Tsamang	144	5		357	1,774	1,638	3,142	22
	Tsakaling	72	5		216	1,093	1,047	2,140	30
	Mongar	77	6		650	1,459	1,184	2,643	34
	Saling	479.5	6		420	1,973	2,016	3,989	8
	Chhaling	72	5	128	312	1,032	493	539	14
	Drepong	54	5		252	1,109	1,008	2,117	39
Lhuentse	Tsenkhar	129	5	57	418	2,141	2,043	4,184	32
Total					2,625	10,581	9,429	18,754	

Source: Gewog website and KII interviews, 2023

Our research involved conducting surveys of 508 households, which comprised 1906 members, of whom 53% were female. The outcome of these surveys suggests an average household size of 3.7 individuals, which is below the district averages. However, when considering the Gewog-level data as illustrated in

Figure 132, there is a variance in household sizes, with some Gewogs showing averages that exceed the national average of 4 people per household. Saling Gewog, for example, has an average household size of 4.50, while Tsamang Gewog's average is slightly higher at 4.51. On the contrary, Mongar Gewog's average household size stands at 2.79, which is considerably lower than both the national and district averages. Tsakaling Gewog's average is 3.75, which is still above the national average but contributes differently to the district average. These differing household sizes at the Gewog level illustrate the diversity within the district populations and their contribution to the overall higher district averages in comparison to the national figure.

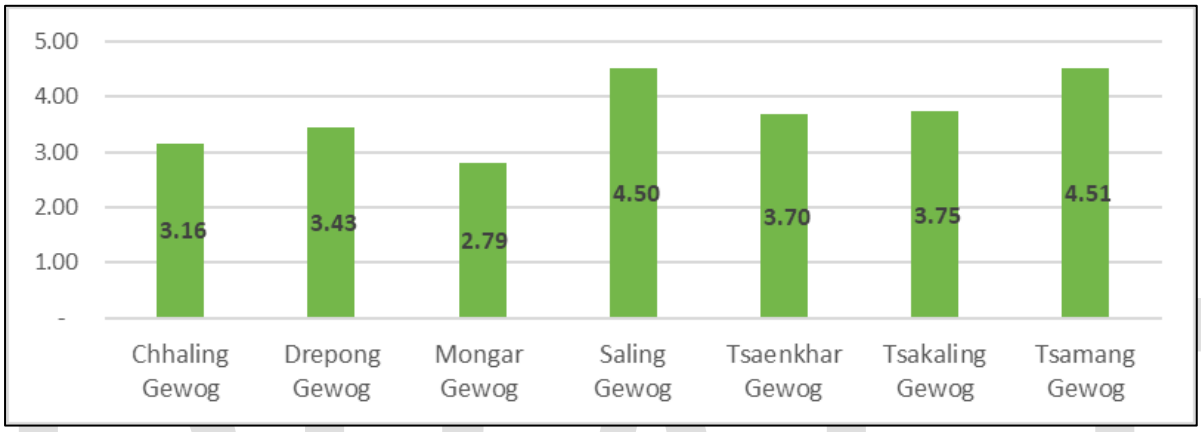


Figure 132: Average household size

Figure 133 illustrates the age and gender distribution within the household members in the study area. The most significant portion of the population, for both men and women, falls within the 25 to 45 age group, each accounting for 36% of their respective genders. This is followed by the under 18 age group, where females constitute a larger share at 27% compared to 25% for males. Both genders have an equal representation within the 45 to 65 age brackets, each at 17%. For the younger adults, between 18 and 25, females make up a slightly higher percentage than males, at 15% versus 13%. In the senior category, 65 or more, men account for a smaller proportion at 6%, suggesting fewer males in the oldest age group compared to their female counterparts. Overall, the graph points to a higher proportion of younger females in the population and a relatively balanced distribution among the central age categories.

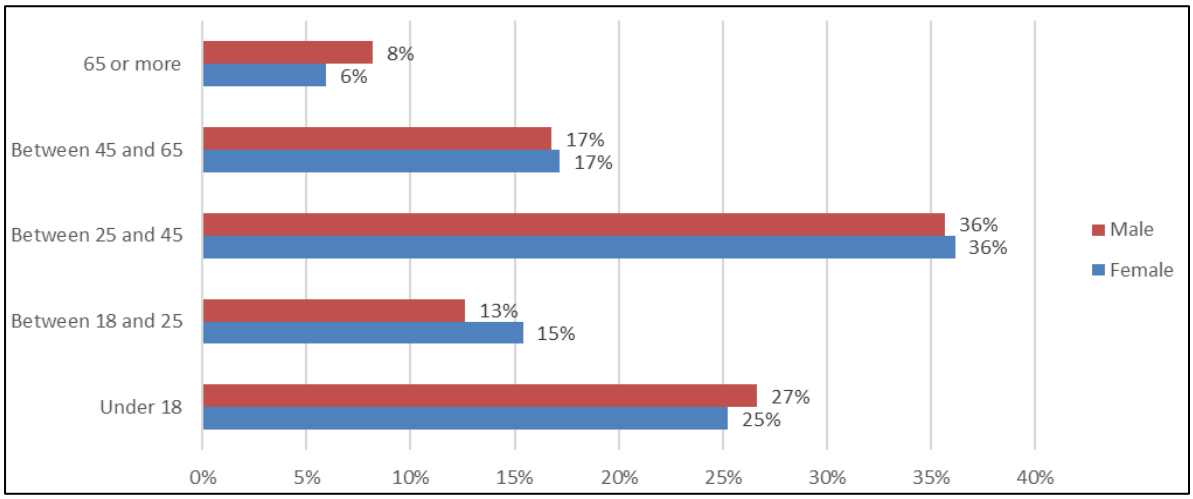


Figure 133: Age category per sex of the sampling population

In terms of marital status, approximately three quarters of the household members (74.2%) living in the 508 households are married, while 18.2% have never been married and 4.6% are widowed (see Figure 135). We can notice that **more men than women are single** (21.7% versus 15.2%), **while more women than**

men are widowed (6.1% versus 2.9%). This discrepancy is due to the difference in life expectancy between men and women in Bhutan. On average, life expectancy for men was 70 years versus 72 years for women (*UN, 2018*).

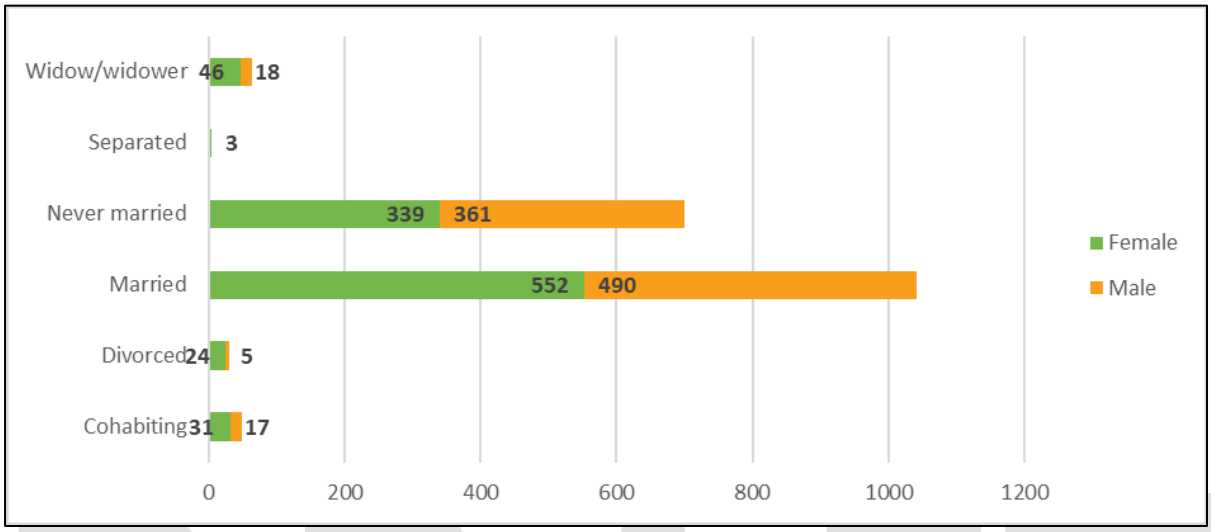


Figure 134: Marital status of the sampling population

8.2.2.2 Languages

8.2.2.2.1 National level

Languages of Bhutan belong to the Tibeto-Burman language family while Lhotshamkha (Nepali) language belongs to the Indo-Aryan language family. Most often students are taught Dzongkha and English in school and speak their mother tongue at home.

As for languages, **although Dzongkha is the national language, Bhutan has at least 19 different languages** (*source: Wangdi, P. (n.d). Language Policy and Planning in Bhutan*). Lhotshamkha (Nepali), is spoken across the southern border, Sharchopkha/Tsanglakha is spoken in the east, Brokpakha is spoken by the communities of Merak and Sakten in Trashigang, Lakha by the laya community in Gasa, Chocangacha in Mongar and Lhuentse, Bumthangka in Bumthang, Kheng in South-central Bhutan, Kurtopkha in northern part of Lhuentse, Dzalakha in Trashi Yangtse, Mangdebkha/Nyenkha in Central Bhutan, Olekha in Wangdue and Trongsa, Lepcha in Samtse, Lobikha in Samtse and southern Chukha, Chalikha and Dakpakha in eastern Bhutan (*source: Druk Asia. Interesting Facts about the Bhutanese Language, 9 April 2021. Retrieved from https://www.drukasia.com*).

8.2.2.2.2 Local level

In the area directly affected by the study, Tsangla is the most spoken language by 40% of the population, while the official language, Dzongkha, is spoken by 29%. Kurmedkha is spoken by 24% of respondents. The prevalence of these languages varies across different Gewogs, with Tsangla being the main language in Chhaling, Drepong, and Mongar Gewogs. Kurmedkha is predominantly spoken in Tsenkhar, Tsakaling, and Tsamang Gewogs. Dzongkha's usage is less common in Saling and Tsakaling Gewogs at 15% and 6%, respectively. Additionally, 25% of Chhaling's population speaks Chhali-kha.

There are respondents (7% of the sample) who speak languages other than the main ones identified, which includes Lhotsamkha speakers primarily found in urban centres within the study area.

Table 131: Languages/dialects spoken per Gewog

Gewog	Language/Dialect spoken by household members (in %)			
	Tsangla	Kurmedkha	Dzongkha	Others
Chhaling	45%	1%	28%	25%
Drepong	41%	4%	49%	6%
Mongar	65%	2%	29%	5%
Saling	59%	20%	15%	6%
Tsenkhar	13%	52%	29%	6%
Tsakaling	6%	88%	6%	0%
Tsamang	22%	44%	35%	0%
Total	40%	24%	29%	7%

Within the project influence area, the Chali dialect (Chalipaikha) is spoken in three villages of Gonpa Chali, Wangmakhar and Chali itself. Chalipaikha is a combination Dzongkha, Tsangla, English, Hindi, Khengkha and Bumthangkha. There are two versions of how the language originated and why it contains so many other languages. That Guru Rinpoche travelled the world distributing languages and when he reached Chhaling, he ran out of languages. So, he emptied the sack of all leftovers. The second version is that as people from Bumthang, Kheng and Kurtoe met at Chali and began living together, they developed a common language by mixing their own languages (source: Chalipaikha: The language of Chali. Retrieved from https://texts.mandala.library.virginia.edu/text/chalipaikha-language-chali).

Language diversity in Bhutan presents certain challenges for project implementation due to the presence of multiple dialects and the limited use of Dzongkha, the national language, among local community members. Effective communication may require the provision of information in various local dialects. Nevertheless, the multilingual nature of Bhutan, as observed in other countries in the region, has accustomed its inhabitants to interacting across different languages. This multilingualism did not pose a significant barrier during social surveys, as local translators facilitated the process effectively. Interviews were conducted in either Tsangla or Dzongkha, adapting to the language preferences of the respondents. It is important for the project's communication strategy to acknowledge and incorporate this linguistic dimension.

8.2.2.3 Religion

8.2.2.3.1 National level

The state religion of Bhutan is the Drukpa Kargyupa sect, a branch of Mahayana Buddhism (*https://www.mfa.gov.bt/rbedelhi/culture/*). About 75% of the population are Buddhist and 25% are Hindus (CIA World Factbook; U.S. State Department Background Notes; US Geologic Survey, 09/2009; 10/2008; 09/2009). Other religions also practiced include Christianity and Islam to a lesser degree.

The 2020 report by the World Christian Database estimated that Buddhists comprised 83% of the population and Hindus 11% in 2019. The Christian population is estimated to be approximately 3.5 percent (*Bhutan 2021 international religious freedom report. Retrieved from http://www.state.gov*).

8.2.2.3.2 Local level

No quantitative data on religion was collected during the survey, as this can be a sensitive topic in Bhutan. However, it is known that in much of central and eastern Bhutan practice Nyingma school of Mahayana Buddhism with local Bon practices are still strong in appeasing deities at certain times of the year.

Religious practices play an integral role in the lives of the communities and these practices are described under Section 8.3.7. These practices include festivals such as 'Kharphue' 'Baphue' 'Kharam', 'Khandro Kongshag', and prayers such as 'Yar-ngo' (full moon) and 'Mar-ngo' (waning moon), 'Tsobum for Sampa Lhendrup' and the Guru Dhakma Drubchen. These are practiced by individual households, as a community or gewog and are conducted monthly, yearly or every three years.

8.2.2.4 Migration

Internal migrations" refers to migrations within a country (between regions, villages, etc.). External migrations" refers to migration from one country to another.

8.2.2.4.1 National level

8.2.2.4.1.1 Internal migrations

In Bhutan, internal migration predominantly occurs from rural to urban areas and within rural regions. The 2017 census identified 334,185 lifetime migrants, accounting for 48.7% of the total population. In 2018, 45% of the population were migrants, with significant rural-to-urban migration representing 21.7% of the Bhutan-born population and 44.2% of all migrants. Key motives for migration include family relocation, employment, and education. The migration patterns show a flow from eastern and central regions to the western parts of Bhutan, particularly to Thimphu Dzongkhag and Phuentsholing Thromde. The eastern dzongkhags, specifically Zhemgang, Lhuentse, and Trashigang, are experiencing a net population loss. Detailed migration patterns are visualized in ESIA Volume 3 Appendix E Social 1st Field Report.

8.2.2.4.1.2 External migrations

From 2015 to May 2023, Kuensel reports that 50,125 Bhutanese migrated internationally via Paro Airport, with an average of 245 departures per month. The highest migration occurred from July 2022 to March 2023, primarily to India and Australia (*https://thebhutanese.bt/the-australia-reality/),* involving mainly individuals aged 25-44. This figure excludes migrations prior to 2015 and those via land. Monthly migration surged to an average of 3,120 since July 2022, peaking at 5,542 in February 2023. Specifically, 15,552 obtained Australian visas in the year ending June 2023. Under the overseas employment scheme, 519 from Mongar and 367 from Lhuentse are employed abroad, mostly in the Middle East. Factors influencing migration include higher income and living standards, and job security abroad, versus job and economic insecurities, poor work conditions, and high living costs in Bhutan (*Migration of Bhutanese, Karma Ura, Jigme Phuntsho, Rinchen Thongdrol, April 2023, Centre for Bhutan Studies*).

8.2.2.4.2 District level

Between 2005 and 2017, migration data for Bhutan's Lhuentse and Mongar districts reveal significant population movements. During this period, Bhutan experienced an overall increase of 80,563 migrants, indicating a trend of migration from rural areas to urban centres.

In 2017 specifically, Lhuentse saw an influx of 4,056 people, 2,213 of whom came from other districts, but 10,664 individuals left the district, many relocating to urban areas. The most common migration pattern in Lhuentse was rural-to-rural (14.9%), with a substantial proportion (30.5%) moving to Thimphu.

Mongar, on the other hand, recorded 12,675 incoming migrants, with 7,091 from outside the district, and 19,800 people leaving Mongar, the majority heading to Thimphu, accounting for 35% of the out-migrants. Rural-to-urban migration was particularly significant in Mongar, at 17%.

Additionally, Mongar experienced other migration patterns: 5% were urban-to-urban, 2.3% urban-to-rural, and 10.7% rural-to-rural migrations. Similarly, Lhuentse had 1.9% urban-to-urban, 2.6% urban-to-rural, 9% rural-to-urban, and 14.9% rural-to-rural migrations.

These figures highlight a major shift in population distribution in Bhutan, with substantial movements from rural areas to more urbanized regions, particularly towards the capital, Thimphu, over the period from 2005 to 2017.

8.2.2.4.3 Local level

Internal migration is an issue in the study area. Indeed, this relatively rural area, like the rest of the country, is suffering from rural exodus. The reasons for internal migration are mainly economic, with one or more

able-bodied family members leaving the area in search of economic opportunities. In the household survey carried out, 8% of households surveyed stated that an able-bodied member of the household had migrated out of the village for economic reasons, causing the number of active members of the household to decline and potentially creating a situation of economic vulnerability (see 8.2.8.2.2).

8.2.3 Ethnicity, indigeneity

Key points related to ethnicity

The field mission and bibliographic research conducted in the project area reveal no evidence of Indigenous peoples as defined by ESS7 criteria. The region is predominantly inhabited by the Sharchopas, yet it also hosts a variety of other socio-cultural groups, particularly in urban areas. Notably, the Chhalips and Kurmae, identified during structured interviews, align closely with the larger Sharchopas group upon deeper analysis. Despite linguistic diversity, these groups are culturally and traditionally integrated into Bhutan's broader society and political framework. Furthermore, they lack a unique connection to natural resources, suggesting their assimilation rather than distinctiveness within the societal fabric, and thereby not fulfilling the criteria for being recognized as Indigenous under ESS7.

8.2.3.1 Introduction

Bhutan's ethnic landscape is diverse. In 1949, Bhutan transitioned its external relations from the United Kingdom to the Indian Union, leading to changes in its international affiliations (Girardin et alii, 2015) (Luc Girardin, Philipp Hunziker, Lars-Erik Cederman, Nils-Christian Bormann, Seraina Rüegger, and Manuel Vogt. 2015. GROWup - Geographical Research on War, Unified Platform. ETH Zurich). This shift influenced the nation's internal dynamics, especially in relation to its ethnic composition.

The 2005 census indicated a population of over 700,000, contrasting with earlier estimates that suggested a population of over 2 million (Girardin et alii, 2015). This discrepancy prompted discussions on the representation of Bhutan's ethnic groups.

Bhutan comprises three main ethnic groups: the Sharchops, Ngalops, and Lhotsampa. The Sharchops are predominant in the east, the Ngalops in the west, both with Buddhist affiliations. The Lhotsampa, primarily in the south, trace their origins to Nepal and follow Hindu practices.

Beyond these primary groups, GIRARDIN notes the presence of other "indigenous tribes" in Bhutan, including the Kheng, Brokpa, Lepcha, Tibetan, Adhivasi, and Toktop. These 'tribes', each with unique cultural and linguistic attributes, are dispersed throughout the country. Some align with Tibetan or Indian Buddhist traditions, while others have ties to regions like West Bengal or Assam.

Given Bhutan's rich ethnic tapestry and its unique historical trajectory, it becomes imperative to harmonize international perspectives with the nation's internal reflections and realities. The global discourse on ethnicity and indigenous rights, while valuable, must be contextualized to respect and understand Bhutan's distinct socio-cultural landscape and its evolving national identity.

8.2.3.2 National perspective about Indigenous of Bhutan

Bhutan does not subscribe to having "Indigenous people" or "minorities" as defined by international standards, such as those set by the UN Special Rapporteur, J.M. Cobo, in 1987. The term "tribes" is viewed with demeaning connotations and is not currently favoured in the social sciences to describe people's groups. Moreover, the word "minorities" suggests an element of discrimination, either by the state or by one ethnic group against another. Such terms are absent from the Constitution of Bhutan 2008, reflecting the nation's stance that no such discrimination exists and that its people are not defined by the term minorities.

The rich tapestry of cultural and linguistic diversity in Bhutan, highlighted by the presence of various groups and their unique attributes, underscored the need to address and clarify the terminology used to describe

these groups. The term "indigenous peoples," while widely recognized and used globally, became a focal point of discussion in Bhutan due to its potential implications and relevance in the country's unique context.

In response to this growing discourse, a workshop was convened in Thimphu on 8 May 2006. This gathering brought together a diverse group of stakeholders: institutions such as the Institute of Language and Culture Studies from the Royal University of Bhutan; International Centre for Integrated Mountain Development; Danish International Development Agency; Helvetas; the Dzongkha Development Authority; the National Commission for Women and Children; the National Library; The United Nations Development Programme; United Nations Children's Fund; and the Youth Development Fund, among others. The workshop allowed these stakeholders to discuss various aspects regarding the terminology issue dominating the debate. Concerns were raised about the dominance of the Dzongkha language leading to the potential demise of other languages. Participants also discussed the upcoming political changes in 2008 and their implications for socio-cultural groups. The workshop served as a platform for these diverse entities to voice their perspectives, share insights, and work towards a consensus on the terminology and other related matters.

Scholars have postulated that Bhutan was populated at various historical junctures, primarily from neighbouring regions like Tibet, Nepal, and India. This migration is often identified through the languages spoken and their original linguistic groups. For instance, the people from western, central, and eastern Bhutan are believed to have migrated from Tibet. Similarly, the Lhotsampas of Southern Bhutan arrived from the middle hills of Nepal and Sikkim in the late 1800s. Yet, there is no conclusive historical evidence to affirm the Indigenous status of any group.

After extensive deliberations during the workshop, participants decided to adopt the term "socio-cultural groups" for Bhutan, a term seen as more inclusive and reflective of the diverse groups within the country. Other terms, such as "tribal groups" and "ethnic minorities," were considered but ultimately rejected.

Bhutan does not have a record of acquisition of land from “indigenous people” as seen in other countries where land has been taken over by the state, multi-nationals, the corporate sector, or one ethnic group from another. Land in Bhutan is either privately owned or owned by the Government.

The historical examination of land ownership systems in Bhutan provides an alternative perspective to the prevailing notion that the country's land tenure was predominantly feudal before modernization. Tashi Wangchuk's analysis (Change in the Land Use System in Bhutan: Ecology, History, Culture, and Power, 2000) reveals that a significant portion of Bhutan's land was under private ownership, with monastic and noble estates cultivated by tenured serfs and slaves.

Delving deeper into Wangchuk's examination, he conducts a comparative study of Bhutan's land use systems before 1960, commonly referred to as "feudal" Bhutan, and the feudalism practiced in Europe. In feudal Europe, land was predominantly controlled by a privileged few—the lords. Conversely, Bhutan's land system, even before 1960, exhibited distinctive features, with property rights predominantly vested in the hands of private individuals within the peasantry. This distinction is further underscored by the fact that most of the Bhutan's population were not serfs or slaves but rather free peasants who owned private land. These differences underscore the unique nature of Bhutan's land tenure system, setting it apart from the traditional European feudal model.

These historical patterns of individual land ownership contribute to the complexity of applying the term "indigenous people" in the Bhutanese context, as they indicate a tradition of private land ownership that is distinct from the collective land ownership often associated with indigenous communities.

Following the introduction of the Land Act in 1978, Bhutan underwent a transformation in its land ownership structure. This legislation formally distinguished between private and public property while

incorporating customary laws that had historically governed land tenure. Despite these regulatory changes, customary practices continued to exert influence at the local level, shaping everyday land-related decisions. This interplay between official regulations and customary norms has resulted in a nuanced and multifaceted land ownership landscape in Bhutan. These historical patterns of individual land ownership, associated with customary practices in the modern structure, contribute to the complexity of applying the term "indigenous people" in the Bhutanese context.

The discussion between Bhutan's use of the term "socio-cultural groups" and the World Bank's term "Indigenous Peoples" is not about equating the two directly. Instead, an Indigenous Peoples (IP) screening in Bhutan seeks to understand to what extent certain socio-cultural groups align with the World Bank's connotation of "Indigenous Peoples." This approach recognizes the nuances and specificities of each context, ensuring that the rights and identities of these groups are respected and addressed appropriately. It's also worth noting that even the World Bank acknowledges the challenges and limitations of applying the term "indigenous" in urban settings, further emphasizing the importance of context in these discussions.

8.2.3.3 Socio-Cultural and Religious Composition of Bhutan

The study of ethnicity in Bhutan is constrained by the fact that this issue is not included in the 2017 Census report. Therefore, the information presented below is based on secondary bibliography with little reference to widely disseminated quantitative data.

The World Directory of Minorities and Indigenous People (WDMIP) identify the primary "minority" groups in Bhutan as Nepali-speakers, often referred to as Lhotsampas or Bhutanese Nepalis, alongside indigenous and migrant groups (https://minorityrights.org/minorities/lhotshampas/-accessed November 2023). However, the term "minority" might not be the most accurate descriptor, given that four ethnic groups—Ngalops, Sharchops, Kheng, and Nepali-speakers—constitute approximately 98% of the Bhutanese population. The US Department of State categorizes the Bhutanese population into four broad ethnic categories: Ngalops, Sharchops, Khengs, and Lhotsampas.

Figure 135 illustrates the territorial distribution and political influence of the three primary ethnic groups in Bhutan as of 2020. The Ngalops, who are the predominant ethnic group in Bhutan, primarily reside in the western and northern regions and wield significant political power. In contrast, the Sharchops, the second-largest ethnic group, are mainly found in the eastern regions and possess minimal political influence. The Lhotsampas, despite being the smallest of the three main ethnic groups, are concentrated in the southern regions.

These are the three largest ethnic groups in Bhutan, but there are also numerous other smaller groups. These groups are often defined by their language, religion, and cultural practices.

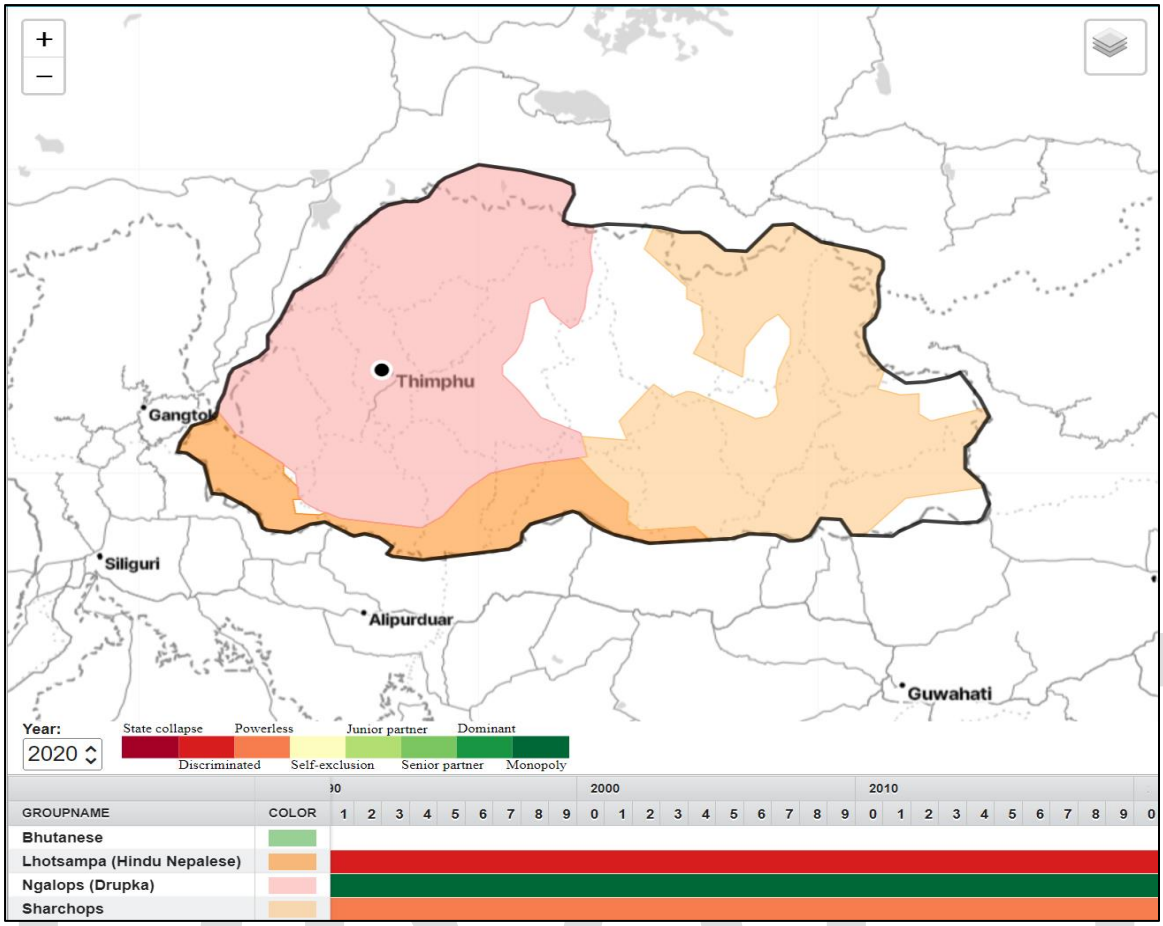


Figure 135: Distribution of Bhutan's 3 main ethnic groups and their political power

Source: Luc Girardin, Philipp Hunziker, Lars-Erik Cederman, Nils-Christian Bormann, Seraina Rüegger, and Manuel Vogt. 2015. GROWup - Geographical Research On War, Unified Platform. ETH Zurich. http://growup.ethz.ch/

8.2.2.3.1 Ngalongs

The **Ngalops**, originating from Tibetan roots, migrated to Bhutan in the ninth century, bringing with them Tibetan Buddhism and culture. They predominantly reside in the western and northern regions of Bhutan and have been a dominant force in shaping the nation's cultural and religious identity (Bhutan Country Studies, pp. 226-227).

Today, the Ngalop are often recognized as the Bhutanese people due to their significant influence. As of 1981, they made up about 17% of the Bhutanese population (Bhutan Tours, "The Ngalop Ethnic Group in Bhutan").

Their language, Dzongkha, is the national language of Bhutan, reflecting their political and cultural dominance. Most Ngalops practice Tibetan Buddhism, particularly the Drukpa Lineage of Vajrayana, which encourages harmony with nature and reverence for the homeland (Bhutan Country Studies, pp. 226-227; Bhutan Tours, "The Ngalop Ethnic Group in Bhutan").

In terms of economy, agriculture plays a crucial role in the Ngalop community, with staple products including Bhutanese red rice, potatoes, barley, and seasonal crops. Their lifestyle is a blend of tradition and gradual social development, with a strong emphasis on wearing traditional dress and maintaining composure in daily life (Bhutan Tours, "The Ngalop Ethnic Group in Bhutan").

Given their rich history and profound influence, the Ngalongs have consistently occupied prominent leadership roles, shaping Bhutan's socio-political dynamics over the centuries. Their pivotal role in the

nation's history and governance firmly establishes them as a cornerstone in Bhutan's mosaic of diverse ethnic groups.

8.2.3.3.2 Sharchops

Sharchops, or **the Sharchokpas** are a dominant ethnic group in Bhutan, with a significant presence in the eastern regions of the country. Believed to be among the earliest settlers of Bhutan, they trace their ethnic roots to Arunachal Pradesh, which suggests an Indo-Mongol lineage rather than a Tibetan one. This differentiates them from the Ngalongs, even though both groups share the Vajrayana Buddhism religion. The Sharchokpas speak the Sharchop language and have deep-rooted agricultural practices, cultivating crops such as maize, rice, and millet. Their terraced farming methods are a testament to their adaptation to the hilly terrains of their regions.

The Sharchop, meaning "easterner" in their language, are the largest ethnic group in Bhutan and primarily inhabit the eastern part of the country. As of 1981, they represented 30% of Bhutan's population. The Sharchop people are known for speaking Tshangla, a Sino-Tibetan language closely related to Tibetan, and many also speak Dzongkha, Bhutan's official language. Additionally, due to their proximity to Northeastern India, some Sharchops also speak Assamese or Hindi (Bhutan Country studies, p. 2-4).

Livestock rearing, encompassing cattle, yaks, and poultry, is pivotal for the Sharchokpas, providing both dairy and meat, essential components of their diet and local commerce. Some Sharchokpas are also involved in handicrafts, producing textiles and traditional crafts that cater to both local needs and broader Bhutanese markets. These crafts, combined with their unique songs, dances, and stories, encapsulate the rich cultural heritage of the Sharchokpas.

In addition to their strong adherence to Vajrayana Buddhism, remnants of the ancient Bon religion can still be observed in certain Sharchokpa rituals. Their distinct regional identity doesn't overshadow their significance in Bhutan's national framework. This is particularly evident in their commitment to national dress codes and customs. Separately, the Khengs, another ethnic group, primarily inhabit central Bhutan.

Historically, the Sharchop practiced 'slash-and-burn' agriculture, where vegetation was burned to plant dry rice for a few years until the soil degraded. However, this method was banned in 1969 by the government, leading to more permanent settlements and the adoption of cattle raising, such as goats and pigs (Bhutan Tours - https://www.gobhutantours.com/the-sharchops-ethnic-group-in-bhutan/).

Culturally, the Sharchop share similarities with the Ngalop, as they predominantly practice Tibetan Buddhism, though some follow Hinduism. Their houses, typically made of stone and wood, are adorned with colorful prayer flags with sacred inscriptions and symbols, representing five natural elements: red for fire, yellow for earth, blue for space, white for air, and green for water.

8.2.3.3.3 Lhotshampas

The **Lhotshampas**, also known as the "people of the south," are a significant ethnic group in Bhutan, primarily residing in the southern lowlands. Originating from Nepali descent, they began migrating to Bhutan in the mid-nineteenth century. Over time, they have become an integral part of Bhutan's diverse ethnic fabric. They are predominantly Nepali-speaking and share a common linguistic and cultural identity, which is evident in their traditional Nepali songs, dances, and festivals. Agriculture is a central aspect of their lifestyle, with the fertile plains of the south allowing them to cultivate various crops, including rice, cardamom, and oranges. Livestock rearing, especially cattle and poultry, further enhances their livelihood (World Directory of Minorities and Indigenous Peoples - https://minorityrights.org/minorities/lhotshampas/-accessed November 2023). They belong to various caste and ethnic groups, including Bahun, Chhetri, Gurung, Limbu, Newar, Rai, and Tamang. Their unity is rooted in the Nepali language, ethnic descent, and predominantly, the Hindu faith.

8.2.3.3.4 Khengpas

The Kheng people, also known as Khengpas, are a prominent ethnic group in Bhutan, predominantly residing in the south-central regions of the country. The 1991 data estimated around 40,000 Kheng individuals, mainly concentrated in the Zhamgang District and western Mongar District (The Joshua Project - https://joshuaproject.net/people_groups/12658/BT). Zhamgang, a historical region, was a conglomeration of small principalities before being integrated into Bhutan in the 17th century. The Kheng's linguistic and cultural identity is significantly defined by their language, Khengkha, which is a part of the Eastern Tibetan branch of the Tibeto-Burman language family. Khengkha has a 92% lexical similarity with Bumthang and 47% with Dzongkha, Bhutan's national language. This language not only serves as a cornerstone of their identity but also exhibits considerable diversity in its dialects within the Kheng region.

In terms of religion, the Kheng predominantly follow Tibetan Buddhism, but the ancient Bon religion also has a significant influence in their spiritual practices. This reflects a syncretic coexistence of Buddhism with local shamanistic traditions, typical of the region's religious landscape. The intermingling of these beliefs has given rise to a unique spiritual identity among the Kheng people.

The Kheng's culture is characterized by a blend of their linguistic uniqueness, rich spiritual heritage, and the diverse ecological landscape they inhabit. Their lifestyle, deeply intertwined with the rugged terrain of south-central Bhutan, involves subsistence agriculture and livestock rearing, alongside skilled craftsmanship in bamboo and cane works. Despite modern influences, the Kheng have managed to preserve their distinctive cultural and spiritual identity, contributing to the rich tapestry of Bhutan's cultural diversity.

While these four groups are culturally integrated, Bhutan also hosts several smaller ethnic groups, including Adivasis, Brahmi, Brokpa, Doya, Lepcha, Tibetans, and Toktop, all of whom are well assimilated. In terms of religious distribution, Buddhists make up about 75% of the population, with Hindus being the next largest group at 22%. The remaining population adheres to other religions, including Christianity, with estimates ranging from 2,000 to 20,000 followers.

8.2.3.4 Situation in the Project Area

8.2.3.4.1 Overview

In the ESIA for the project, a screening process was conducted to determine the presence of IP within the project area (see Section 2.4.2 of ESIA). This process initiated with a bibliographic review to identify potential IP groups in Bhutan and particularly within the project's region, laying the foundation for the subsequent field surveys.

The phenomenon of being or not being an IP, because it is a social, group phenomenon, is not correctly captured by an individual perspective. What is important to the ESS7 are not "indigenous person (or household)", unless they are part of an indigenous people group. Therefore, household surveys are important elements to verify very distinct socioeconomic characteristics, but they do not allow for the attribution of a community the character of IP. Therefore, the ESIA´s rich HH survey has not been explored in detail for this IP assessment, apart from the use of languages and dialects. In fact, being an IP is a social phenomenon captured by a set of information and observations made in the field and based in the available bibliography.

Artelia notes that mapping of the socio-cultural groups in the specific Project area is not possible as it is not government policy to map them (not included in the Census). Furthermore, apart from the dominant groups, individuals from smaller groups, not communities, were identified in the Project area.

Post-field survey consultations with the Royal Government of Bhutan confirmed the absence of Indigenous communities in the proposed project location, as stated in an e-mail dated 25th July 2023. This finding was corroborated by local government consultations in five gewogs.

8.2.3.4.2 Field Survey

The field surveys integrated the World Bank's Environmental and Social Standard 7 (ESS7) criteria, encompassing aspects such as self-identification as members of an indigenous cultural group, collective attachment to geographical habitats or ancestral territories, the existence of customary institutions separate from mainstream society, and the usage of distinct languages or dialects.

In the field surveys, a combination of interviews and group dynamics was employed. Among all the other themes, participants answered questions relating to ESS7 criteria. The group dynamics played a pivotal role in the data collection process. Focus Group Discussions (FGD) were organized sessions with selected community members where topics related to community identity, environmental relationships, and other pertinent issues were discussed in depth. Community mapping exercises were hands-on sessions where community members illustrated their territorial affiliations, resource utilization areas, and significant historical and cultural landmarks. Seasonal calendar elaborations involved community members detailing their annual events, rituals, agricultural practices, and other cyclical activities, providing insight into the community's interactions with other communities and their environment.

As can be seen from Table 132, 4 of the 5 Gewogs indicated the presence of Kurmaeds, and only Chhaling the presence of Chhalips as socio-cultural groups distinct from the 4 larger ones already presented.

Table 132: *Outputs of KIIs with Gewog*

No.	Questions	Chhaling	Saling	Tsamang	Tsenkhar	Tsakaling
2.3	Are there any Indigenous communities in the gewog?	No	No	No	No	No
2.4	What are the different socio-cultural and ethnic groups in the community? What ethnic minority groups are present in the community, if anywhere?	Chhalip	Kurmaed, Khengpa, Sharchop, and a few Southern Bhutanese (Lhotsampas)	None, all are from the same ethnic group speaking Kurmaed-kha so can be called Kurmaedpas	Kurmaed.	None, all are from the same ethnic group (Kurmaedpas)
3.3	Are there any customary tenure rights over commonly owned/managed resources?	Sokshing (ownership) for the leaves.	Community ownership and management of forests. Everyone uses the streams equally.	No.	Yes, but due to a lack of knowledge and negligence (in the words of an official, contrasting the legal, administrative vision that coexists with traditional experiences of belonging to a territory).	No.

8.2.3.4.3 Community Mapping

Socioeconomic field surveys have revealed the existence of two specific sociocultural groups in the Project area: the Chhalips and the Kurmaed. These were mentioned alongside the Sharchokpas, Khengpas, and Lhotsampas. Given this, a more detailed analysis of the "indigenous peoples" status became necessary and is reflected in this document.

The following paragraphs present the primary characteristics identified **by the participants themselves** during the community mapping exercises in the study area. This includes detailed insights into various communities, namely Tokari, Lingmethang, Banjar, Autsho, Chhali, Drangmaling-Nangar, and Gyalpozhing. Each of these communities is defined by unique geographical boundaries, natural features, infrastructure, cultural heritage, and utilization of local resources:

- **Tokari:** Characterized by natural features like forests and streams, well-served with basic facilities like drinking water systems and roads. It has cultural sites like Serbum Lhakhang and Gonpa Lhakhang and does not utilize the Kurichhu river for resource collection.
- **Lingmethang**: A semi-urban settlement with limited natural resources. It uses the Kurichhu river for fishing and medicinal hot baths.
- **Banjar**: A large settlement with scattered homes, agricultural land, and a community forest. It has a temple and three chortens as cultural heritage.
- **Autsho**: Features the Namdroling Gonpa as a significant cultural site. The Kurichhu river is used for hot stone baths, but not for fishing or resource collection.
- **Chhali**: Noted for its diverse cultural heritage with numerous religious sites. It has agricultural fields and does not have significant interaction with the Kurichhu river.
- **Drangmaling-Nangar**: Characterized by its dry land cultivation and limited use of the Kurichhu river. It has cultural sites like Mani dungkar and Drangmaling mang Lhakhang.
- **Gyalpozhing**: An urban settlement with limited natural features but significant infrastructure. Its relation to the Kurichhu river is primarily through the dam site and reservoir.

The analysis of the communities mapping reveals several key similarities that challenge the classification of one of them as Indigenous Peoples under the ESS7 criteria of the World Bank:

1. Integrated with Mainstream Society: These communities display a degree of integration with broader society, evident in their semi-urban characteristics, access to modern infrastructure, and general lifestyle practices.
2. Cultural Heritage Similar to Mainstream Society: While each community possesses cultural sites, these do not distinctly set them apart as indigenous. Their cultural heritage does not appear to be unique or central to an indigenous identity, but rather aligns with broader regional or national cultural practices.
3. Lack of Unique Environmental Dependence: None of the communities demonstrate a unique or traditional reliance on specific natural resources. Their environmental interactions, such as agriculture or limited use of local rivers, do not reflect the specialized, often ancestral resource use typical of Indigenous Peoples.
4. Absence of Distinct Social or Political Systems: There is no evidence of unique social or political institutions within these communities that are separate from the national mainstream, which is a key characteristic of Indigenous Peoples.
5. Generalized Agricultural Practices: The communities engage in agriculture and cultivation practices that are common and not unique to a specific indigenous lifestyle or subsistence pattern.

6. Collective Attachment to Land and Resources: The summaries do not indicate a profound, identity-defining collective attachment to the land and resources, a trait that is usually deeply embedded in the lifestyle of Indigenous Peoples.
7. Self-Identification and External Recognition: There is no indication that these communities self-identify as Indigenous Peoples or are recognized as such by external entities, which is critical for identification under ESS7.

What is clear from the results of the FGD, and community mapping is that the communities present in the area of influence of the Project share an important set of social systems and structures. Firstly, in all the communities, the meeting to introduce the project and the subsequent socio-economic research was held in the presence of a leader who was both a member of the community and a representative of the central political administration. In no activity did another leader, whether traditional or religious, take the place of the formally constituted leadership. Furthermore, all the communities share some form of Buddhism and recognize themselves as such. Finally, they are all integrated into the same economic systems and commodity and value circuits (they buy and sell the same products on the same markets, including the labour market). Therefore, the integration of all communities into Bhutanese society takes place in a profound way under the political-religious-economic tripod. Even if different groups are integrated in different ways, the combination of these three aspects of daily life would make it difficult to classify them as an indigenous people according to the criteria of the ESS7.

In addition, it is important to note that an element not explicit in ESS7, but which is at the basis of its formulation, was also not found in the region. To some extent, and in some way, when we generally classify a community as indigenous peoples, whether they declare themselves to be IP or not, this recognition goes hand in hand with the understanding that this community, in their country, has a status, formal or not, of a group towards which the society of that country has some duty of historical reparation. The community claims it (formally or in its customs) and the society, officially or not, somehow recognizes this historical debt. This is the case in the Americas, in Oceania and in a considerable part of Africa. This is how it is where the so-called Western colonization took place and where it has left deep traces of inequality. This is not the case in Bhutan, and even less so for the communities in the Project's area of influence.

In summary, these communities, while distinct, do not exhibit the collective, unique cultural, social, and environmental characteristics that are typically associated with IP as defined in the WB ESS7. Their lifestyles, cultural practices, and interactions with the environment and mainstream society suggest a level of integration and absence of distinct indigenous traits.

8.2.3.4.4 Language/Dialect

The KII and HH survey identified a diversity of languages spoken in the region. As described in 8.2.2.2 of the ESIA, the linguistic landscape of the project area is varied, with languages such as Tsangla, Kurmedkha and Chhali-kha widely spoken. The national language is used by 29% of respondents to the household survey.

Both Challipas and Kurmaedpas are distinguished from the Sharchokpas primarily by the dialect each of these groups speaks (as seen by the household surveys). In general, the rest of the customs, traditions and culture of these two groups and the Sharchokpas are very similar. Often, when one asks a person from eastern Bhutan what ethnicity he or she is, it is likely that they may say that they are Sharchokpa and if they are asked which Dzongkhag they are from, they say Mongar or Lhuentse. Then if you ask which dialect they speak, they may mention that they speak a dialect which is not necessarily Sharchokpa-kha. This suggests that people in fact have multiple identities, like claiming to be Sharchokpa as a regional identity and if they say Chhalipa or Kurmaedpa, it is a socio-linguistic group identity and a local differentiation.

In Bhutan, as noted earlier, there are three prominent ethnic groups, each encompassing a variety of sub-groups with their unique characteristics. Among these, the Kurmaedpas and Chhalipas are notable sub-groups, yet they are generally considered part of the larger Sharchokpas group. This categorization highlights the complexity of ethnic identity in the region, where individual sub-group distinctions coexist with broader group affiliations.

Likewise, in the southern region dominated by the Lhotsampas, the prevalent language is Lhotsamkha (Nepali). Within this group, however, there is a linguistic diversity, with sub-groups such as the Rai, Tamang, Magar, and Limbu, each speaking their distinct languages. These languages are not mutually intelligible with Lhotsamkha. This scenario underscores the nuanced nature of ethnic identity in Bhutan, where local group identification is integrated into the broader regional ethnic landscape.

Given the conclusion that the Chhalipas and Kurmaedpas, despite their unique dialects, share many cultural, traditional, and customary similarities with the larger Sharchokpas group, and considering the diverse linguistic groups within the Sharchokpas, the implications for the ESS7 criteria become clear: The Chhalipas and Kurmaedpas, while linguistically distinct, exhibit a broad cultural congruence with the Sharchokpas, which blurs the lines of distinct self-identification and collective attachment crucial under ESS7 for distinguishing separate indigenous groups. Their linguistic differences, significant within the Sharchokpas, do not necessarily constitute a separate cultural or social identity, as ESS7 focuses on distinct cultural, economic, social, or political institutions beyond just language. Furthermore, the integration of the Chhalipas and Kurmaedpas into mainstream Bhutanese society, particularly in terms of customs and traditions, suggests their alignment with the broader community. This assimilation challenges their identification as distinct entities under ESS7, a classification often reserved for groups that are marginalized or face substantial barriers to integration within the wider society.

In essence, while the Chhalipas and Kurmaedpas, along with the linguistically diverse groups within the Sharchokpas, exhibit unique linguistic characteristics, their overall cultural and social integration with the larger Sharchokpa ethnic group in Bhutan suggests they might not meet the specific criteria for recognition as Indigenous Peoples under ESS7. This evaluation is critical for determining the applicability of ESS7 to projects in Bhutan, especially regarding land use, cultural heritage, and resource management.

The absence of historical records or collective memory regarding the Kurmaedpas' origins, as revealed in field interviews with local government officials, points to their extensive cultural integration with the Sharchokpa group. This evidence further complicates their classification as a distinct group under the ESS7 criteria, underscoring their assimilation into the wider Sharchokpa cultural landscape.

8.2.3.4.5 Customary tenure rights

The concept of **sokshings** in Bhutan offers a clear illustration of customary tenure rights and the relationship between the population and natural resources. Sokshings, derived from the Dzongkha words "sok" (leaf litter) and "shing" (tree), are traditional and collective forest management systems deeply integrated into the nation's culture and agricultural practices. These government-owned forest plots, historically passed down through generations, allow individuals or households to collect leaf litter. However, in 1969, the government began nationalizing these plots, leasing them out for ten-year periods. This approach ensures sustainable leaf litter harvesting for agriculture, thereby enhancing soil fertility, providing income sources to Bhutanese families, and contributing to the country's goal of maintaining 60% of its land as forests.

The management of sokshings varies between individual and collective forms. Individual sokshings are leased to single households or individuals and are often located near the lessee's residence, allowing for specific control and tailored management of the plot. This autonomy, however, can increase susceptibility to encroachment. In contrast, collective sokshings are leased to groups of farmers and are typically larger, located farther from residences. Their collective nature facilitates economies of scale and better protection

against threats, although they may present challenges in coordination and equitable contribution. Both individual and collective sokshings, when managed sustainably and equitably, significantly contribute to Bhutan's agricultural and environmental objectives.

It is important to note that access to sokshings, whether individual or collective, does not necessarily imply a direct belonging relationship of a specific group or community with a particular territory. In cases where these areas are lost, the government assists in leasing other sokshings to the affected families. Therefore, the use of sokshings, whether individual or collective, does not characterize a dependency on a specific territory, but rather reflects a traditional approach to resource utilization and management within the community.

8.2.3.5 Specific assessment regarding the applicability of ESS7

8.2.3.5.1 Application

The ESF Guidance Note 7 Indigenous Peoples has been referenced for this assessment.

ESS7 applies to all groups under the various terms used "Indigenous Peoples/ Sub-Saharan African Historically Underserved Traditional Communities" "Indigenous ethnic Minorities" "Aboriginals", "hill tribes", "vulnerable and marginalized groups" "minority nationalities" "scheduled tribes" "first nations" or "tribal groups".

For this ESIA the term used will be "Indigenous Peoples" (IP).

The objectives of ESS7 are:

- To ensure that the development process fosters full respect for the human rights, dignity, aspirations, identity culture, and natural resource-based livelihoods of IPs.
- To avoid adverse impacts of projects on IP or when avoidance is not possible, to minimize, mitigate, and/or compensate for such impacts.
- To promote sustainable development benefits and opportunities for IPs in a manner that is accessible, culturally appropriate, and inclusive.
- To improve project design and promote local support by establishing and maintaining an on-going relationship based on meaningful consultation with the IPs affected by a project throughout the project's lifecycle.
- To obtain the Free, Prior and Informed Consent (FPIC) of affected IPs, if one of the three circumstances described in Paragraph 24 if the ESS7 is met.
- To recognize, respect and preserve the culture, knowledge and practices of IPs, and to provide them with an opportunity to adapt to changing conditions in a manner and in a timeframe acceptable to them.

8.2.3.5.2 Screening process

The screening process aims at assessing if the ESS7 applies (according to paragraphs 8 and 9 of ESS7): this assessment is based on existing literature review, official documents, key informant interviews (KII) and results of focus-group discussions (FGDs) and household (HH) survey. Please also refer to the social baseline in Appendix M - IP memo for more details.

Table 133: IP Screening for Dorjilung HPP

Criteria	Situation for Dorjilung HPP	Verified for Dorjilung HPP
1- If a distinct social group and cultural group possesses:		

Criteria	Situation for Dorjilung HPP	Verified for Dorjilung HPP
(a) self-identification as members of a distinct Indigenous social and cultural group and recognition of this identify by others	Despite the recognition, in the field, of the presence of different socio-cultural groups that mark Bhutan's cultural diversity (such as Chalip, Kurmaed, Khengpa, Sharchop, and a few Southern Bhutanese), it was not reported that these cultural differences imply deep social differences to the point of claiming the need to recognize that they belong to a distinct social (indigenous) group. Each socio-cultural group recognizes itself as such, and the other groups respectively, but they see themselves as part of the diversity that makes up Bhutanese society as, for example, the Chhalips and Kurmaed as being part of the broader Scharchop group. No group sought to define itself predominantly by its differences, on the contrary, always emphasizing customs and habits that they share with other communities. The very idea of "indigenous" doesn't make sense to local communities, and as a result, they don't really claim this recognition.	No
(b) collective attachment to geographically distinct habitats, ancestral territories, or areas of seasonal use of occupation, as well as to the natural resources in these areas	In Bhutan, land ownership is primarily delineated into two categories: private ownership, held by individuals and institutions, and government ownership. Wangchuk's (2000) analysis underscores that historically, a significant portion of Bhutan's land was privately owned, contrasting with the conventional understanding of feudal systems. This private ownership extended to forest areas, which were managed and utilized by individual families or communities based on customary practices. However, with the introduction of the Land Act and subsequent forest regulations, there was a shift in the management and ownership of forest areas. Before these regulations, forest areas, even if communal, were managed with a significant degree of individual or local community discretion. Post the Land Act and forest regulations, the distinction between private and community forests became more pronounced, with the state playing a more active role in the management and conservation of these areas. The regulations brought about a more structured approach to forest management, emphasizing conservation, sustainable use, and state oversight. Within the proposed project area, no group perceives their lands and resources as collective assets, even in the case of community forests. These community forests, while communal in nature, do not hold any major significance. Furthermore, there's an absence of any collective attachment to geographically distinct habitats or ancestral territories. Wangchuk's conclusions suggest that, even in communal settings, the relationship with the land in Bhutan historically also has an individualistic dimension, emphasizing the predominance of private land ownership by the peasantry rather than a concentration in the hands of a collective ownership or few elites. The practices and uses of natural resources differ very little from community to community. Despite cultural differences, they are well interacted economically.	No

Criteria	Situation for Dorjilung HPP	Verified for Dorjilung HPP
(c) customary cultural, economic, social or political institutions that are distinct or separate from those of the mainstream society or culture, and	No distinct institutions (whether formal or informal) for the local groups have been identified. In Bhutan, equity in balanced regional development is a Constitutional provision (Article 9-Principles of State Policy). The local planning processes in the Chiwog, Gewog and Dzongkhag (district) levels are inclusive of all resident population, regardless of their ethnic or group belongings. In no community were the meetings led by someone who was not, at the same time, someone from the community and formally linked to formal administrative and political authority. In no community were the meetings mediated by a local traditional and/or religious leader other than the formal representative.	No
(d) a distinct language or dialect, often different from the official language or languages of the country or region in which they reside.	Although Dzongkhag is the national language, Bhutan has at least 19 different languages. In the project area, 40% of respondents in the HH survey speak Tsangla, 29% speak Dzongkha, 24% Kurmedkha and 7% other languages. While the Chhalipas and Kurmaedpas, along with the linguistically diverse groups within the Sharchokpas, exhibit unique linguistic characteristics, their overall cultural and social integration with the larger Sharchokpa ethnic group in Bhutan suggests they might not meet the specific criteria for recognition as Indigenous Peoples under ESS7.	Yes – however not considered to meet ESS7
2- OR		
A community or groups of IPs have lost collective attachment to distinct habitat/ ancestral territories in the project area because of forced severance, conflict, government resettlement programs, dispossession of their land, natural disasters, urbanising.	The field research and bibliographic review in the project area, predominantly inhabited by the Sharchopas and other socio-cultural groups, reveal their cultural and traditional integration into the wider Bhutanese society. This integration is a key indicator of their lack of a distinct, collective connection to specific natural resources or ancestral lands. Furthermore, the historical patterns of land ownership in Bhutan, characterized by individual rather than collective ownership, further demonstrate the absence of a deep, communal tie to the land that is typically associated with indigenous communities. This lack of collective attachment to ancestral territories among the groups in the study area significantly contributes to the non-applicability of this criterion. There are no communities in the region without enough land to plant or graze, to the same extent as their neighboring communities. In other words, there are no differences that could be a sign of some kind of discriminatory imposition of loss against any community.	No

8.2.3.5.3 Conclusion on ESS 7 for Dorjilung HPP

In conclusion, the intricate socio-cultural dynamics of Bhutan, as explored in the research and field surveys conducted for the ESIA and considered against the World Bank's ESS7, indicate that the proposed Dorjilung Hydropower Project area does not include indigenous communities as defined by ESS7. Bhutan's rich diversity, resulting from numerous waves of migrations, has fostered a tapestry of languages, traditions, and customs. This multicultural fabric, while distinct, does not align with the characteristics of "indigenous" as per ESS7.

The ESIA research, incorporating socio-economic surveys, reveals no self-identification or reference to "indigenous" traits among groups like the Chhalipas and Kurmaedpas, cited in the KII. Despite their unique dialects, these groups demonstrate considerable cultural, traditional, and customary congruence with the

larger Sharchokpas group, challenging their classification as distinct entities under ESS7. Their assimilation into mainstream Bhutanese society, particularly in customs and traditions, and the absence of a unique connection to natural resources suggest a cultural and social integration that does not meet the ESS7 criteria for indigenous recognition.

Given these factors, the Dorjilung Hydropower Project, based on the ESS7 screening, does not consider the Indigenous Peoples (IP) criteria applicable. This conclusion is provisional, pending the World Bank's final determination on the applicability of ESS7.

The following measures will be applied for the Project:

- Respecting the principle of the Constitution of Bhutan 2008 to guarantee to all citizens equality before the law and with inclusive outreach and participation of all socio-cultural processes in the development process; and
- Including participatory approaches of planning from the grassroots, continuous engagement and informed consent are in place.

8.2.4 Management of land and natural resources

Key points related to land use

All the Gewogs of the study area contain a high proportion of forest (from 75% to 95%), which is higher than the national level (71%). The cultivated land represents 1% in Lhuentse and 3% in Mongar.

Little flat land is available to cultivate. Land pressure and land disputes remain rare.

More details about the governance and management of land use and natural resources are given below.

8.2.4.1 Land uses

8.2.4.1.1 National level

The Land Use and Land Cover Map of 2016 provides insight into the distribution of land across Bhutan. At the national level, cultivated lands occupy 3% of the total area, built-up areas less than 0.2%, and forests and shrubs combined make up 81% (FRMD, 2017). As can be seen in ESIA Volume 3 Appendix E – Social 1st Field Report, Mongar's forest coverage stands at 91%, surpassing the national average and Lhuentse's 65%. Unlike Mongar, Lhuentse has a significant 17% of its land covered by snow and glaciers. Shrubs and rocky outcrops are more prevalent in Lhuentse, while Mongar has a minimal presence of these land types. Cultivated land in Mongar is at 3%, higher than Lhuentse's 1.3%, with both regions having lower built-up areas than the national average. The cultivated land is categorized into Chhuzhing (irrigated land), Kamzhing (non-irrigated), and orchards (MOAF, RNR Census Report 2019).

Over 610 acres of agricultural land were converted to other land uses between 2016 and 2021 (NEC, 2022). These other uses include mining, with 1,228.94 acres allocated within state forest land, 31 active mines, and 50 stone quarries (Department of Geology and Mines, 2021). Lhuentse has no registered mines and lacks data on stone quarries. In contrast, Mongar has a stone quarry in Drepong gewog, leased until March 2023 (ACC, 2014), and sand mining activities along the Kurichhu in Gyelpozhing.

8.2.4.1.2 Local level

The following table summarizes land use according to Gewog:

Table 134: Land use at the local level

Gewog	Land use
Tsamang	Tsamang gewog contains a high proportion of forest (95%) and minimal shrub cover (2.16%). 78.87% is mostly broadleaf forest, 2.89% mixed conifer and the remaining Chirpine and

Gewog	Land use
	Fir at the higher elevations. The towns and settlement areas occupy less than 0.10% of the Gewog level and approximately 1.57% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (0.02) and Kamzhing (1.55%).
Tsakaling	Tsakaling gewog contains a high proportion of forest (87.08%) and shrub cover (7.37%). 72.15 % is mostly broadleaf forest, 4.77% mixed conifer and the remaining Chirpine and Fir at higher elevations. The towns and settlement areas occupy less than 0.10% of the Gewog level and approximately 4.77% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (0.72%) and Kamzhing (4.05%).
Mongar	Mongar gewog contains a high proportion of forest (84.65%) and minimal shrub cover (4.13%). 57.84% is mostly broadleaf forest and the remaining 26.82% is Chirpine at the higher elevations. The towns and settlement areas occupy 1.46% of the Gewog level and approximately 9% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (0.65%), Kamzhing (7.90%) and Orchards (0.04%).
Saling	Saling gewog contains a high proportion of forest (95.58%) and minimal shrub cover (1.76%). 61.17% is mostly broadleaf forest, 12.21% mixed conifer and the remaining is Chirpine and fir at the higher elevations. The towns and settlement areas occupy 0.15% of the Gewog level and approximately 1.12% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (0.25%) and Kamzhing (0.87%).
Chhaling	Chhali gewog contains a high proportion of forest (75.68%) and minimal shrub cover (6.82%). 43.76% is mostly broadleaf forest and the remaining is Chirpine at higher elevations. Approximately 15.66% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (4.57%), Kamzhing (10.84) and Orchards (0.25%).
Drepong	Drepong gewog contains a high proportion of forest (88.70%) and minimal shrub cover (4.03%). 54.85% is mostly Chirpine and the remaining 33.85% is broadleaf. The towns and settlement areas occupy 0.17% of the Gewog level and approximately 5.41% of the land is cultivated area. The cultivated area is categorized into Chhuzhing (0.51%) and Kamzhing (4.90%).
Tsenkhar	The Gewog is 85.95% forested mainly by Broadleaf forests and 6.59% of it is cultivated and 0.32% built upon. The cultivated area is categorized into Chhuzhing (2.10%) and Kamzhing (4.49%).

Source: Land use land cover, NLCS 2016

See ESIA Volume VIIIB, Appendix E – Social 1st Field Report for complete information by Gewog.

8.2.4.2 Protected areas, community forest and natural resources management

8.2.4.2.1 Protected areas

Tsamang gewog- A significant part of Phrumshingla National Park and BC7 falls under Tsamang gewog however there are no project components in Park or biological corridors (BCs).

Tsakaling gewog- A small portion of BC 7 falls under this gewog but there is project component in this BC area.

Mongar gewog. There are no protected areas or BC in this gewog.

Saling gewog. A significant part of Phrumshingla National Park falls under Saling gewog but there are no project components within the park.

Chhaling gewog- There are no protected areas or BC in this gewog.

Drepong gewog - There are no protected areas or BC in this gewog.

Tsenkhar gewog - The Biological Corridor (BC 7) traverses the gewog.

8.2.4.2.2 Community forest

National Information

There are 839 community forest groups spread across the country, covering an area of 107,866.39 hectares/266,543.65 acres) and managed by 34,761 members (DOFPS, 2021. Annual Forest Statistics). A community forest management group is granted the right to manage the forest and ensure the sustainable harvest of specific species of areas according to its approved management plan. It promotes the protection of water sources, catchment areas, and encourages the community to protect the forest resource from outsiders. Where available, though the sale of non-wood forest products, it is aimed at enhancing socio-economic benefits to the local communities. **Dzongkhag**

There are 37 community forest management groups in Lhuentse covering an area of 3,576.8 hectares and managed by 1,095 members. On the other hand, while the number of CF groups is almost the same, with 38 CF groups, the area coverage under CF is more than 2.5 times (11,978.53 hectares) with double the number of members (2,276). (Source. DOFPS, 2021 Annual Forest Statistics).

Project gewogs

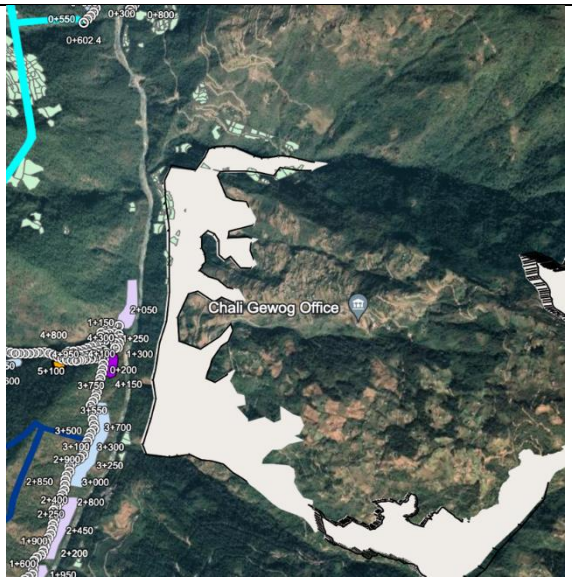
Within the project area of influence (5km) there are 10 community forest groups: 3 in Tsamang, 1 in Tsakaling, 1 in Saling, 2 in Chhaling, and 3 in Tsenkhar. Three Community Forest groups may be impacted by the Project, two from Construction Power Line, and one from road widening, however the full impact is not known. The Community Forest groups, and potential impact are presented in the table below.

Table 135: Community forest within Area of Influence (5 km)

No.	Gewog	Community Forest Groups	Community Forest Management Group Members (HH)	Community Forest (acres)	Areas impacted by project components
1	Tsamang	Drangmaling Kuenphen CF Administered by PNP	22 households	298.55	Construction power line (1000m)
2	Tsamang	Banjar CF Administered by PNP	46 households of Banjar, Pam and Jargot	539.43	Construction power line (840m approx..)
3	Tsamang	Ganglapong CF, Ganglapong Khuenphen CF Administered by PNP	Ganglapong Khuenphen - 72 households	Total area together 936.12	No
4	Tsakaling	Takhambi I and II CF	70	1-330.53 2- 114.83	No
5	Saling	Masang Daza CF		222.39	No
6	Chhaling	Chali Khatoed Khamey CF	89 households	619.59	Maybe due to road widening
7	Chhaling	Chulabi CF/ Chuli Gonpa Norbu Chushel	62 households	1067.68	No
8	Tsenkhar	Sisingneysa CF	38 households	470.59	No
9	Tsenkhar	Yangla CF	15 households	113.61	No
10	Tsenkhar	Chalibadeb CF	26 households	99.93	Road Realignment

Source: Consultation with Forest Resources Development Division, DOFPS and Community management plans (DRCF mgt. Plan, 2022, Banjar CF mgt. plan 2021, Yakpogang CF mgt. plan 2021)

Table 136: Community forest within Area of Influence (5 km) mapping

In terms of project impacts, only one is likely to be impacted by the project footprint - possibly the Chali Khatoed Khamey CF, due to widening of the highway. Source: map and data from DOFPS consultation, 2023, Google earth.	
The southern portion of the Chalibadeb CF is close to the highway realignment but will not be impacted by it. Source: map and data from DOFPS consultation, 2023, Google earth.	
The proposed water pipeline for Adit VI, SS and PH will traverse the Drangmaling Kuenphen CF. Almost 50% of the pipeine is proposed to be laid along the existing road inside the CF to the telecommunication tower. Source: map and data from DOFPS consultation, 2023, Google earth.	

See ESIA Volume 3 Appendix E – Social 1st Field Report for more detailed information.

8.2.4.2.3 Uses of Kurichhu River

The uses of the Kurichhu River across various villages are diverse. In Autsho Town, the river is utilized for hot stone baths near Jarey Gewog, but there is no fishing or other use. Villages such as Banjar and Chhali do not employ the river for any specific activities. Drangmaling-Nangar only uses the river to cross via a suspension bridge. Gyelposhing Town's interaction with the river is limited to the vicinity of the dam site and reservoir, serving as a viewing point. Lingmethang Town engages in limited fishing, which is prohibited, and hot stone baths. In Tokari, the riverbank at Bemasidha is used for medicinal hot baths during March and April, though the river itself is not used for fishing or plant collection. Tsakaling Gewog does not use the river for any particular purpose.

This information was meticulously compiled through participatory methods, including community mapping and Key Informant Interviews (KII), involving extensive discussions with the local population. These methods provided a detailed understanding of the community's interaction with the Kurichhu River, ensuring that the data reflects the actual uses and significance of the river to these communities.

See below for an example of the representation of the community relationship with the Kurichhu River in Autsho Town (which, as already mentioned, includes the residents of the other bank of the river, already in Lhutense).

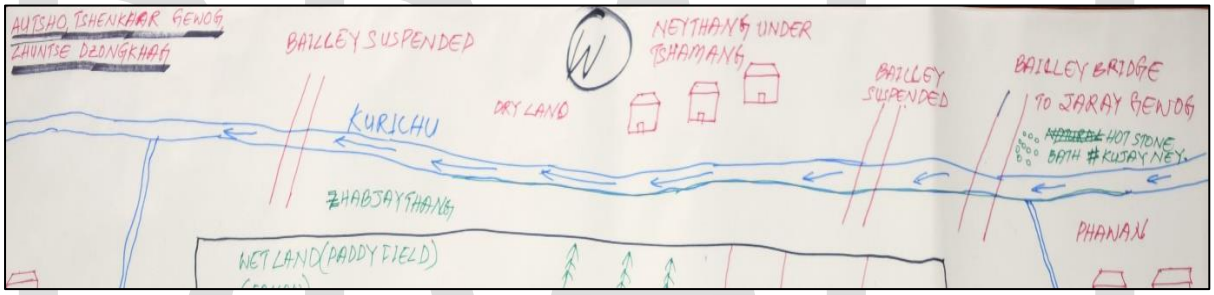


Figure 136: Use of and relationship with the Kurichhu River in Autsho - community mapping

As pointed out in section 8.2.5.3.1, the Kurichhu River is referenced as a natural water resource for several areas in the surveyed Gewogs. Specifically, it serves as one of the natural water resources on the eastern side of Drangmaling-Nangar and on the western side of Tsakaling Gewog. However, it's important to note that the Kurichhu River is not directly cited as the primary source of drinking water for these villages. Instead, the villages rely on various other sources for their drinking water needs:

- In Autsho Town, the main source of drinking water is Phawan Chu, despite the Kurichhu River being nearby.
- In Drangmaling-Nangar, the drinking water is piped from Yemarutoed, even though the Kurichhu River is one of the natural water resources in the region.
- Tsakaling Gewog has piped water in all chiwogs from stable sources, but the specific source of this piped water is not directly attributed to the Kurichhu River.

Thus, while the Kurichhu River is an important natural water resource in the region, it is not the primary source of drinking water for the communities mentioned in the survey. The communities have access to clean drinking water, primarily through piped systems from various other sources.

8.2.5 Living conditions and access to basic services

Key points related to living conditions and access to basic services

Education and literacy

There are major disparities in the project influence area: some schools are below capacity and would welcome new students, while others are overcrowded and struggling to cater for their existing students. In primary school the

number of girls and boys is similar. Regarding literacy 38% of surveyed household members over 18 years old are non-literate (meaning they can neither read nor write). There is a big gender difference, with more women (43%) than men (32%) being illiterate.

Health

In the project influence area, the health services are insufficient in terms of human resources. The main diseases are common cold, Upper Respiratory Tract Infection, alcohol consumption, Skin diseases (Fungal infections), colds, Diabetes and hypertension. A substantial majority of 93% of the participants reported no difficulties in accessing an adequate food supply (as opposed to the remaining 7% who encountered difficulties), reflecting a favourable food security situation within the communities.

Waste, water and sanitation

Most households surveyed are connected to the water supply system directly in their homes, or to their neighbours from whom they obtain water. For households for which water availability is sometimes insufficient, the reasons are damage/blocking of springs, misuse of taps by villagers who leave them open and damage to connection pipes. Regarding sanitation facilities, a significant proportion of 73% of the respondents reported having access to flush toilets. In the project area, there is no waste management; most of the population burn their waste. The lack of disposal has become an issue in some places where the population is growing.

Energy

The entire study area is covered by the power grid, and all populations have access to it. During the survey, no report of any power cuts or network instability was made.

Road, traffic and transportation

The area has only one main road (highway) that is narrow and hilly. Some roads lead to the villages, but not all villages are interconnected/have access to vehicles.

Telecommunication

Mobile phone coverage is 100% in both districts. The more remote communities' access mobile telephony through Tashi Cell whereas rest of the areas access services provided by Bhutan Telecom

Shops and markets

Most villages have only a handful of shops with basic food items. For monthly supplies, farmers go to the nearest market, which is located at Lingmethang, Autsho, Gyelpozhing or Mongar town.

Bank services, credits and savings

55% of the sampled population has taken out at least one loan during the year. The typical lenders are mostly banks. Most loans are made to renovate a house or invest in a business. Almost half of survey respondents said they had savings.

Security, safety and public order

On average, between 2015 to 2018, 26 crime reports are reported annually in Lhuentse. In Mongar, between 2017-2021, an average of 52 cases per are reported.

8.2.5.1 Education

8.2.5.1.1 National level

8.2.5.1.1.1 Education system

The educational system in Bhutan comprises of general education, monastic education, and non-formal education. The school education system consists of one year of pre-primary, primary education (PP-VI), lower and middle secondary (VII-X), and higher secondary (XI-XII).

The formal education is free education up to the 12th standard. Students not qualifying for tertiary education may opt for vocational training, or national certificate (NC) courses in hospitality, tourism environment related courses, or diploma courses in Engineering, finance, accounting and nursing.

Those successfully completing the 12 standards must compete for government scholarship to pursue higher and tertiary education. Students who do not qualify for government scholarship can pursue their tertiary education through private arrangements on a self-financing basis within the country or overseas.

Those working in various government, corporate and sometimes private sectors can also compete for master's scholarships both in and ex-country through the government, donor agencies, CSO's or Bhutan Chamber of Commerce and Industry (BCCI).

8.2.5.1.1.2 Availability of education centres

As of 2022, there were 491 ECCD Centres (children's development and transition to primary education), 62 extended classrooms, 320 Primary schools, 60 Lower Secondary Schools, 64 Middle Secondary Schools, 92 Higher Secondary Schools, 18 Tertiary Institutes, 6 Vocational Institutes, 2 institutes of Zorig Chusum (arts, crafts and skills in thirteen different domains,) 79 Monastic Education Institutes, 1 Continuing Education Centre and 430 Non-formal education Centres (*MOE, Annual Education Statistics, 2022*). These are detailed in the ESIA Volume 3 Appendix E – Social 1st Field Report.

A total of 162,536 (83,446M, 79,090F) students were reported in schools: from extended classrooms, primary schools to higher secondary school and special institutes; 1125 in the vocational and technical institutes, 7,390 in monastic institutes and 5,329 learners in 505 non-formal Education centres (MOE, Annual Education Statistics, 2022). The total number of teachers/lecturers/instructors for the educational institutes totals 10687, resulting in a ratio of **1 teacher for 16 students.**

There are also Special Education services for children with special needs. This includes the Muenselling Institute for visually impaired children in Khaling, Trashigang, a Special Education Needs Unit in Changangkha LSS for physically and mentally challenged children to the mainstream school. In 2003, the Wangsel school for the Hearing Impaired in Paro. Eight schools (one in Lhuentse) have programs for children with special education needs and there are 366 students with special needs enrolled in these schools *(MoE 2014. Bhutan Education Blueprint 2014-2024*).

8.2.5.1.1.3 Level of education and literacy

While the youth (15-24 years) literacy rate in 2017 was 93.3% (93.1% for males, 93% females), the average national literacy rate in 2017 is lower at 71.4% (78.1% for males, 63.9% females), because of the lower adult literacy rate of 66.6% (75% for males, 57.1% females) (*MOE, AES, 2021*).

As of 2022, there were 12,694 students pursuing various courses in all tertiary institutions within Bhutan (MoE 2014. Bhutan Education Blueprint 2014-2024). In addition to this there were 957 students studying outside the country as of 2020 (*MoE, State of Higher Education of Bhutan, 2020*).

From the figures presented in ESIA Volume 3 Appendix E – Social 1st Field Report, we can deduce that about 70% of individuals with a bachelor's or master's degree reside in urban areas. Of these, 62.5% are men, a figure that rises to 66% when only considering those with degrees in rural areas.

There are **178,085 unemployed people** (between ages 15-65), in the country. Of these, 38% of these are uneducated, 17% have Middle or Higher Secondar education, 8% have bachelor's degree and 1% have a master's degree.

8.2.5.1.2 District level

8.2.5.1.2.1 Availability of education centres

Since Lhuentse has only 8 gewogs, and less than four thousand students, it has fewer number of educational institutes compared to Mongar. There are in total 20 schools, of which 2 are Central Schools. Lhuentse also has 11 Non-Formal Education Centres (NFE) and 23 Early Childcare and Development Centres (ECCDs).

Mongar has one tertiary institute and 39 schools, of which 4 are Central Schools. Mongar also has 52 NFE and 52 ECCDs.

Table 137: Number of institutes for each Dzongkhag

Type of institute	Number of institutes in Lhuentse	Number of institutes in Mongar
Tertiary Institute under RUB	0	1
Central Schools	2	4
Higher Secondary Schools	2	6
Middle Secondary Schools	2	5
Lower Secondary Schools	2	2
Primary Schools	10	22
Extended Classroom	2	14
Non-Formal Education Centres (NFE)	11	52
Early Childcare and Development Centres	23	52

Source: NSB, 2021. Dzongkhag at a Glance and NSB, 2022. Dzongkhag at a Glance

8.2.5.1.2.2 Number of teachers and students

The total enrolment in schools in Lhuentse was 3,302 students in 2021. There were more female students in schools compared to male students. In terms of teaching staff, there were 246 teachers, with the number of male teachers almost double the number of female teachers. Female NFE instructors was 6 times more than male NFE instructors and the number of female NFE learners was almost three times more than male learners. **The pupil-teacher ratio was 16**.

In Mongar, the total enrolment in schools in 2022, was 9,172 students. Like Lhuentse, the number of female students was higher compared to male students. In terms of teaching staff, there were 643 teachers, with the number of male teachers almost double the number of female teachers. Female NFE instructors was 10 times more than male NFE instructors and the number of female NFE learners was double the number of male learners. **The pupil-teacher ratio was 14.**

8.2.5.1.3 Project area

8.2.5.1.3.1 Availability of education centres

Within the project area, there are 2 central schools, at Gyelpozhing and Autsho, a Lower Secondary School at Chhaling while the rest are all Primary Schools. The Gyelpozhing College of Information Technology recently moved its campus to Thimphu.

Table 138: Education centres statistics

Dzong-khag	Gewog	Name of School	Students	Total students	Teachers (Male / Female)	Total Staff
	Tsamang	Tsamang Primary school	44M, 53F	97	1M, 5F	6
		Ganglapong Primary school	6M, 12F	18	3M, 0F	3

Dzong-khag	Gewog	Name of School	Students	Total students	Teachers (Male / Female)	Total Staff
Mongar	Tsakaling	Tsakaling Primary school	37M, 57F	94	4M, 4F	8
	Mongar	Gyelpozhing Central school	288M, 255F	543	30M, 14F	44
	Saling	Lingmethang Primary School	195M, 221F	416	19M, 15F	34
		Saling Primary School	10M, 9F	19	2M, 1F	3
		Kalapang Primary School	16M, 17F	33	2M, 2F	4
		Thridangbi Primary School	19M, 36F	55	5M, 2F	7
	Chhaling	Chhaling lower secondary School	103M, 133F	236	12M, 8 F	20
Lhuentse	Tsenkhar	Domkhar Primary School	16M, 9F	25	1M, 3F	6
		Autsho Central School	208M, 313F	521	22M, 17F	64

Source: Dzongkhag websites

Few observations can be made:

- Currently, Tsamang and Tsakaling primary schools are reaching their maximum capacity in terms of students' number while other primary schools tend to be downgraded and close classes due to the shortage of students (e.g Chhaling PS has been downgraded, Banjar School has been shut down). Ganglapong has only 17 students and can accommodate over 100 students. Gyelpozhing Higher Secondary School (HSS) has no Class XI this year due to shortage of students and is far below capacity as it can accommodate 780 students. The Autsho Central School and Gyelpozhing HSS are also below capacity.
- Lingmethang MSS is already gearing up to cater to more students because of the projected demand from various other projects and offices.

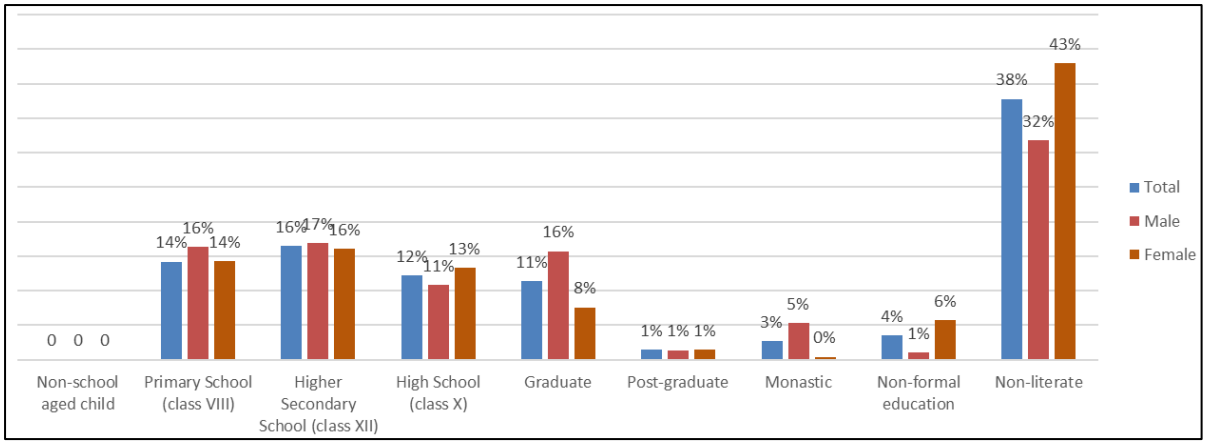
8.2.5.1.3.2 Level of education and literacy

The surveyed population over 18 years old (1,407 people in total in our sample survey) has reached the following highest school levels:

- 14% of respondents had gone as far as primary school (including 16% men and 14% women).
- 16% of respondents attended school up to higher secondary school (of which 17% were men and 16% were women).
- 12% of respondents went up to high school (11% men and 13% women).
- The education gap between men and women widens at graduate level: 11% of respondents have a graduate degree (of which a large majority are men: 16% vs. only 8% of women).
- Very few respondents went up to post-graduate studies (1% of both men and women).
- Monastic education tends to be reserved for men, who make up 5% of the total sample, compared with 0% of women. No women's monasteries have been identified in the study area, although there are some nationwide.
- Non-formal education tends to be reserved for women, with 6% attending this type of establishment, compared with only 1% of men.

In the study area, 38% of those surveyed household members over 18 years old are non-literate (meaning they can neither read nor write). There is a big gender difference, with more women (43%) than men (32%) being illiterate.

Table 139: Level of education achieved by people over 18 in the study area, by gender



8.2.5.2 Health

8.2.5.2.1 National level

8.2.5.2.1.1 Health system

The constitution mandates that all Bhutanese be provided with basic free health care. The health care system comprises of a three-tiered system, with the national referral hospital at the centre in Thimphu, regional referral hospitals in Mongar and Gelephu, district hospitals as the second tier and Basic Health Units or Primary Healthcare centres supported by Outreach clinics and sub-posts at the gewog level. Traditional health care is delivered through the traditional medicine units with the same BHU and in the district hospitals.

As of 2021, there were 58 hospitals, 179 Primary Healthcare centres, 76 indigenous units (healthcare facilities offering traditional Bhutanese medicine, Sowa-Rigpa, which integrates spiritual, psychological, and physical health aspects. These units provide herbal medicine, acupuncture, and other traditional therapies. They coexist with Western medical practices), 552 Outreach clinics and 54 sub-posts. These are staffed with 354 doctors and 1622 nurses (*NSB, 2022, Annual Statistics*).

Wherever available, patients have the choice to be treated by an Indigenous Doctor. Where medical services are not available, patients are referred outside the country at the expense of the Government.

8.2.5.2.1.2 Population's health profile

Since 2021, from all Health Facilities in the country, 1,198,013 morbidity cases and 84,286 Outpatient and 47,663 in-patient cases (587 in Lhuentse and 4,190 in Mongar) were recorded. In addition, there were 101,866 availing traditional treatment and 130,044 therapeutic cases receiving treatment from Traditional Medicine. 57,246 patients received immunization. The nutritional and Vitamin 'A' Status of children attending clinics was recorded for 54,272 children (949 from Lhuentse and 3,143 from Mongar) (*NSB, 2022. Annual Statistics*). Health screening programs were also conducted for all districts (MoH website). Until September 2022, 61,730 cases (33,755M, 27,975F) of COVID 19 were reported, of which 3,433 were affected children. The total number of deaths from COVID 19 is reported to be 21 (10M, 11F). (*MOH website. Situational Update on COVID 19*).

The top ten inpatient mortality cases in 2021 are listed in ESIA Volume 3 Appendix E – Social 1st Field Report.

In 2021, the highest in-patient cases were due to other complications of pregnancy which accounts for 10.66% of the total cases followed by respiratory and diseases of the nose (excluding asthma, common cold, pharyngitis/tonsillitis and pneumonia) with 6.21% of all cases (MOH 2022, Annual Health Bulletin).

1,188 deaths were reported from all health facilities in 2021. Of these 11 patients were reported from Lhuentse and 92 from Mongar.

Maternal health

In Bhutan, maternal health is a priority supported by government initiatives to improve antenatal care, access to medical facilities and women's reproductive health education.

The Bhutanese government is working closely with international partners and non-governmental organizations to strengthen maternal health services and reduce maternal mortality rates: in 2023, the MoH has embarked on a comprehensive Mother and Child Health (MCH) program, leading in a new period of care and support for expecting mothers and the child. This initiative aligns with national priorities and the 2020 Policy, with a primary goal to strengthen the wellbeing of mothers and children throughout Bhutan.

While Bhutan has made remarkable progress in the maternal and child health, several challenges continue, including high maternal and newborn mortality rates, inadequate utilization of maternal health services, and a deficiency in early-stage care for pregnant women. According to UNICEF data, Bhutan has an under-five mortality rate of 26.7 deaths per 1,000 live births and a neonatal mortality rate of 15 deaths per 1,000 live births. The data available on maternal mortality rate in Bhutan is from 2020, which was 60 maternal deaths per 100,000 live births.

These challenges are further complicated by the declining Total Fertility Rates. Bhutan's commitment to addressing these issues is unwavering. Recent statistics reveal that the country's fertility rate has dropped to 1.866 births per woman in 2023, marking a 1.43% decline from the previous year. The declining trend in fertility rates has raised concerns, prompting the government's goal of raising TFR from 1.9% to 2.1% by 2034 as outlined in the 13th Five-Year Plan.

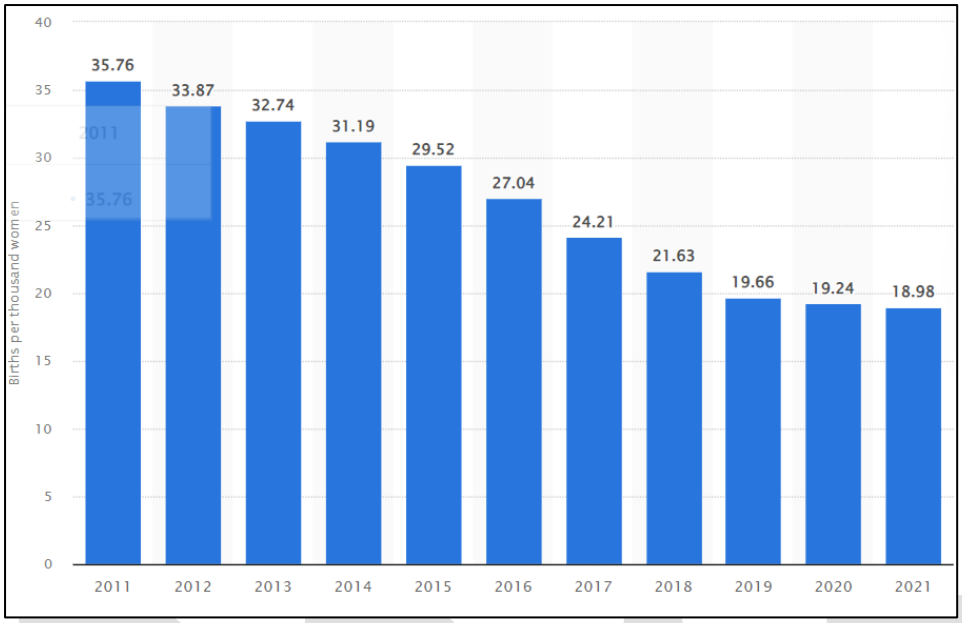
The comprehensive MCH program aims to tackle the above-mentioned challenges head-on by focusing on two key aspects: improving access to maternal and child health services and promoting health-seeking behaviors. The program encompasses a wide array of services, including fertility and preconception services, medical screening, multiple micronutrient supplements, mental health screening during Antenatal Care and Postnatal Care, screening for intimate partner violence, oral health screening, maternal exercises, lactation management, screening and management of developmental delays, and conditional cash incentives for eligible women.

MoH has identified several key issues affecting the health and well-being of mothers and children in the country. These include variations in healthcare access across different regions, limited use of healthcare services in remote areas, particularly among women with lower educational backgrounds and lower socioeconomic status.

Early pregnancies

Early pregnancies are declining overall in Bhutan: between 2011 and 2021, the rate of pregnant teenagers between the 15 and 19 years old dropped from 35.76‰ to 18.98‰ (source: Statista, 2024).

Table 140: Adolescent fertility rate in Bhutan, 2011 - 2021 (per 1,000 women)



Source: Statista, 2024

An analysis of the Statistical Yearbook of the Royal Bhutan Police reveals that in most cases, the perpetrators were known to the minors. They included stepfathers, brothers, uncles, biological fathers, or neighbours. The teenage girls who became pregnant predominantly come from low-income backgrounds and belong to illiterate groups. Agencies attribute the probable causes of teenage pregnancy to poor parental guidance, the absence of comprehensive sex education in schools, and access to pornographic content online. Y-PEER Bhutan facilitator, raising awareness about sexual and reproductive health rights (SRHR) and teenage pregnancy raised that compared to western dzongkhags, students in eastern dzongkhags lack education on teenage pregnancy. (Kuensel, September 2nd, 2023, https://kuenselonline.com/teenage-pregnancies-spark-urgent-awareness-campaign-in-the-east/).

GBV

According to a 2017 report from UNFPA (Violences Against Women – Regional Snapshot, 2017. https://reliefweb.int/attachments/8dd72a38-de7c-3e8d-8446-c3570a434f94/VAW%20Map%20September%2014%202017.pdf) in Bhutan:

- More than one in every four women (27%, see map below) experienced one or more forms of partner violence in their lifetime, including 13% over the last 12 months.
- 4.5% experienced partner sexual violence in their lifetime and 2.3% in the past 12 months (among ever-partnered women and girls)
- 12.5% women and girls (aged 15-64) experienced non-partner physical violence and 5.8% non-partner sexual violence during their lifetime.
- 6.9% of women and girls reported being abused sexually during their childhood (before age 15). Such abuse typically occurred between the ages of 10-14 years girls.
- WHO reported that children experiencing sexual abuse identified male strangers as the most common perpetrators.

The map below illustrates the statistics on violence against women by their partners in the Asia-Pacific region, for comparison.

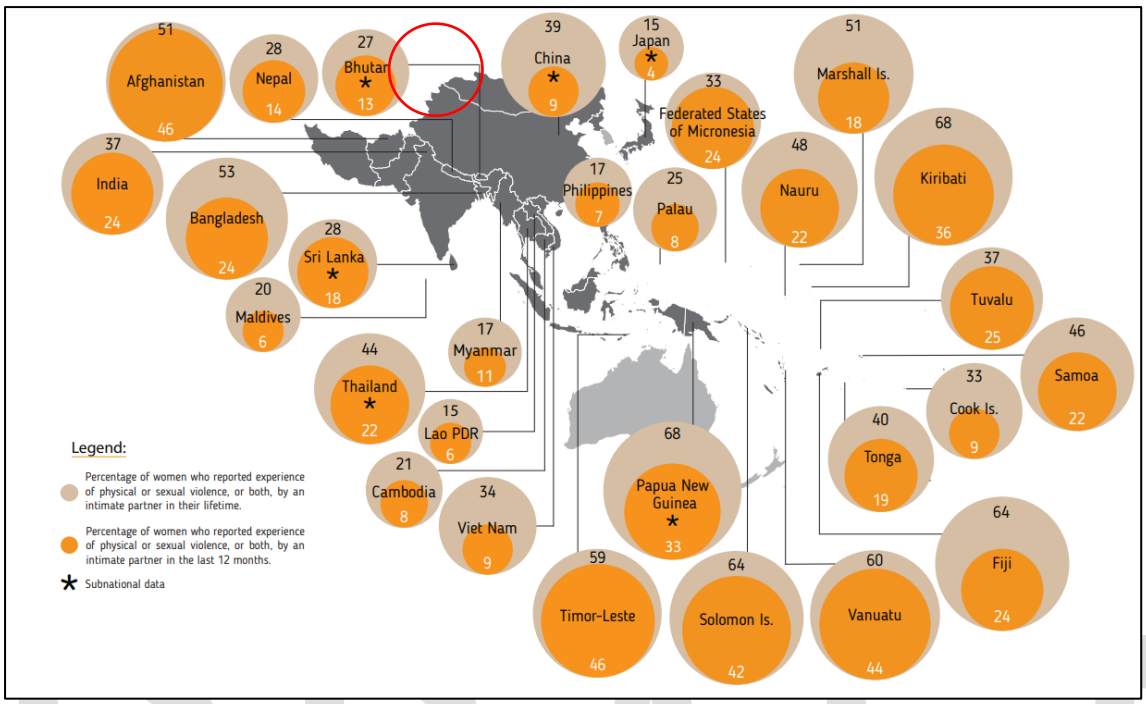


Figure 137: Women who experienced intimate partner violence, 2020-2017 - UNFPA Asia and the Pacific Region

Source: UNFPA, Violences Against Women – Regional Snapshot, 2017

Despite strong political commitment and a supportive legal and policy framework, gender-based violence (GBV) in Bhutan remains a significant problem.

A study done by a CSO - RENEW on Gender Norms on Sexual and Gender-Based Violence (SGBV) among men in Bhutan in November 2021 suggests that there is limited evidence on men's perception around issues of sexual SGBV and how they could be engaged in prevention efforts. The Bhutanese newspaper on 3rd August 2021 reported that the NCWC, by then, had registered 162 different cases in total in 2021, out of which 61 cases were related to GBV. The statistics with the NCWC showed that of the total registered survivor, 8 were male and 53 were female. Accordingly, in 2020 they registered 123 GBV related cases whereby 8 were male survivors and 115 were female. In 2019, NCWC registered 85 cases of GBV with 9 male survivors and 76 female survivors.

Sexual and Gender Based Violence (SGBV) including domestic violence (DV) among women remains a public health and social issue in Bhutan impacting health, well-being, productivity, and overall development.

NCWC as a nodal agency for the protection and promotion of the rights of women and children and also as the Competent Authority for the Domestic Violence Prevention Act (DVPA, 2013), Child Care Protection Act (CCPA, 2011) and Child Adoption Act of Bhutan 2012 (CAA) has developed numerous Standard Operating Procedures (SOPs) and guidelines to provide systematic approach to addressing VAW/G. In addition, a toll-free helpline (which is under the Pema Secretariat now) was established in 2018 to enhance services for women and girls in need of care and protection. In a similar manner, CSOs like RENEW play a significant role in the protection of victims/survivors of VAW/G. They provide services like shelter, counselling and livelihood alternatives and creating awareness on VAW/G).

8.2.5.2.1.3 COVID-19 impacts

According to the Asian Development Bank report (Asian Development Bank. (2021). Overcoming COVID-19 in Bhutan: Lessons from Coping with the Pandemic in a Tourism-Dependent Economy), Bhutan's response to the COVID-19 crisis has faced the following challenges:

Healthcare Staffing Constraints: Bhutan's medical workforce was significantly below the WHO's recommended standards, with only 4 doctors and 18 nurses per 10,000 population, compared to the suggested 10 doctors and 40 nurses. This shortfall presented a formidable challenge in managing the health crisis efficiently.

Robust Testing and Detection Regime: Despite these resource limitations, Bhutan achieved one of South Asia's highest per capita RT-PCR testing rates, conducting 1,150,014 tests per million inhabitants as of September 30, 2021. The country administered a total of 783,191 RT-PCR and 366,823 RDT tests, a crucial strategy in preventing the spread of the virus through timely detection and isolation of cases.

Quarantine Measures and Financial Allocation: From March to November 2020, 24,148 individuals underwent government-funded mandatory quarantine. To support its prevention and containment strategies, the Ministry of Health was initially allocated Nu1.0 billion (approximately $13.33 million) and later an additional Nu2.0 billion ($26.66 million). This funding facilitated the expedited recruitment of around 140 healthcare professionals, bolstering the country's pandemic response capabilities.

Additionally, the pandemic also significantly affected mental health in Bhutan (Tsheten, T., Chateau, D., Dorji, N., Pokhrel, H. P., Clements, A. C. A., Gray, D. J., & Wangdi, K. (2023). Impact of COVID-19 on mental health in Bhutan: a way forward for action. The Lancet Regional Health - Southeast Asia, 11, 100179), with notable increases in depression and anxiety disorders. The prevalence of depression nearly doubled from an average of 9 per 10,000 in the pre-pandemic years to 16 per 10,000 in 2020, and anxiety disorders rose from 18 per 10,000 to 55 per 10,000 in the same period. The government's response included initiatives like medicine home delivery and tele-counselling to mitigate these mental health challenges. Nonetheless, the situation calls for enhanced investment in mental health services and infrastructure to fully address the emerging needs.

Economically, also by the ADB report, the pandemic severely impacted sectors like tourism, leading to job losses and income reductions. The government's response included financial relief and investment programs, with a significant focus on reviving tourism while safeguarding public health.

Before the pandemic, Bhutan's economy was on a robust growth trajectory, with an average annual growth rate of 7% from 1998 to 2018. This growth was underpinned by substantial public investments in social infrastructure and hydropower, alongside consistent performance in sectors like tourism, construction, and manufacturing.

However, the advent of COVID-19 drastically altered these dynamics. The economy, which was forecasted to grow by 5.2% in 2020, experienced a significant setback, with growth projections revised to a contraction of 3.4% in 2021 from an actual growth of 0.9% in 2020. The expected rebound in 2021, with a growth of 3.7%, hinges on increased government investment.

The tourism sector, a crucial component of Bhutan's economy, was particularly hard-hit. In 2019, the sector generated approximately $345 million in gross receipts and $23.4 million in direct government revenue through sustainable development fees. The pandemic's impact was amplified due to the sector's high employment intensity.

Economically, Bhutan also faced a reduction in sales taxes and corporate income taxes across various sectors, leading to a weakened revenue stream. This decline was so significant that domestic spending, which accounts for 27.4% of the Gross Domestic Product (GDP), saw a 9% fall in 2020 compared to initial projections. As a result, the fiscal deficit widened significantly, from 3.0% of GDP in 2020 to an expected 6.18% in 2021, with further widening to 7.4% of GDP projected due to a 23% decline in domestic revenue.

In summary, while Bhutan's response can be considered one of the most efficient from a health point of view, this does not mean that the economy has not been profoundly impacted. However, it is worth noting

that, due to the prevalence in the Project region of agricultural activity as a source of income, the region has suffered less impact than the country's average.

8.2.5.2.2 District level

8.2.5.2.2.1 Health centres availability

Lhuentse Dzongkhag has one Hospital and Mongar has two. The Mongar Regional Referral Hospital (MRRH) is a fully fledged 150 bedded hospitals as it is the Regional Referral Centre for all the 6 eastern Dzongkhags (Trashigang, Lhuentse, Trashi Yangtse, Mongar, Samdrup Jongkhar and Pema Gatshel).

There are 14 Primary Health Care centres, 1 Indigenous unit and 37 Outreach clinics in Lhuentse. Mongar has 22 Primary Health Care centres, 5 Indigenous units and 58 Outreach clinics. (*NSB, 2022, Annual Statistics and Mongar Dzongkhag Website*).

Where patients are not able to be treated in Mongar, they are referred to the National Referral Hospital in Thimphu for further treatment. Some patients are evacuated overseas (mostly to India) for complex treatments and for private health services.

8.2.5.2.2.2 Medical staff

The Hospital in Lhuentse has only 2 Doctors, one of which provides traditional treatment.

The Mongar Referral hospital has 26 doctors and 129 nurses and 91 support staff. This according to the Medical Superintendent (Key Informant Interview, May 2023) is far below the required number as the hospital should ideally be having 42 doctors and 204 nurses.

8.2.5.2.2.3 Population's health status

In terms of patient numbers, the MRRH has at least a hundred thousand patients a year and patient loads are highest between the months of May-September (due to the difficulties associated with the monsoon season). No data is available for patient numbers in Lhuentse Hospital, as this was not visited since it is too far from the project site.

The general trend of patients visiting MRHH has increased due to improvement in connectivity. Patient numbers from nearby districts such as Trashigang and Trashiyangtse decreased due to the establishment of cluster hospital in Trashigang. While the general trend of diseases has remained the same, trauma related cases have increased. The top five diseases reported in MRRHH include Musculoskeletal diseases, Kidney and genital diseases, Conditions originating from perinatal period, Hypertension and Disease of digestive system. There is no data on gender-related diseases. In the last year, one suicide case (M), 3 cases of rape, 200 STD cases and 7 teenage pregnancy cases were reported. Constraints faced by the MRHH include inadequate infrastructure in terms of inadequate chambers for doctors, lack of Pharmacy as per the required standard and lack of proper waste storage facilities (KII interview with MRRH Superintendent, May 2023). The health indicators for each Dzongkhag are provided in Table below. However, it must be noted that the data for Mongar includes patient information for all patients from 6 Dzongkhags.

The health indicators for the Dzongkhag indicate that infant mortality is less than 1 per 1000 for Lhuentse and 2 per 1000 for Mongar. The crude birth rates are between 12-14 per 1000 for both Dzongkhags and crude death is at 3.2 per 1000 population for Mongar MRRH.

Table 141: Health indicators by Dzongkhag

	Lhuentse	Mongar
Health Indicators	2021	2022
Infant Mortality Rate (Per 1,000 live births)	0.68	2
Crude Birth Rate (Per 1,000 population)	12.42	13.3
Crude Death Rate (Per 1,000 population)	No data	3.2
Maternal Mortality Rate (%)	0	203.6
Doctors per bed	0	0.89
Birth attended by trained personnel	165	491
Under one immunization coverage (%)	96.9	97.3

Antenatal and Postnatal care services are also provided through the health facilities as part of the maternal and child (MCH) health services. The MCH handbook is given to every mother and records of all post-natal visits, child growth and vaccinations or vitamins given are recorded in the book. The MCH handbook is used to track a person pregnancy and child progress through the health management information system. The table below shows how the data from the MCH handbook provides useful information on the status of children being treated across different areas.

Initially, the immunization program included six antigens (BCG, DTP, TT, OPV and Measles) but this has slowly expanded to 13 different antigens in the routine immunization program in the country. Bacille Calmette-Guérin (BCG) is a vaccine for tuberculosis (TB) disease; DTP is a vaccine for diphtheria, tetanus, and pertussis; MR is a vaccine for measles and rubella; OPV is the oral polio vaccine; TT is the tetanus toxoid vaccine. Data on the primary antigens provided are included in the ESIA Volume 3 Appendix E – Social 1st Field Report.

8.2.5.2.3 Local level

8.2.5.2.3.1 Health centres availability

The availability of medical centres is quite good in the study area, but the services are insufficient in terms of human resources.

The following table summarizes the key-findings from the KII and Community mappings:

Table 142: Health facilities, types of diseases and count

Gewog	Hos-pital	Basic Health Unit	Sub-post	Outreach Clinic	Disease and count
Tsamang		Banjar and Tsamang		Dramaling (Not-operational)	Common cold (191), Musculo-skeletal system (135), skin infection (130), Work related and other unknown injuries (90), dental caries (45), Conjunctivitis (34), Scabies (100), other eye disorders (65), Diarrhoea and Dysentery (200).
Tsakaling		Tsakaling	Takhambi	Chubar, Petshobi and Kadam	Common Cold (792), Skin infection (208), Peptic Ulcer Syndrome (83), Other muscle-skeletal disorders (316), Diarrhoea and Dysntry (74), Other eye disorder (210), work related injuries (151), Dental

Gewog	Hos-pital	Basic Health Unit	Sub-post	Outreach Clinic	Disease and count
					Caries (66), Conjunctivitis (56), Scabies (21).
Mongar	Regional Referral Hospital	Gyelposhing		Wangling, Konbar, Thamdangbi & Tongsing	LATEST DATA NOT AVAILABLE AT GEWOG LEVEL.
Saling		Sengor (under construction) & Lingmethang.		Thridangbi, Saling, Tsenzibi, Broksar, Kalapang & Resa	Common Cold (1719), Other Disorders of Skin and Subcutaneous Tissue (1350), Other Nervous Disorders (includes Peripheral disorders) (1020), Other Diseases of the Digestive System (933), Other Eye Disorders (514), Other Musculo-Skeletal Disorders (324), Peptic Ulcer Syndrome (291), Other Respiratory & Nose Diseases (240), Acute Pharyngitis / Tonsillitis (230), Other Injures (180).
Chhaling		Gewog centre (Garwaling)		Goenpa	Common Cold (987), Skin infection (456), Peptic Ulcer Syndrome (508), Other muscle-skeletal disorders (245), Diarrhoea and Dysentery (144), Other eye disorders (224).
Drepong		Laptsa		Tshangkhar, Drepong & Zunglen	Dis. Of respiratory system (289), Dis. Of the other nervous including peripheral disorder (137), Dis of the Musculo-skeletal system (114), Dis. Of the skin and the subcutaneous tissue (106), other diseases of the digestive system (95), Dis. Of the eye and ear (95), Work related and other unknown injuries (77), Dis of the teeth and gums (47), Diarrhoea cases (Ao2+Ao3) (19), Bites and stings (13.)
Tsenkhar		3		6	

Source: Gewog website & NSB (2018)

A few observations can be made:

- Overall, **the health sector in the study area lacks facilities, medical staff, and equipment**. The PHC in Lingmaythang cannot cater to increase in patient load, due to lack of facilities and staff shortage, while Autsho hospital is not complete although equipment has been received. The Mongar Referral Hospital is currently short-staffed as well.
- Now, patients that cannot be treated at the PHCs are referred to Gyelpozhing Hospital or the Mongar Regional Referral Hospital.

- The construction of a **new maternal and child hospital** (65 beds), with equipment funded by JICA, is planned in Mongar. The two departments from the MRRH will be shifted to the new hospital and the dialysis (4 bedded) will be expanded to 8 or 10, the number of ICUs will be expanded from 6 to 8.
- Patient number range from over 100-418 at the PHCs in Chhaling, Tsamang, Ganglapong, Tokari and Banjar, and over 300 patients in Tsakaling. The Autsho Hospital receives between 400-600 patients and the Lingmaythang PHC and Gyelpozhing Hospital receive over 1500 patients each month.
- Frequency of visit to Outreach clinic, BHU **and Hospitals (HH survey): 80% of respondents in the HH survey never use the service of an outreach clinic in a year, while 72% of the respondents would use the service of the BHU at least once a month and 87% at least once a year. 50% of respondents visit the hospital at least once a month and 91% once in a year (HH survey, 2023)**
- Access to emergency services: 93% of respondents consider that they have good access to emergency services (which include health emergency services). While people from Tsakaling Gewog are fully satisfied as well as 98% of Mongar population surveyed, Tsamang Gewog seems particularly disadvantaged with 10% of respondents considering their access to emergency services as poor (see Figure 138).

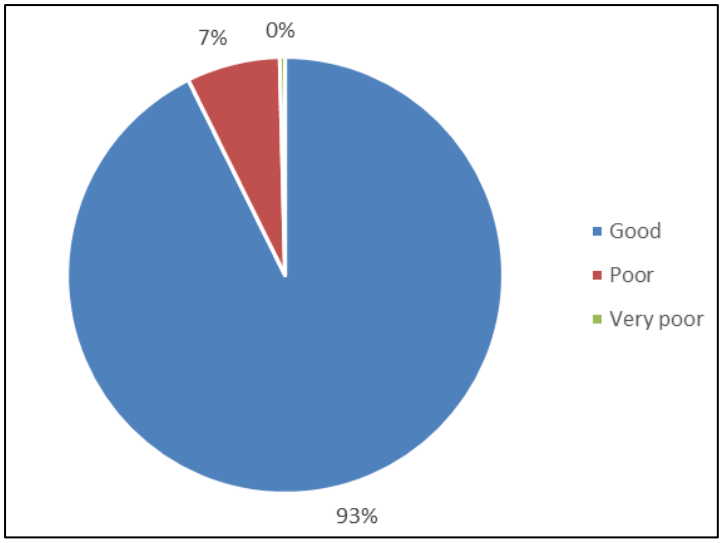


Figure 138: Perception of access to emergency services in the study area

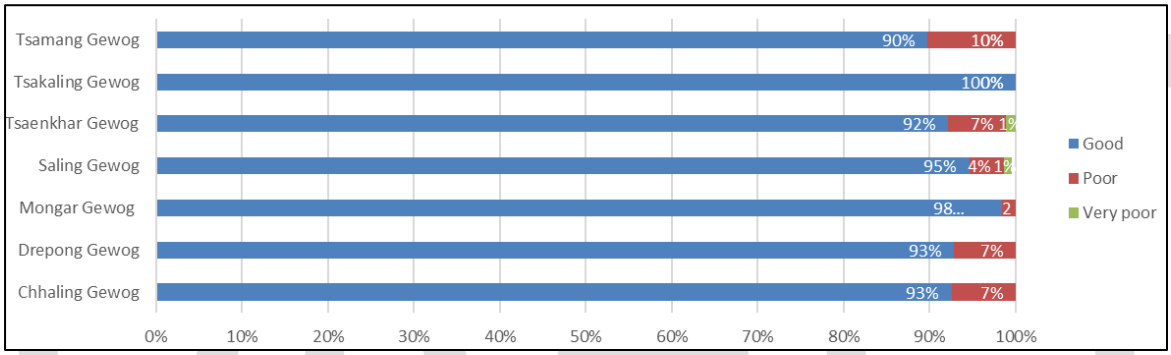


Figure 139: Perception of access to emergency services, per Gewog

8.2.5.2.3.2 Population's health status

18% of the Households interviewed declared having one family member sick in the last year. The Gewogs with the highest rate of Households declaring a family member sick in the last year are Drepong (one third of respondents), Saling (29%) and Tsamang (28%), as shown in the figure below.

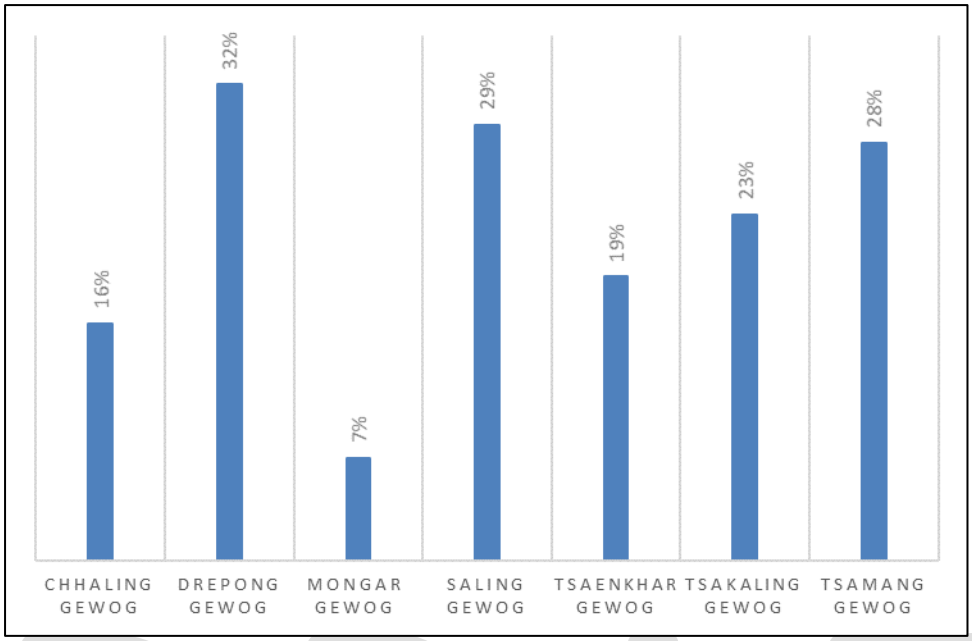


Figure 140: Percentage of Households declaring a family member sick in the last year per Gewog

According to health professionals consulted, the most common diseases include common cold, upper respiratory tract infection, alcohol consumption, skin diseases (fungal infections), colds, diabetes, and hypertension. There have been a few suicide cases at Lingmaythang and Drametse (which are outside the project area).

The results of the survey do not show any major illnesses. In the sampling most common are cold/cough/flu (15% of all cases), asthma and body pains (8% each), diabetes (7%). 5% of cases relate to stomach and gastric problems that may be associated with waterborne disease, but it cannot be verified from the survey.

For 90% of the families declaring a member sick last year, this resulted in an inability to work, and the loss of working days. Besides the 4 cases of those who could not work for the whole year, the average of working days loss amounts 12,3 days over a year.

Sexual health

Most health facilities reported that there are cases of syphilis, gonorrhoea, HIV, teenage pregnancies, domestic violence, and rape. Teenage pregnancy is always invariably reported, but domestic violence is seldom reported, and figures are likely to be not representative.

GBV

The FGDs conducted locally reveal that GBV mostly happens relating to excess consumption of alcohol. Instances of gender-based violence (GBV) and domestic violence, often attributed to alcohol consumption, are addressed through private resolution, involvement of the Tshogpa, or by seeking assistance from NGOs like RENEW at the district level.

Children health

30% of the family members who fell sick were children, with no significant prevalence of any disease. As shown below 94% of respondents consider that the nutritional status of children is good. This situation is however worse in Tsenkhar Gewog and Chhaling Gewog, reaching mostly 10% of respondents considering that children have poor nutrition status.

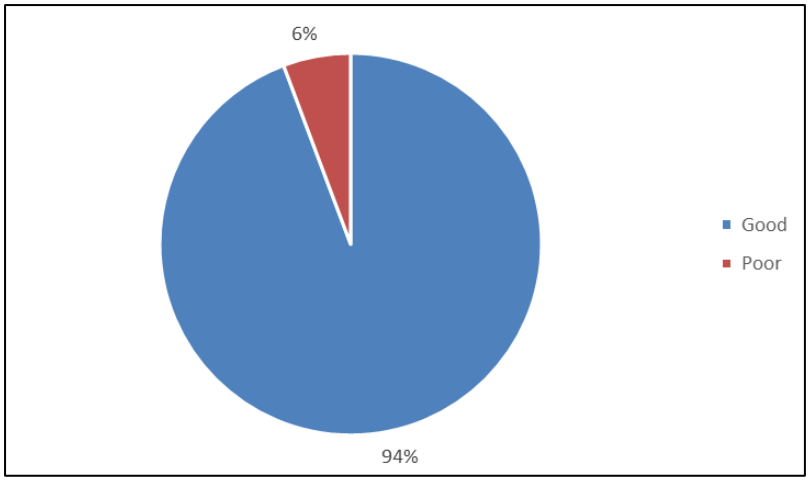


Figure 141: Perception of children's nutritional status

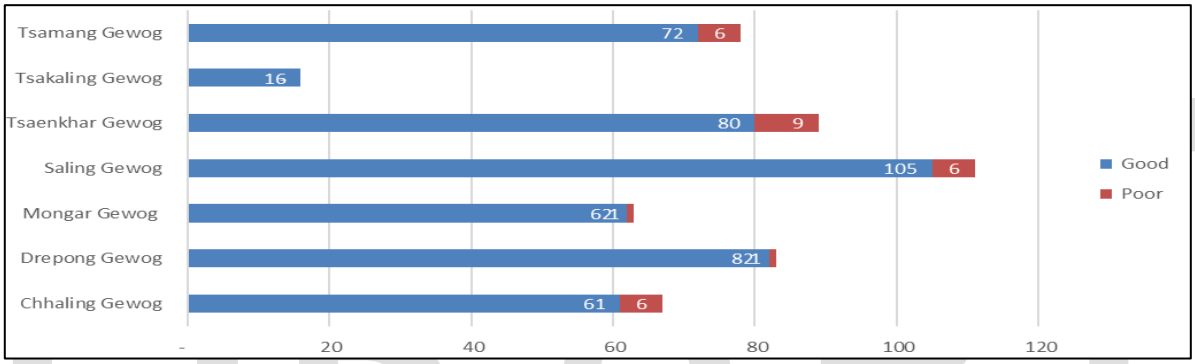


Figure 142: Perception of children's nutritional status, per Gewog

Food supply

A substantial majority of 93% of the participants reported no difficulties in accessing an adequate food supply, reflecting a favourable food security situation within the community.

Health status of women

According to 93% of respondents, the nutritional status of women is good. As for the nutrition status of children, the Chhaling and Tsenkhar Gewogs have a worse situation with up to 12% respondents considering the nutrition status of children n as poor.

1 case of birth complication was reported in the study area in the previous 12 months.

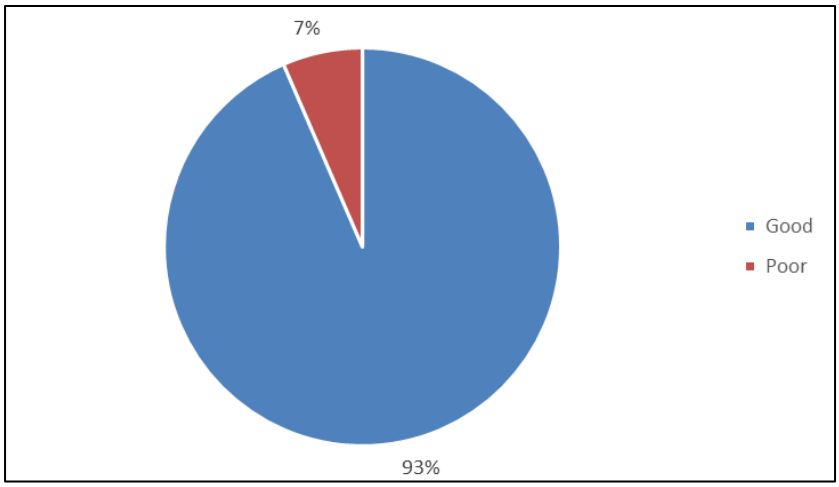


Figure 143: Perception of women's nutritional status

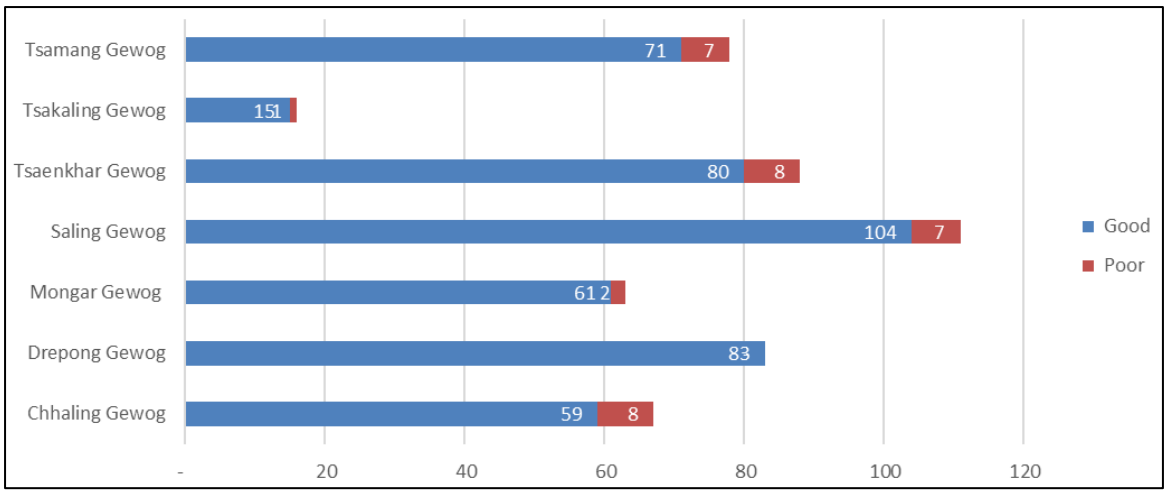


Figure 144: Perception of women's nutritional status, per Gewog

8.2.5.3 Waste, Water and Sanitation

8.2.5.3.1 Drinking water

8.2.5.3.2 National and regional level

Water available for drinking is categorized as improved or unimproved. Improved drinking water source means water that is available to the household through a pipe, a public tap from covered reservoirs, protected wells/spring/streams, protected rainwater collection or bottled water. Unimproved means water from unprotected sources (uncovered reservoirs, springs, streams), or from tanker trucks or surface water. The Bhutan Living Standards Survey 2022, reports that 99.9% of the households in the country have access to 'improved' drinking water source. However, only 83 % of the households have 24 hours access to water and only 57.2% of households have piped water in their dwelling.

The Ministry of Health handles the overall planning, implementation, and management of infrastructure for drinking water supply and quality monitoring of the same for rural areas, in collaboration with local governments. It Water supply varies from urban town to rural areas. Of the 99.9% households with access to improved water sources, 83.53% of urban households have piped water inside their dwellings while in rural areas, only 39.5% of the households have such piped water. For 60% of the rural households, the piped water is within the compound. Water supply was one of the top three priorities and concerns for households in both urban and rural areas (*NSB, 2022. BLSS report*).

The statistics at the national, river basins or district level do not accurately depict the actual picture of water availability. Water is accessed mostly from springs and larger streams and rivulets flowing down mountain slopes, rather than the main rivers at the valley bottoms. As a result, water is not readily accessible for dispersed and fragmented populations, especially those not within proximity to any water source. The major challenges on water resources are unpredictable climate, drying up of water sources, increasing population and urbanization, accelerated glacier melting, accessibility and management issues and stakeholder participation or multi-sectorial coordination issues (*NEC 2018. Water inventory Bhutan*).

Local level

The following table summarizes the key findings of the local surveys concerning water supply, by Gewog:

Table 143: Waste, water and sanitation facilities, by Gewogs

Gewog	Waste, water and sanitation facilities
Tsamang	In Banjar chiwog for drinking and irrigation purposes, the villagers source water from the top of the hill in the north that is divided into 4 sources. All the households have access to clean drinking water. However, there are 2 households without adequate water supply. Similarly, there is 1 household without PIT/VIDP/FLUSH Latrine.
Tsakaling	All the households have access to clean drinking water and none of the houses are without PIT/VIDP/FLUSH Latrine.
Mongar	All households, except for three, have access to clean, safe surface drinking water through pipes, according to Gewog Level Data for 2018. In the same pattern, three homes lack functional water pipes. 1791 households use waste disposal pits, while about 60 households lack PIT, VIDP, or flush latrines. Every day, the gewog produces roughly 0.96 tons of garbage. Once a week, the Thromde collects the garbage from the city. E-waste, medical waste, and municipal solid trash are the categories of garbage generated, and the collection process uses block collection and curbside collection.
Saling	Under Saling gewog 37 households have no PIT, VIDP, or flush latrines and have no access to piped water supply. Most of the people use Garbage disposal pit for waste management
Chhaling	Gewog contains 307 families without access to piped water supplies, PIT, VIDP, or flush latrines. However, the waste management method used by all these residences is a waste disposal pit.
Drepong	The gewog has a 100% clean piped water supply to all the households in the community while 261 families are without PIT, VIDP, or flush latrines. For waste management the locals use garbage disposal pits.
Tsenkhar	The settlement gets its drinking water from Phawanchu which serves the entire settlement of Autsho. There are also some forested areas below the diversion near Phawan, with a road going down to the bricks manufacturing unit and below that there is a forested area. The water source for Namdroling, lhakhang, Nethang and Chalibhadep is from Dortenchu. which also drains into the Kurechu. The school also receives water from the Phawenchu.

Sources: Gewog Data, 2018

Most households surveyed are connected to the water supply system directly in their homes, or to their neighbours from whom they obtain water. In fact, **87.6% of the respondents have access to drinkable water directly from taps in their homes**, highlighting the availability of clean water infrastructure within the community.

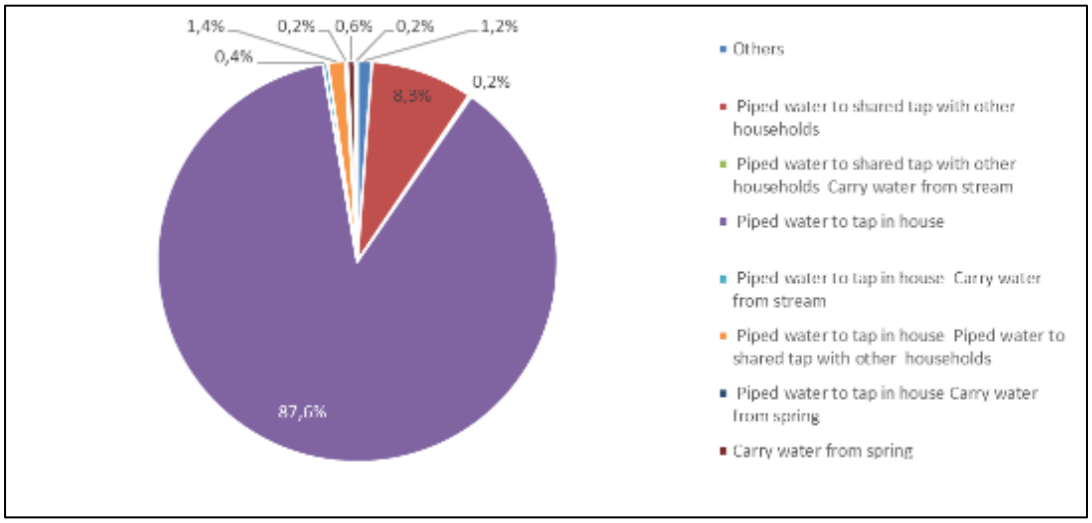


Figure 145: Main source of drinking water from the surveyed population

While water resources are accessible to virtually all households in the study area, 10% of respondents say that the quantity available is barely sufficient for their domestic needs, and 2% say that the quantity is insufficient for their needs. Household taps are connected to nearby springs.

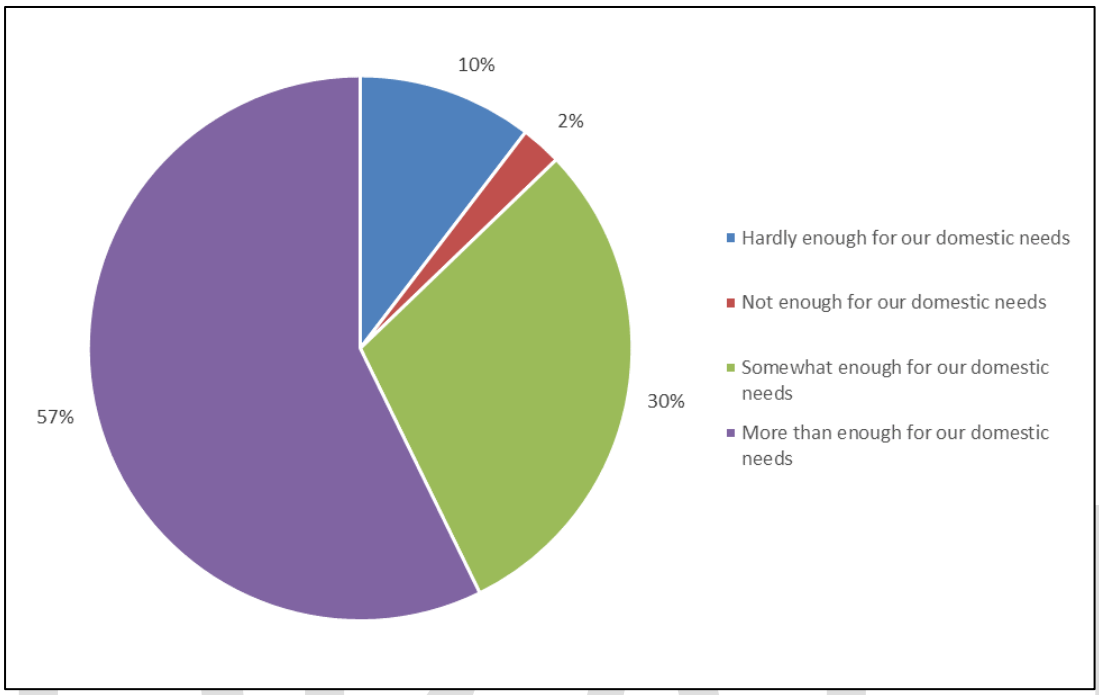


Figure 146: Surveyed population's opinion on the adequacy of water supply

The following table gives information related to the water resources used and the source of drinking water for each village.

Table 144: Natural water resources, source of drinking water for each Gewog

Village	Water resources (natural)	Source of drinking water
Autsho Town	Western side: Kurichhu River Southern side: Dortan Chu, Phawan Chu	Phawan Chu
Banjar	Natural source Various natural springs	North of the village
Chhali	Northern side: Trowanchu stream Southern side: Kangalachu stream East: Tsangphula, Kurichhu River	No data
Drangmaling-Nangar	Northern side: Meralungchu River Eastern side: Kurichhu River Yemaruchu stream, few springs (Pagalachu, Shumachu)	Piped water from Yemarutoed
Gyelposhing Town	Piped water from the Drepong and Tsangkhar sources.	Kalapong
Lingmethang Town	Southern: Drupchuzampa river	Pangsibi water source (piped)
Tokari	Eastern side: Kurichhu River Northern side: Phewagchu stream Southern side: Yemaru stream	Drinking water system from Phewangchu, Namkhey source
Tsakaling Gewog	Northern side: Drakar chu Southern side: Threwan chu Western side: Kurichhu river Many streams: Romnanchu stream, Pramategpachu, Chhimung chu, Takham Chhu, Lama Chu, Rewanchu	Piped water in all the chiwogs is available from stable sources

The Tsakaling Gewog is the one where the quantity of water seems to be the greatest, with 94% of respondents more than satisfied with the quantity of water available. Conversely, the Tsamang Gewog appears to be the least well-lotted in terms of water quantity, with 25% of respondents in this Gewog rating the quantity of water available as insufficient or almost unsatisfactory.

Table 145: Level of appreciation of water supply adequacy per Gewog

Level of appreciation of water supply adequacy	Chhaling Gewog	Drepong Gewog	Mongar Gewog	Saling Gewog	Tsenkhar Gewog	Tsakaling Gewog	Tsamang Gewog
Hardly enough for our domestic needs	6%	6%	16%	11%	9%	0%	16%
Not enough for our domestic needs	0%	4%	0%	1%	1%	0%	9%
Somewhat enough for our domestic needs	55%	16%	17%	28%	40%	6%	28%
More than enough for our domestic needs	39%	74%	67%	59%	49%	94%	48%

8.2.5.3.2.1 Issues related to water supply

For households for which **water availability is sometimes insufficient**, the reasons given are, in order of occurrence:

- Damage/blocking springs (33%).
- Misuse of taps by villagers who leave them open (23.6%).
- Damage to connection pipes (21.7%).

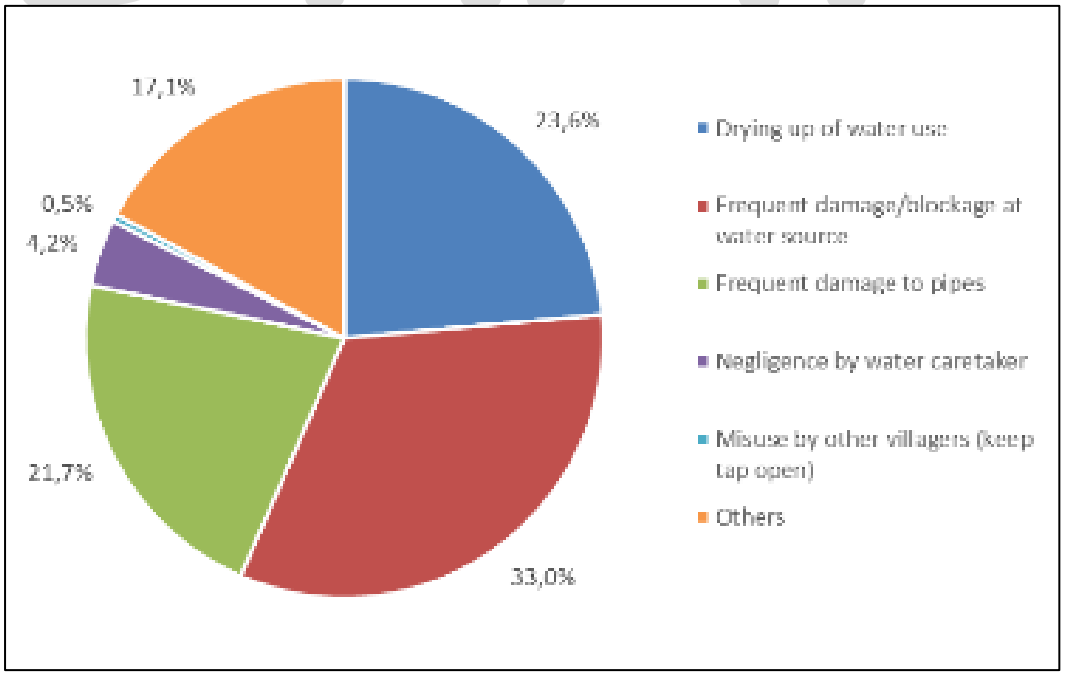


Figure 147: Reasons for tap water insufficiency

Regarding **the problems with the channel water**, the main issues raised by respondents are, in order of occurrence, the following:

- Not enough water during rice transplant (68.5%).
- The canals are damaged during summer (8.5%).
- Springs dry up (4.7%) or are poorly maintained (3.8%).

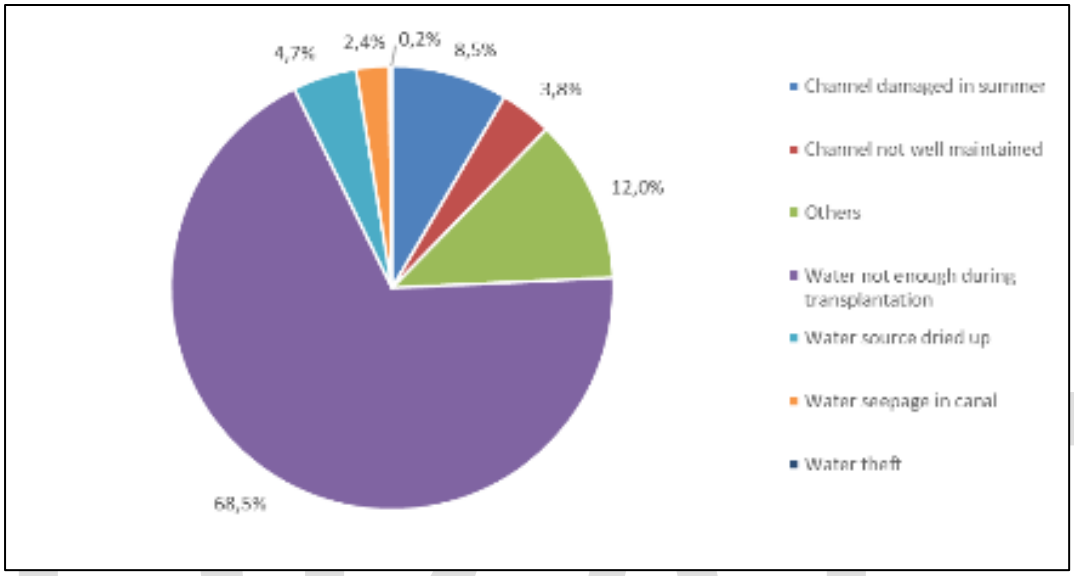


Figure 148: Occurrence of the problems with the water channel

8.2.5.3.2.2 Water Resources for Urban Centres and Rural Areas

The National Water Inventory (NEC 2018) covers 20 districts only includes water inventory data for four gewogs (including Tsenkhar gewog) in Lhuentse, and 4 gewogs (including Saleng gewog) in Mongar Dzongkhag.

Water for towns is sourced from perennial streams. However, due to the climatic conditions when there is no rainfall between October-April, water availability is a yearly issue especially in urban towns such as Thimphu due to reduced flows and issues with water supply infrastructure.

The Department of Engineering Services maintains the annual information on drinking water sources for urban areas only, but water source information for rural areas is not documented. In Lhuentse, water supply for the urban centres is provided from Ngar river, Phawanchhu, and the stream in Pangzamor or from surface water. At Autsho, the water supply source is from Phawanchhu river and is available 24 hours a day. In Mongar, the water sources for Mongar town are from the Yakpogang (with a treatment plant) and Kadam, while the water for Gyelpozhing is tapped from Kalapong (*MoIT.Annual information Bulletin 2022*).

Table 146: Percentage coverage in terms of water source and sanitation in 2017

Infrastructure	Lhuentse	Mongar
Rural water supply coverage (%)	100.0	97.87
Rural population access to safe drinking water supplies (%)	98	97

Source: NSB, 2022. Dzongkhags at a Glance

The rural water supply coverage as shown in the table above indicates that Lhuentse and Mongar Dzongkhag have 100% and 97.87% rural water supply coverage respectively. However, both Dzongkhags suffer from water shortage issues. In Mongar, gewogs such as Jurmed and Khengkhar face acute water shortage. (The Bhutanese. 24 December 2022. How people of Khengkhar and Jurmed gewogs in Mongar

are coping with water shortage). In Lhuentse Gangzur gewog has been reported to face water shortage (UWICER, 2018. Choden, K., Wangchuk, J., Yoezer, D., Wangdi, N., Wangchuk, S. and Tenzin, K. (2018). Climate Change Vulnerability Assessment in Kurichhu Watershed: A case of Gangzur and Kengkhar, Bhutan)

8.2.5.3.3 Irrigation

8.2.5.3.3.1 National level

Irrigation is practiced in three methods: Surface Irrigation (water is applied and distributed by gravity), Sprinkler irrigation and Localized irrigation (micro or drip irrigation). About 32,023 households irrigate their land nationwide, which represents 48.1 percent of the total farming households. (MoAF, 2019. RNR Census of Bhutan 2019).

In the past farmers constructed their own irrigation facilities using local knowledge and resources. In 2016, there were 1200 community managed irrigation systems (CMIS) of which 1000 were functional irrigating 64,248 acres of land. These CMIS were mostly run of river type, with weak, inappropriate structures and easily susceptible to damage by landslides or floods.

Water for Agriculture is the biggest consumer of water in terms of irrigation (NEC, 2016. National IWRM Plan 2016). The RNR census found that nationwide, Irrigation problems rank in the top three constraints faced by agricultural landholders (RNR Census 2019).

To tackle the problem of water scarcity for drinking and irrigation, the Water Flagship Program was initiated as part of the 12th FYP, to provide uninterrupted water supply to every household and to ensure proper management and channelling of irrigation water. A national roll out of water project with an estimated budget of Nu. 3 billion (Prime Minister's Office. Pmo.gov.bt) is ongoing. The project is assisted by donors such as the ADB Water Flagship Program Support Project to provide drinking water and irrigation to 100,000 people in Thimphu and Gelephu municipalities, Chhukha, WangduePhodrang, Zhemgang and Mongar Dzongkhags (Bhutan Water Flagship Program Support Project 42173-017. https://www.adb.org/projects/42173-017/main).

The Building Climate Resilient Water Resources in Bhutan Project by FAO which is under preparation is being planned to provide drinking water and irrigation for certain gewogs in Lhuentse, Mongar, Pemagatshel, Samdrupjongkhar, Trashigang, and Trashiyangtse within the Drangmechhu river basin (https://kuenselonline.com/fao-supports-a-climate-resilient-water-resource-project).

The Desuung National Service Program (dessung.org.bt) is also implementing 39 water supply projects across the country. Project gewogs in Mongar under this program includes the Kalapang drinking and irrigation project for 27 HH and the Gyeposhing drinking water supply (4126 people) project.

Of the volume of water available for irrigation, 84.28% is from streams and tributaries of larger rivers. Ground water use is less than 1%. More than 10% of farming households use municipal water for irrigation.

This represents 48.1 percent of the total farming households. In Lhuentse and Mongar, 59.66% and 38.36% of the households in the Dzongkhags irrigate their land respectively. This only translates to 3.05 % and 2.26 % of the area irrigated in the respective Dzongkhags (MoAF, 2019. RNR Census of Bhutan 2019).

8.2.5.3.3.2 Dzongkhag level

Irrigation by surface water is very high for Lhuentse (99.42%) as compared to Mongar (54.55%), where almost 41% of agricultural land holdings use municipal water. Lhuentse has 109 irrigation channels, totalling 319.5km and benefiting 2432 households. On the other hand, Mongar has only 73 irrigation channels, totalling almost 98km and benefiting 1347 households.

Table 147: Percentage of agricultural land holdings using various water sources for irrigation

	Nationwide	Lhuentse	Mongar
Surface water	84.28%	99.42%	54.55%
Ground water	0.93%	0.08%	0.91%
Both surface and ground water	3.23%	0.17%	3.74%
Municipal water	11.56%	0.33%	40.81%
Irrigation channels	No data	109	73
Total length of Irrigation channels (Km)		319.5	97.94
Area covered by irrigation (acres)		3573.4	1214.6
Number of households benefitted by irrigation		2432	1347

Source: RNR census report 2019, NSB, 2021, 2022. Annual Dzongkhag statistics.

Local level

In terms of irrigation practices, only a minority of 24% of the respondents indicated using irrigation channels, suggesting a relatively low reliance on artificial water sources for agricultural activities.

Table 148: Access to an irrigation channel for the wetland per Gewog

Answer	Chhaling	Mongar	Saling	Tsen-khar	Tsaka-ling	Tsa-mang	Dre-pong	Total
No	44%	100%	57%	100%	72%	89%	No data	76%
Yes	56%	0%	43%	0%	28%	11%	No data	24%

Source: NSB 2022 Dzongkhags at a Glance

8.2.5.3.4 Sanitation

8.2.5.3.4.1 National level

Improve sanitation facilities are reported in use in 99.1% of households in the country. This includes use of flush toilets (97%), ventilated improved pits (1%) and pit latrine with a slab (1%). The remaining 0.9% of households use pit latrine without slab or flush to open drain/open spaces. Currently, over 80% of the urban population use on-site sanitation system for their domestic wastewater disposal and over 40% of these properties lacked a soak-pit system. (Ugyen D et al. 2019. Wastewater management in urban Bhutan: Assessing the current practices and challenges. Process Safety and Environmental Protection, Volume 132, 2019, Pages 82-93, https://doi.org/10.1016/j.psep.2019.09.023.)

UNICEF reported that as of 2022, there is improved sanitation coverage in schools (97%), monastic institutions (89%) and healthcare facilities (99%) but only 19% of schools, 17% monastic institutions, and 31% healthcare facilities toilets are appropriate for persons with mobility/vision disability. (https://www.unicef.org/bhutan/press-releases/red-dot-bhutan-and-partners-construct-eight-inclusive-wash-facilities)

Sewerage systems and sewerage treatment plants have been constructed only in the larger towns such as Thimphu, Phuentsholing, Gelephu and Samdrup Jongkhar. In other towns, facilities such as cesspool trucks

or sludge treatment facilities are provided. Phaling town in Lhuentse has a cesspool truck (MoIT, 2021. Annual information bulletin). Mongar has a sewerage facility below the hospital (MoWHS, nd. Compliance and Development Review of Mongar).

8.2.5.3.4.2 Dzongkhag level

The proportion of households using improved sanitation facilities is higher in urban areas than in rural areas by 0.1%. (NSB, 2022. Bhutan Living Standards Survey Report).

Table 149: Access to sanitation facilities in the Dzongkhags

Facility	Lhuentse 2019	Mongar 2022
Rural population access to improved sanitation (%)	98	100
Latrine	99.1	100

Source: NSB, 2022. Dzongkhags at a Glance

In 2008, with support from the NGO SNV, the National Rural Sanitation and Hygiene Programme (RSAHP) was started with a pilot project in Lhuentse dzongkhag, covering the entire dzongkhag and reaching an estimated 20,000 people. Beneficiaries **included** households from Taskaling, which was reported to have 100% improved toilets. The incidence of water-borne diseases like diarrhoea was reported to have reduced after pour-flush toilets were introduced (MoH and UNICEF, 2017. Documentation of Best Practices for RSAHP.

8.2.5.3.4.3 Local level

In the study area, 72.4% of households are connected to the sanitary drainage system and have a flush system for their toilets (including 39.8% of toilets in the dwelling and 32.7% of toilets outside the dwelling), and 26.4% of respondents use a pour and flush system (of which 10.2% inside the dwelling and 16.1% outside the dwelling). Only 0.8% of households have no sanitary facilities and carry out open defecation (0.2%) or in a pit latrine (0.6%).

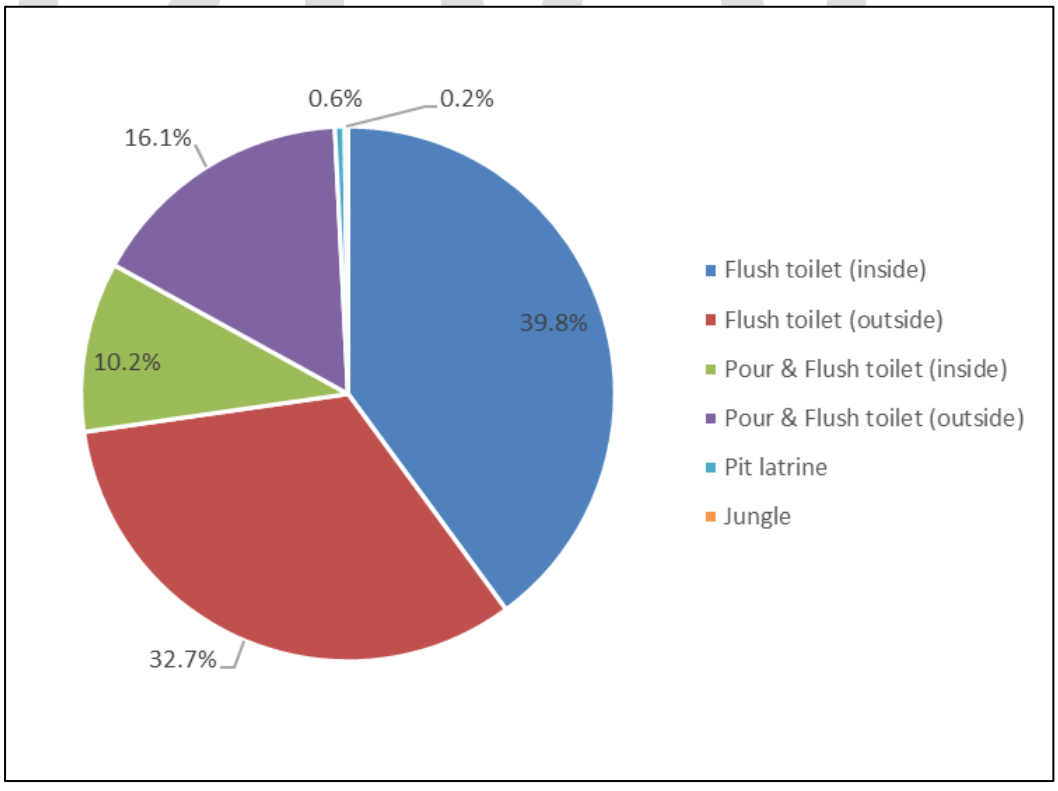


Figure 149: Sanitation system

Tsamang gewog appears to be more poorly connected to the sewage system than the other gewogs (64% of households have an indoor or outdoor flushing system, compared with 73% for the average gewog studied). Conversely, Mongar gewog is better connected than the other gewogs, with 88% of households having an indoor or outdoor flushing system.

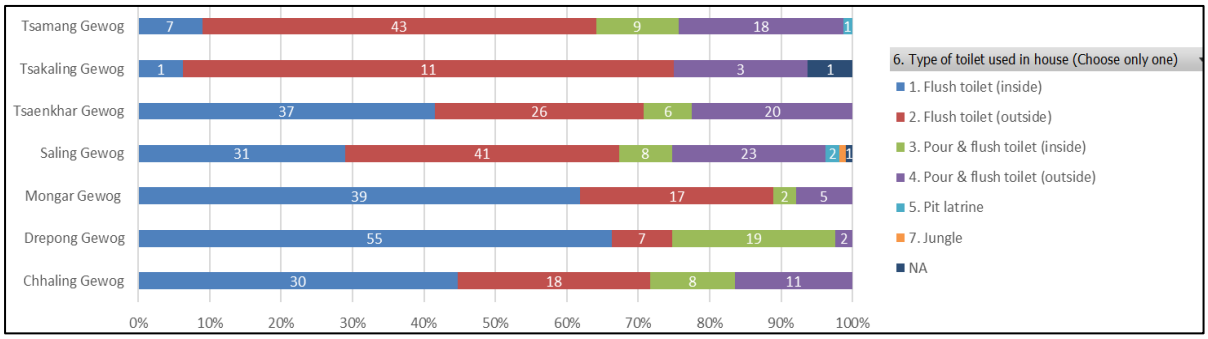


Figure 150: Sanitation system (disaggregated by gewog)

8.2.5.3.5 Solid Waste

National and regional level

The only comprehensive information on solid waste at national and district level is from the National Waste Inventory Survey (NWIS) 2019 (NSB, 2019. National Waste Inventory Survey of Bhutan 2019 (NWIS-19)). According to this report, Bhutan generates 172.16 metric tons of waste with aper capita waste generation of 0.23 kilogram per day. Almost 50 percent of it comes from households, followed by commercial units (40%). On average, each urban household generates 0.7 kgs of wastes a day, while each rural household generates 0.4 kgs of waste a day. 50% of total household waste is food waste, 33% is plastic and paper. In 2019, almost 65% of the households in the country did not have access to waste collection service and only 15 percent of the households in rural areas had such access.

Within the district centres, municipal waste collection and disposal systems are implemented. Their coverage depends on the infrastructure and availability of waste collection trucks and range from three to five days a week.

Of the total households in Bhutan, more than 60% lack access to waste collection services. More than 75% of urban households have access to waste collection services against 15% of the rural households. In urban areas, 88.5% of the households segregate their waste compared to 78.4% in rural areas. The data on waste generated in Lhuentse and Mongar is provided in the table below.

Table 150: Solid waste generated in Lhuentse and Mongar

Dzongkhag	Town	Waste generated (tonnes/ day)	Method of collection	Frequency	Types of waste collected	Service provider
Lhuentse	Lhuentse	2	Kerbside collection and Block collection	4 days a week	Municipal Solid Waste, household waste	Thromde
Lhuentse	Autsho	1	Kerbside collection and Block collection	2 days a week		Thromde
Mongar	Gyelpo-zhing	0.95	Block collection	no info	Medical Waste and Municipal Solid Waste	Thromde

Mongar	Mongar	0.96	Kerbside collection and Block collection	2 days a week	E-waste, Medical and Municipal Solid Waste	Thromde
Mongar	Yadi	0.2	Block collection	Once a week	E-waste, Medical and Municipal Solid Waste	Private Sector

Source: MoIT, 2022. Annual Information Bulletin

There are two landfill sites in Mongar (Gyelpozhing and Mongar) and one at Lhuentse. There are no established waste collection and disposal systems for rural areas but once a month, all villages conduct mass cleaning campaigns.

There is one private waste collector in Mongar.

In Lhuentse, 82.5% of households use a garbage pit (2019) and 93,5% in Mongar (2022) (NSB, 2022, Annual Statistics).

Both Mongar and Lhuentse Dzongkhags have landfill sites, but these are not considered to be maintained as per the national standards. A new landfill site had already been identified by Lhuentse Dzongkhag but as this site is not adequate, Dzongkhag will be looking for a bigger landfill site to accommodate the project needs as well as the needs of the Dzongkhag.

The landfill site for Gyelpozhing and the surrounding gewogs has been taken over by Gyalsuung Academy so the Dzongkhag is in the process of looking for a new landfill site.

During the regional discussions, both Dzongkhags requested the project to assist with sanitary landfill sites. A meeting was also conducted with the Waste Division, DECC (9 June 2023) where it was pointed out that with the transformation process, MoIT will be responsible for setting standards, planning, design and implementation of waste infrastructure. The DECC also recommended having one contained landfill site as maintenance of many landfill sites would both expensive and does not promote waste segregation.

During subsequent discussions with MoIT (22 September 2023 and 3 January 2024), it was suggested by MoIT to look at the possibility of the project establishing landfill site that could be shared between the two Dzongkhags as it is not feasible to have 1 for every Dzongkhag. It was agreed that a tri-partite meeting would be held between the Dzongkhags, MoIT and DGPC to finalize this.

The Mongar Referral Hospital is also suffering from inadequate waste management facilities, and this was discussed during the stakeholder meeting with Ministry of Health on 14 February 2024, and it was suggested that the project also aid MOH for construction of medical waste management facilities. MOH then shared waste management protocols and standards for medical waste management from the contractor's clinic, noting that contractor clinics should follow standard waste management protocols for clinics, where medical waste is treated and converted to non-medical waste.

Local level

Disposal facilities are non-existent in some areas, or the community can access only a small pit and due to the mountainous set up it is difficult to identify proper site for landfills. Gewogs and chiwogs defined local processes for waste collection, examples are given below.

As per the rules, however, the minimum distance for a waste disposal site is 5km from town.

Table 151: Availability of solid waste disposal facilities, by Gewog

Gewog	Are there any waste disposal facilities in Gewog? How is waste managed?
Chhaling	None of waste is taken to Konbar landfill with hired vehicle.

Saling	A major issue as population and town are growing but Gewog has no disposal site and proper facilities. Waste is taken to Gyelposhing, once a week (every Friday). It is due to a lack of space for dumping site.
Tsamang	No disposal, the population burns their waste. Tokari: On day 2 of every month the community collectively comes together and picks up trash and burns it in pits. The waste is not segregated. They feed wet waste to cattle's, sell bottles (beer bottles) and burn the rest.
Tsenkhar	Two small disposal pits.
Tsakaling	No disposal, the population burns their waste.
Mongar	Every month (on 15th) they collect all the waste and the Tshogpas transport this in their private cars to the waste disposal site at Konbari, 5 km from Mongar town (north).
Tsenkhar	Kerbside collection and block collection by Thromde (MoWHS. Annual Information bulletin,2022)

8.2.5.4 Energy

8.2.5.4.1 National level

Druk Green Power Corporation Limited (DGPC) operates and maintains hydropower assets of Bhutan. There are seven major hydropower plants in operation. The current total installed capacity is approximately 2.45 gigawatts (GW). The total power generated and supplied is provided on the table below. Hydropower plants contributed 15.64% to the GDP in 2021. Almost all the households in the country are electrified (99.97%). This includes 47 towns and 4,505 villages (NSB, 2022. Annual Statistics)

The Bhutan Power Corporation is sole agency responsible for power evacuation and distribution. There are currently 222,056 customers and a population of 756,131 people. The per capita energy consumption in 2021 was 3,466.80 kWh. The industrial load constitutes around 73% of the total domestic load. 8,075 MU Energy was exported to India and 98.04MU was imported. (BPC, Annual Report 2021).

8.2.5.4.2 District level

Within Lhuentse there is a 120 kW Gangzur Micro Hydropower constructed in 2000 and 200kW Rongchu Micro Hydropower at Thimyul constructed in 2001. A 32 MW Yungichhu Hydro Power Project is under construction in Maetsho Gewog in Lhuentse. Within Mongar, the 60MW Kurichhu hydro power Plant is located at Gyelpozhing (inaugurated in 2006), the 30kw Khalanzi Mini Hydropower constructed in 1976. (Bhutan Electric Authority. 2001 Licence conditions to generate, transmit, distribute, and supply electrical energy).

The electricity tariff ranges from 1.28 Nu/kWh to 2.66 Nu/kWh for low voltage lines.

99% of households in Lhuentse and 100% of the households in Mongar are electrified. Since 2013, rural households have been given 100 units of electricity free (*BPC, 2023*). For remote communities not electrified, solar PV is provided by the government.

8.2.5.4.3 Local level

Overall, the entire study area is covered by the power grid, and all populations have access to it. During the survey, no report of any power cuts or network instability was made.

8.2.5.4.3.1 Cooking

In the study area, households use either electricity (57%) or LPG (42%) for cooking. Only 1% of households use fuel wood for this purpose.

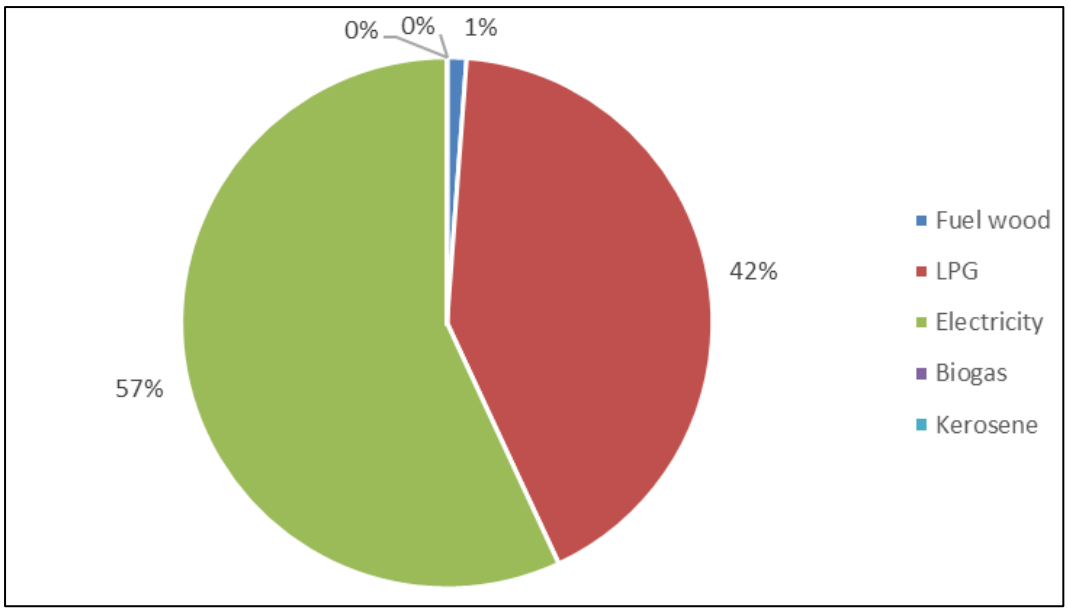


Figure 151: Main sources of energy used for cooking

8.2.5.4.3.2 Heating

Most households also use electricity for heating purposes (86%). This is followed by fuel wood (13%) and kerosene (1%).

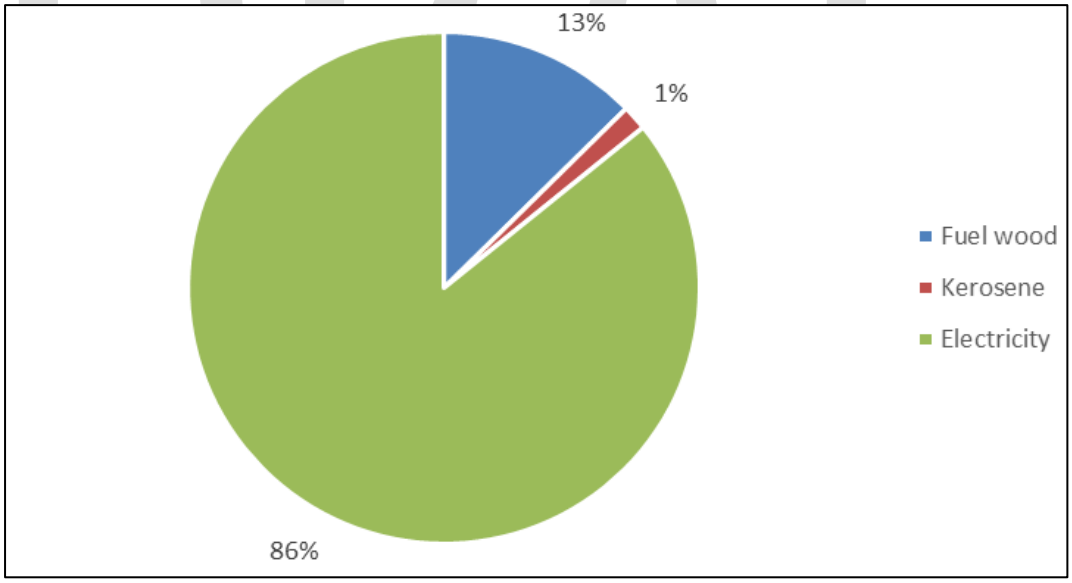


Figure 152: Main sources of energy used for cooking

8.2.5.4.3.3 Lighting

100% of households surveyed in the study area use electricity for lighting.

8.2.5.5 Road, Traffic and Transportation

8.2.5.5.1 National level

8.2.5.5.1.1 Air Traffic

The Department of Civil Aviation is responsible for providing air traffic services; operation and maintenance of airports; and the safe and efficient operation of air services.

Bhutan has one international airport at Paro and three national airports at Yongphula, Gelephu and Bumthang.

There are two airline services: Druk Air/Royal Bhutan Airlines owned by the Government and Tashi Air/Bhutan airlines which is privately owned. Druk Air provides international flights from and to Paro to India (Kolkata, Guwahati, Bodhgaya, Bagdora and Delhi), Nepal (Kathmandu) Thailand (Bangkok), Singapore and Dhaka (Bangladesh). It also provides chartered flights as required. National flights to and from Paro are provided to Yongphula (Trashigang), Gelephu (Sarpang) and Bumthang. The Druk Air also provides helicopter services for search and rescue, medical evacuation, firefighting, cargo and tourism or as official government transport.

The Tashi Air/Bhutan Airlines provides flights to Bangkok, Kolkata, Delhi, Bodhgaya and Kathmandu.

Mongar and Lhuentse can be reached by a 45-minute flying from Paro to Yongphula airport and then by road from Yongphula to the respective Dzongkhags. Lhuentse is accessible via Mongar which is 91km from Trashigang.

8.2.5.5.1.2 Road network

The Road network in Bhutan is classified into National Highway, (which include Asian Highway (AH), and Primary National Highway (PNH)) and Secondary National Highway (SNH), Dzongkhag Roads, Thromde Roads, Farm Roads, Access roads and Industrial roads (*Source: MoWHS, 2020 Road Classification and Network Information of Bhutan*).

8.2.5.5.1.3 Transportation

Being a land-locked country, the **road network is the primary means of transportation across the country**. Inter-Dzongkhag public transportation is privatised and is highest where transport demand is high, such as towns and district centres. The total number of passenger buses in 2022 was 778 (281 passenger buses, 328 institutional/school buses, 168 tourist buses) *(https://bcta.gov.bt/)*.

Vehicles registration is conducted region-wise as shown in the table below. Mongar covers all the eastern Dzongkhags (Trashigang, Trashi Yangtse, Mongar, and Lhuentse). As of June 30, 2022, the country recorded a total of 123,000 registered motor vehicles. This, however, includes power tillers, tractors and earth moving equipment.

The eligibility criteria for obtaining learner license except for requirement to attain 17 years of age.

In the rural areas however, transport services are limited, and locals depend on local taxis and free rides in government vehicles or personal cars. Mongar dzongkhag lies along the primary national highway to Trashigang and Trashi Yangtse and therefore the traffic includes all travellers going to the eastern districts.

The performance audit of the surface road transport system (*RSTA. Annual report 2020-2021 and 2021-2022, Road Safety and Transport Authority Ministry of Information and Communications Thimphu: Bhutan*) reported that, based on the statistics from Royal Bhutan Police, (*Traffic division*), 5,945 cases of motor vehicle accident were reported over five years from 2015 to 2020. In 2020, there was a significant decrease in accidents, with only 810 recorded, reflecting a 45% drop compared to the previous year. The trend continued in 2021, with 745 accidents, representing an 8% decrease (*Tshering Dema, 2023, https://thebhutanese.bt/bhutans-growing-vehicle-population-claims-nearly-100-lives-and-leaves-600-injured-each-year/*). All 20 Dzongkhags have one traffic police call centre, where calls related to road accidents are communicated to officials on duty and accordingly officials are deputed for respective duties. All 20 Dzongkhags have one traffic police call centre where calls related to road accidents are communicated to officials on duty and accordingly officials are deputed for respective duties.

8.2.5.5.2 District Level

The Mongar Dzongkhag Centres is about 460 km from Thimphu. Mongar lies along the Primary National Highway also called the East-West, connecting the western part of the country to the eastern Dzongkhags. The primary highway bifurcates at Gangkola towards Lhuentse, which is about 53 km away.

All the gewogs in the two Districts are connected by District roads.

- Lhuentse Dzongkhag has 53 km of Dzongkhag Road, 580 km of farm road, 151 km of access road, 17 motorable bridges and 21 non-motorable bridges.
- Mongar Dzongkhag has 313 km of Dzongkhag Road, 1,424.57 km of farm road, 44.8 km of forest road, 22 motorable bridges and 24 non-motorable bridges. In some areas, across the rivers, suspension foot bridges are available where roads are not present.

The information is summarised in Table 152: Length of roads (in km) in the Lhuentse and Mongar as of June 2022Table 152.

Table 152: Length of roads (in km) in the Lhuentse and Mongar as of June 2022

Type of Road	Lhuentse	Mongar
Asian Highway	0	142.9
Primary National Highway	-	222.45
Secondary National Highway	105	8
Dzongkhag Road	53	313
Urban Road	1	12
Farm Road	580	1,425
Access Road	151	65
All roads	889	2,045
Motorable Bridges (Nos.)	17	22
Non-Motorable Bridges (Nos.)	21	24

Source: NSB, 2022. Annual Statistics and MOWHS, Annual Information Bulleting 2021

Dzongkhag roads and Gewog connectivity roads are clubbed together as they have the same specification. 6.2 Km of Asian highway is included in the express way and 145.15km. The Regional Office of the Department of Surface Transport (DOST) covers Mongar and Lhuentse Dzongkhags and is responsible for the construction and maintenance of secondary national highways.

Traffic data

Neither the Royal Bhutan Police (RBP), nor the Bhutan Construction and Transports Authority, Mongar, does have any traffic data, because this is not a common procedure or requirement at the Dzongkhag level. The RBP only conducts checks for traffic violations.

Traffic counts were conducted for one hour each day during the field survey on four days, between 19-24 May 2023. The number of vehicles in both directions were counted in four locations: Mongar Gyelpozhing highway, Gankola to Autsho (below Tsakaling), Kurizam to Gyelpozhing ang Kurizam to Lingmethang. During the one-hour count, the maximum number of vehicles was 60 (30 in each direction) along the Mongar –Gyelpozhing highway and the lowest on the same highway three days later was 30 (11 in one direction and 19 in the other).

Table 153: One-hour traffic count along the highway (May 2023)

Date	Highway	Type of Vehicle	Light Vehicles	Two Wheelers	Heavy Vehicles	Total
19-May-23		Toward Gyelpozhing	21	2	7	30

Date	Highway	Type of Vehicle	Light Vehicles	Two Wheelers	Heavy Vehicles	Total
	Mongar Gyelpozhing highway	Away from Gyelpozhing	20	0	10	30
23-May-23	Gankola to Autsho (below Tsakaling)	Away from Autsho	19	0	4	23
		Towards Autsho	0	0	0	0
24-May-23	Mongar Gyelpozhing highway	Towards Mongar	7	0	4	11
		Away from Mongar	18	0	1	19
24-May-23	Lingmithang to Kurizam	Towards Kurizam	7	0	7	14
		Away from Kurizam	16	1	5	22

It is expected that the Bumthang-Trashigang highway passing through Kurizam will have high traffic as it is the national east-west highway. Regular vehicles such as taxis and bus services use the Lhuentse highway, but because Lhuentse is the destination, the traffic ends there.

Trend in vehicle accidents

Nationwide, between 2017 and 2022, there were 6,028 road accidents, averaging 1005 accidents per year. The number of road accidents in the country rose sharply in 2018 and 2019 to 1471 accidents and since then dropped to less than 800 in 2021 and 2022. Accidents were highest in Paro, Thimphu, Chukha and Wangduephodrang with the 4 Dzongkhags accounting for almost 50% of the total number of accidents (NSB 2022. Statistical yearbook of Bhutan 2022.).

In 2022, on average, 6 people were killed and 45 people were injured in traffic accidents every month. Chukha had the maximum number with 87 deaths and 20 injured people (*RBP, 2021*).

8.2.5.5.2.1 Dzongkhag

Road accidents are very low for Lhuentse with only 20 accidents between 2017-2022, averaging 4 accidents per year. On the other hand, 120 accidents were reported in Mongar between 2017 and 2022, with an average of 20 accidents per year. In 2022, 3 people were killed and 2 injured in Lhuentse while in Mongar, there were 9 deaths and 22 injuries because of motor vehicle accidents (*RBP, 2021*).

Road renovation projects

The two following road renovation projects are considered:

- **Plans for the road widening and the 13 FYP and for connectivity to Nganglam** – The road widening is planned for Nganglam as this is very narrow and risky, but currently there are budget constraints so this will probably not be implemented in the 13FYP. The recently damaged bridge at Nganglam requires a permanent bridge as the current bridge cannot bear the expected project load. This is the only bridge that requires rebuilding- all other bridges are permanent so can carry up to 40MT-50MT. It is recommended to consult with MOIT as the Ministry may need to reprioritize the expansion works sooner.
- **Autsho-Lhuentse road widening**- The stretch extends from Gangola to Lhuentse and DPR has been completed and the widening will commence very soon (within the next two months). The work will be awarded in two packages covering 30 km till Autsho as a budget needs to be sought for the additional stretch to Lhuentse.
- The concern is the submergence area. It is not possible to realign the road now because the cost will escalate. On the other hand, road widening will take at least 4-5 years depending on fund availability and widening will not have reached the submergence area and may be taken up by the project.

8.2.5.5.3 Local level

Over the last year, the villagers have observed development in the field of transportation, with an increase in road traffic. The table below describes the road infrastructures in the villages.

Table 154: Description of road and trails by the communities

Village	Road infrastructure
Autsho	The main highway runs through Autsho settlement. The highway comes from Mongar and goes along to Lhuentse Dzong. This is the main highway and from this we can see roads which branch down to different areas of outsource settlement. For example, there is a road going down to the Department of Road Office and Camp and to the Automobile Workshop. There is also a feeder road coming down to the Forest Office, the Autsho Hospital and BHU and there is a road coming down to the school and the Autsho central school. There is a road also going up to Namdroling Gonpa which is a significant place here and and to Chalibadeb village.
Banjar	The GC all-weather road runs mostly above the settlements and culminates at the Gewog Office. From this, some farm roads serve at least four settlements.
Chhali	The main road goes up from the National Highway which serves the several chiwogs and at the gewog centre which is located at Chulibi chiwog.
Drangmaling-Nangar	There is a farm road which is aligned by crossing the Meralungchu which connects Drangmaling and goes above Artochan and connects to the Gewog Centre Road which goes to Tsamang School and there is also a farm road which connects from the Gewog Centre Road to Nangar Community.
Gyelposhing	The main highway to Nganglam, and the highway proceeding to Mongar passes through the settlement. There is a diversion however, but one can also reach the Nganglam highway by driving through the town. Besides that, there are small approach roads going down to different areas such as the VIP colony, the Khurichu hydropower office as well as the BPC colony and Royal Cottage. The settlement receives piped water from the Drepong and Tsangkhar sources.
Lingmethang	There is access roads diverted from the national highway to the Gewog Centre and BHUU as well as to the other Government offices, the farm and agro-processing plant and the Park Office.
Tokari	The Gewog Centre (GC) all-weather road runs roughly through the middle of the community from which two farm roads, the Tokari farm road and the Banjar-Gangtho farm road brach out to serve villages in the eastern area of the community.
Tsakaling	There are several roads which connect each of these chiwogs. For example, from the Mongar-Lhuentse highway, the Gewog Centre road cuts across mostly all chiwog serving the RNR Centre but goes beyond to Drengling as well as Drungtoed chiwogs. The chiwog therefore is well connected with the GC and farm roads connecting the hamlets.

The following map summarizes the transportation infrastructures in the survey area:

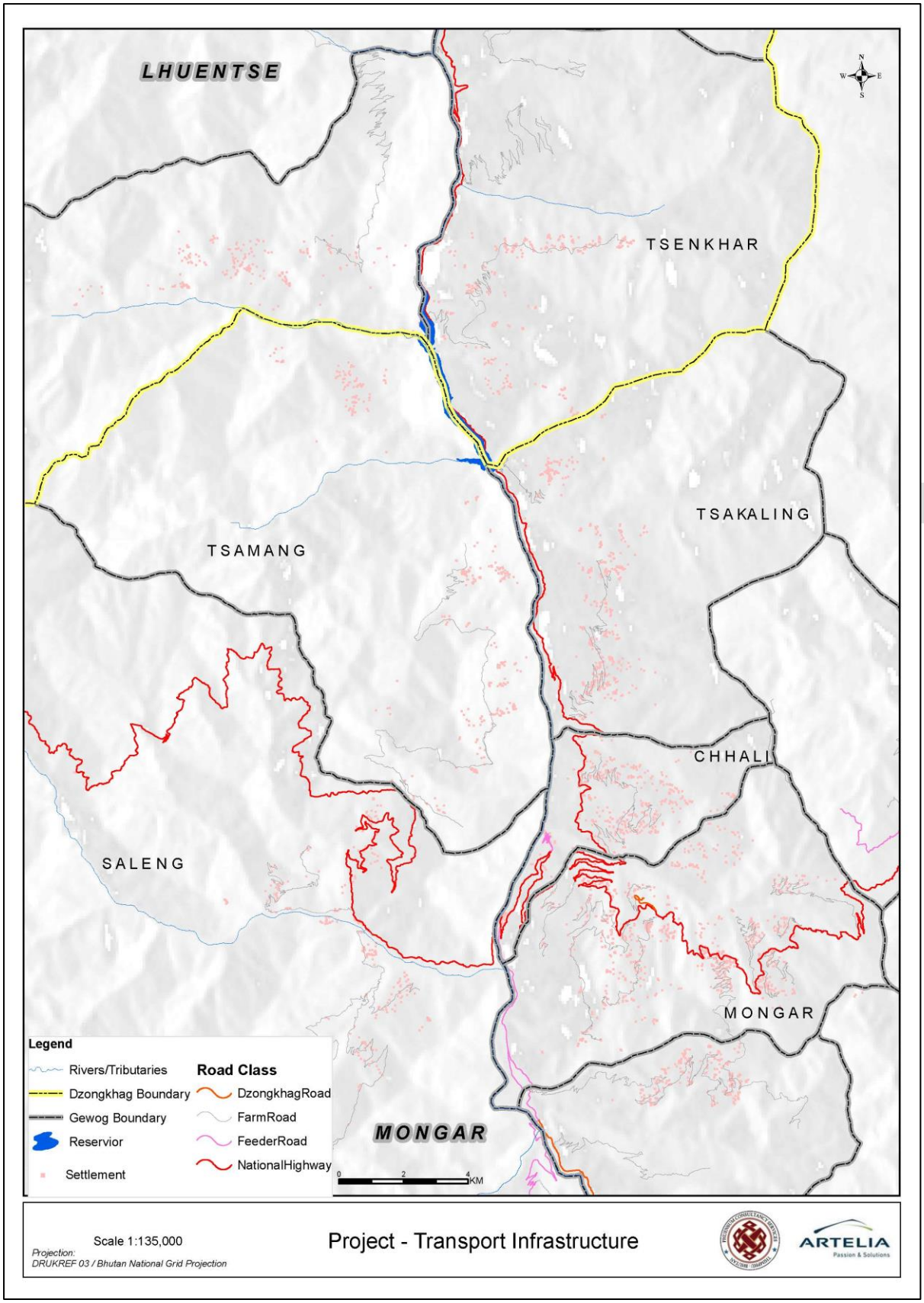


Figure 153: Transport infrastructures

Table 155 summarize the key findings of the survey concerning the transportation topic network per Gewog:

Table 155: Transportation network per Gewog

Gewog	Transportation network
Tsamang	The gewog has access to a total of 88.9 km long road which is categorized as highway (49 km), Farm Road (31.3 km) and GC Road (8.63 km).
Tsakaling	The highway to Lhuentse runs through the Gewog acting as a main artery for economic development. Most villages are now connected with farm roads. Gewog has a total of 55.6 km of road access. These are categorized as Highway (21.7km), Farm Road (22.6km) and GC road (11.3km).
Mongar	The gewog has a total of about 73.07km of road access. These are categorized as Highway (2.4km), Farm Road (53.65km) and Feeder Road (17.02km).
Saling	The gewog has a total of 94.8km. These roads are categorized as Highway (2 km) and farm road (92.8 KM).
Chhaling	The gewog has a total of about 42.8 km of road access. These are categorized as Farm Road (7.8km) and Farm Road (42.8km). There are about 130 or more people who own vehicles including power tillers and about 50 people who only own vehicles.
Drepong	The gewog has access to a total of 82.15 km long road which is categorized as highway (30 km), Farm Road (31.15 km) and GC Road (21 km).
Tsenkhar	Tsenkhar Gewog has 161.7km of 15 farm roads, and 0.05km of Gewog centre road.

8.2.5.6 Telecommunication

8.2.5.6.1 National level

There are three FM Stations, Kuzoo FM, Radio Valley and Centennial Radio, one broadcasting station (Bhutan Broadcasting Services) and two newspapers (Kuensel and Bhutan Times). There are telephonic and internet services providers Bhutan Telecom Ltd (BTL) and Tashi InfoComm Ltd. (TICL). The first also provides fixed line services in addition to the mobile network and internet services.

There are 19,680 fixed lined phone connections, 465,104 BMobile and 312,904 Tashi cell subscribers nationwide.

Of all the households in the country, 70.0% of have television connection (NSB, 2022. BLSS survey) and 98% of households in the country use mobile phones (95% own smart phones). On average, a household owns 2.7 mobile phones, and 99.60% of households in the country have internet connection, mostly mobile internet connection (96.0%). About 4.0% have other connections such as broadband, leased line and data card/Wi-Fi dongle.

For Postal services, there is one national service (Bhutan Postal Service) and three private (DHL, DrukBees, Tamu) large private services and a few smaller ones. The Bhutan Postal Service is the only service with national coverage. There are 4 general post offices, 39 post offices, 6 community mail offices and 43 fax offices in the country (NSB, 2022. Annual statistics taken from Bhutan Postal Corporation Limited).

Every gewog has a community information centre (CIC) to provide public services through a single window. These provide offline services printing, photocopying, government to citizen services where any person can avail online registration, tax, permits, clearances, payments, census and student services.

8.2.5.6.2 District level

Lhuentse has 488 fixed phone line subscribers. 89 internet connections and 2 cable TV operators, while Mongar has 527 fixed phone line subscribers,435 internet connections and 8 cable TV operators (*NSB, 2022, Dzongkhag at a Glance 2022*).

Table 156: Telecommunication facilities in the dzongkhags, 2021

Description	Lhuentse	Mongar
Telephone connections (Nos.)	488	527
Internet lease line connections (Nos.)	8	125
Internet broadband connection (Nos.)	81	310
Cable TV operators (Nos.)	2	8
% of HH with TV	70.3%	64.8%
% of HH with Smartphone	90.4%	93.4%
% of HH with other phone	32.3%	35.8%
% of HH with Computer/laptop	20.2%	14.8%

Source: Compiled from NSB, Annual Statistics, Dzongkhag at a Glance, 2021, 2022 and Bhutan Living Standards Survey 2022

8.2.5.6.3 Local level

The 4G mobile phone coverage is comprehensive and efficient in both districts, ensuring almost 100% connectivity. In more remote communities, Tashi Cell is the primary provider of mobile telephony, offering robust and reliable service. Meanwhile, Bhutan Telecom caters to the rest of the areas with its high-quality network. While broadband internet coverage is typically concentrated in urban areas and gewog administration offices, the rural population enjoys seamless and full access to high-speed internet through advanced mobile technologies. This widespread availability of 4G ensures that quality internet access via smartphones is the norm across the region.

8.2.5.7 Shops and Markets

8.2.5.7.1 National level

The country has large urban towns in Thimphu, Phuentsholing, Samdrup Jongkhar and Gelephu and smaller towns within the districts. The largest town in Thimphu has a population of over 100,000 people, Phuentsholing has less than 30,000 people while other towns have less than 10,000 people (*NSB, 2022, Annual Statistics*). The larger towns in the districts are at the district centres where all government corporations and private business are located. During weekends, the farmers from rural areas bring their farm produce to the market for sale and make their own purchases during such visits. In the rural areas, a few shops, restaurants, and bars are scattered mostly along access roads to the villages or near settlements.

8.2.5.7.2 District level

Mongar Dzongkhag has 6 towns, including Mongar town. All the towns together have a population of less than 11,000 people. The largest town is Mongar town as this is the Dzongkhag centre housing all the government offices, national referral hospital, resorts, and the Mongar Gewog office. After Mongar town, Gyelpozhing and Lingmethang are the two larger towns. Gyelpozhing has the Kurichhu Hydropower Plant and while Lingmethang houses many of the eastern regional offices, the Gyelsuung Project and the Bhutan Agro Industries Limited. There are only 2 fuel and gas depots in Mongar and Gyelpozhing.

In Mongar there are a few market sheds in Gyelpozhing. In Chhaling, the community has 8 grocery stores.

Lhuentse has only two towns. Lhuentse Town is about 70km from Mongar town, while Autsho town is approximately 40km from Lingmethang and about the same distance from Lhuentse. Most of the communities from gewogs visit these four towns depending on the distance for their purchases.

8.2.5.7.3 Local level

At the local level, there may be a few people who see a business opportunity with enhancement of rural connectivity through farm roads to establish administration shops (small business establishment located near Gewog Administration offices. These shops typically emerge to capitalize on the increased connectivity provided by farm roads, catering to people visiting the area for administrative, health, or educational services). Therefore, a few shops can be found mostly near Gewog Administration offices to cater to people coming to the centre to access various administrative services as well as other social service such as health and education. See some photos in the ESIA Volume 3 Appendix E – Social 1st Field Report.

8.2.5.8 Bank services, credits and savings

8.2.5.8.1 National level

The Royal Monetary Authority is an autonomous Central Bank of Bhutan that handles issues of the national currency, the management of the external reserves and foreign exchange operations. It also handles licensure, regulation and supervision of financial institutions of Bhutan.

In 2023, the average exchange rate between the Ngultrum (BTN), Bhutan's national currency, and the USD is approximately 82.5053 BTN. Over the past 5 years, Bhutan has seen an average annual inflation rate of approximately 4.87%. Looking at a longer time frame, the average annual inflation rate over the past 10 years is approximately 5.18%. (*Source: https://www.rma.org.bt/about_rma_background.jsp*).

There are 9 financial institutions that provide their services in Bhutan. 5 banks (Bank of Bhutan, Bhutan National Bank, Druk Punjab National Bank, T Bank Ltd, and Bhutan Development Bank) provide personal banking (current and saving accounts), corporate banking, loans, and international transfer services.

The National Pension & Provident Fund provides loans and pension plans to only civil servants and the Royal Insurance Corporation of Bhutan Ltd and Bhutan Insurance Ltd provide insurance services and loans. BDBL is the only Development Bank that provides seasonal and other small and medium-term loan and banking services to the rural farmers. It also provides term and working capital loan to industrial, commercial and agricultural enterprises in Bhutan.

Table 157: Branch and Extension Offices for all financial institutions and their availability in Lhuentse & Mongar

Financial Institution	Branch Office	Agent/Extension/ Field Offices	Lhuentse	Mongar
Bank of Bhutan Limited	54	312	Yes	Yes
Bhutan National Bank Limited	11	22	No	Yes
Druk Punjab National Bank Limited	8	-	No	No
T Bank Limited	10	-	No	Yes
Bhutan Development Bank Limited	33	26	Yes	Yes
National Pension & Provident Fund	4	-	No	Yes
Royal Insurance Corporation of Bhutan Limited	25	-	Yes	Yes
Bhutan Insurance Limited	4	8	No	Yes

Source: www.bob.bt, www.bnb.bt, www.bil.bt, www.tbankltd.com, www.bdb.bt, www.nppf.org.bt, www.drukpnbbank.bt, www.ricb.bt

The Druk Punjab National Bank is not available in both the project districts, but the Bank of Bhutan and Bhutan National Bank Limited have branches in both Lhuentse and Mongar.

Digital financial inclusion

The document "Current State of Financial Inclusion in Bhutan and the Way Forward" (https://www.rma.org.bt/RMA%20Publication/papers/2021/The%20current%20state%20of%20financial%20inclusion%20in%20Bhutan.pdf), published in 2022 by the National Financial Inclusion Collaboration" (NFIC), reports on the digital financial situation in Bhutan. It provides insights into Bhutan's efforts to promote financial digital inclusion and the challenges it faces in achieving greater financial inclusion, especially in rural areas.

The country has set ambitious targets for financial inclusion, aiming to achieve 85% financial inclusion by 2023.

The Royal Monetary Authority (RMA) is leading efforts to promote financial inclusion through various initiatives, including the development of the National Financial Inclusion Strategy (NFIS) and Financial Inclusion National Action Plan (FINAP).

The document mentions the importance of infrastructure development to enhance financial accessibility. It notes an increase in the number of access points, including alternative delivery channels like ATMs, POS terminals, and agents. Mobile banking and e-wallet usage have also seen significant growth.

Having access to financial services is one aspect, but enabling their usage is equally important. The document highlights an increase in the percentage of adults with bank accounts in Bhutan, indicating a positive trend in financial inclusion. However, there are still challenges, such as low financial literacy, especially in rural areas.

The document also discusses the role of regulatory frameworks, such as the Regulatory Sandbox (RS) introduced by the RMA, in responding to emerging technologies and fostering innovation in the financial sector.

8.2.5.8.2 Local level

8.2.5.8.2.1 Credit

Of the households surveyed, 55% of the sampled population has taken out at least one loan during the year. The typical lenders are mostly banks, which 91% respondents. On a smaller scale, CSOs (4%), relatives (3%) or friends (2%) can also be approached for a loan.

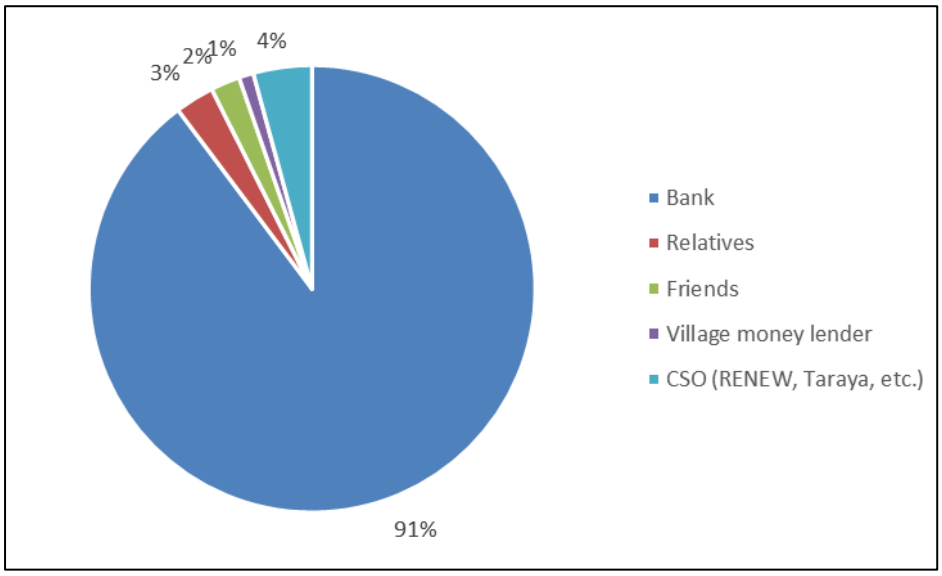


Figure 154: Source of loan in the survey area

Most loans are made to renovate a house (19% of loaners) or invest in a business (15% of loaners), but also for agricultural (6% of loans are made for buying agricultural inputs), land (5%) or education (5%) needs.

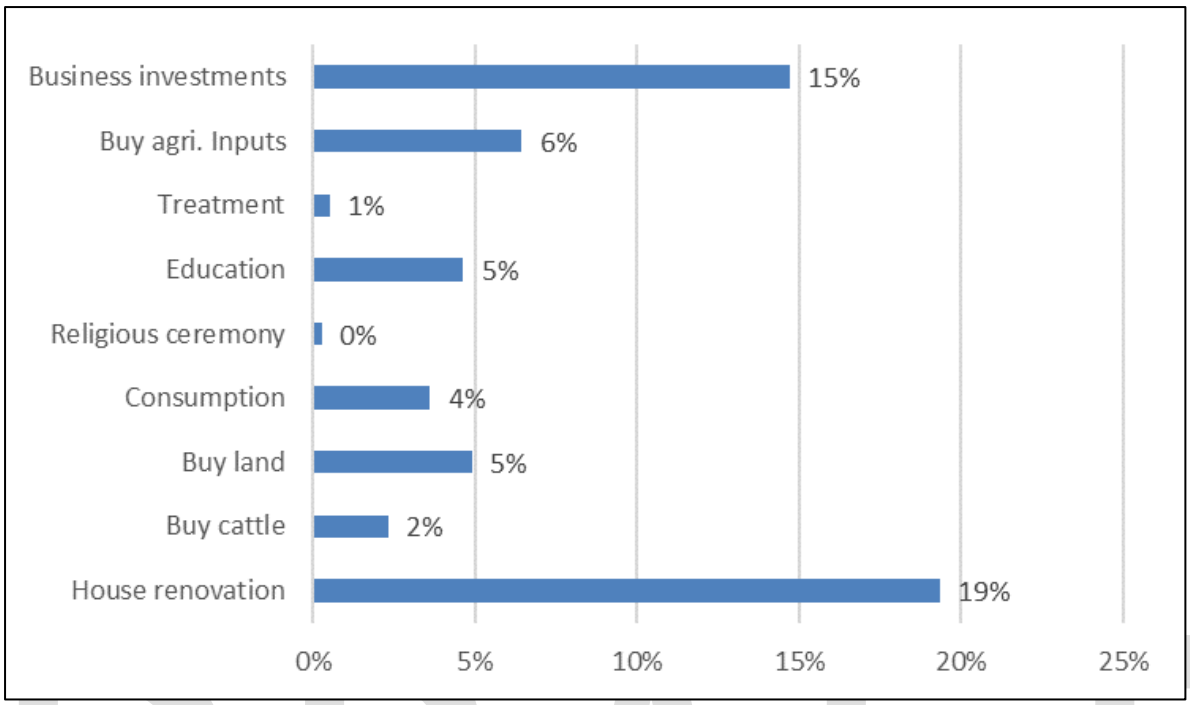


Figure 155: Main reasons for taking out a loan

There are disparities between Gewogs regarding the question of taking out loans, with Drepong (67%), Saling (59%) and Mongar (52%), while in Chhaling, only 25% of the population do so.

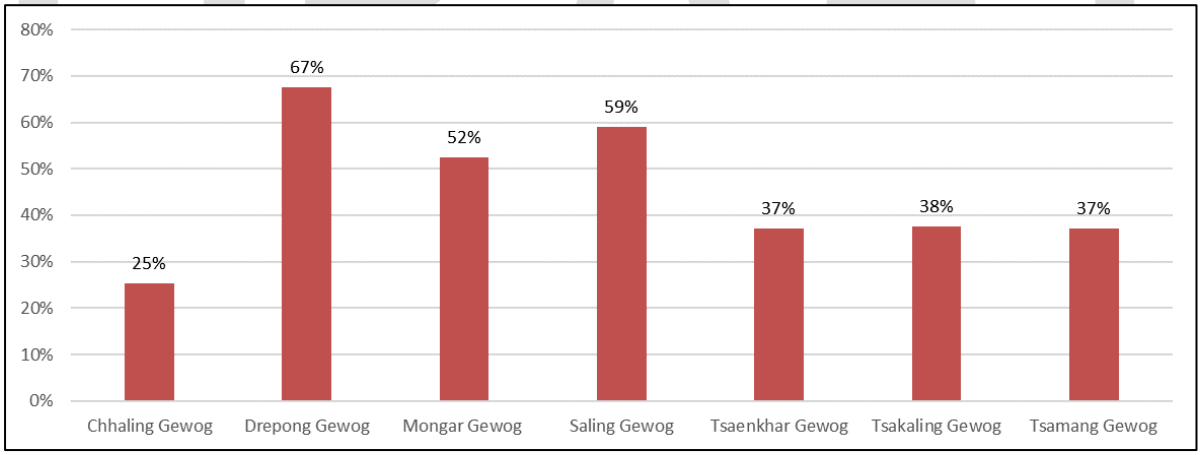


Figure 156: Proportion of households that have taken a loan during the previous year, per Gewog

The survey did not reveal any disparities between men and women when it comes to loans: women are almost as likely as men to pay a loan, and most respondents (29%) said that both the man and the woman repay the loan.

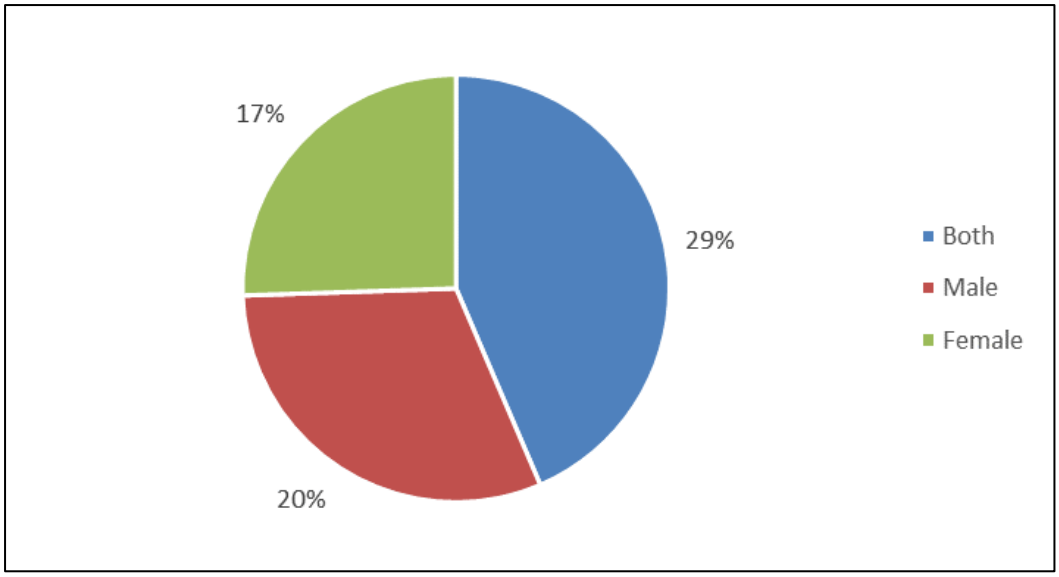


Figure 157: Who pays the loan, by gender

8.2.5.8.2.2 Savings

Almost half (54%) of the survey respondents said they had savings. This figure varies by Gewog: Tsaenhkar has a higher number of people owning savings, while Tsakaling has a lower number (see Figure below):

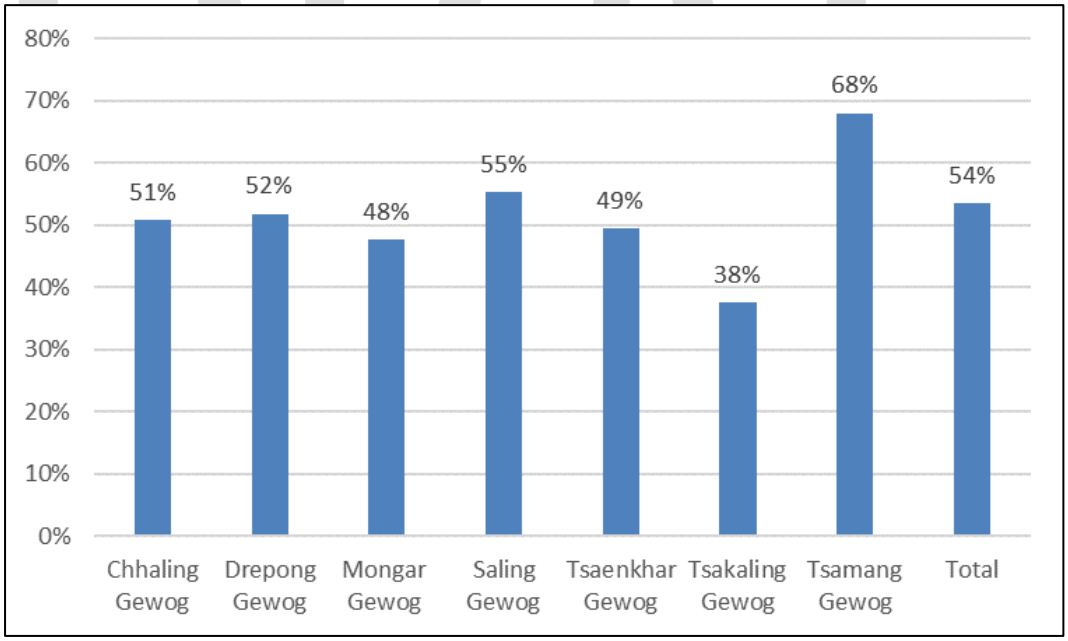


Figure 158: Proportion of households that have savings

70% of respondents with savings have the equivalent or less than 50,000 Ngultrum (BTN), equivalent to around 550 euros. 16% have between 50,000 and 100,000 BTN (1,100 euros) to spare, and 10% have between 100,000 and 300,000 BTN.

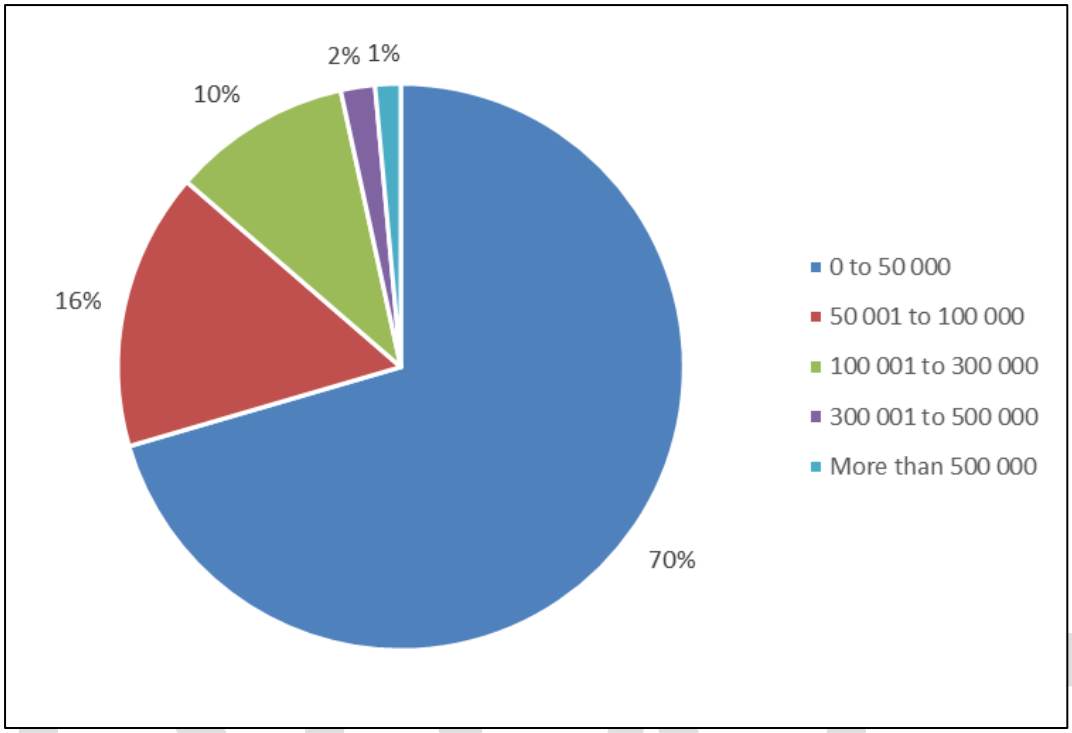


Figure 159: Amount of savings in BTN

The Gewogs of Chhaling and Drepong have more households with large savings (over 100,000 BTN), while the Gewogs of Tsakaling and Tsamang have more respondents with smaller savings (Figure 159). A large majority of respondents keep their savings in the bank (86% of respondents). Of the remaining respondents, 5% entrust their savings to relatives or keep them at home (3%) (Figure 161).

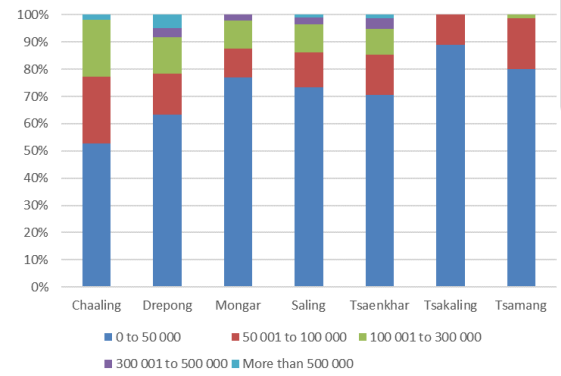


Figure 160: Amount of savings, by Gewog

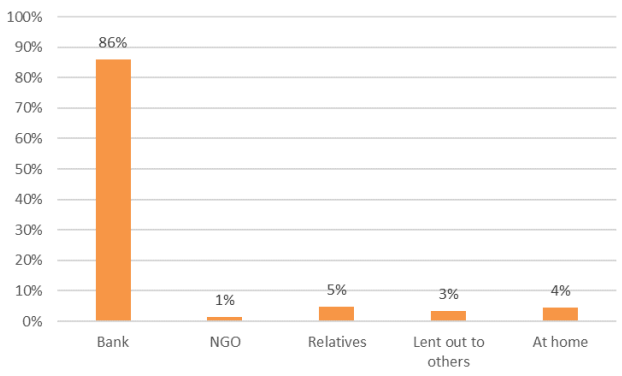


Figure 161: Where are the savings kept

8.2.5.9 Security, safety and public order

8.2.5.9.1 National level

8.2.5.9.1.1 Social protection

Social protection in Bhutan in the past has focused on the provision of free health and education (including school feeding programs and starting from ECCD centres).

Those employed in the civil service can avail maternity Leave for six months (applicable for mothers of legally adopted newborn babies) and Paternity Leave to ten working days. These employees are also eligible for Earned, Casual, Medical, Bereavement Leave and Extraordinary leave and Pension. Such leaves are also provided in varying degrees in non-government, corporate and the private sectors. Depending on their

work, they are also eligible for difficulty allowance (A Difficulty Allowance shall be paid to a civil servant including contract employees, GSP and ESP posted to a place beyond one dholam from the motorable road), uniform allowance and overtime allowance.

The establishment of **the National Commission for Women and Children (NCWC),** in 2004 contributes to social welfare: it mainstreams, promotes and protects the rights of women and children in the country. This is the Competent Authority for ensuring compliance with the Domestic Violence Prevention Act 2013.'

The kidu functions as a welfare system and is under the prerogative of the King of Bhutan. This is especially beneficial for those who fall through the system and are left out of social policies. Kidu categories include provision of land for the landless, income supplements through provision of a living allowance for the destitute and impoverished (The 'destitute' and 'impoverished' categories included orphans, children raised by single parent or relatives, children of landless farmers, children born to families with no or little cash income, disabled children with no support and old people without any source of income or family to support them.), scholarships for poor students from families that cannot afford to send their children to school despite the free education provided by the government. Kidus is also granted during times of disaster, in terms of free medical treatment abroad, pardoning and reducing prison sentences, and granting citizenship. Each Dzongkhag and gewog have a kidu coordinators (in addition to their regular function/ post), who identify those needy of Kidu and submit these to the Kidu office in Thimphu.

The Department of Employment and Entrepreneurship Labour under MoICE, provides services to ensure gainful employment opportunities, entrepreneurship, self-employment, skills development, for all including persons with disabilities, employment advocacy & awareness, career guidance services to job seekers, enhance school-to-work transition programs.

The Department of Labour is responsible for promoting a fair social protection and welfare system in the country, protection of workers' rights and vulnerable groups, ensuring job security at the workplace, decent working conditions and safer working environments, and poverty alleviation through benefits like provident fund, gratuity & various compensation programs for injury, accidents, death, leave, and enforcement of related labour acts and regulations.

Farmers benefit from specific support and assistance through:

- The Regional Agricultural Machinery centres, as well as Agriculture and Livestock Extension Offices, Agriculture seed production farms, Farm sale shop. It can consist in the provision of electric fencing against human wildlife conflict, plant protection and pest management services.
- Farm Machinery Corporation Limited (FMCL), a state-owned enterprise, provides farming mechanization goods and services to the farming community at affordable prices. To enhance the accessibility of farm machineries to the farmers who cannot afford to own farm machines, the FMCL operates via two modules: Central Hiring via Regional centres, and Gewog hiring via the Gewog Dzongkhag focal person /Farm manager/Gewog power tiller operator appointed by FMCL at 50% subsidized rates to end users by the Government in a form of subsidy injection to FMCL (http://fmcl.bt).
- The Regional Agriculture Machinery Centre (RAMC) in Khangma, Trashigang that provides farm mechanization services to six eastern Dzongkhags (Trashigang, Mongar, Lhuentse, Tashi Yangtse, Pema Gatshel and Samdrup Jongkhar). The centre provides training for farmers, school dropouts, students, and technical training institutes students free of cost on operation, maintenance of farm machines and farming technologies (http://www.amc.gov.bt).

CSOs/ NGOs and independent initiatives are also available for specific needs:

- **The NGO Respect, Educate, Nurture, and Empower Women (RENEW)** established in 2004 to empower survivors of domestic and Gender Based violence. Services provided by RENEW include free counselling, community-based support system, shelter for victims (Gawaling Happy Home), free legal advice, assistance and representation, educational support to vulnerable children (abandons, neglected or survivors of domestic/sexual/gender-based violence), medical aid and micro-finance for rural women in ten Dzongkhags and advocacy, training, youth programs and livelihood programs (RENEW website. renew.org.bt).
- Ability Bhutan Society (ABS), established in 2011, aids children living with diverse abilities provide early intervention (home, school, centre based) programs, family empowerment forums, advocacy and awareness, capacity building (https://www.draktsho-bhutan.org/),
- Disabled People's Organization of Bhutan (DPOB) legally registered with the Civil Society Organizations Authority on 26th November 2010 functions as a platform to represent all persons with disabilities in policy formulation, legislations and programmes that impact the lives of persons with disabilities. (https://dpobhutan.org/)
- Draktsho (https://www.draktsho-bhutan.org/) provides vocational training to young people with disabilities and has a centre in Trashigang.
- The PEMA provides health care services (treatment, rehabilitation, reintegration) for persons with mental health condition (https://thepema.gov.bt/)
- Tarayana Foundation, established in 2003 provides multi-sectoral support to people living especially in rural areas. The Foundation provided housing, energy, and rural entrepreneurship to enhance rural livelihoods and reduce poverty. (https://www.tarayanafoundation.org/

8.2.5.9.1.2 Armed forces

The branches of the armed forces in Bhutan are the Royal Bhutan Army (RBA) with approximately 8,000 active personnel; Royal Bodyguards (RBG), an elite unit with a strength of more than one thousand soldiers; and the Royal Bhutan Police (RBP), with numbers not available. Bhutan does not have an air force, nor a navy. Other immigration and customs laws are enforced by the Department of Immigration. The Indian Army maintains a training mission in Bhutan, known as the Indian Military Training Team (IMTRAT) that is responsible for training the RBA and RBG personnel. It is headquartered in Haa in Western Bhutan. Project DANTAK of the Border Roads Organisation, a sub-division of the Indian Army Corps of Engineers, has been operating in Bhutan since May 1961. Since then, Project DANTAK has been responsible for the construction and maintenance of over 1,500 km of roads and bridges. It has headquarters in Thimphu. Regarding compulsory service, it was customary, but not obligatory, for one son from each Bhutanese family to serve in the army. The service in the RBA is voluntary and the military age is 18.

(Source: https://factsanddetails.com/south-asia/Bhutan/Government_Justice_Military_Bhutan/entry-7924.html)

8.2.5.9.1.3 Royal Bhutan Army

The Royal Bhutan Army is responsible for maintaining the country's territorial integrity and sovereignty against security threats. The King of Bhutan is the supreme commander in Chief of the RBA. The Chief Operations Officer is Goonglon Wongma (Major General) Batoo Tshering.

The RBA consists of its headquarters in Thimphu, a training centre in Tenchholing, Wangdue Phodrang, and four operational wings in Changjukha (Gelephu), Damthang (Haa), Goinichawa (Paro), and Yonphula (Trashigang).

(Source: https://www.globalsecurity.org/military/world/bhutan/army-orbat.htm)

8.2.5.9.1.4 Royal Bodyg Guards

The RBG is a branch of the RBA that is responsible for the security of the King, the Royal family and other VIPs. They consist of three companies all located in Thimphu.

8.2.5.9.1.5 Public Order

The **Royal Bhutan Police** is responsible for maintaining law and order and the prevention of crime in Bhutan. They have 5 branches:

- 1. Additional Chief of Police (made up of the Information & Communication Division and the Planning & Research Division)
- 2. Special Police Branch (made up of the Prison Service Division, Fire & Rescue Division, Security Division, and Traffic Division)
- 3. Crime & Operations Branch
- 4. Investigation Bureau (National Central Bureau – Interpol)
- 5. Administration & Finance Branch.

They maintain 13 divisions in Paro, Punakha, Phuentsholing, Samtse, Gelephu, Tsirang, Trongsa, Samdrup Jongkhar, Trashigang, Mongar, Thimphu, Wangdue, and Bumthang.

The Mongar Division (Divison X) has its headquarters based in Mongar Dzongkhag. The jurisdiction coverage includes Mongar and Lhuentse Dzongkhags with Mongar Police Station, Lhuentse Police Station, Gyelposhing Police Station and Weringla Outpost. (*source:* https://www.rbp.gov.bt/mongar)

There is no police station in Autsho, but there are stations in Lingmethang and Gyelpozhing and in Mongar and Lhuentse Dzongkkhags. Lhuentse has a Female Police Officer in Charge. The other police station has female constables but no female officers.

8.2.5.9.1.6 Crimes

The total number of criminal incidents in the country between 2018-2022 was 17,778, an average of 3556 cases a year. In 2022, of the 996 cases against a person, 778 were battery cases, 15 child molestation, 10 rape attempts, 63 rape cases, and 19 sexual harassment cases.

Non-criminal incidents include natural death, unnatural death, attempted suicide and missing of persons. The average number of non-criminal incidents per year between 2018-2022 was 420. There has been a gradual decrease in the numbers of non-criminal incidents from 512 to less than 400 in 2022. Un-natural death and missing of persons were the commonly reported non-criminal incidents in 2022 with 190 people dying (112 suicide cases) and 155 people reported missing respectively.

8.2.5.9.2 Regional level

In the last 5 years, the average annual number of criminal cases in Lhuentse is 23, while in Mongar it is 57. Details on the type of criminal cases in each Dzongkhag are not available. In terms of non-criminal incidents, there were 4 and 10 cases reported in Lhuentse and Mongar respectively. Of these 2 were suicide cases in Lhuentse and 4 were reported from Mongar.

According to Regional government agencies, there are no social conflicts related to the presence of expat workers normally, especially as they do not engage in local festivities and religious occasions. The foreign workers have their own festivals, and the Royal Bhutanese Police also ensures the security for these events. So far there have been 1-2 cases of rapes reported and linked to foreign workers.

8.2.5.9.3 Local level

At the community level, the village head (Tshogpa) assures that people have a platform to air their grievance and as the first point of contact, the tshogpa will mediate conflicts to resolve it locally. If it cannot be

resolved at the village level, the complainants can escalate it to Gewog. Though the Royal Bhutan Police is not available at village level- because there are no regular needs, however their services can be availed for any crimes against persons.

Women raised some cases of GBV and domestic violence- related to previous projects (1-2 cases related to Kurichhu HPP construction, Hospital construction) or within their household or relatives's households. They consider that domestic violence is the result of alcohol consumption and they or (i) resolved it privately by divorcing, or (ii) called Tshopgpa. Women also have access to RENEW's volunteers at the district level who receive and react on complaints received on domestic violence among others. The tshogpa in coordination with the Kidu Officer based at the Dzongkhag Administration and the gewog identifies vulnerable people and refers them for welfare support from His Majesty's Kidu Fund.

At the local there are no military or other armed personnel posted. However, during emergencies, army and desungs may be deployed also at local level to deal with natural disasters and to contribute to humanitarian effort to redress impacts of disasters. At the local level, voluntary patrolling and search teams may be constituted during emergencies to aid the armed forces.

In Tsakaling, alcoholism has reduced due to the bylaws and resolutions passed within the community where alcohol consumption is prohibited during social gatherings and rituals. Mostly the rural communities are law abiding so safety is not an issue in the project gewogs.

8.2.6 Livelihood and Economic Activities

Key points from livelihood and economic activities

Bhutan's economy has grown significantly, largely due to the hydropower sector, with a notable contribution from tourism. Despite this growth, the **informal sector remains a substantial** part of the workforce. At the **local level, agriculture and livestock are the primary activities**. However, there is a **lack of diversification** and **limited flat land for agricultural development**. Livestock is a significant part of the rural economy, with **substantial ownership rates and its use for both consumption and sale**.

Bhutan's economic structure is divided into primary (agriculture), secondary (industrial), and tertiary (service) sectors. Despite recent declines in **agricultural** growth, it **remains a major employer**. The secondary sector is varied but not fully operational across all licenses. In the tertiary sector, services dominate, but tourism has faced setbacks. Employment trends show **higher agricultural employment in certain districts compared to the national average**, with a **gender disparity** in various occupations.

Farming in the study area is mostly **small-scale and traditional**, focusing on self-consumption with some surplus for sale. **Female participation is notably high in agriculture**. Livestock farming is diverse, with variations based on geographical and personal factors. Land ownership shows a higher percentage in rural areas, with a significant portion owned by women, indicating a possible matrilineal and matrilocal inheritance pattern in certain districts.

8.2.6.1 National and regional level

Bhutan's economy, as a lower-middle-income country, has seen significant growth over the last two decades, leading to substantial poverty reduction. This growth, averaging 7.5 percent annually since the 1980s, is primarily driven by the public sector-led hydropower sector and robust performance in services, including tourism. Bhutan's strong economic and strategic relations with India are pivotal, especially as a major trading partner, foreign aid source, and buyer of surplus hydropower (World Bank, 2023). In terms of GDP per capita, Bhutan was ranked 113th globally with a GDP per capita of $8,720, as reported by the International Monetary Fund in 2017 (World Economic Outlook database, October 2017). The economy comprises three main sectors: the primary sector contributes 19.19%, the secondary sector contributing 34.20%, and the tertiary sector being the largest contributor at 46.61%. The year 2021 saw the Bhutanese

economy grow by 4.09%, with significant contributions from agriculture (19.19% of GDP), hydropower generation (15.64%), trade (10.82%), and transport, storage, and communications (8.93%).

Agriculture, within the primary sector, includes farming, livestock, and forestry. There has been a recent decline in agricultural growth, partly due to a decrease in crop production like buckwheat, wheat, and barley. One reason for this decline is the conversion of agricultural land for development, as highlighted by the Bhutan State of the Environment Report (NEC, 2022), which reported a loss of 533.47 acres of kamzhing and 77.51 acres of chhuzhing between 2016 and 2021 for development activities. The limited increase in livestock productivity compared to population growth is also a concern. Still, this sector remains the largest employer in the country (MoICE, 2023), accounting for 43.5% of Bhutanese individuals are engaged in the agriculture sector (Labour Force Survey Report, 2023).

The secondary sector is categorized based on the scale of operations, with 31,707 active industrial licenses as of June 2023. Not all these industries are operational; some are under construction, while others have renewed licenses to maintain business activity (MoICE, 2023). The sector includes production and manufacturing, services, and construction. The industrial sector has the lowest employment rate in Bhutan, with 13.6% of the population employed in the industrial sector (Labour Force Survey Report, 2023).

In the tertiary sector, there were 21,528 service industries as of 2021, with the majority being small-scale businesses. This sector covers a range of activities, including wholesale and retail trade, hotels and restaurants, transport, storage, communication, finance, insurance, real estate, and private social and recreational services.

Tourism, a significant part of the economy, faced setbacks due to the increased sustainable development fee for international tourists and the impacts of the Covid-19 pandemic. The government's response included introducing unemployment aid to support about 30,000 Bhutanese directly affected by the crisis (diplomatie.gouv.fr).

Youth unemployment increased from 20.9 percent in 2021 to 29 percent in 2022, leading to a rise in outward migration (World Bank). The informal sector, predominantly rural and agrarian, accounts for about 80% of employment, with the highest proportion of informal jobs (93%) among workers with no schooling, closely linked to poverty (BTI transformation index 2022).

The bar graph in Figure 162 presents a comparison of employment sectors in Lhuentse and Mongar Dzongkhags (respectively 2 and 6% of the country's total employment) against a national benchmark. In both districts, agriculture farming is a significant employer, with Mongar showing a notably higher percentage than Lhuentse and surpassing the national average. Employment in private businesses is substantial in Lhuentse, reflecting a greater percentage than the national average and considerably more than in Mongar.

For government employment, both districts fall below the national average, with Lhuentse having a slightly higher percentage than Mongar. In the armed forces, Lhuentse representation is minimal, with Mongar slightly higher but still below the national figure. State-owned companies employ a moderate percentage of the workforce in Lhuentse and less so in Mongar, both under the national average.

Public limited companies show a small percentage of employment in both districts, with Mongar just above Lhuentse, yet both are below the national average. Employment in private limited companies is more prominent in Lhuentse compared to Mongar, with both exceeding the national average.

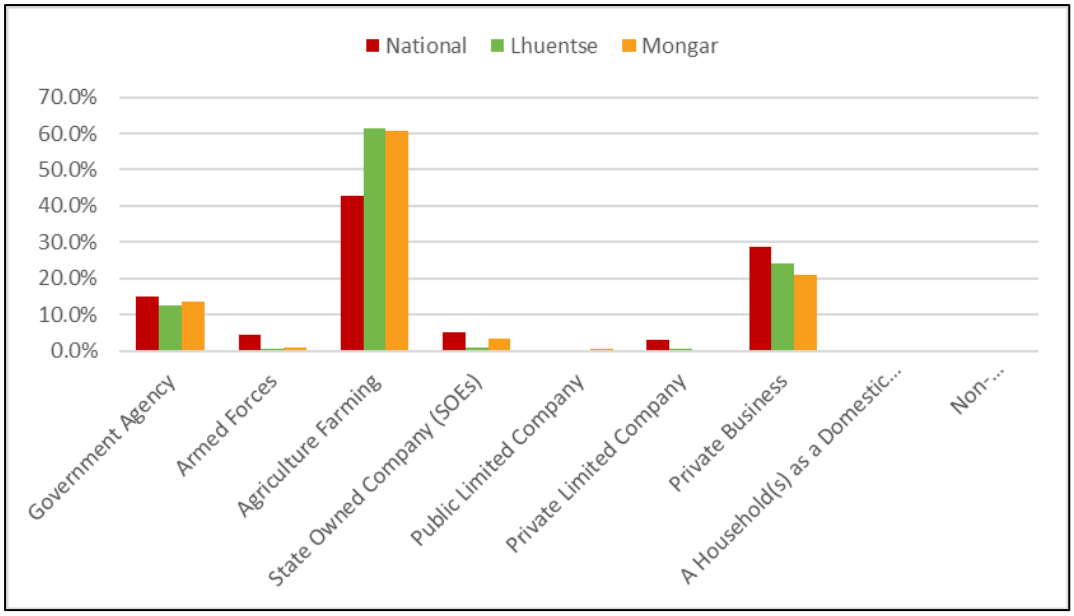


Figure 162: Employment Sector Comparison in Lhuentse, Mongar, and Nationally

In Lhuentse, women occupy key government roles, with employment figures showing 33 females to 107 males (http://www.lhuentse.gov.bt/staffs-of-the-dzongkhag). Mongar has a different distribution, with 30 females amongst 66 males, and women are not in positions of authority (http://mongar.gov.bt/about-district). In administrative roles within gewogs, women's participation is approximately 12-15%, while in civil service positions, it is higher at 24%.

The radar chart shown in Figure 163 reflects female employment across sectors in Lhuentse and Mongar, indicating an average female employment rate of 52%. Agriculture is the leading sector for female employment, particularly in Lhuentse. Private business in Mongar employs a higher percentage of women compared to Lhuentse.

In government agencies, private limited, and state-owned companies, female employment is lower than in the primary sectors. The armed forces and public limited companies record the least female employment in these districts. Overall, the data shows that female employment is predominantly in the agriculture and private business sectors.

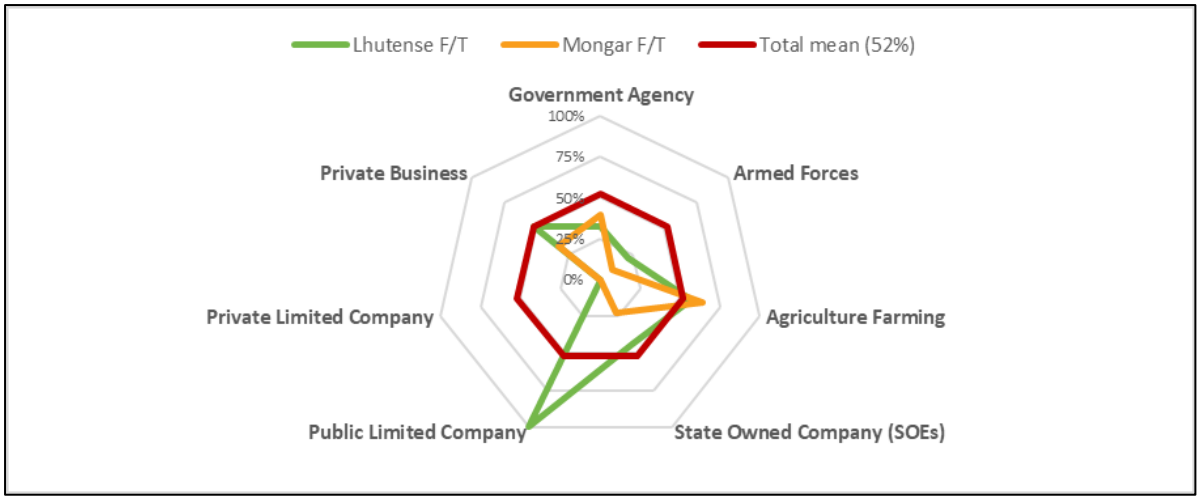


Figure 163: Female Employment by Sector in Lhuentse and Mongar

Agriculture in Bhutan covers only 2.75% of the land (DOFPS, 2017), with the sector being primarily subsistence-based and employing traditional farming practices. The arable land distribution includes 1.78% under dryland cultivation, 0.83% under irrigated/wetland cultivation, and the remaining 0.14% classified as orchards. Bhutanese farms average 3.7 acres in size (MoAF, 2019).

The limited agricultural land is due to the country's steep and rugged terrain, altitudinal variation, and lack of infrastructure, such as irrigation facilities. Agricultural production focuses on crops like irrigated and upland paddy/rice, maize, wheat, buckwheat, barley, millet, as well as oilseeds, legumes, quinoa, spices, roots, tubers, fruits, and vegetables. Livestock farming includes cattle, yaks, pigs, poultry, sheep, goats, and fish, with mixed farming systems common. Livestock products comprise milk, butter, cheese, meat, eggs, honey, and wool. Commercial farming is limited, with exports including fruits like apples, oranges, plums, arecanut, spices, and vegetables such as potatoes.

Regarding fallow land, 1,839 acres in Lhuentse and 6,072 acres in Mongar are fallow (MoAF, 2019), reflecting significant underutilization in an already limited arable landscape. Top farming challenges include irrigation problems, wildlife crop damage, and labour shortages. In terms of crop production, Lhuentse major crops are paddy and maize, while Mongar's maize production is substantially higher than paddy. Both Dzongkhags also grow wheat, buckwheat, barley, millet, quinoa, beans, vegetables, and spices.

In livestock, Mongar has almost double the cattle and poultry numbers compared to Lhuentse. Yak herding is more common in Lhuentse higher elevations, while sheep and goat rearing are less popular. Mongar hosts 14 fishery farms (NSB, 2022), diversifying its agricultural activities. The major livestock products from both districts include milk, butter, cheese, and beef, with poultry primarily for egg production.

8.2.6.2 Local level

The study area is predominantly **agricultural**. This is reflected in the occupations of the members interviewed households: of the survey population of working age (i.e. over 18), 42% are farmers. In this occupation, there are more women than men (57% for the former versus 43% for the latter).

The second most common occupation is **civil servant** (20%), with more men than women in this profession 70% male and 30% female). 15% of surveyed population has a **business**, with 65% of business are woman-owned and 35% are men-owned. However, while more women than men run businesses, their businesses are often small-scale (selling surplus agriculture products, staple foods, etc.), whereas men run larger-scale businesses.

The occupations with the most gender disparities include:

- **Monastic occupations**, with 91% men versus 9% women. This disparity can be explained by the fact that, until recently, monastic education was reserved exclusively for boys. While this is no longer the case, the number of monastic schools reserved for girls is still greatly lower than monastic schools for boys.
- **National army professions**, with 88% men and 13% women. As in every other country in the world, the military sector is dominated by men in Bhutan.
- **Civil servant**, with 70% men and 30% women. This gap between men and women in public jobs is aligned with the national trends, where women in Bhutan tend to have a shorter education than men (which explains why their propostition declines in the higher education levels). As a result, they are less present in skilled positions (in both the civil service and the formal private sector).

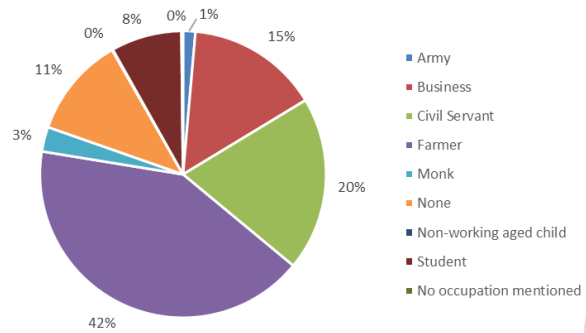


Figure 164: Main occupation of sampled population

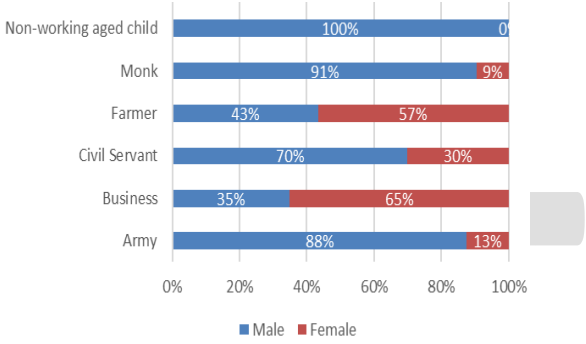


Figure 165: Main occupation of sampled population, by gender

Among the working population in the study area, we find 39% **employees** (divided into the following categories: casual employee (10%) and regularly paid employee (29%). Overall, there are more men than women in salaried jobs, while there are more women in non-formal work categories (like unpaid family worker). This is aligned with the national statistics, where only 14% of women are employed, compared to 41% of men.

While 26% of respondents are **self-employed**, 33% are **unpaid family workers**. This category is made up mainly of women (64% vs. 36% of men) who, in addition to being homemakers, often engage in one or more livelihood activities (farming or small-scale trading) to contribute to the household economy.

These disparities between men and women in the figures above suggest that in Bhutan, there still are societal beliefs that harm a girl's opportunity to enter the market, and therefore, reduces the total income she will make in her lifetime. This is aligned with the fact that the ratio of female to male students suddenly become very skewered by the time of college – a major factor in determining how high someone's income will be – comes around. There are also reasons why there are fewer women in engineering, industry, and construction. It could be associated with stereotypes about how field jobs like engineering and industry should be for men. It is also worth noticing that most part time workers are women.

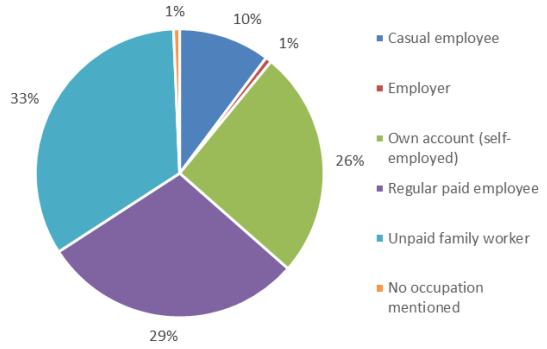


Figure 166: Employment status in the study area

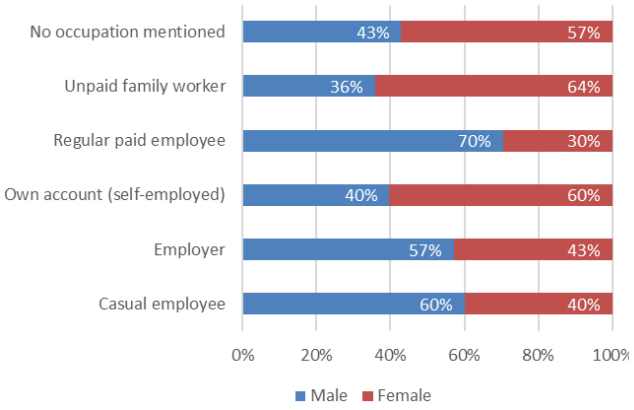


Figure 167: Employment status in the study area, by gender

8.2.6.2.1 Agriculture

In the study area, farming is practiced on a small scale, with each household cultivating its own plot of land with the main aim of consuming its own produce and selling any surplus. Farming is rarely mechanized, and households use mainly mechanic tools to do it.

Overall, 36% of respondents in the study area claim to own and cultivate a garden, 43% of respondents declare owning and cultivating a kitchen garden and 29% declare owning and maintaining a pastureland (see Figure 168 below).

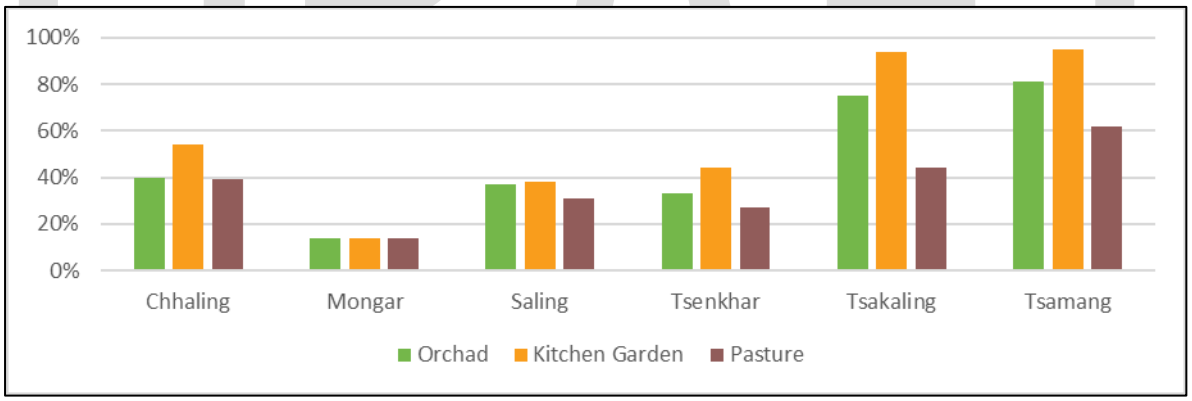


Figure 168: Proportion of respondents that own/cultivate an orchard, kitchen garden or pasture

The bar graph in Error! Reference source not found. provides insights into agricultural practices across v arious Gewogs, highlighting the prevalence of different types of land use. Tsakaling and Tsamang Gewogs stand out with a high percentage of both kitchen gardens and pastures, indicating a strong agricultural presence. Conversely, Mongar, Tsenkhar, and Saling Gewogs exhibit a lower proportion of these land uses, suggesting a reduced engagement in agricultural activities, which could be attributed to the proximity of urban centres influencing land use patterns. Orchard presence is relatively lower across all Gewogs, with Mongar having the smallest percentage, while Chhaling shows a more balanced distribution between orchards, kitchen gardens, and pastures.

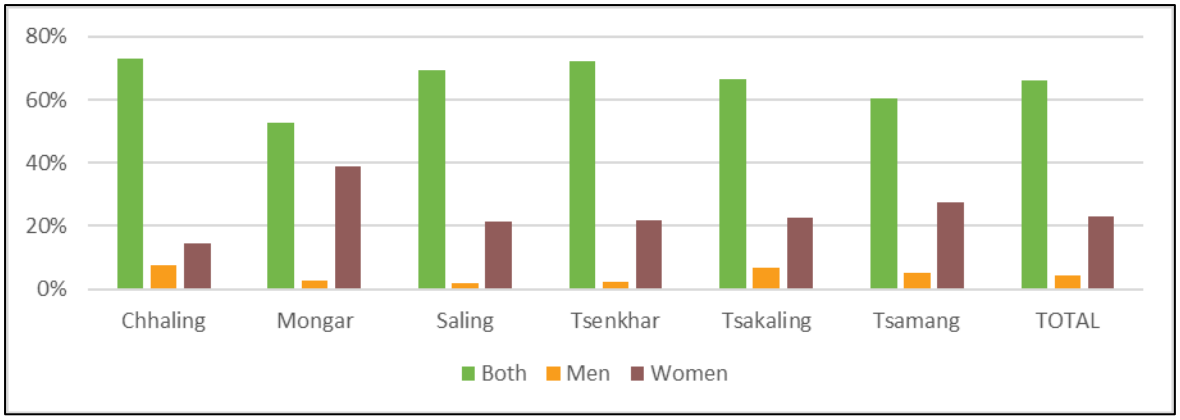


Figure 169: Gender-Specific Agricultural Activity Participation in Gewogs

It outlines gender participation across various agricultural activities, revealing a general trend of significantly higher female involvement compared to males, particularly in vegetable cultivation and non-wood forest product collection. The overall average for both activities across all Gewogs is predominantly joint, with women participating individually in vegetable cultivation at 35% and non-wood forest products at 22%, compared to men at 4% and 10%, respectively.

In cereal crops, Tsenkhar shows the highest joint participation (81%), with women's individual participation across Gewogs peaking in Mongar (22%). For vegetable cultivation, Mongar stands out with women's participation at 67%, the highest individual rate among all Gewogs. Cash crops also see higher female involvement, especially in Mongar, with women's participation at 56%.

When examining non-wood forest products, Chhaling has the highest joint collection rate (82%), with Mongar again displaying the highest rate of female collection (33%). These activities exhibit the greatest gender gaps, with female participation substantially exceeding that of males.

Breaking down by Gewog:

- In **Chhaling**, joint farming of cereal crops is at 72%, with women's individual contribution at 19%. Vegetable cultivation and cash crop production show similar trends in joint effort, while non-wood forest products collection is the most significant joint activity.
- **Mongar** presents a unique profile where women individually contribute to 22% of cereal crop farming and 56% of cash crop production, surpassing joint efforts in vegetable cultivation at 33%.
- **Saling** has joint participation rates of 70% in cereal crops and cash crops, with women individually contributing 30% in both sectors.
- **Tsenkhar** demonstrates the highest joint farming rates for cereal crops (81%) and cash crops (73%), with a notable 35% of vegetable cultivation attributed to women alone.
- **Tsakaling** shows equal individual participation from men and women in cereal crops at 14%. Vegetable cultivation and cash crops have higher joint participation rates, with equal contributions from both genders in non-wood forest products collection.
- In **Tsamang**, cereal crop farming has a joint participation rate of 67%, with women's individual participation at 29%. Women also lead in vegetable cultivation and cash crop production.

The aggregated data indicates that while joint participation is prevalent, female individuals are the main contributors to several agricultural activities, particularly in Gewogs closer to urban centres like Mongar. Men's contributions remain consistently lower across all activities and Gewogs.

As illustrated by Figure 170, the main species grown in agriculture are **maize, chili, beans and potatoes**. There are also oranges and spinach, as well as cauliflowers and rice.

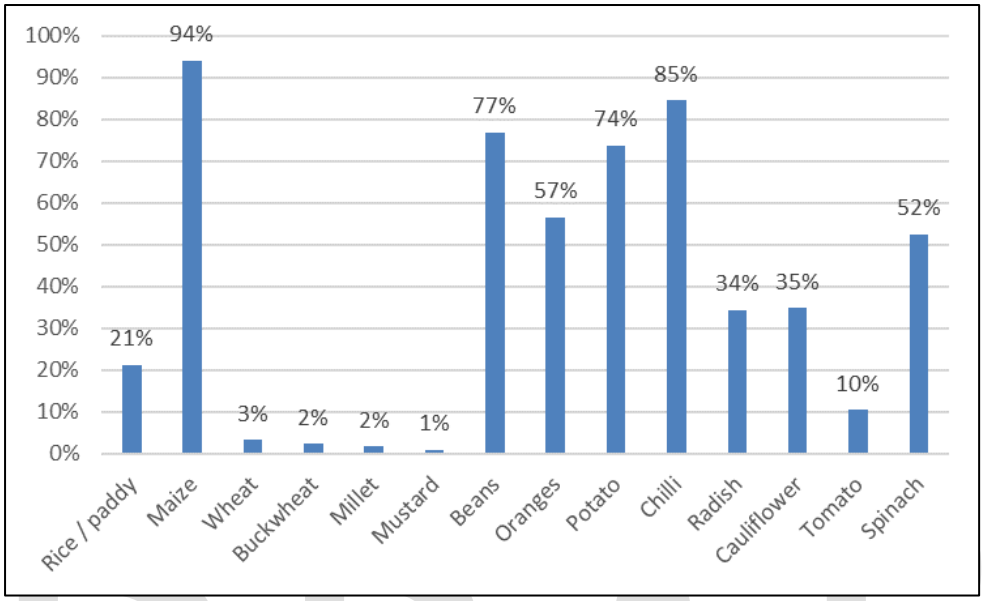


Figure 170: Production of agricultural products

Figure 171 provides a perspective on the agricultural practices of households in the region, focusing on the production of 14 important crops. The data shows that for 12 out of these 14 crops, more than 90% of the produced households also consume from their yield, which highlights the dual role of these crops in both feeding the household and serving as potential commercial goods.

Despite the high percentage of households consuming from their own production, the graph indicates that these households are not limited to subsistence farming. This is evident as, except for wheat and radish, at least 20% of households are also selling their produce, revealing an ability to produce surplus beyond their own needs.

On average, the data shows that for the remaining 12 crops, more than one-third of the households can produce a surplus that is sold, contributing to income generation. This suggests that a significant portion of households in the region not only achieve self-sufficiency through their agricultural activities but also participate in the broader market, creating additional economic value from their produce.

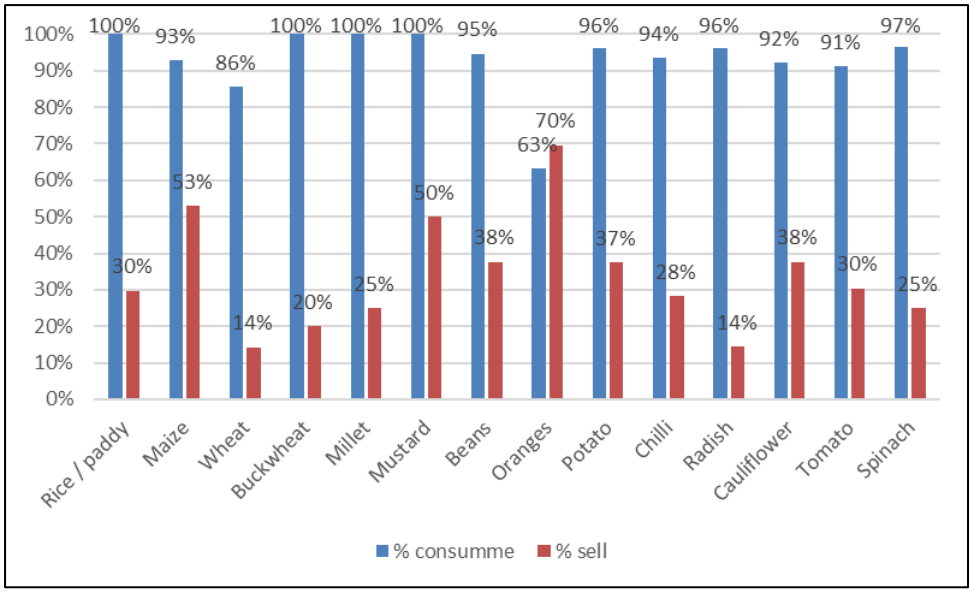


Figure 171: Agriculture: share of households which consume and sell agricultural products

8.2.6.2.2 Livestock

Livestock farming is an important economic activity. Farmers rear cattle, yaks, buffaloes, horses, mules, donkeys, sheep, goats, pigs, and poultry. Cattle numbers range from one per household to as many as 384 cattle (RNR census 2019).

The type of livestock reared varies according to the climatic conditions, terrain, availability of grazing land and individual preference and budget. Livestock systems practiced include 66.84% grazing (cattle left to free roam), 2.82% industrial (where cattle are fed 90% cattle feed) and 30.34% mixed systems (combination of grazing and industrial systems).

There are 51,244 exploitations (76.96%) rearing bovine animals (Jersey Cross breed, Nublang (Thrabam), Jatsa-Jatsam, Yanku-yankum, Doethra- doethram, Jersey Pure breed, Doeb-doebum, Jaba, Yak, Brown Swiss cross, Zo-Zom, Mithun Pure, Holstein Freisan, Buffalo, Brown Swiss pure and Goleng). The top three bovine animals are Jersey cross breed, Nublang (Thrabam) and Yak. Of the 27,771 holders rearing Jersey cross breed, Mongar (10.37%) has the highest holders rearing Jersery cross breed. A total of 56% of Rural Households own livestock while only 2% in urban areas do. Most rural households have two or more heads of cattle.

The data on livestock ownership and its utilization (Figure 172) among households surveyed in the study area reveal the following key points:

- Livestock Ownership Rates:
  - Overall Ownership: A substantial 76% of households surveyed own livestock. This figure is very close to the national average.
  - Types of Livestock: The herds predominantly consist of cows (both lactating and non-lactating), oxen, calves, and poultry.
  - Specific Ownership Rates: Among the respondents, 68% own calves, while about half of the households have chickens.
- Utilization of Livestock:
  - Consumption: In Tsamang, 17% of the households that own livestock reported consuming their livestock meat. This practice of consumption was only recorded in Tsamang.
    - Sales: Tsamang and Saling are notable for selling livestock. In Saling, 11% of livestock-owning households also engage in selling them.

- Livelihood Strategies:
    - Livestock rearing, along with farming, forms one of the principal livelihood strategies for these households.

This information demonstrates the significance of livestock in the rural economy of the area, highlighting both its role in self-consumption and as a source of income through sales.

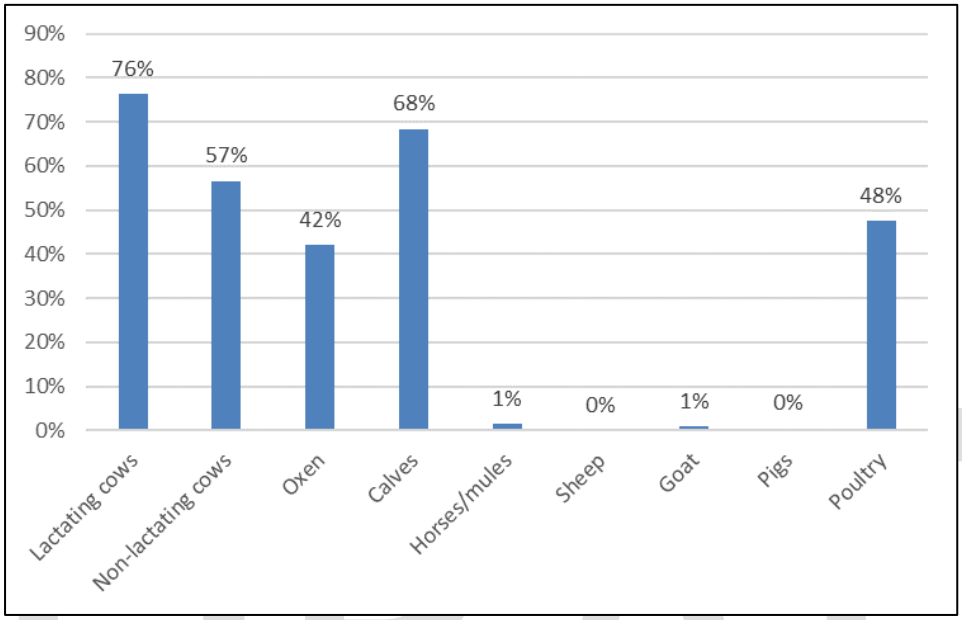


Figure 172: Livestock ownership

Figure 173 presents the percentage of households that have cattle producing various livestock products in different Gewogs. Tsamang Gewog has the highest percentage of households producing butter (25%), cheese (26%), milk (24%), and eggs (22%). Saling follows with 16% of households producing butter and cheese, and 15% producing milk. Chhaling Gewog shows production rates of 12% for both butter and cheese, 11% for milk, and 7% for eggs. Mongar has the lowest production rates among the Gewogs, with only 2% of households producing butter, cheese, and milk, and none producing eggs. Tsenkhar and Tsakaling have similar production rates for butter, cheese, and milk, ranging from 5% to 9%. The overall mean across all Gewogs highlights that 11% to 12% of households are involved in the production of butter and cheese, 11% in milk production, and 7% in egg production.

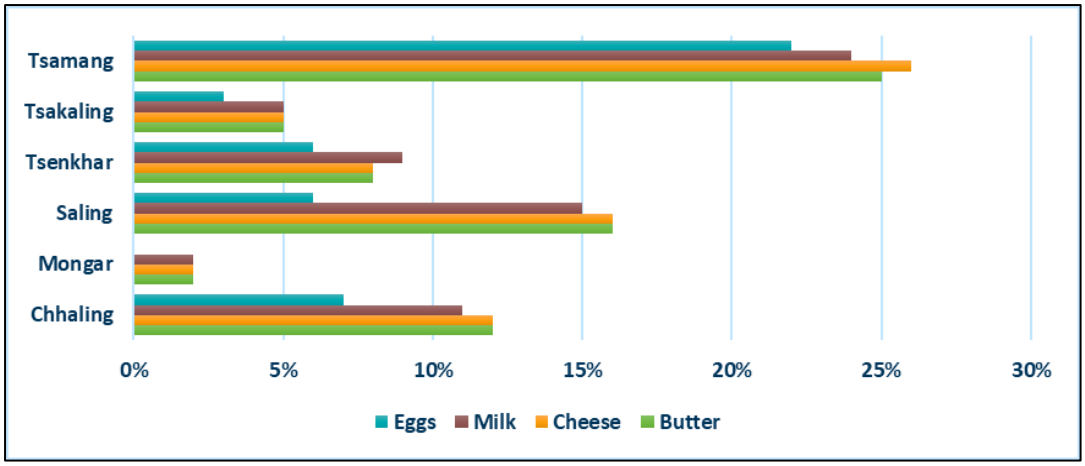


Figure 173: Livestock products produced among Gewogs

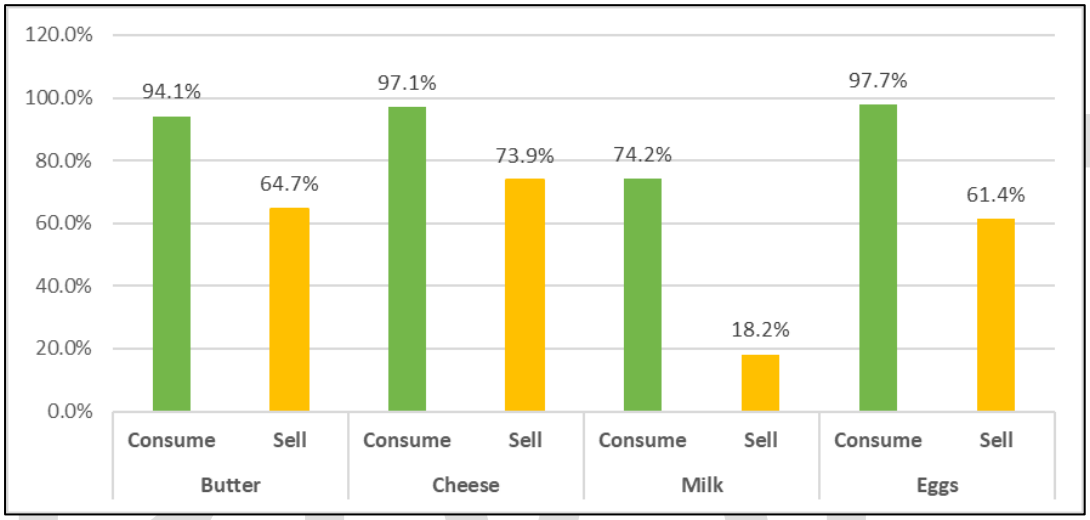


Figure 174: Livestock: products consumed or sold

The economic activities in Gewogs, as detailed on the Gewog website, are categorized into agriculture, livestock, and other activities. Here is a summary of these activities across various Gewogs:

- Tsamang Gewog:
  - Agriculture: Participates in vegetable farming.
  - Livestock: Includes poultry and dairy farming.
  - Others: Features a hazelnut plantation covering 80.2 acres with 28,605 trees and has two community forest groups.
- Tsakaling Gewog:
  - Agriculture: Has one vegetable farm group.
  - Livestock: Engages in poultry and piggery farming.
  - Others: Boasts a hazelnut plantation of 45.3 acres with 17,502 trees and one community forest group.
- Mongar Gewog:
  - Agriculture: Supports nine vegetable farm groups.
  - Livestock: Maintains a primary cooperative for dairy and two poultry farms group.
  - Others: Includes a large hazelnut plantation of 184.6 acres comprising 95,055 trees.
- Saling Gewog:
  - Agriculture: Has two vegetable farm groups.

- Livestock: Operates three dairy farm groups and one poultry farm group, along with two community forest groups.
- Others: Runs a hazelnut nursery and a hazelnut plantation of 46.9 acres with 17,261 trees.

- Chhaling Gewog:
  - Agriculture: Engages in vegetable, mandarin, and maize farming through five farmer groups registered with RAMCO.
  - Livestock: Includes four poultry farms and four piggery farms.
  - Others: Has a hazelnut plantation of 25.1 acres with 12,217 trees and two community forest groups.
- Drepong Gewog:
  - Agriculture: Comprises two vegetable farmer groups.
  - Livestock: Contains 30 backyard poultry farms.
  - Others: Features a hazelnut plantation covering 82.5 acres with 38,206 trees.
- Tsenkhar Gewog:
  - Agriculture: Involves six vegetable farmer groups.
  - Livestock: Houses two commercial poultry farms.

This detailed enumeration reflects the diversity and range of economic farming activities across these Gewogs.

The information collected during the focus group discussion related to agriculture and businesses is summarized in Table 158.

Table 158: Key information from FGDs

Village	Land use/ agriculture	Businesses

Autsho	- Mostly dry lands are used for vegetable growing.
	  - Private plots are on the lower side of the highway and below town: wet land left fallow, dry land near the private plots.
	  - Chhalidabep village: mostly dry land
	- average surface area: 2000 acres
	- 260 people working in agriculture for both consumption and commercial purposes (vegetables, annual crops mostly for sale) (50% and 50%).
	- Thongphugang and Autsho are two local farmers group established since 2018 consisting of 5 and 9 members respectively. Thongphugang group is mainly engage for vegetables plantations and sale, while the other is halted due to water shortage.
	- They use an electric fence, chain line fence, stone and wood for delimitation of parcels. Mostly they cultivate by hiring with neighbour's land and some use the fallow land left by their siblings
		- 60 households engaged in the business, of which 40 are women and 20 are men
		- It is mostly small in nature and established since 2003.
		- Samdrupjongkhar and Phuntsholing are the two main stakeholders of the business in the town.

Banjar	No FGD	
Chhali	- Mostly dry land, rice field/ paddy fields (for home consumption), maize, fruit trees, vegetables for selling - Average land owned 7 acres - 500 people working in agriculture (90% for selling) - two farmer associations. - Community engagement platform (CEP): formed in 2015 (32 members) - Milk community, established in 2022 (29 members).	n.a, or minor (rural and remote settlement)

Village	Land use/ agriculture	Businesses
Drangmaling-Nangar	- 60 villagers working in agriculture for both consumption and commercial purposes (vegetables, annual crops mostly for sale) (50% and 50%). - Seasonal market gardening, annual crop: maize, perennial crops or fruits. Average size of land 4,5 acres	n.a (rural and remote settlement)
Gyelposhing Town	n.a (urban settlement)	Almost 60 people engaged in business (restaurant, hardware, general shop, hardware shop, saloon etc.) Mostly small and permanent shops established since 2000
Lingmethang	Urban settlement mostly	40 people engaged in business (36 women), most businesses established in 2007, they are medium and permanent. One dairy farm product (8 members) General shops and restaurants are the most common as well as most profitable business in this area.
Tokari	500 villagers making sustenance from agriculture Average size of land owned: 100 acres Seasonal vegetables, annual crops, maize (self-consumption and for sale), rice and fruits for consumption only	
Tsakaling	400 villagers involved in farming for consumption (70%) and selling (30%) Average exploited surface is 1000 acres Seasonal vegetable gardening for selling purposes. Annul crops: maize (selling and consumption) and rice (consumption). Perennial crops or fruits trees: Commercial 1 local organization (Paetsholing) incepted 2018 with 3 members engaged in the production and sale of asparagus.	

8.2.6.2.3 Tourism

Bhutan promotes 'high value, low impact' tourism. Tourists are categorized as regional visitors (Nationals of India, Bangladesh and Maldives) and International Visitors (Nationals of all other countries).

Prior to the COVID 19 pandemic a daily fee of USD 250 per person per night was charged including a sustainable development fee (SDF) of USD 65. SDF is the fee that goes into contributing towards sustainable development initiatives undertaken by the Government and compensating for the negative environmental impacts associated with tourism. SDF fees for Indian tourists are Nu. 1200 per person.

Pre Covid-Bhutan saw a record number of tourist arrivals (315,599 in 2019) (With Mongar and Lhuentse districts accounting for less than 4% of the total, with the exception of 2018 when they received 14.5% of the more than 60,000 tourists who visited Bhutan), but this number dropped due to the pandemic by 91% to 29,812 visitors in 2020 (TCB, Bhutan Tourism Monitor 2019 and 2020). From September 2022 to April 2023, 40,655 tourist's arrivals were reported *(https://thebhutanese.bt/40665-tourists-have-visited-bhutan-from-september-23-to-april-15-2023/).*

In May 2023, the Cabinet announced 3 different SDF packages that tourists could choose from effective from June 1, 2023. These include:

- the 4+4 (pay the SDF for the first 4 nights with 7 additional nights without SDF)
- 7+7 (pay the SDF for the first 7 nights with 7 additional nights without SDF)
- the 12+18 package (pay the SDF for the first 12 nights with 18 additional nights without SDF)

Source: https://thebhutanese.bt/government-announces-new-sdf-incentives-of-4-7-and-12-nights-sdf-waivers-to-encourage-visits/, https://bhutan.travel/announcements.

A total of 40,665 tourists have arrived in Bhutan from 23rd September 2022 until 15th April 2023.

The Yongkola area in Mongar is a popular bird watching destination but due to their distance from the Paro International Airport and the limited tourist attractions or infrastructure, tourist visits are very low in Lhuentse and Mongar.

On the other hand, although there is no data, the religious sites in the two districts are also visited by nationals from other Dzongkhags, especially Aja Ney in Mongar and the Guru Statue at Takila and Singye Dzong in Lhuentse

The study area has little or no tourism, according to the seasonal calendars drawn up in the study area. There are some birds watching activities (including with international tourists). There are currently no tourism recreational activities (e.g., whitewater rafting, canyoning, fishing) in the Project area.

The town of Gyelpozhing has 2 hotels with rooms for travellers. The hotels on average have 8 rooms. There are some hotels in Autsho and Lingmithang. Most hotel facilities are otherwise located in Mongar.

8.2.6.3 Ownership, housing and equipment

8.2.6.3.1 National level

The BLSS (Bhutan Living Standard Survey) 2022 classifies assets into three general groups:

- Durables (which include kitchen and laundry; recreation, telecommunications, and culture; furniture and fixtures; machinery and equipment; and transport equipment)
- Livestock
- Land.

8.2.6.3.1.1 Land categorization

Land categorization in Bhutan is administered by the National Land Commission of Bhutan, this system ensures that land usage aligns with national development goals, cultural preservation, and environmental conservation. The categories of land in Bhutan include agricultural, residential, commercial, industrial, forest, and institutional land. Bhutan also places a significant emphasis on environmental conservation, as reflected in its forest land and protected areas. These areas are crucial for maintaining ecological balance and protecting biodiversity. The country also dedicates land for cultural and religious purposes, which is indicative of its rich heritage and Buddhist traditions.

8.2.6.3.1.2 Land ownership

Land can be owned by individuals, families, joint ownership, communities, institutions and civil society organizations. Land can also be leased for various purposes. Proof of land ownership is a Thram which is the officially accepted record of landholding.

At the national level 34% of the households do not own any land. From those who own land, 8% of households own more than 5 acres of land and 58% own 5 acres or less. Land ownership is higher in rural

households with the average landholding at 2.7 acres (2.0 acres in urban areas and 2.9 acres in rural areas). At the national level, the ratio of males to females owning land is almost equal.

At the national level, there are 178,179 Thrams covering a total of 468,993.091 acres of land (NLCS, nd. Land Information at a Glance). In terms of landownership, more people own land in rural areas than in urban areas. The average land holding is about 2.7 acres at the national level and on average 57.7% of landowners own less than 5 acres of land with only 8.4% owning more than 5 acres of land.

8.2.6.3.2 District level

8.2.6.3.2.1 Durables

Over 90% of households in Lhuentse and Mongar own rice cookers, curry cookers and smart phones. Above 80% own water boiler and stove, and above 60% own television sets. Other items such as washing machines, microwave oven computers and laptops are owned by the minority. In terms of furniture, houses in rural settings do not normally use sofa sets, as traditionally people sit on mats on the floor. Also, brooms are used for cleaning rather than vacuum cleaners.

Only 30% and 25% of households in Lhuentse and Mongar own a family car. With respect to farm equipment/machinery, more households own power tillers (20%, power chains (26.6%), grinding machines (35.7%) compared to households in Mongar where only 5.6% own power tillers, 16% own power chains and 27% own grinding machines.

More households in Lhuentse (89%) use wooden flooring compared to Mongar (80.6%), while concrete floors are more common in Mongar (19.1%) compared to Lhuentse (10.7%).

8.2.6.3.2.2 Land ownership

At the Dzongkhag level, land is also owned by government institutions such as schools, Dratshang, religious institutions, corporations and the community. There are 162 such thrams and one community owned land in Lhuentse Dzongkhag, while Mongar Dzongkhag has 319 such thrams and 11 community owned land.

Mongar district has in total 11,985 land registrations with 42,376 plots of land totalling 34,594.91 acres while the average land holding is 2.9 acres. The owners of this land are mostly women with 53.1% while 43.8% of landowners are men. In Lhuentse, there are 4,519 land registrations with a total of 26,492 plots totalling 15,684 acres of land while the average landholding is 3.5 acres. Among owners, 65.4% are women while 29% are men (NLC, 2022). Women tend to hence own most of the land in these two districts suggesting a matrilineal and matrilocal form of inheritance and residence followed in these two districts. No information about joint male/female land ownership is available at regional level.

8.2.6.3.3 Local level

8.2.6.3.3.1 Land ownership

The field survey corroborates national and regional data: it reveals that women are the most likely to own land alone (56% of women own agricultural land and 57% own residential land), while men own land alone in 26-27% of cases.

An even higher proportion of women own land in the Tsamang gewog (see graphs below), where 80% of women own both agricultural and residential land alone; however, the trend is reversed in Mongar, Tsakaling and Drepong, where there are as many women as men owning land.

Drepong and Chhaling gewogs have the greatest number of respondents who own the land collectively, both men and women (25% for Drepong and 24% for Chhaling), while shared ownership between men and women is virtually non-existent in Tsamang and Tsakaling.

Figure 175: Land ownership (by gender and gewog)

8.2.6.3.3.2 Housing

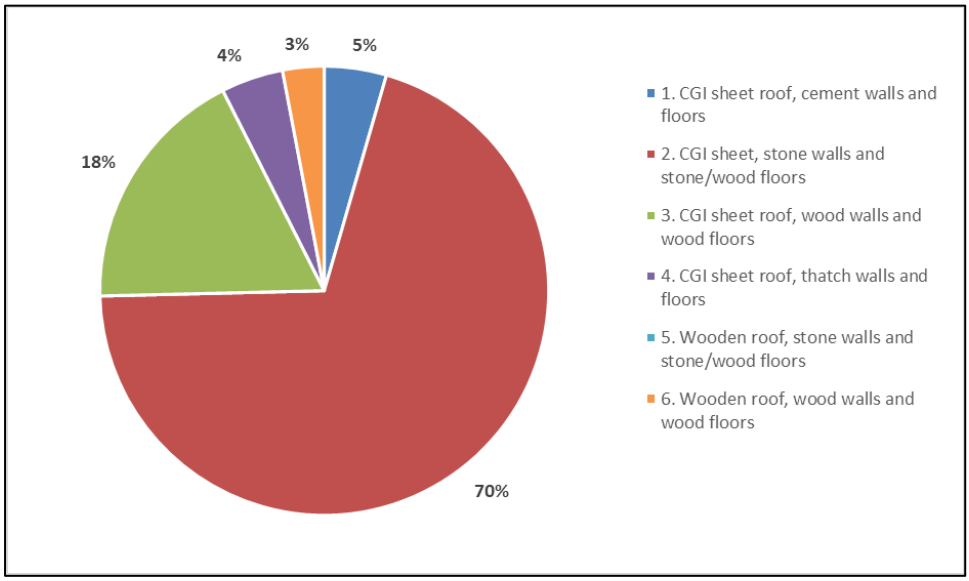


Figure 176 visualizes housing trends across all Gewogs, highlighting CGI sheet roofs paired with stone walls and stone/wood floors as the most common architectural choice. Dominating the chart, this style accounts for nearly half of the total 492 documented residences, underscoring its widespread preference. In contrast, the dataset reveals a singular occurrence of a house featuring a wooden roof atop stone walls and floors, marking it as an exceptionally uncommon selection among the surveyed households.

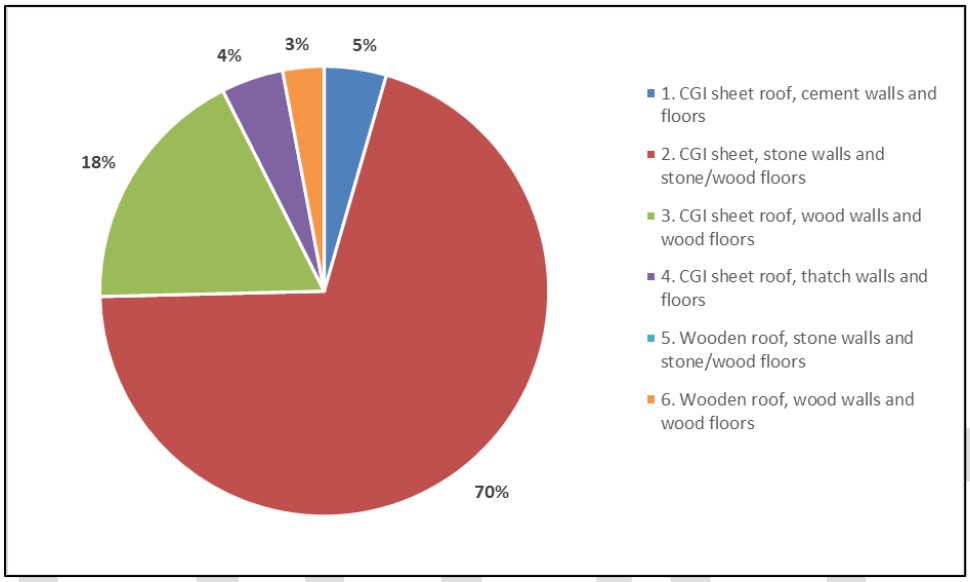


Figure 176: Distribution of house types

Figure 177 displays the distribution of house types across Gewogs. The types of houses are categorized by the materials used in their construction, specifically for roofs, walls, and floors. Here's a summary based on the bar chart:

- **Chhaling**: Most houses have CGI (corrugated galvanized iron) sheet roofs with wood walls and floors, followed by houses with CGI sheet roofs, stone walls, and stone/wood floors.
- **Drepong**: The predominant house type has CGI sheet roofs with stone walls and stone/wood floors, with a significant number also having CGI sheet roofs with cement walls and floors.
- **Mongar**: Houses with CGI sheet roofs, stone walls, and stone/wood floors are the most common.
- **Saling**: This Gewog has a high number of houses with CGI sheet roofs and stone walls and floors, followed closely by houses with CGI sheet roofs, wood walls, and floors.
- **Tsaenkhar**: Houses with CGI sheet roofs, stone walls, and stone/wood floors are the most common.
- **Tsakaling**: There are few houses, but they mainly have CGI sheet roofs with stone walls and stone/wood floors.
- **Tsamang**: The dominant house type has CGI sheet roofs with stone walls and stone/wood floors.

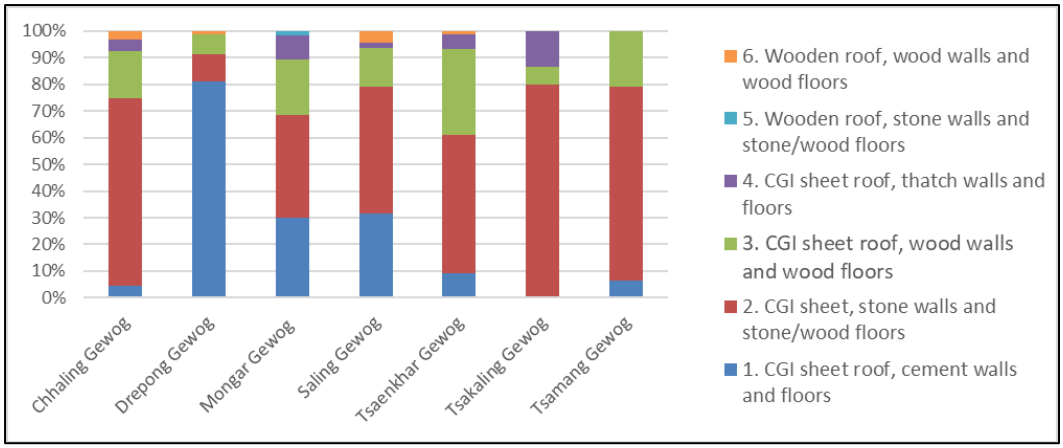


Figure 177: Distribution of house types across Gewogs

8.2.7 Human rights

Key points related to Human rights in Bhutan

The human rights situation in 2023 is improving because of the government's efforts. The government took steps to identify, investigate, prosecute, and punish officials who committed human rights abuses or engaged in corrupt practices. The constitution states no person shall be discriminated against based on race, sex, language, religion, or politics. Efforts are made to enforce the laws.

Considering World Bank standards and Equator principles, specific attention is required regarding Human rights. This section summarizes the information from the US Bureau of democracy, Human rights and Labor (*https://www.state.gov/reports/2022-country-reports-on-human-rights-practices/bhutan/*)

Respect for the integrity of the person

The constitution prohibits torture and other cruel, inhuman or degrading treatment or punishment, and other related abuses, and there were no credible reports that government officials employed them.

Prison and Detention Centre Conditions

There were no significant reports regarding prison or detention centre conditions that raised human rights concerns. Police administered the prison system. Authorities conduct investigations of credible allegations of mistreatment. The government permitted monitoring by independent non-governmental observers in past years.

Arbitrary arrest or detention

The law prohibits arbitrary arrest and detention and provides for the right of any person to challenge the lawfulness of his or her arrest or detention in court. The government generally observed these requirements. By law, police may arrest a person if they have probable cause, or a court-issued arrest warrant. Authorities generally respected the law.

Respect for civil liberties

The constitution prohibits arbitrary or unlawful interference with privacy or family life and the government generally respected these prohibitions; however, citizens seeking to marry noncitizens require government permission.

Freedom of expression

The constitution provides for freedom of expression, including for members of the press and other media, and the government generally respected this right. An independent press, an effective judiciary, and a

functioning democratic political system contributed to freedom of expression, including for members of media. Independent media are active and generally express a variety of views. The law does not provide specific protection for journalists or stipulate freedom of information, but there were no official restrictions on media.

Freedom of association

The constitution provides for freedom of association, and the government respected it.

Freedom of movement and the right to leave the country

The law provides for freedom of internal movement, foreign travel, emigration, and repatriation, but the government limited freedom of movement and repatriation for some groups.

In-country Movement: The law establishes categories of residency, which determine whether a person requires a "route permit" to travel internally.

Protection of refugees

In the 1960s, the country sheltered Tibetan refugees who were initially located in seven settlements. According to the Central Tibetan Administration (CTA), the self-described "Tibetan exile administration" based in Dharamshala, India, a total of 1,298 Tibetan refugees lived in Bhutan in the year, compared with 1,847 persons in 2021.

Freedom to participate in the political process

There were no reports of significant irregularities during the election process.

Discrimination

The constitution states no person shall be discriminated against based on race, sex, language, religion, or politics.

Acceptable conditions of work

The Department of Labour generally enforced minimum wage, work hours, and occupational health and safety standards effectively in the formal sector. Penalties, including payment of damages, were generally commensurate with other types of workplace violation fines, and inspection was sufficient in 2022.

8.2.8 Transversal analysis of vulnerability

Key points related to analysis of vulnerability

- Vulnerable groups.
- Gender issues.

Women: issues on sexual and reproductive health care depending on the areas. Access to medical care for pregnant women in some remote rural areas is a challenge because of difficult terrain.
More details are given below.

The vulnerability analysis in this ESIA will be carried out in two stages. In the first, using secondary data and data from the socio-economic surveys carried out in May/2023, it is possible to indicate the greater or lesser presence of vulnerability groups or typologies in the study area. This information will feed into the preparation of the questionnaires that will be applied to Project-Affected Persons (PAP) in the second round of surveys, so that we can define the PAP's individual levels of vulnerability, the goal of this analysis. It is therefore important to remember that in this first stage we are not yet working on the individual vulnerability of those directly affected.

Additional Focus Group Discussions were held as part of the LALRP survey in February 2024 to deepen our understanding of specific groups vulnerabilities: elderly, low-income households, youths, and resource-constrained women. These focus groups were held in Tsaelnkhar, Tsakaling, Chhali, Saleng, Tsamang and Drepong.

8.2.8.1 Definition of vulnerability

Vulnerability refers to the potential to be affected more severely than other individuals in the same situation. It characterizes the degree to which a system or unit (in this case, the socio-demographic or socio-economic group) is likely to suffer harm from exposure to a disturbance or constraint (in our case, the impacts of the Dorjilung project). It is composed of three dimensions: exposure, sensitivity and resilience, as shown in the figure below.

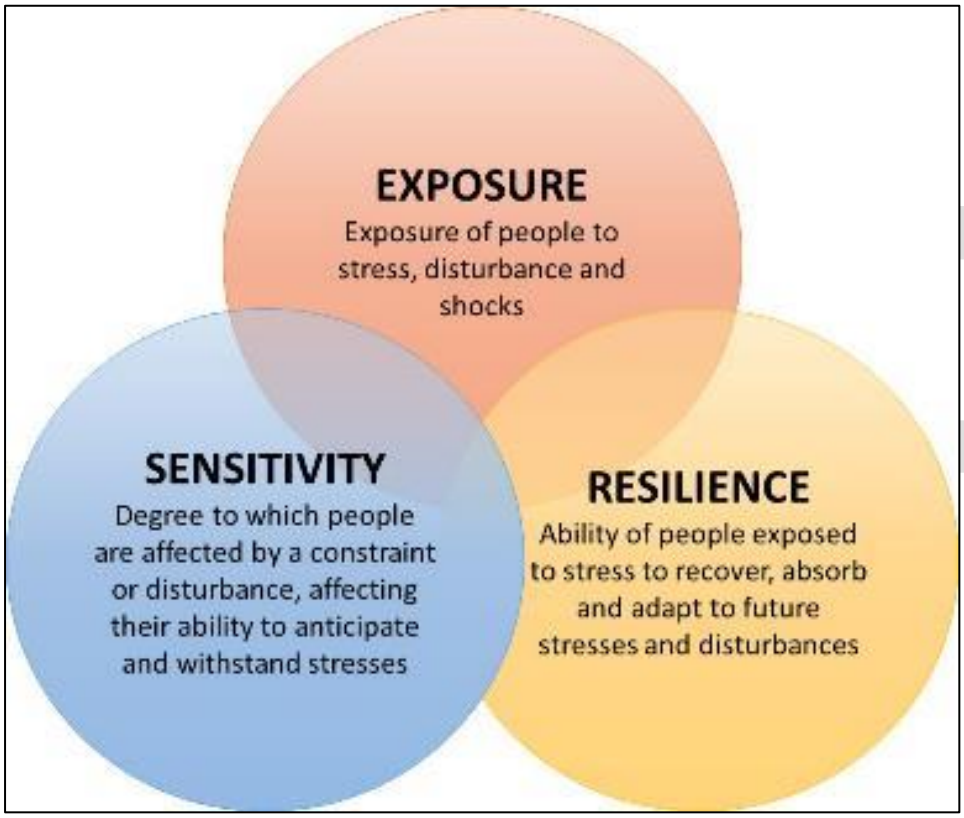


Figure 178: The three dimensions of vulnerability

Source: Kasperson et al., 2001

A distinction should be made between:

- The **intrinsic vulnerability** of a group or community, i.e., which is specific to them, and which exists independently from the Project. The analysis of intrinsic vulnerability aims to assess the group's sensitivity and resilience, considering their characteristics and their ability to withstand the impacts of the Project. This index considers both economic and social vulnerability, understood in a broad sense: the approach is multidimensional and not purely monetary. This form of vulnerability is important because it is now widely recognized that certain groups are more vulnerable (The IFC defines "at-risk" or vulnerable groups as people who, by their gender, ethnicity, age, physical or mental disability, economic disadvantage, social status, dependence on natural resources or other specific factors, may suffer more than others from perturbations, and who have limited ability to seek and/or obtain assistance) than others to impoverishment and the breakdown of social ties during the implementation of major development projects, due to their initial vulnerability and their difficulties in taking advantage of the measures and opportunities offered by the Project.

- **Project-induced vulnerability**. The analysis of induced vulnerability aims to assess the precise exposure of groups, to distinguish those who will be hardest hit by the Project.

That said, it is necessary to develop measures that are specifically adapted to the most vulnerable groups. In addition to the use of inclusive survey techniques (for example: organizing focus groups adapted to the issues at stake, ensuring that the personal characteristics of interviewers do not hinder the freedom of speech of those consulted, etc), this requires their identification. This is also an IFC requirement, as PS1 requires projects to identify "individuals and communities likely to be directly and differently or disproportionately affected by the project due to their disadvantaged or vulnerable situation (§12 of IFC PS1), during the ESIA.

The evaluation of vulnerability criteria within the project's scope was conducted through a multifaceted approach. Literacy rates were assessed by collecting data on the ability to read and write across different gender and age groups, providing insight into educational disparities. Poverty levels were gauged by examining household income, access to basic services, and comparing these against national poverty lines, with particular attention to the differences between rural and urban populations. Food insecurity was evaluated by surveying households about their food consumption patterns, instances of food shortage, and the factors contributing to such conditions, including agricultural productivity and incidences of crop damage. Additionally, land ownership vulnerability was analysed by reviewing landholding records to understand the patterns and disparities in land ownership, considering factors like gender and household headship.

Throughout the process, inclusive survey techniques were employed to ensure a comprehensive representation of the community, considering the personal characteristics of interviewers to avoid any bias that could affect the responses.

8.2.8.2 Intrinsic vulnerability

8.2.8.2.1 Literacy

Nationwide, as of 2021, the illiteracy rate among adults over the age of 15 stands at 29%, with a gender disparity evident as 22% of men and 37% of women fall into this category, according to the World Bank. Within the study area, the illiteracy rate is slightly lower at 28% for the same age group, comprising 24% of men and 33% of women. This indicates that although the local gender gap in illiteracy is narrower compared to the national figures, gender differences in literacy still exist within the project's area of influence.

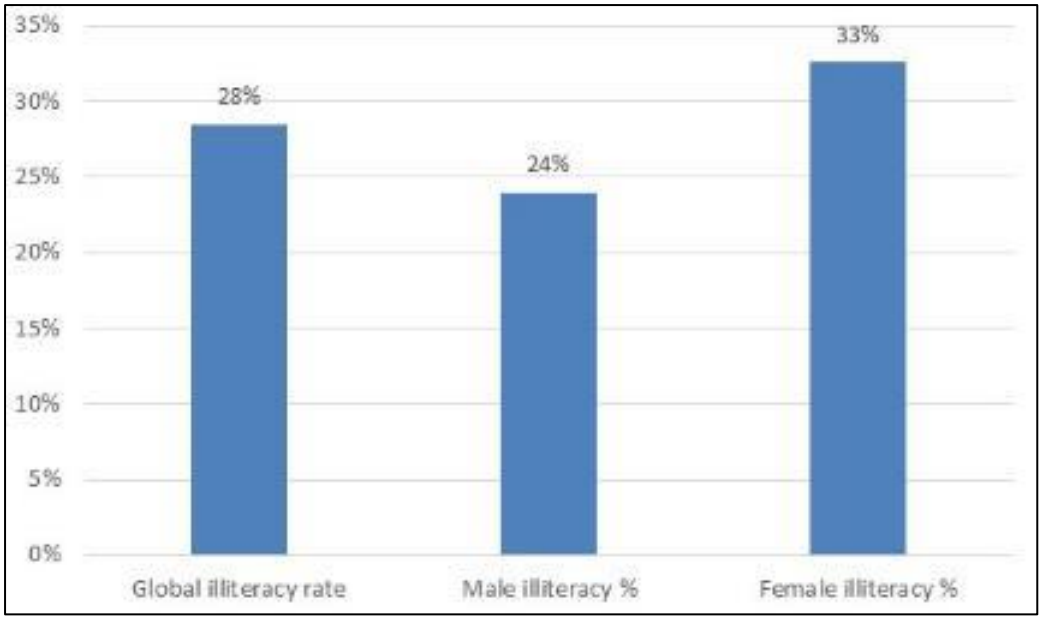


Figure 179: Illiteracy rate (global and per gender) in the project influence area

There is a difference in illiteracy rates between gewogs: while Chhaling and Tsakaling have a high proportion of illiterate people (respectively 42 and 45%), the gewogs of Drepong and Mongar have fewer than the average for the project area respectively 18 and 17%).

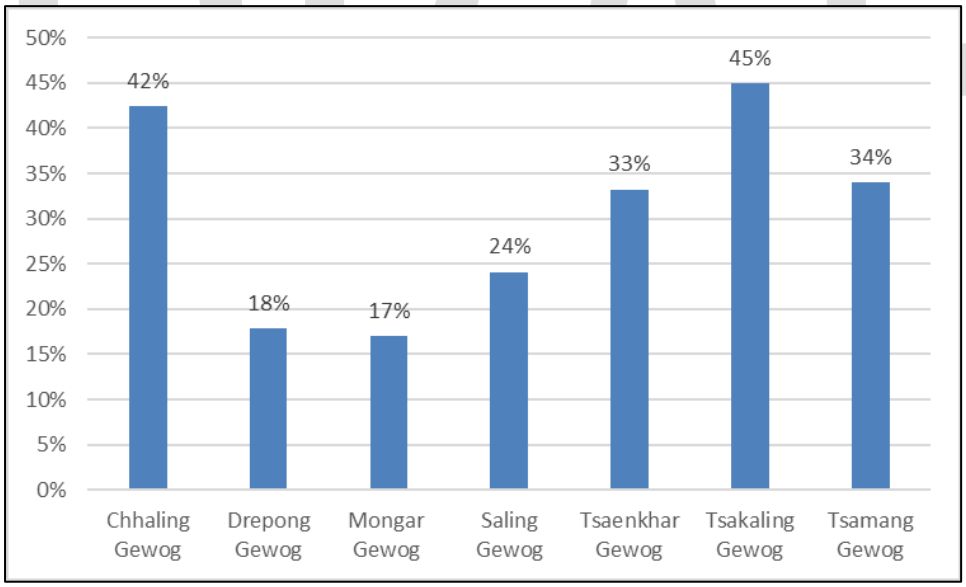


Figure 180: Illiteracy rate (per gewog)

8.2.8.2.2 Poverty

Poverty, considered multi-dimensional, is the result of several factors. Particularly present in rural areas (56% of the country's rural population, *Source: World Bank, 2022*), it renders those it affects vulnerable to any change involving a modification of subsistence strategies.

8.2.8.2.2.1 National level

In Bhutan, the share of population living under the poverty line but increased to 12.4% in 2022. The poverty rates mean these are households whose monthly per capita real expenditure is below the upper bound poverty line of 6,204 (current Nu/person/month). According to the latest World Bank recommendations (2022), the poverty line is set at $3.65 per day per person and the extreme poverty line is set at $2.15 per

day per person. See more at: https://blogs.worldbank.org/opendata/september-2022-global-poverty-update-world-bank-2017-ppps-and-new-data-india.

Poverty rates are three times higher (17.5%) in rural areas as compared to urban areas (4.2%) and varies across districts, with the lowest poverty rate in Thimphu and Punakha (less than 3%), lower than average poverty rates in 6 dzongkhags (Bumthang, Dagana, Gasa, Ha, Paro and Sarpang) while all the remaining 12 Dzongkhags below poverty line. (NSB, 2022. Poverty analysis report).

Food poverty is low at 0.4% (households where monthly per capita real expenditure is below the food poverty line of Nu. 2,852/person/month) and this is higher in rural areas at 0.7%.

While this marks a continuation of progress over previous years, the pace of poverty reduction has slowed down recently. Inequality is relatively high in regional comparison, with the Gini index estimated at 37.4 in 2017. As of 2017, less than 4% of Bhutanese lived in multidimensional poverty according to the World Bank's Multidimensional Poverty Measure. This compares favourably with countries with similar income levels.

8.2.8.2.2.2 District level

Compared to the national poverty rate of 12.4%, poverty rates are higher than average in both Lhuentse and Mongar Dzongkhags at 15.7% and 17,8% respectively. Lhuentse is in 9th place while Mongar is 12th place with 8 more Dzongkhags at higher poverty levels.

8.2.8.2.2.3 Local level

In the study area, 9% of households surveyed have declared to be below the poverty line Among these households, 5% fall below the extreme poverty line.

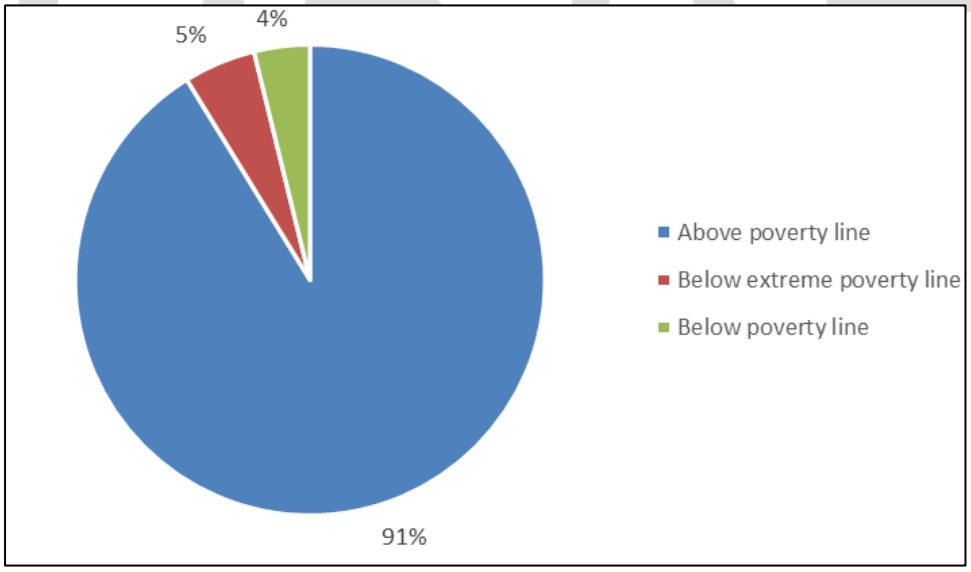
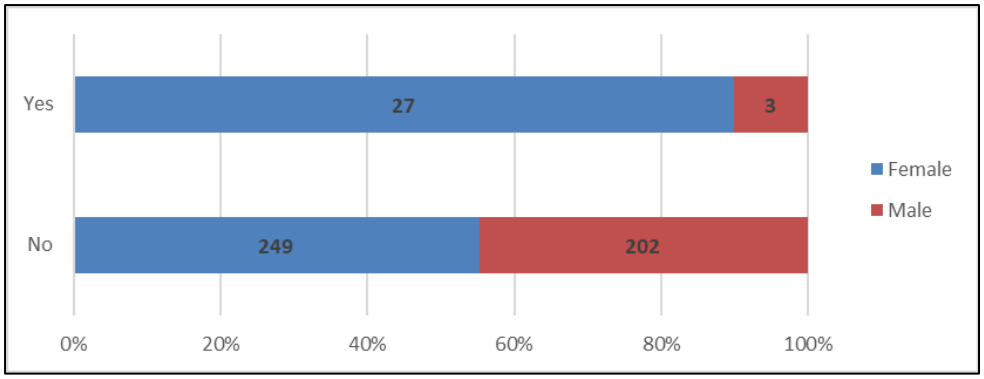


Figure 181: Poverty level

Female-headed households seem to be more susceptible to poverty, as our study shows. Indeed, among households below the poverty line, 63% are managed by women, compared with 27% by men (see figure below). Similarly, 83% of households below the extreme poverty line are managed by women, compared with 17% by men.



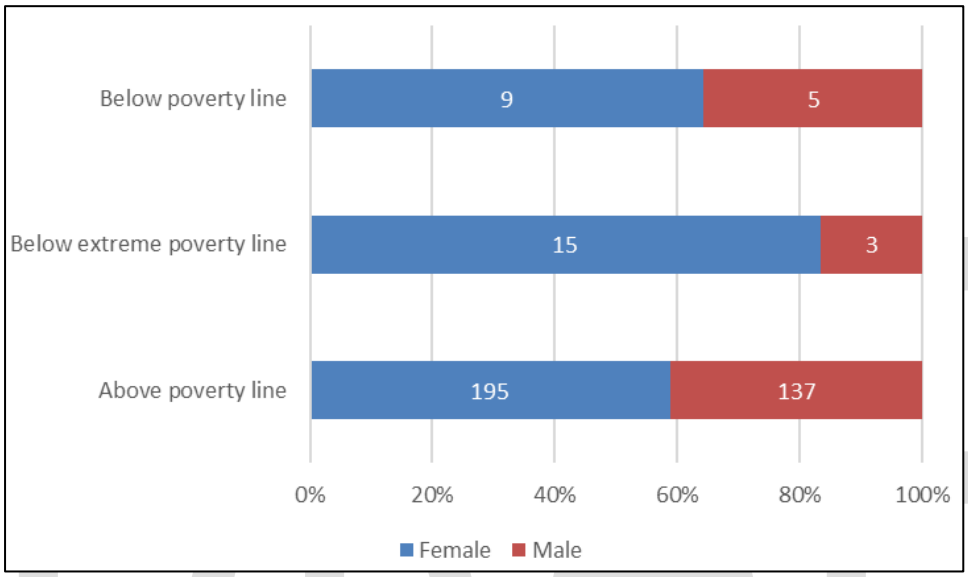
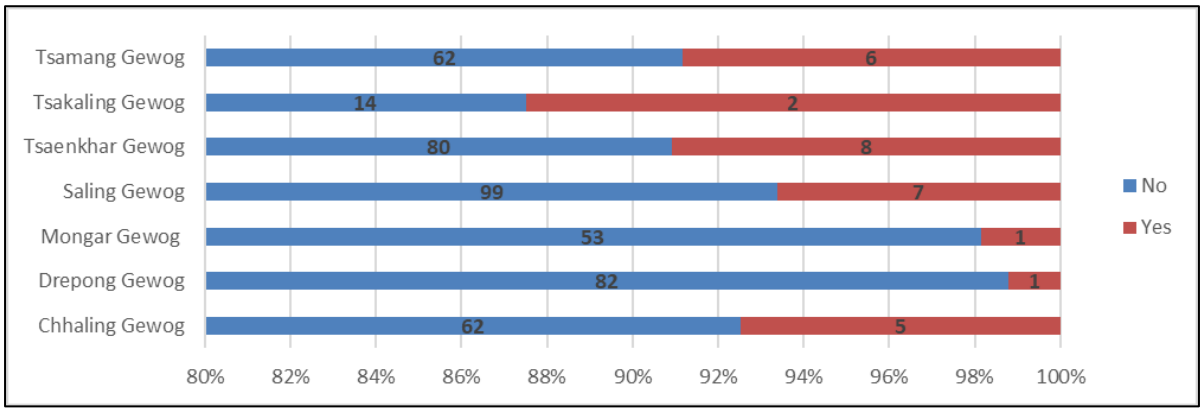


Figure 182: Poverty level (disaggregated by gender)

Among the gewogs in the study area, Tsamang stands out for having more households below the poverty line than the other gewogs. Indeed, while other gewogs have between 1% and 5% of households below the poverty line, the Tsamang gewog has 14% (see graph below):



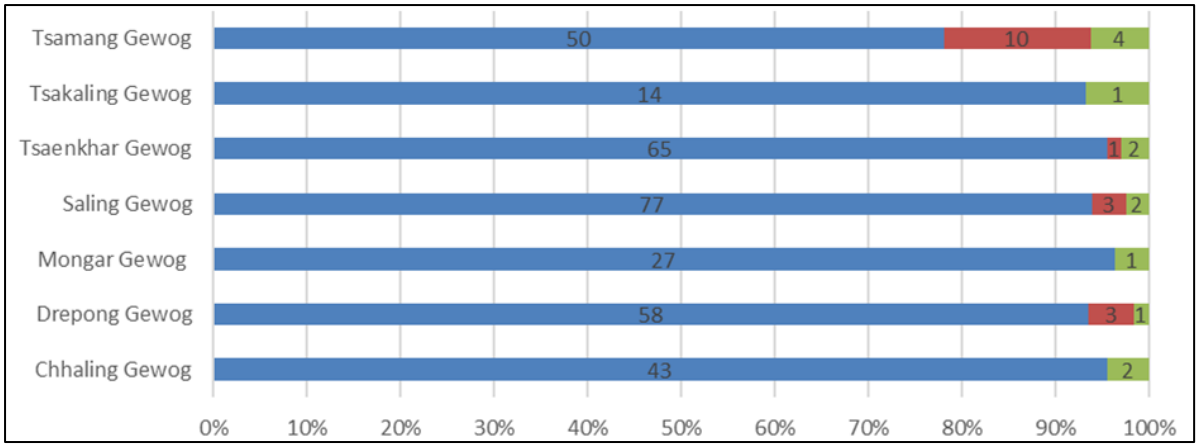


Figure 183: Poverty level (disaggregated by gewog)

Poverty is often induced by other vulnerability factors. Thus, the incidence of poverty is higher among households:

- Which have become a **female-headed household** (12% of household over the past 2 years),
- Whose head of household is a **widow** (4% of widowers over the past 2 years),
- With only **elderly people in house** (6%), and that do not have able manpower for agricultural works (13%)
- With a **disabled person in household** (3%) or with a working member that became disabled (7% over the past 2 years)
- For whom a working member migrated out of the village (8% over the past 2 years).

These vulnerability factors are more prevalent in rural areas than in urban areas (see figure below).

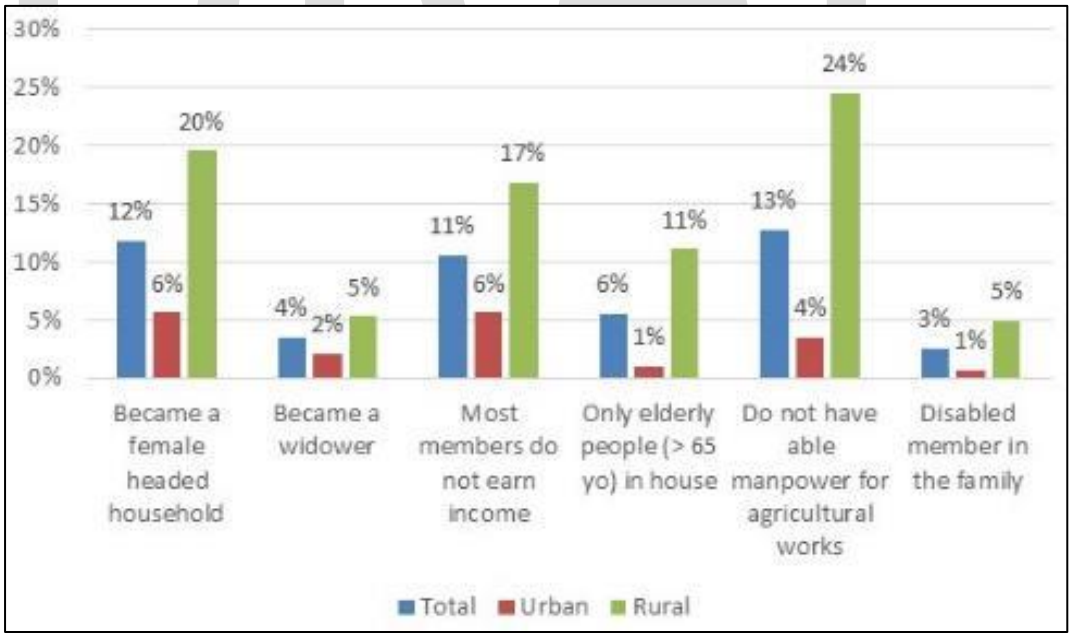


Figure 184: Poverty factors (global and per urban / rural area)

Focus group discussions with low-income groups were conducted during the LALRP survey in February 2024. It emerged that the local population depends mainly on agriculture for its livelihood. Lack of land, natural disasters or destruction of crops by animals, lack of labour and limited access to the sale of agricultural surpluses are all factors contributing to their impoverishment, in which cases, they find it difficult to meet their children's education, health and consumption (food) expenses (also refer to the next chapter). To do so, they must borrow from the community (grain or money), accept occasional jobs or

send their children to work (looking after relatives' children, for example), rely on local natural resources for their food/income (collecting and selling wild vegetables), rely on labour exchanges, remittances from relatives and Kidu's help.

8.2.8.2.3 Food insecurity

8.2.8.2.3.1 National level

According to the WFP, while the population's overall nutritional status has improved, Bhutan still suffers from the 'triple burden of malnutrition' with undernutrition, overnutrition and micronutrient deficiencies due to lack of knowledge and access to nutritious and diversified foods. This was further exacerbated by the COVID 19 pandemic exposed the vulnerabilities in food and nutrition security in Bhutan (WFP, 2022. Bhutan Annual Country Report).

According to the World Bank, nearly 27% of Bhutanese households consume less than the daily minimum calorific requirement of 2,124 kcal, and are either malnourished or face health issues (World Bank, https://blogs.worldbank.org/endpovertyinsouthasia/what-are-we-doing-improve-food-security-bhutan)

The World Food Program works with the Government through the National School Feeding and Nutrition Programs to improve the quality of school meals and the World Bank is implementing the Food Security and Agricultural Productivity Project (FSAPP) project through the FAO to reduce the country's reliance on food imports, combat malnutrition in children, and improve agricultural productivity.

The International Fund for Agricultural Development (IFAD) project Building Resilient Commercial Smallholder Agriculture (BRECSA) focuses on poverty alleviation and improved food and nutritional security (https://www.ifad.org/es/web/latest/-/ifad-gafsp-and-wfp-announce-partnership-to-support-bhutan-transition-to-commercially-oriented-agroecological-farming).

The agriculture sector is vulnerable to climate change, pandemics and disasters/natural hazards and human wildlife conflicts, and arable land in Bhutan is under continuous threat from varied sources such as urbanisation, land degradation and development.

In 2021, there were 101,762 students benefiting from the school feeding program availing, from one to three meals (MoE, 2021. Annual Education Statistics). Students in 16 schools in Lhuentse and 46 schools in Mongar benefit from the school feeding program (MoE, 2021. Annual Education Statistics).

8.2.8.2.3.2 Local level

Food insecurity is a state in which a person, or a group of people, find themselves when the availability of safe and nutritious food, or the ability to acquire personally satisfying food through socially acceptable means, is limited or uncertain.

In the study area, **7% of the respondents** declared to have suffered from food insufficiency over the past two years. No significant difference was observed between rural (6%) and urban (8%) areas.

The main reasons cited for food insufficiency are, in order of occurrence (see Figure 185):

- Crops damaged by natural calamities (38%),
- Crop failure (25%),
- Damage to crops by wild animals (24%),
- The fact that the productive member of the household has emigrated (9%) or got sick (4%).

To overcome food insufficiency, the strategies implemented by households are as follows, in order of occurrence (see Figure 186):

- Worked for (39%), borrowed (26%) or bought grain (21%),
- Sold assets (14%).

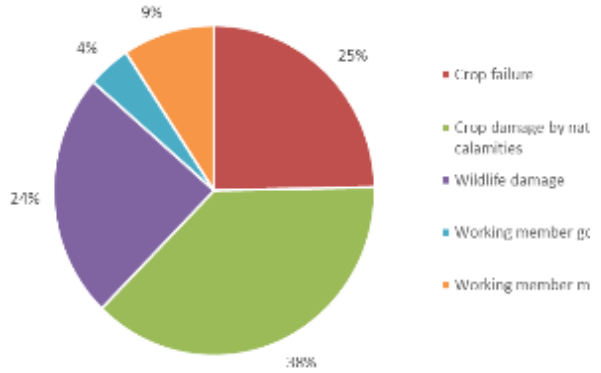


Figure 185: Reasons for food insufficiency in the study area

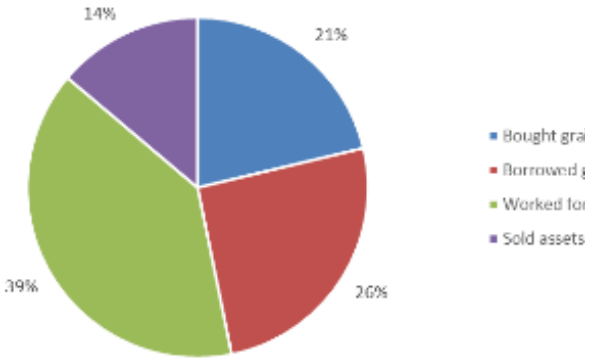


Figure 186: Strategies in case of food insufficiency

By disaggregating the data by gewog, we can observe that (see graph below):

- Drepong seems to be the only one not to have suffered from crop failure.
- Tsakaling and Mongar seem to have been spared wildlife damage, compared to tother gewogs.
- Between 12 and 25% of households suffered from food insecurity because an active member of the household was ill or migrated, except for the Chhaling, which seems to have been spared this phenomenon.

In terms of food shortage strategies:

- Selling assets to remedy food shortage seems to be common in Mongar and Drepong, where 36% and 66% of households experiencing food shortage respectively resorted to this strategy. In comparison, this strategy is virtually non-existent in the other gewogs.

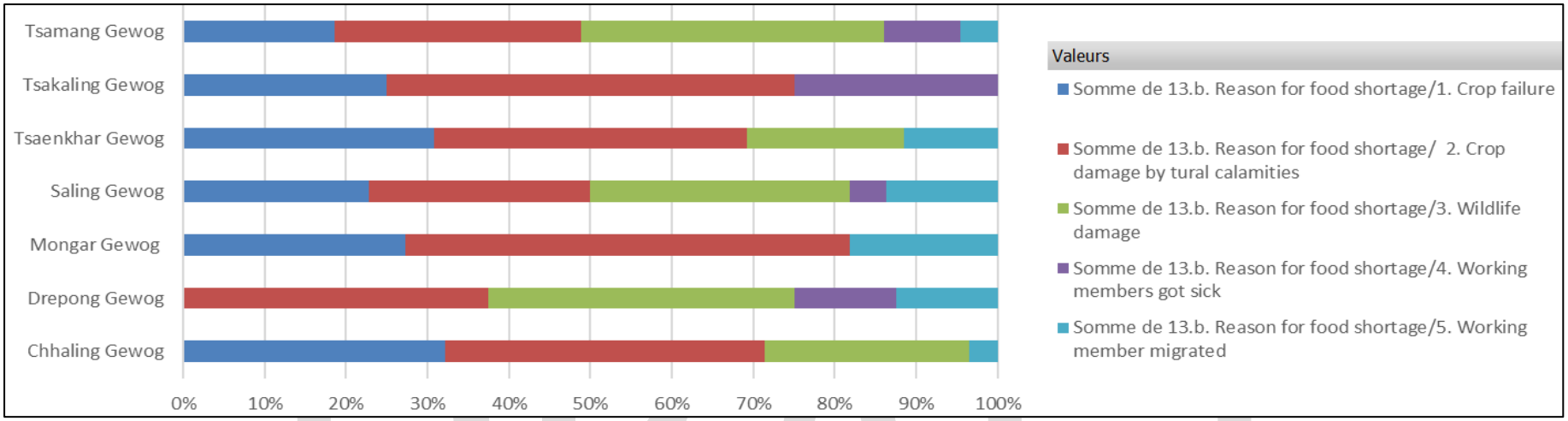


Figure 187: Reasons for food insufficiency (peer gewog)

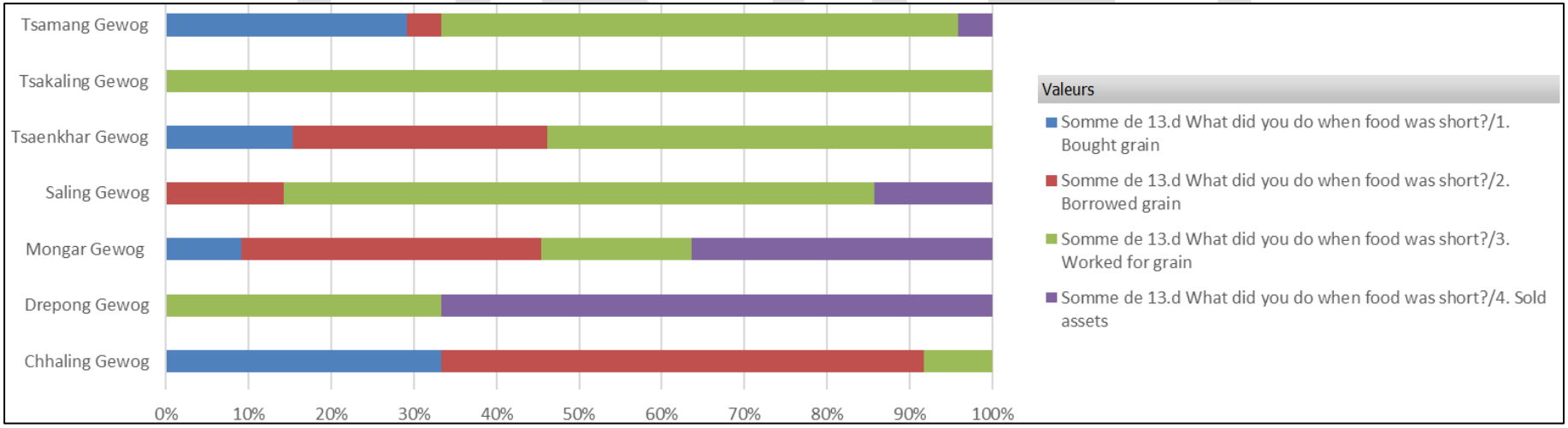


Figure 188: Strategies in case of food insufficiency (per gewog)

8.2.8.2.4 Landownership vulnerability

Aligned with the national situation, field surveys reveal that there are no issues associated with landownership in the study area.

8.2.8.3 Induced vulnerability

In terms of induced vulnerability, three groups were identified as potentially vulnerable in the study area within the framework of the project: elderly people; women; and persons with disabilities.

8.2.8.3.1 Elderly people

The elderly can be considered vulnerable in Bhutan, particularly in rural areas. Indeed, in rural areas where traditional family structures can be strong, younger generations often migrate to the cities to find work. This can leave older people on their own, without family support, which can lead to significant social isolation. This is the case in the study area, where many young men, constituting the main labour force of their households, leave in search of work in the cities.

Increased migration of children from rural to urban areas, especially the breadwinner(s) leaves the elderly people with limited or no care and support. Elderly people may be abandoned by their families wilfully or forcefully. Some are left alone due to the absence of immediate family. In such cases, they are left with no formal support, putting them in a very vulnerable position. Old age, coupled with their dependency on children for care and support, leaves the elderly people open to physical, psychological and financial abuse (from children/caretakers).

Elderly people who are subjected to physical and psychological abuse can withdraw from social activities. In other cases, their children can put restrictions on their movement, thereby curbing their social interactions.

Elderly people may not have an independent source of income. As a result, they may not be able to afford treatment for many age-related ailments (https://www.undp.org/sites/g/files/zskgke326/files/2023-08/undp-bhutan-vulnerability_baseline_assessment_2016.pdf)

Retired population faces major challenges and there are no State-sponsored arrangements and amenities for the elderly. Although a National Pension Scheme does exist, it only covers Government employees. The Gross National Happiness Commission in collaboration with the Health Ministry and the Royal Society for Senior Citizens worked on formulating the National Policy for Senior launched in October 2023. The policy aims to encourage productive ageing, health care and protection, safety and security, housing and age-friendly services, and welfare for senior citizens.

(https://rssc.org.bt/our-programme-details/launch-the-national-policy-for-senior-citizens)

The Royal Society for Senior Citizens (RSSC) looks after the welfare of the senior citizens. However, the CSO has limited funding as well as a shortage of staff. There is no Government counterpart and limited partnerships. The Tarayana Foundation works for elderly people through an integrated rural development approach to provide basic needs in many districts.

Elderlies interviewed as part of FGDs in February 2024 held during the LALRP survey, confirmed that if they can they continue some agricultural activities and sell small surplus- but transportation of products to markets is an issue. As elderly have less labour power and youths have left to other areas, they do let their more remote lands fallow- as they cannot access these lands easily, nor protect their crops against animals- but elderly precious their land an inheritance that will bring back their children to their originate village.

Elderly do also rely quite a lot on remittances from their children abroad or in other Dzongkhags and recognise that other villagers are supportive whenever needed. Elderly, except in Saleng where the outreach clinic is closed for 6 years, have access to essential public services and resources (medicine, health services)

for free or affordable prices. Gewogs centre provides a lot of the support needed. In Drepong, the discussions with poor households highlighted that only old people are alone back in the village, and during emergency and needy hours there is no one to take care of them. Some elderly mention that the Dratshang Lhentsog (the Commission for the Monastic Affairs of Bhutan) as well as voluntary cooperative works in the village as helpful. They express need to protect their crops against animal, shed to sell vegetables, support for mushrooms production (Tsamang) and reliable transportation systems (Tsamang).

8.2.8.3.2 Women

In Bhutan, there is no overt discrimination among women and is considered as a country where they enjoy relative freedom and equality in many spheres of life. However, women's status in the country is influenced by gender stereotypes and socio-cultural perceptions which generally hold them behind. This has influenced access to education, employment, leadership positions in the government and public decision-making, which poses a greater challenge as it is to do with the more subdued and indirect forms of gender bias.

Table 159 presents a summary of some of these challenges:

Table 159: Challenges regarding women's vulnerability

Access to education	Girls and boys have similar access to early childhood, primary, and basic education. Disparities between men and women tend to emerge in secondary and higher education, where fewer girls enrol. Males tend to have higher enrolments in tertiary education, both within and outside Bhutan.
Empowerment	Women face higher illiteracy rates compared to men. More men occupy salaried jobs, while women often engage in non-formal work categories or unpaid family work. Issues like early pregnancies and domestic chores hinder women's personal and economic empowerment.
Economic participation	Female labour force participation is lower than males, especially in urban areas. Women are more engaged in low-paying sectors like agriculture, contributing to the feminization of this sector. Access to resources like agriculture, labour, and health services is generally equal for both genders.
Property rights	Bhutan guarantees equal inheritance rights to men and women. Traditionally a matriarchal society, women often inherit property and account for a significant number of landowners. However, inheritance practices can impact choices related to education, occupation, and remaining in one's village.
Health risks and rights	Gender norms affect health status. Women face challenges beyond sexual and reproductive health due to social, economic, and environmental factors. Access to sexual and reproductive health services has improved, but challenges like cervical cancer prevalence and limited awareness persist. Some areas face disparities in access to skilled birth attendants due to terrain difficulties.
SGVB	SGBV, including domestic violence, remains a significant issue, impacting health and overall development. Reported cases of violence against women are notable, and efforts to engage men in prevention are ongoing. As the level of GBV in Bhutan and in the project, area is not particularly high, the GBV services are currently limited and judicial or police services to facilitate redress for survivors are under-represented (and inexistant in small villages).
Political rights	Women's participation in politics is encouraged, but their representation in parliament and leadership roles is relatively low compared to men. There's a lack of gender-neutral laws that encourage women's political participation.

Gender identity and sexual orientation	Bhutan doesn't criminalize consensual same-sex conduct but lacks explicit protection against discrimination based on sexual orientation, gender identity, or sex characteristics. LGBTQI+ individuals face social stigma and difficulties in registering advocacy organizations.

A detailed analysis of these challenges is provided in ESIA Volume 3 Appendix N – Social Baseline Additional Data.

The focus groups held in February with resource constrained women- or single mother- highlighted that single mothers are constrained by their multiple responsibilities (time poverty) and labour shortage to working the fields, limiting them to traditional subsistence farming. They are therefore more subject to food shortage and financial constraints: they cannot afford to invest in farming equipment that would ease their work, they face difficulties in meeting children's education needs and face unforeseen circumstances. They manage the situation by proposing labour exchange locally, rely on informal borrowing, work extra-hours. They also observe that female work is paid less than male work as they are considered weaker. They also can't attend social events like social voluntary work for development of their community. This contributes to single mother's low self-esteem.

8.2.8.3.3 People with disabilities

People with disabilities did not have equal access to education, health services, public building, and transportation. A CSO working on disability rights, the Disabled People's Organization of Bhutan (DPOB), stated there were difficulties for and social stigma towards persons with disabilities. The DPOB stated inaccessible infrastructure was one of the major issues faced by people with disabilities.

The UNDP Bhutan vulnerability baseline assessment (2016) list the following vulnerabilities related to person with disability:

- Absence of an enabling environment, in the form of disabled friendly infrastructure, assistive technology, special educators, caregivers, non-adaptive school curriculum and examination, and prevalence of stigma and discrimination at school, limits access to education for persons with disability.
- Shortage of trained human resources, challenges pertaining to delivery of health services like early diagnosis, referral and intervention services and limited access to psychotropic medications aggravate their health-related vulnerability. Absence of quality education and life skills, limited employment opportunities, lack of disabled friendly infrastructure and discrimination at workplace limit the employment opportunities available to persons with disabilities.
- Limited communication ability and fear of not being believed make people with disability a soft target for physical and sexual abuse.

Moreover, CSOs said **people with HIV/AIDS continued to face some social stigma**, and many such people were reluctant to reveal their health status due to fear of negative attitudes.

The government provided free medical and counselling services to people with HIV/AIDS and maintained programs designed to prevent discrimination. The CSO Lhak Sam provided support to people living with HIV and to their families and cooperated with the Ministry of Health to create and promote effective responses to HIV/AIDS, and their impacts.

Nationwide, there are a total of 30 schools enrolling 754 children with special educational needs of which 21 are categorized as inclusive schools or schools with SEN programmes and two are categorized as special institutes/schools as the schools have specialized educational provision for students with disabilities.

In Lhuentse, the Autsho Central School has 12 students enrolled in the SEN program (5M, 7F), while in Mongar there are 43 students in Mongar Middle Secondary School (33M, 10F) and 5 students in Mongar Higher Secondary School (2M, 3F) (MoE, 2021. Annual Educational Statistics).

According to the field report of the Bhutan Foundation, the Mongar Middle Secondary school provides inclusive sessions with the mainstream classes, as well as pre-vocational classes for children with disabilities that include daily living skills such as cooking, washing, and tailoring training. (https://www.bhutanfound.org/field-notes-solar-power-special-education-and-womens-empowerment/). One of the main challenges faced by the school is poor awareness of SEN services in the community the school has five SEN providers (https://businessbhutan.bt/poor-awareness-of-sen-services-in-mongar/).

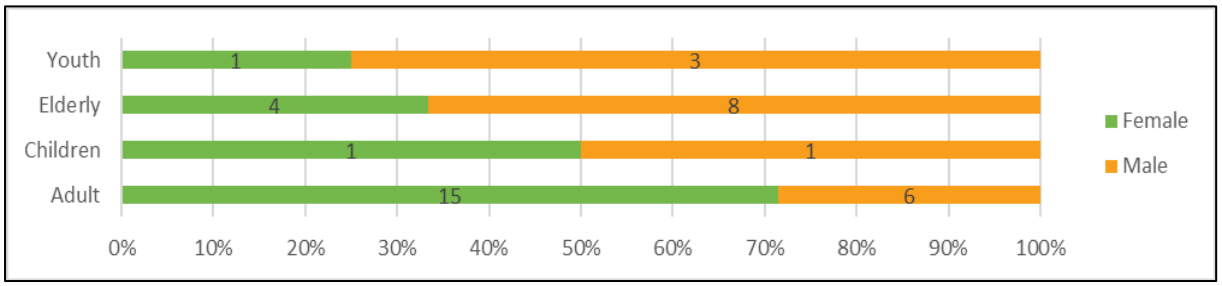


Figure 189: Gender and Age Distribution of Individuals with Disabilities

In the study area, household surveys identified 39 individuals with disabilities, representing approximately 2.5% of the population. The accompanying graph categorizes these individuals by age and gender. It shows that within the adult category, there are more females (15) with disabilities than males (6). Conversely, among the elderly, there are more males (8) with disabilities than females (4). The youth category has a smaller presence, with disabilities reported in three males and one female. The count for children with disabilities is balanced, with one male and one female each. This data reflects a higher incidence of reported disabilities in adult females and elderly males within the surveyed population.

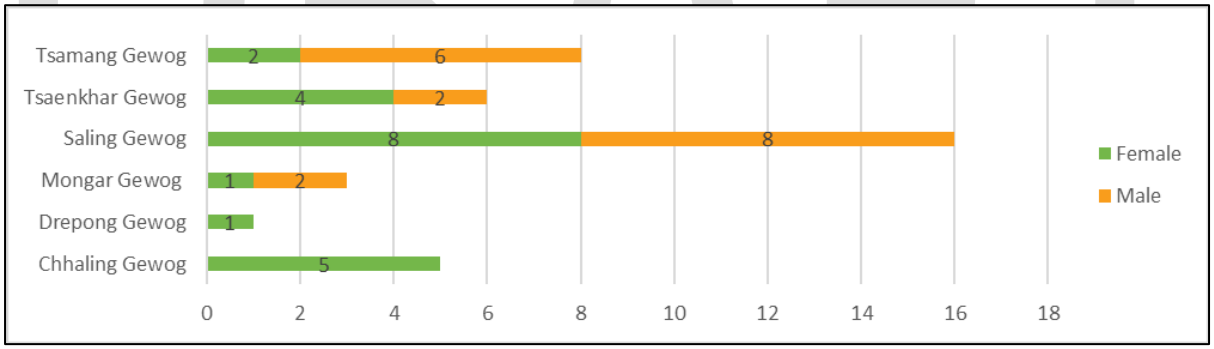


Figure 190: Disability Prevalence by Gender Across Gewogs

From the HH surveys Chhaling Gewog has the highest number of females with disabilities at five, while Saling Gewog has the highest overall with eight males with disabilities. Tsamang Gewog presents a higher number of males with disabilities (six) compared to females (two). In Tsakhar Gewog, more females with disabilities are reported (four) than males (two). Conversely, Mongar Gewog and Drepong Gewog both report a lower number of individuals with disabilities, with Mongar showing more males (two) than females (one), and Drepong showing the opposite, with one female and no males. This distribution indicates variability in the prevalence of disability between genders across different Gewogs.

When asked about the number of vulnerable people, the people who took part in the focus group discussions during the surveys were able to give an estimate of the number of vulnerable people in certain localities.

Table 160: Number of vulnerable people in certain locations of the study area

Location	Number of vulnerable people
Autsho	15
Chhali	50

Location	Number of vulnerable people
Autsho	**15**
Drangmaling-Nangar	0
Tokari	4
Tsakaling	40

The household surveys and focus group discussions provide complementary data sets that are essential for the fieldwork aimed at identifying PAPs. The household surveys have highlighted specific Gewogs with notable numbers of individuals with disabilities, such as Chhaling and Saling, with a discernible gender-related prevalence in certain areas. This quantitative data will guide the team to focus their efforts on where the numbers are greatest and where gender-specific vulnerabilities may exist. Additionally, the qualitative insights from focus group discussions offer estimates on the number of vulnerable individuals in particular localities, allowing for a targeted approach in these areas.

8.2.8.3.4 Youth

Bhutan has a relatively young population, and finding suitable employment opportunities can be a challenge. With limited job prospects, especially in rural areas, mismatch between skills and market demand, and barriers to accessing employment, youth unemployment rates can be high, leading to financial insecurity and underemployment. All this is more difficult for youth from rural areas who have even less access and support. **(**http://drukjournal.bt/wp-content/uploads/2021/11/Young-Bhutanese-Hopes-Anxieties-and-Mandate_Dasho-Kinley-Dorji.pdf**)**

Youth (15-24 y.o) unemployment rate in 2022 was at 14,6% - it reached 21,22% in 2020 during COVID-19 pandemic. *The youth unemployment rate is the share of the total workforce aged 15 to 24 that is currently without work, but actively searching for employment. It does not include economically inactive people such as full-time students or the long-term unemployed.* **(**https://www.statista.com/statistics/811680/youth-unemployment-rate-in-bhutan/**)**

The general view of the youth population in Bhutan pertaining to the job market points towards a feeling of disillusionment and disempowerment, which can be followed by deviancy or crime**.** (http://drukjournal.bt/wp-content/uploads/2021/11/Employment_-Youth-Perceptions-and-Expectations_Kuenga-Norbu.pdf)

While Bhutan has made significant strides in improving access to education, there can still be disparities in quality and access, particularly in rural and remote areas. Limited access to quality education can hinder youth's ability to compete in the job market and fulfill their potential.

Issues such as mental health, substance abuse, and sexual health can affect youth disproportionately, and there might be inadequate resources and support systems to address these concerns effectively.

Traditional societal norms and expectations can put pressure on Bhutanese youth to conform to certain roles and behaviors, which may not align with their aspirations or identities. This pressure can contribute to stress, anxiety, and a sense of inadequacy among young people.

While access to technology and the internet is growing in Bhutan, there can still be disparities in access, particularly in rural and remote areas. The inequities between the rural and urban population place rural youth at a disadvantage in starting their careers. A major disadvantage today is the poorer digital and telephone connectivity and access in rural Bhutan. The digital divide can limit young people's access to educational resources, information, and opportunities for social and economic advancement.

FGDs with youths were conducted in the project area by February 2024 as part of the LARP survey. Young people are involved in sall agriculture and some males in small construction. While young farmers aspire to develop the family farms for more intensive agriculture and value-added products, they are hampered by a lack of financial resources and practical difficulties (access roads/means of transport) to reach the market.

They are also looking for more job opportunities and skills training. They do not suffer from mental health problems unless they have financial difficulties and lack family support.

8.3 Archaeological and Cultural Heritage

8.3.1 Definition of cultural heritage

Religion and culture, whether tangible or intangible, is an integral part of the Bhutanese identity and lifestyle. The promotion and preservation of this culture is one of the four pillars of Gross National Philosophy. This emphasizes the promotion of cultural identity, documentation of knowledge and practices and developing cultural resilience.

Tangible cultural heritage includes Dzongs, monasteries, temples, religious objects, manuscripts, statues, lus and neys. Dzongs are large fortresses, Lhakhang are temples, Goenpas are monasteries (Goenpa), and Chortens are stupas. Lus are subterranean beings that live in sacred places and are vulnerable to pollution (https://bhutan.virginia.edu/). Before any development can occur in such places, the Lus must be appeased through prayers to seek permission. Otherwise, it is believed to inflict pain, illnesses, or misery. Neys are sacred sites/imprints that are considered the abode of a spiritual being. It can be a mountain, rock, lakes, springs, or trees. These are considered to provide spiritual blessings.

Intangible heritage includes Driglam Namzha, dress, language, arts and crafts, food, traditional games, and festivals (GNHC. 2013 Eleventh Five Year Plan). Driglam Namzha is the prescribed carriage of ku (body), sung (expression of thought) and thug (mind) (Source. Driglam Division. Department of Culture and Dzongkhag Development) and is a unique form of cultural expression.

The Department of Culture and Dzongkhag Development, Ministry of Home Affairs released the Essential Guide to Sacred Sites (Nyes) for various Dzongkhags, wherein nationally recognized tangible and intangible religious and cultural sites and items are documented. For Lhuentse and Mongar, a total of 11 such sites in Lhuentse and 5 in Mongar districts have been inventoried and described in detail, of which only one is described from Tsenkhar Gewog (Phu Ningla Nye) which is beyond 5km from the project components.

The National Biodiversity Centre has also prepared a map with the location of historical sites in the country. This map indicates that most of these numerous sites are scattered towards central and eastern Bhutan.

The community mapping conducted with 8 groups also allowed the study to identify and cross-check information about the location of PCRs. This is documented in the social survey report on the community maps.

8.3.2 Specific issues

Both tangible and intangible cultural heritage values could be at risk from construction / operation activities depending on their proximity to the project component sites.

8.3.3 Objectives and conduct of field surveys

The objective of the specific field surveys was to identify and document both tangible cultural heritage assets that could be impacted or lost under the project as well as the possible impacts upon intangible cultural heritage.

The team followed a consultative process beginning with stakeholder mapping, including relevant agencies in the stakeholder engagement plan to consultation with the relevant agencies and communities.

Prior to the field surveys, the team prepared a preliminary list of Physical Cultural Resources (PCR) sites for all the gewog and approached the Department of Culture and Dzongkha Development, Ministry of Home Affairs, in April to inform the office of the project and to seek clarification on the preliminary list of PCR sites for all the gewogs and request guidance to confirm whether all significant sites have been included.

The Director informed that there were 3 Divisions under the Department – Division Culture, Conservation of Heritage Sites, and Intangible heritage and that the list would be internally discussed and reshared with the team. An email response with the list of Lhakhangs, Nyes and Intangible heritage was shared with the team.

During the community meetings at the gewogs, the list was discussed with the Gups, Tsogpa or Mangmi in each gewog and further modified based on the distance of the site (5 km) to the project components.

Wherever possible, the caretaker was consulted on the significance of the PCR, heritage, and intangible heritage. Apart from one female, all those consulted during the site visit were males.

8.3.4 Survey findings

Table 161 indicates the total number of tangible and intangible cultural heritage recorded during the field discussion. The number of PCR and intangible heritage documented as well as the number received from the Department of Culture and Dzongkha Development. In total 45 sites were documented, of which 4 are less than half a kilometre away, 8 are between 0.5-1 km away, 9 are between 1-2 km, 21 are between 2-5 km and 4 are more than 5 km away.

The list of sites in brackets is the number of sites provided by the Department of Culture and Dzongkha Development, while the figures before the bracket are the number of sites documented during the field visit.

Table 161: Summary of documentation of PCR and Intangible heritage (the 'documented' figure reflects the number of sites actually surveyed and groundtruthed as part of the field surveys)

Gewog	Lhakhangs and Goenpas	Nyes	Intangible Cultural heritage
MONGAR DZONGKHAG			
Tsamang	3 (7 documented)	2 (2 documented)	5 (4 documented)
Saleng	6 (6 documented)	5 (none documented)	0 (2 documented)
Chhaling	11 (6 documented)	6 (10 documented) + 1 hot stone bath area	0 (3 documented)
Tsakaling	16 (9 documented)	4 (none documented)	3 (3 documented)
Mongar	0	4 (none documented)	0
Drepong	9 (none documented)	1 (none documented)	0 (none documented)
LHUENTSE DZONGKHAG			
Tsenkhar	0 (6 documented)	1 (none documented)	0 (2 documented)
Total	45 (34 documented)	23 (13 documented)	8 (6 documented)

Table 162: Number of tangible and intangible heritage documented at the project site.

	Lhakhangs and Goenpas			Nyes			Intangible Cultural heritage		
Gewog	DoCDD	Survey	PC	DoCDD	Survey	PC	DoCDD	Survey	PC
Tsamang	3	7		2	2		5	4	
Saleng	6	6		5	0		0	2	
Chhaling	11	6		6	10+1		0	3	
Tsakaling	16	9		4	0		3	3	
Mongar	0	0		4	0		0	0	
Drepong	9	0		1	0		0	0	
Tsenkhar	0	6		1	0		0	2	
Total	**45**	**34**	**0**	**23**	**2**	**0**	**8**	**14**	

8.3.5 Tangible heritage within project area

Details on cultural elements were collected from a variety of stakeholders: Department of Culture and Dzongkha Development, Ministry of Home Affairs- Division Culture, Conservation of Heritage Sites, and Intangible heritage, the Gups, Tsogpa or Mangmi in each gewog and the communities themselves. The consultation was completed by site visits with locals and site caretakers to document many sites.

In the area surrounding the project, a total of 23 sites were documented during the first field campaign in consultations as important cultural heritage elements. The number and locations of cultural heritage elements in relation to the project are shown in the following tables. Table 163 provides the number and distance from project elements, of which 4 are less than half a kilometer away, 8 are between 0.5-1 km away, 9 are between 1-2 km, 21 are between 2-5 km and 4 are more than 5 km away. Table 164 provides, for these same 20 sites, the types of cultural heritage sites identified. Table 165 provides further detail (GPS coordinates and significant features) on these sites.

No sites were identified in Mongar or Drepong gewogs.

Further information, including the detailed description of tangible cultural heritage in Gewog is provided in the ESIA baseline (Section 8.3).

Table 163: Number and distance of tangible cultural heritage sites from the project elements

Distance from project components	Tsamang Above HRT	Saleng	Chaling	Tsakaling	Tsenkhar
< 0.5 km		• Lingmethang Lhakhang (CCF 9)	• Namnying Chorten (close to Highway) • Hot stone bath (dewatered section) • Namnying Drubchu		• Autsho Chorten • Autsho Dhoetrey (cremation ground)
0.5-1 km	• Tokari Goenpa Lhakhang • Lamai Zhabjey Ney • Guru Rinpoche Ney • Serbum Goenpa		• Kurizam pema yoedling Lhakhang • Kurizam nagdra Dorjecho Lhakhang		
1-2 km	• Banjar Dungnga Choekhorling Lhakhang • Kadam Chorten			• Tashi Choeling Lhakhang	
2-5 km	• Drangmaling Nangkar Lhakhang (new)	• Thridangbi Lhakhang (but close to the highway to Bumthang)		• Takhambi Thekcholing Lhakhang	

Distance from project components	Tsamang Above HRT	Saleng	Chaling	Tsakaling	Tsenkhar
	• Drangmaling Nangkar Lhakhang (old) •				
>5 km	• Ganglapong Jangchu choling Lhakhang • Kuling Goenpa Lhakhang	• Jangdung chiwog Lhakhang (CCF 9) • Marsang daza Lhakhang (CCF 9)			
Total	**10**	**4**	**5**	**2**	**2**

Table 164: Type and number of tangible cultural heritage sites in the project area

	Tsamang	Saleng	Chaling	Tsakaling	Tsenkhar	Total
Lhakhangs and Goenpas or Chortens	8	4	3	2	1	**18**
Neys, stone bath or crematorium	2	0	2	0	1	**5**
Total	**10**	**4**	**5**	**2**	**2**	**23**

Table 165: Cultural Heritage Site details

SN	Gewog	Name	GPS	Significant features
1	Tsamang	Ganglapong Jangchu choling Lhakhang	27°25'30.84618"N 91° 8' 36.6338"E Elevation:1589m	This has statues such as the Toenpa, Guru Pema Juney and Chenrezig. It is on the slope north of the HRT,
2	Tsamang	Kuling Goenpa Lhakhang	27°25'48.00"N 91° 7'30.96"E	The caretaker Jigme Dorji did not know details about the Goenpa but claims that the Lhakhang is very old.
3	Tsamang	Drangmaling Nanggar Lhakhang (old)	27°18'44.69515"N 91° 9' 14.84215"E Elevation:1825m	This Lhakhang has existed for four generations and is a part of a private house. Because of this, the community decided to construct a new Lhakhang, and the Lhakhang was handed over to the house owner, Ngawang Gyeltshen. It was built to mark the boundary between Tsamang and Wangling. Relics include statues of Sangay Sacha Thuba, Milarapa, Dorlma, and Zamba lha. Many of the statues are in a very poor state. According to the DCDD (February 2023, this will no longer be considered a cultural site as the relics will be moved to the new lhakhang).
4	Tsamang	Serbum goenpa	27°19'25.7"N 91°10'52.6"E Elevation:2016 m	Belongs to the community but has no one to look after it. It contains the Chugchi zhay. The caretakers cannot remember when it was built. It is believed to be built by Raychunpa a disciple of Melarapa. The goenpa is under the care of a Khenpo, and there are 5 monks. The main statue is Chagtongchentong, No Tsechus are performed here

SN	Gewog	Name	GPS	Significant features
5	Tsamang	Drangmaling Nanggar Lhakhang (New)	27° 18' 4.48826"N 91°13'43.59295"E Elevation:1746m	The lhakhang is newly constructed and yet to be consecrated. No relics or statues have been installed yet.
6	Tsamang	Tokari Goenpa Lhakhang	27°20'20.18803"N 91° 11'25.98659"E Elevation:1436m	The temple is quite old, but the caretaker was not able to say when it was constructed. The lhakhang contains important relics such as statues of the eight manifestations of Guru Padmasambhava, Chenrezig, Dhu Sum Sangay, Khando Mandarava, and Yeshe Tsogyal. The second Gyalwa Karmapa founded the Lhakhang and handed it over to the community, who handed it over to Gangtey Tulku. The Lhakhang has currently undergone three renovations. The community is waiting for the clearance to cut the wood needed for the building of Lhakhang's upcoming renovation. Seven nuns reside at the nunnery at the Lhakhang and are undergoing their grade 2 studies.
7	Tsamang	Kadam Chorten	27° 20' 8.93209"N 91° 11'19.98974"E Elevation:1525m	It was constructed to subdue evil spirits in the area.
8	Tsamang	Banjar Dungnga Choekhorling Lhakhang	27°22'16.03898"N 91°10'56.58542"E Elevation:1768 m	The main relic found in the Lhakhang is Guru Rinpoche and Sangay Tempa which were received from Punakha. Other relics are the statue of Zhabdrung Ngawang Namgyel, Chenrezig and Dorji Sempa. The Llhakhang was renovated to its current size in 2003
9	Tsamang	Lamai Zhabjey	27°21'17.5334"N 91°11'23.03372"E Elevation:1500 m	This Ney features the footprint of Gyalwa Karmapa, the second Karmapa. The chorten is currently managed by an elderly woman named Karma mo, who always offers a butter lamp each day. It was constructed by the late Tekpala.
10	Tsamang	Guru Rinpochoe Ney Go	27° 20'4.28762"N 91°11'21.96823"E Elevation:1514 m	This location is said to have been marked as the entrance to a secret treasure by Guru Rinpoche. On auspicious days, locals visit the site and offer butter lamps. The sacred location is home to a stone relic that is believed to be Guru Rinpoche's shoe and Conch.
11	Saleng	Lingmethang Lhakhang	27°15'40.99"N 91°10'14.74"E Elevation:800m	The land belongs to the Department of Roads but the lhakhang is currently being taken care of by Kadam Gomdhey. It is also called the Depong Zenglen Lhakhang. The lhakhang contains the KheyLo Choe Sum. The lhakhang was constructed 30 years ago, to protect the community from evil spirits. A three-day Tshog Bum is recited in the ninth month of the Bhutanese calendar. Every year, the caretakers are changed.
12	Saleng	Thridangbi Lhakhang	27°17'4.86"N 91° 9'33.46"E Elevation:1450m	The caretaker was absent, and the Lhakhang was locked, no information could be gathered.

SN	Gewog	Name	GPS	Significant features
13	Saleng	Jangdung Chiwog Lhakhang	27°15'52.37"N 91° 9'2.12"E Elevation:750m	The caretaker was absent, and the Lhakhang was locked, no information could be gathered.
14	Saleng	Masang daza Lhakhang	27°14'53.14"N 91° 9'16.11"E Elevation:830	The caretaker was absent, and the Lhakhang was locked, no information could be gathered.
15	Chaling	Namnying Chorten	27° 18' 44.2656"N 91° 13' 9.70075"E Elevation:969.542m	The chorten is about 300 years old. This is a sacred stupa of enlightenment that Kyabji Namkhai Nyingpo Rinpoche constructed, funded by Aum Dedron from Chaling. In 2021, it was renovated by the community. The statue of Namkhai Nyigpo Rinpoche's third incarnation is located inside the glass enclosure adjacent to the chorten, financed by Tulku Wangdla. The surroundings also have a sacred fig tree (*Ficus religiosa*) planted by Namkhai Nyingpo Rinpoche.
16	Chaling	Kurizam Pema Yoedling Lhakhang	27°16'24.53"N 91°11'38.06"E Elevation:526m	There was no one available to give information.
17	Chaling	Kurizam Nagdra Dorjeechoe Lhakhang	27°16'24.53"N 91°11'38.06"E Elevation:526m	Gyeltshen tulku oversees the lhakhang. Over 50 monks reside at the lhakhang. Three Buddha sculptures were among the major artefacts found. Every year, grand prayers are held, during which 500 or so visitors are welcomed and given blessings.
18	Chaling	Hot stone bath	27°16'3.49"N 91°11'34.77"E	This place is in the dewatered section of the Kurichhu below the Kurizam. It is used by both local people and outsiders to have stone baths during winter
19	Chaling	Namnying Drubchu	27°19'27.56766"N 91°13'33.88289"E Elevation:871 m	According to legend, the third Namkhai Nyingpo Jample Ngawang Drukda's stomach was washed in the sacred spring and the stone stained with the Karmapa's blood can still be seen in the Ney.
20	Tsakaling	Takhambi Thekcholing Lhakhang	27°23'40.33025"N 91° 13' 0.76483"E Elevation: 1537m	The construction began in 2002 and has not yet been completed. Relics include the 13-foot-tall Guru Rinpoche, Pema Lingpa, and Drolma. Khenpo Thekcho Dorji looks over the lhakhang, The Lhakhang is home to 40 monks.
21	Tsakaling	Tashi Choeling Lhakhang	27°23'54.35624"N 91°12'31.57067"E elevation:1537m	The Lhakhang was built in the eighth century. It houses the Chenrezig. On the 13th, 14th, 15th, and 16th of Dawdangpa in the Bhutanese calendar, Nungneys are held at the Lhakhang every year.
22	Tsenkhar	Autsho Chorten	27° 26' 3.26656"N 91° 10' 23.30234"E Elevation:820 m	There was no one present to provide information. Information will be updated after the February 2024 field visit.
23	Tsenkhar	Autsho Dhoetrey (cremation ground)	27°26'47.38"N 91°10'19.33"E Elevation:830 m	Used by locals for cremation. This is located upstream of the submergence area.

A list of Physical Cultural Religious sites with their GPS coordinates, location on the maps and a description of each site within 5km from the current proposed project layout is documented in the Cultural Heritage Field Work Report.

8.3.6 Importance of Springs, streams and rivers

Water is considered very important for religious purposes because of the daily practice of offering water to the deities, along with butter lamps. Water used must be fresh, clean and pure and therefore is often collected from taps at homes and springs rather than from rivers. Other traditional practices include using clean water to bless newborn children, and for purification purposes during rituals. It is also common to find Choekormani (prayerwheels containing mantras) on streams and rivulets.

Figure 191: Image of a choekarmani in Lhuentse (field survey photos)

Tsachhus are hot springs that are believed to have curative properties and people soak in these to cure their ailments. Menchus are also springs with mineral properties and not as hot in temperature as Tsachhus. Water from menchus is collected in tubs and heated by hot stones, that are dipped in the tub after being warmed over a fire.

These tsachus and menchus are often visited by locals from around the country for relaxation, recreational or healing purposes. There are no menchus in the project site but there are two hot stone bath areas, along the Kurichhu River. One is located below the kurichhu bridge in Gyelpozhing (see map below) and the other is located north of the gewog office in Autsho, Tsenkhar Gewog. The first one is used by neighbouring gewogs such as Tsamang and Saleng and Mongar gewogs.

The second one located at Autsho is more than 10km from the dam site and approximately 3km above the submergence area.

There is a Namnying Drubchu (holy spring), 0.57 km from MD-13, below the highway Chhaling village. This is located above the Mongar-Lhuentse Highway.

8.3.7 Kurichhu river

During the key informant interviews, when asked about whether the Kurichhu River was considered sacred, the Principal of Namdroling Monastery clarified that the Kurichhu is deemed a holy river because it flows into sacred rivers in India, such as the Brahmaputra and the Ganges. However, he emphasized that the ongoing project would not alter the river's sacred value. He expressed that the project is welcomed by both the local population and the monastery, with the hope that it will help repopulate the area, indeed due to rural exodus for ecomomic reasons, the population in the area is less than in previous periods. The monastery offered to assist the project in conducting any required religious ceremonies in the future. Additionally, it is interesting to note that during the community mappings, when exploring both the tangible

and intangible relationship of the community with the Kurichhu River, aside from hot bathing spots, no intrinsic religious or spiritual characteristics of the river itself were mentioned.

8.3.8 Intangible heritage

The intangible cultural heritage identified during the first visit in consultation with the population is summarised in this section.

8.3.8.1 Religious practices

Religious practices play an integral role in the lives of the communities.

- In Tsamang, all chiwogs celebrate the 'Kharphue' festival for 7 days in June each year (on the same days in Drangmaling, Banjar and Tsamang but on a different date in Ganglapong).
- The 'Kharam' is practised in most gewogs, for one to two days by individual households from June-November each year. This is the festival/prayers for the wellbeing of the cattle. Days vary from June to November.

Table 166: Details on religious practices in the project area

Name	Location	Description	Significance and other observations
Khandro Kongshag Tsechhu	Tsakaling & Chaling	This rite is carried out every three years. Depending on the zakar, it is conducted in the 11th and 12th month of the Bhutanese calendar.	They perform mask dances, pujas, and prayer recitation. It is typically held in lhakhangs to cleanse one's soul of sin and ask for forgiveness.
Worshiping or appeasing local deities	Tsakaling	It is held on the first day of the 4th month of the Bhutanese calendar. To please Bumthang Nepo, a local god, the community members gather and do a little puja. They make offerings in the form of tshog.	It is done to request the deity's assistance in defending the community, their animals, and their crops from outside threats like wildlife.
Kharam	Tsakaling	This is a religious ceremony conducted in the eighth month of the Bhutanese calendar for two days. There is no special dress, or ornaments wore during this occasion	Toward against bad luck and the evil eye.
	Chaling	Trees are planted by people. Celebrated in the eighth month of the Bhutanese calendar, exact date unknown. lasted for two days.	Toward against bad luck and the evil eye.
Kharam	Tsamang Banjar	Cattle festival/prayers for cattle 1 day in November (doesn't know exact date)- done by individual households.	This is to offer prayers for the wellbeing of cattle
Kharphue	Chaling	Festival in June each year	To celebrate and to bring peace, wellbeing to the community and to seek the deity's assistance in defending the community, their animals, and their crops from outside threats like wildlife.

Name	Location	Description	Significance and other observations
Kharphue	Celebrated at Banjar Lhakhang ground, Tsamang gewog and at Ganglapong	Festivals for 7 days in June each year Held in every chiwog- Drangmaling, Banjar and the festival is held in Tsamang on the same date but in Ganglapong, it is on different date.	To celebrate and to bring peace and wellbeing to the community.
Yar-ngo and Mar-ngo	Saleng	Every month in the Bhutanese calendar, the 10th and 25th are dedicated to prayers/ Tsechus such as 'Yar-ngo' (full moon) and 'Mar-ngo' (waning moon).	
Tshobum (Sampa Lhendup)	Saleng	Depending on who is available, the community make feast offering for the monks to offer prayers for fulfilling all wishes, especially community wellbeing, protection from calamities and good harvest.	Yearly event This is carried out in the nearest Lhakhang by the monks, while the community attend, if possible, in daily attire.
Art of making baskets and rope out of cane	Tsamang Banjar	Livelihood	Currently DOFPS is conducting surveys to assess locations for cane and bamboo. Location of collection – at the top of the hill along the ridgeline.
Baphue	Tsamang Banjar	Cattle festival/prayers for 1 day- November 8 day, before kharam. The community gathers in the ground to conduct prayers for the cattle.	They collect all the cattle and make offerings – Rimdro for the cattle to the deities.

8.3.8.2 Festivals

In all the gewogs, there are no special dresses or ornaments worn during the festivals. During religious ceremonies, the focus is on prayers and offerings. During Tsechhus the community wears their finest ghos and kiras and their tradtional jewelry (zees, jurus, gold and silver).

- In Chaling, the Kharphue and Kharam are also celebrated.
- Another cattle festival is the 'Baphue' celebrated in Tsamang, before 'Kharam'. The community gather together on community grounds to conduct prayers for the cattle, for one day in November each year.
- In Tsakaling. Khandro Kongshag festival is carried out every three years, on the 11th and 12th month of the Bhutanese calendar. Mask dances, pujas, and prayer recitations are held in the Lhakhang to cleanse the soul of sins and ask for forgiveness. Deities are also worshipped on the first day of 4th month of the Bhutanese calendar, to please Bumthang Nepo, a local god through offerings.
- In Tsenkhar, aside from Kharam, the Guru Dhakma Drubchen is held for 2 weeks in December, where prayers for wellbeing are conducted.

8.3.8.3 Languages

In the area directly affected by the study, Tsangla is the most spoken language by 40% of the population, while the official language, Dzongkha, is spoken by 29%. Kurmedkha is spoken by 24% of respondents. The prevalence of these languages varies across different Gewogs, with Tsangla being the main language in Chaling, Drepong, and Mongar Gewogs. Kurmedkha is predominantly spoken in Tsenkhar, Tsakaling, and

Tsamang Gewogs. Dzongkha's usage is less common in Saleng and Tsakaling Gewogs at 15% and 6%, respectively. Additionally, 25% of Chaling's population speaks Chaling-kha.

There are respondents (7% of the sample) who speak languages other than the main ones identified, which includes Lhotsamkha speakers primarily found in urban centres within the study area.

8.3.8.4 Traditional arts and craft

Some of the forms of traditional art and crafts found in the project area are Thangka painting, pottery, weaving, mask making, calligraphy, metalworking, bamboo crafts.

In addition to this list, the Tsamang community practices the art of making baskets and ropes from cane, especially in the villages of Tsamang and Banjar.

9 SUMMARY OF SENSITIVITY OF ENVIRONMENTAL AND SOCIAL COMPONENTS

The following table recalls the sensitivity defined for each component of the physical, biological and social environment.

Table 167: Summary of physical, biological and human environment sensitivity

Sensitivity level reflects potential project impacts

Subtopics	Issues and sensitivities	Sensitivity level
Physical environment		
Climate	Climate is a highly sensitive and critical aspect, aligning with various international conventions ratified by Bhutan to address climate change. Numerous elements of the physical, biological, and human environment rely on the climate as it forms the foundation of abiotic factors within ecosystems.	High
Topography	High to Medium sensitivity due to the variation of relief. The declivity is high in this area (slope > 10%), which is an aggravating factor of soil water-induced erosion. This fact increases the sensitivity of this environmental issue.	High to Medium
Geology and soil	Geological studies do not show any specific sensitivity inherent to the geological substratum on this portion of the study area.	Low
Natural hazard	The Dzongkhag Disaster plan rated the probability of windstorm, landslide, earthquakes and forest fire as high, lightning and thunder as medium. Hailstorms and floods as low probability.	Medium to low
Seismicity	The historical seismic activity in the region has not affected the project area.	Low
Hydrology	Component with a moderate to low sensitivity because of the typology of existing rivers and limited use of surface water resources by local population.	Medium to low
Sediment quality	Sediments are regularly collected by local communities for various uses.	High
Air quality	Population density in the area raises the sensitivity of this component.	High
Noise level	Population density in the area raises the sensitivity of this component.	High
Biological environment		
Natural terrestrial habitats	Cover the vast majority of the AoA. Mainly forest habitats with riparian broadleaf forest, broadleaf forest, and Chirpine forest. Also, there are some cliffs and rocky areas. Area dominated by Natural habitat in 5km Radius of project components.	High because of ecosystem services and associated fauna and flora sensitive species
Classified area	2 nationally classified area partially in the AoA/AoI: (i) Phrumsengla National Park (NPN) and Corridor #77 3 KBA (Birdlife) in one EBA: Pallas fish eagle, Thrumsing La (same area than PNP) and Kori La KBA. All included in the Eastern Himalaya EBA.	High
Flora	One CHQ herbs, *Hoya Bhutanica* (Apocynaceae). Endangered and restricted range species 3 other EN/CR and or Restricted range present or likely present in the AoA 1 other VU, 1 other NT and 65 LC species identified on field	Hight for CH Low to Medium for other flora species

Subtopics	Issues and sensitivities	Sensitivity level
Mammals	3 CHQ mammals (Chinese Pangolin, Capped Langur and the Tiger), 6 other EN/CR and or Restricted range species present or likely present in the AoA 3 VU and 2 NT other species	Hight for CH Low to Medium for other mammal species
Birds	4 CHQ birds (Dark-rumped Swift, White-rumped Vulture, Pallas's Fish-eagle and Red-headed Vulture), 3 other EN/CR and or Restricted range species present or likely present in the AoA 13 VU and 12 NT other species	Hight for CH Low to Medium for other birds species
Amphibians and reptile	0 CHQ herpetofauna species, No other EN/CR and or Restricted range species present or likely present in the AoA 5 VU and 1 NT other species	Low to Medium
Aquatic habitats	River and stream habiat. Habitats are minerals with fast flowing waters with presences of riffles and torrent ecologically important for species.	High because of ecosystem services and associated fauna and flora sensitive species
Aquatic Flora	No strict aquatic plant has been inventoried in the project area. Not all riparian species are species of concern. See also riparian broadleaf forest in terrestrial natural habitat.	Low
Ichthyofauna	4 CHQ fish species (*Creteuchiloglanis bumdelingensis*, *Parachiloglanis bhutanensis*, *Parachiloglanis dangmechuensis* and *Tor putitora* Highest diversity in the tributaries with matures individuals (high). Fish are not a food resource for local people (medium). Three endemic species considered as CH qualifying.	High for CH Low to Medium for other ichthyofauna species
Aquatic invertebrates	Orders observed reflect a good water quality and aquatic invertebrates are valuable food resources for fish	Medium
Socio-demographic characteristics		
Demography and migration	The project influence area is low populated. Rural exodus is an issue in the project influence area for economic reasons and can lead to a situation of economic vulnerability for the households.	Medium to high
Languages and religions	Language disparities could lead to some challenges during Project implementation. Some local community members don't use Dzongkha, and communication also needs to be provided in multiple local dialects. This component will have to be considered in the Project's communication elements.	Medium
Management of natural resources and land use		
Management of natural resources	Every gewog in the study area has community forests, managed by the surrounding households. The Tsenkhar gewog is unique in that it encompasses the biological corridor (BC 7). In addition to the protected corridor, the gewog has 27.8 km of irrigation canals, 5 community forestry groups and 3 community forest management group members, demonstrating a high level of community involvement in forest management. The Kurichhu River is used in all Gewogs for hot stone baths. Banjar and Chhali villages don't employ the river for any activities, whereas Drangmaling-Nangar only uses it for crossing via a	Low

Subtopics	Issues and sensitivities	Sensitivity level
	suspension bridge. Gyelposhing Town interacts with the river mainly around the dam site and reservoir. Although the Kurichhu River is recognized as a natural water resource in the region, it's not the primary source of drinking water for the surveyed communities, as they mostly rely on piped water systems from stable sources.	
Land use	All the gewog of the study area contains a high proportion of forest (from 75% to 95%) Little flat land is available to cultivate. Land pressure and land disputes remain rare.	Medium
Living conditions and access to basic services		
Education and vocational training	More and more schools are closing in the area, leading to overcapacity in the remaining schools and the need for education further from home.	High
Health	The health centres are sufficiently numerous and well-equipped, but there is a lack of qualified health professionals who know how to use the centres equipment.	Medium
Water and sanitation	Water availability and quality are good. Most households surveyed are connected to the water supply system directly in their homes (90.2%), or to their neighbours from whom they obtain water All households are equipped with toilets.	Low
Waste	Waste management is problematic because it is not organized on a collective level. Landfill sites exist, but most households burn their waste.	High
Energy	Households are all connected to the power grid - energy doesn't seem to be an issue.	Low
Transport	The area has only one main road (highway) that is narrow and hilly. Some roads lead to the villages, but not all villages are interconnected/have access to vehicles.	High
Telecommunications	Mobile phone coverage is 100% in both districts. The more remote communities' access mobile telephony through Tashi Cell whereas rest of the areas access services provided by Bhutan Telecom.	Low
Shops and markets	Most villages have only a handful of shops with basic food items. For monthly supplies, farmers go to the nearest market, which is located at Lingmethang, Autsho, Gyelpozhing or Mongar town.	Low
Bank services, credits and savings	55% of the sampled population has taken out at least one loan during the year. The typical lenders are mostly banks. Most loans are made to renovate a house or invest in a business. Almost half of survey respondents said they had savings.	Low
Security, safety and public order	At the community level, the village head (Tshogpa) plays a crucial role in providing a platform for grievance airing and conflict resolution. While the Royal Bhutan Police is not typically available at the village level, their services can be accessed for crimes against persons. Instances of gender-based violence (GBV) and domestic violence, often attributed to alcohol consumption, are addressed through private resolution, involvement of the Tshogpa, or by seeking assistance from NGOs like RENEW at the district level. At the local level, alcoholism has recently decreased due to community-enforced by laws, and rural communities generally adhere to laws, ensuring safety in project gewogs.	Low

Subtopics	Issues and sensitivities	Sensitivity level
Economic activities and livelihoods		
Economic growth	Hydropower development and tourism contribute to a large part of economic growth. Rapid economic growth in Bhutan has contributed to substantial poverty reduction over the last two decades but economy remains fragile.	High
Means of subsistence	In the study area, the main activity is agriculture. There is a lack of opportunities and diversification in the area. In addition, the area suffers from a lack of flat land for agricultural development.	Medium
Housing and equipment	At the local level, CGI sheet roofs paired with stone walls and stone/wood floors as the most common architectural choice. All household's areas have smartphones and a good internet connection. Dwellings are adequately furnished (furniture, etc.).	Low
Sub-groups and vulnerabilities		
Ethnicity	No Indigenous people identified nor victimized. Various Socio-cultural groups are well integrated.	Low
Vulnerable groups	Vulnerable households are more likely to be single/with few assets, disabled or elderly. Four groups were identified as potentially vulnerable in the study area within the framework of the project: the youth, women (including female-headed households with no support), the elderly and people with disabilities. That said, all the vulnerable groups identified benefit from accompaniment and support, both from national programs and from the local community	Low
Human rights	The main issues requiring attention for all phases of the project are mainly related to work conditions, forced labour and gender issues and will require specific measures to be avoided.	Low
Gender issues	Although there are fewer job opportunities outside the home, women are autonomous economically: they run businesses in the cities and manage the farm in the countryside (rather matriarchal society). Literacy: There is a big gender difference, with more women (43%) than men (32%) being illiterate. Teenage pregnancy, domestic violence against women and rape are seldom reported. There are no gender disparities regarding loans and regarding access to land.	Medium
Archaeological and cultural heritage		
	Most cultural sites have been vandalized already to steal values. Some lhakhangs fall within the project area: Banjar lhakhang and Ganglapong Jangchu Choling Lhakhang (in Tsamang). The Kurichhu River is considered a holy river because it drains into the holy rivers in India, but the Principal at Namdroling Monastery informed that the project does not change the holy value of the river.	Medium

C. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

Methodology

Potential impacts associated with the footprint

Potential impacts associated with the construction

Potential impacts associated with operations

Potential impacts on ecosystem services

Potential cumulative impacts

10 ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS

10.1 Impact Assessment Methodology

10.1.1 Introduction

The impact assessment is analysed and documented in accordance with the approaches developed by the main international donors, which distinguish between (i) impacts related to the location of the project, (ii) impacts related to construction activities and (iii) impacts related to operation of the facilities of the project.

The results of the analysis of the impacts are presented in the sections below:

- Section 10.2 – impacts associated with the direct footprint of the project. The permanent and temporary changes induced by the project footprint (e.g., submergence in the reservoir and land clearing for installations) are analysed to estimate the direct and indirect impacts on the physical environment, the natural environment, and the human environment.
- Section 10.3 - impacts associated with the construction of the project. The construction activities at different sites are analysed to estimate the direct and indirect impacts on the physical environment, the natural environment and the human environment.
- Section 10.5 - impacts related to the operation of the hydropower plant. This analysis focuses on the various aspects of HPP operation such as maintenance and operating mode.
- Section 10.6 - Potential impacts on ecosystem services
- Section 10.6.5 – Dam safety
- Section 11 – Cumulative Impacts Summary

Section 7.7 documents the Critical Habitat Assessment (CHA) undertaken for the Project. Impacts associated with EFlow are documented in a separate report.

10.1.2 Methodology of environmental and social impact assessment

10.1.2.1 Principles

The impact assessment results from (i) the description of the project (see Section 3), which establishes a set of impact factors, and (ii) the description of the physical, natural and human environments, who relates to sensitivity of the environmental and social components with which the project will interact. The experts in charge of the impact assessment perform a cross-referenced analysis of the impact factors of the project with the sensitive elements of the biophysical, natural, and human components of the environment to assess the significance of the impact.

The impacts are assessed based on the features of the project and the local context, the experience of ARTELIA in similar hydropower developments and environment, specialized field literature, as well as internationally recognized good practice guidelines developed by the main multilateral development banks (including World Bank, International Finance Corporation, etc.).

To provide a logical and readable document, the impacts are presented thematically by environmental and social issues and organized into subsections of the sections. Each subsection follows the same thread comprising (i) the impact factors, (ii) the environmental sensitivity, (iii) the impact description and (iv) the assessment of potential impact.

There are many approaches to estimate impacts. However, national regulation and international standards leave room in the assessment methods as well as in the organization of the presentation. The assessment of potential impacts and residual impacts is ultimately an expert's opinion who considers qualitative, semi-quantitative and quantitative aspects to build its judgment:

- Qualitative aspects include the qualitative understanding of the mechanisms explaining/predicting the modification of environments.

- The semi-quantitative aspects include concepts such as (i) the sensitivity of the affected environmental component, (ii) the duration, (iii) the extent, (iv) the intensity (negative or positive), (v) the onset time and (vi) the likelihood of the impact. These semi-quantitative aspects are both a means of interpreting the qualitative elements and a direct means of estimating the impact.
- The quantitative aspects are associated with numerical values of the project which can be interpreted (i) directly through known thresholds resulting from regulations or good practices or (ii) indirectly through various comparisons. For example, the assessment of the project location can be made based on different types of areas affected, the number of people affected, and the number of buildings relocated.
- Previous experience shows that impact rating systems must remain simple coding tools objectifying the expert's judgment, because in any case they do not correspond to strict impacts modelling which remains very complex. The expert's judgment therefore contains an element of subjectivity and estimates which are inevitable but minimized when assessing the impact. The precautionary principle can also be used to justify the usefulness of implementing a measure to avoid, reduce or monitor an impact.

10.1.2.2 Rating system

10.1.2.2.1 Potential impacts

A simple rating system is used for the assessment of the potential impacts which are the impacts of the project without the implementation of any measure. The significance of the potential impact is rated on a four-level scale: (0) Low, (1) Moderate, (2) Substantial and (3) High. When the potential impacts results in positive outcomes, they are simply described as **Positive** without rating.

This system considers two criteria: (i) the likelihood of the impact within the framework of the project, (ii) the expected severity of the impact without specific corrective measures. These criteria are defined as follows:

- The **likelihood** relates to the frequency of observation of impacts during construction or operation activities. Some impacts are inevitable (noise, dust, downstream hydraulic changes) while others may only occur exceptionally. The likelihood is rated on a three-level scale: **(1) Low, (2) Medium, (3) High.**

Table 168: Likelihood scale

Likelihood	
Low	Rare or no occurrences. It can occur in case of negligence or accidental events.
Medium	Uncommon with documented occurrences. Generally observed a few times during construction or during the operation of a hydropower plant.
High	Common, will occur with certainty.

The **severity** of an impact includes various considerations contributing to the intensity of the effects on the natural or human environment, such as its extent, its duration, its reversibility, its intensity, the sensitivity of the affected component and it is time to onset. Severity is rated on a three-level scale: **(1) Low, (2) Medium, (3) High**. The severity includes the consideration of several aspects such as:

- The extent (i.e. spatial dimension) of the impact reflects the expected change that may take place at a national, regional (county) or local (village and household) level.
- The duration (i.e. temporal dimension) of the impact, including whether the impact is short, medium or long-term, and/or temporary or permanent.
- The type of impact, including whether the impact is direct - indirect, and/or reversible - irreversible.

- The intensity of the impact reflects the extent of change that is predicted from baseline conditions and the number of villages or households potentially affected.
- The sensitivity of the affected component, taking into consideration stakeholder value that reflects the importance of change against the receptor's current conditions.

The two tables below describe the severity criteria of negative environmental and social impacts:

Table 169: Severity criteria for negative environmental impacts

	Duration	Description of how environmental conditions and ecosystems are impacted
Low	Short-term (up to one year) / quickly reversible	Affects environmental conditions, species, and habitats over a short period of time, is localized and reversible.
Medium	Medium-term (one to seven years) / reversible	An effect on environmental conditions, species and habitats in the short to medium term. Ecosystems integrity will not be adversely affected in the long term, but the effect is likely to be significant in the short or medium term to some species or receptors. The area/region may be able to recover through natural regeneration and restoration.
High	Long-term (more than 7 years) / irreversible	Affects environmental conditions, species and habitats for the long term, may substantially alter the local and regional ecosystem and natural resources, and may affect sustainability. Regeneration for its former state would not occur without intervention.

Table 170: Severity criteria for negative social or health impacts

	Duration	Extent	Ability to adapt	Socio-cultural outcome	Health outcome
Low	Short-term (up to one year)	Individual / Household	Those affected will be able to adapt to the changes with relative ease, and maintain preimpact livelihoods, culture, quality of life and health	Inconvenience but with no consequence on long-term livelihoods, culture, quality of life, resources, infrastructure and services	Events resulting in annoyance, minor injury or illness that does not require hospitalization
Medium	Medium-term (one to seven years)	Small number of households	Those affected will be able to adapt to change, with some difficulty, and maintain pre-impact livelihoods, culture, quality of life and health but only with a degree of support	Primary and secondary impacts on livelihoods, culture, quality of life, resources, infrastructure, and services	Event resulting in moderate injuries or illness, which may require hospitalization
High	Long-term (more than 7 years) / irreversible	Large part of/ full settlement – up to a whole region	Those affected will not be able to adapt to changes and continue to maintain pre-impact livelihood	Widespread and diverse primary and secondary impacts are likely to be impossible to reverse or compensate for	Catastrophic events resulting in life loss, severe injuries or chronic illness requiring hospitalization.

The table below details how severity and likelihood are crossed to define the significance of the impact.

Table 171: Impact rating system

		Likelihood		
		Low	Medium	High
Severity	Low	Low	Moderate	Substantial
	Medium	Moderate	Substantial	High
	High	Substantial	High	High

Regarding the categorization of the impacts, different impacts can be regrouped in a single impact category when it is relevant. For example, all the economic activities and livelihood activities impacted by the project are regrouped under the section called "economic and livelihood losses." As relevant, they can be broken down in further detail.

10.1.2.2.2 Residual impacts and Mitigation measures

The same rating system is used for assessing the residual impacts (impact remaining after the implementation of specific measures). The significance of the impact is rated on a four-level scale: (0) **Low**, (1) **Moderate**, (2) **Substantial** and (3) **High**.

The rating system considers three criteria. This includes (i) the likelihood of the impact within the framework of the project and (ii) the expected severity of the impact without specific corrective measures as previously described. The additional criterion considered is (iii) the effectiveness of the measures to control the impacts. The effectiveness of the measures is the result of its ease of implementation, the reliability of the impact control and the predictability of the results. Effectiveness is rated on a three-level scale: **(1) Low, (2) Medium, (3) High.**

The mitigation and enhancement measures will target, with different levels of efforts, the impacts rated as High, Substantial and Moderate. All the necessary efforts for the implementation of corrective and monitoring measures must focus on the impacts considered to be potentially serious and likely**.** Thus, an impact with a low likelihood, of medium severity and requiring easy-to-implement corrective measures presents a low risk level.

The greatest risk level will be attributed to impacts that are frequently observed, with serious consequences for the environment or for humans and for which corrective measures are more difficult to implement effectively.

It is noted that residual impacts are ranked without the implementation of offsetting measures.

Controlling an impact often involves the implementation of several corrective measures, which can be of various types and carried out in different phases:

Types of measures presented in the mitigation hierarchy:

- **Avoidance measures (AM)**: Avoidance measures allow to fully avoid the environmental and/or social impact of the project.
- **Reduction measures (RM):** Reduction measures partially, or in some cases fully, reduce the environmental and/or social impact of the project.
- **Mitigation Measures (MM)**: Measures implemented when avoidance and reduction are not sufficient. These measures aim to alleviate the impact by providing specific remedies, such as habitat restoration, pollution remediation, or community support programs.

- **Restoration measures (RES):** Restoration measures partially reduce the environmental and/or social impact of the project for temporary footprint with actions that help to recover the initial natural habitats.
- **Offsetting measures (OFM):** Offsetting measures are only considered when a residual impact is not considered to be insignificant. Offsetting measures are implemented only if the avoidance, reduction and restoration measures cannot be implemented or are considered insufficient. Offsetting measures include restoration, creation, enhancement, and preservation, aiming for no net loss for natural habitats and a net gain for critical habitats. Compensation measures are also included but are treated more specifically in the Land Acquisition and Livelihood Restoration Plan (LALRP).

Complementary measures are usually required to ensure that the Avoidance / Reduction / Compensation measures are properly delivered or to contribute to improve further the condition of the issue considered. This includes:

- **Monitoring measures (MM):** They relate to the general control activities carried out by the works supervision team or by national institutions during construction and during the first years of operation of the works.
- **Training measures (TM):** Training measures are based on awareness raising and training of employees and populations to reduce the risks of impacts related especially to health and safety. This also includes capacity building and specialised training.
- **Enhancement measures (EM):** These measures do not aim to avoid, reduce or compensate for a particular negative impact of the project, but support the project in a general way to participate in the socio-economic development and/or the protection of the biophysical environment in the project's area of influence. This can also include measures implemented to maximise the benefits of positive impacts (e.g., for employment).

Phasing of measure implementation:

- **Measures during the pre-construction and preparatory phase:** These are preventive and/or preliminary measures aiming at limiting the impacts during the design of the hydropower plant and its components. Such measures can be additional studies necessary for the implementation of measures such as design studies of a fish passage or additional investigations aimed at reducing the remaining uncertainties on impacts.
- **Measures during the construction phase related to site activities:** These are measures which are related to a particular construction activity or the installation of equipment during the implementation phase of the project. These measures are usually included in the tender specifications for the construction company and are part of the contractor's contract. This is typically the waste management plan, the site rehabilitation plan after construction activities, the occupational health and safety management plan, the hazardous products, and explosives management plan, etc.
- **Measure during the operation phase:** These are measures which are related to the operation of the hydropower plant and associated activities. Some of these measures are related to the operation mode of the hydropower plant which will impact several components of the environment. These measures will also include monitoring measures.

In accordance with international practices, **the Avoid / Reduce / Restore / Offsetting** approach will be implemented. Whenever possible, avoidance measures will be preferred followed by reduction measures which may include restoration of the temporary footprint. If the avoidance and reduction of the impact are not considered sufficient and the environmental risks remain significant, offsetting measures will be sought. The principles of adaptive management will also be followed as some measures need to be calibrated and adjusted over time. The value scale used is summarized in the table below:

Table 172: Summary of the rating system of residual impacts

Criteria	Level 0	Level 1	Level 2	Level 3
Difficulty in implementing corrective measures and effectiveness		(1) Low: inexpensive and generally effective measure(s).	(2) Medium: Measures requiring special attention and/or good technical skills. The measure(s) can be expensive but has a recognized level of effectiveness. Must be monitored.	(3) High: Measures with a low or very random level of effectiveness which can be expensive. Require monitoring which can be complex and difficult.
Residual impact or Global residual risk (GRR) (with avoidance and reduction measures) *Need to implement compensatory measures*	(0) Low: The measures implemented are sufficient. ☐ *No offsetting measure required*	(1) Moderate: The measures implemented are likely to be sufficient although monitoring is required. ☐ *No offsetting measure is required but monitoring measures must be implemented*	(2) Substantial: Avoidance and/or reduction measures do not provide sufficient and/or reliable control, compensation measures must be implemented. The extent of the impact reduction to be achieved remains limited. ☐ *Require limited offsetting measure(s)*	(3) High: Avoidance and/or reduction measures do not provide sufficient and/or reliable control. Significant compensation measures must be implemented. The magnitude of the impact reduction to be achieved is significant. ☐ *Require significant offsetting measure(s)*

10.2 Analysis of impacts related to project Footprint

10.2.1 Estimated inundation and Land clearing

Following consideration of the DPR 2016, additional calculation of the approximate land clearing and submergence were carried out by ARTELIA to inform the impact assessment and are shown in Table 173. Figure 11 shows that the current land is used in the reservoir area.

Table 173: Estimates inundation, land clearing and dewatered impacts

Aspect	Key points	Est. impact amount (acres)
Reservoir	The submergence area extends 6.80 km	359.89
Dam works zone	For dam wall construction.	11.1
Portal	For tunnel access	1.78
New Access Roads	27.58 km of new access roads to various project components and work sites will be required to be constructed	96.04
Road realignment	5.4 km of public roads needing realignment due to project components	24.9
Muck disposal sites	12 MDS to cater to access roads, HRT, Adits, Surge Shaft, Powerhouse	198.74
Non-residential buildings	1 temporary site office	4.7
Contractor Construction Facilities	9 CCFs are proposed to accommodate the contractor site offices, employee housing, labour camps, stores/warehouse, workshops, parking yards for equipment and fabrication yard	101.13
Stockyards	Four stockyards will be used for material stockpiling.	21.46
Explosive Magazine	5 Explosive magazines	2.8
Batching Plants	5 locations	13

Aspect	Key points	Est. impact amount (acres)
Quarries and borrow pits	Five quarry locations have considered for the Project	58.2
Dewatered impact Zone	May change species composition of the banks	532.4
Downstream Impact Zone	May change species composition of the banks	52.3
Construction Power	Total length approximately 19.81 km.	58.74
Power Evacuation Transmission lines	DGPC is managing the power evacuation transmission line, and ESIA, separately to the main ESIA. An E&S Management Framework will be prepared as part of the updated main ESIA. Approximately location extends south from Dorjilung HPP powerhouse to Durungri PS.	Unknown
TOTAL		1537.18 total (947 land clearing, 585 dewatered impacts)

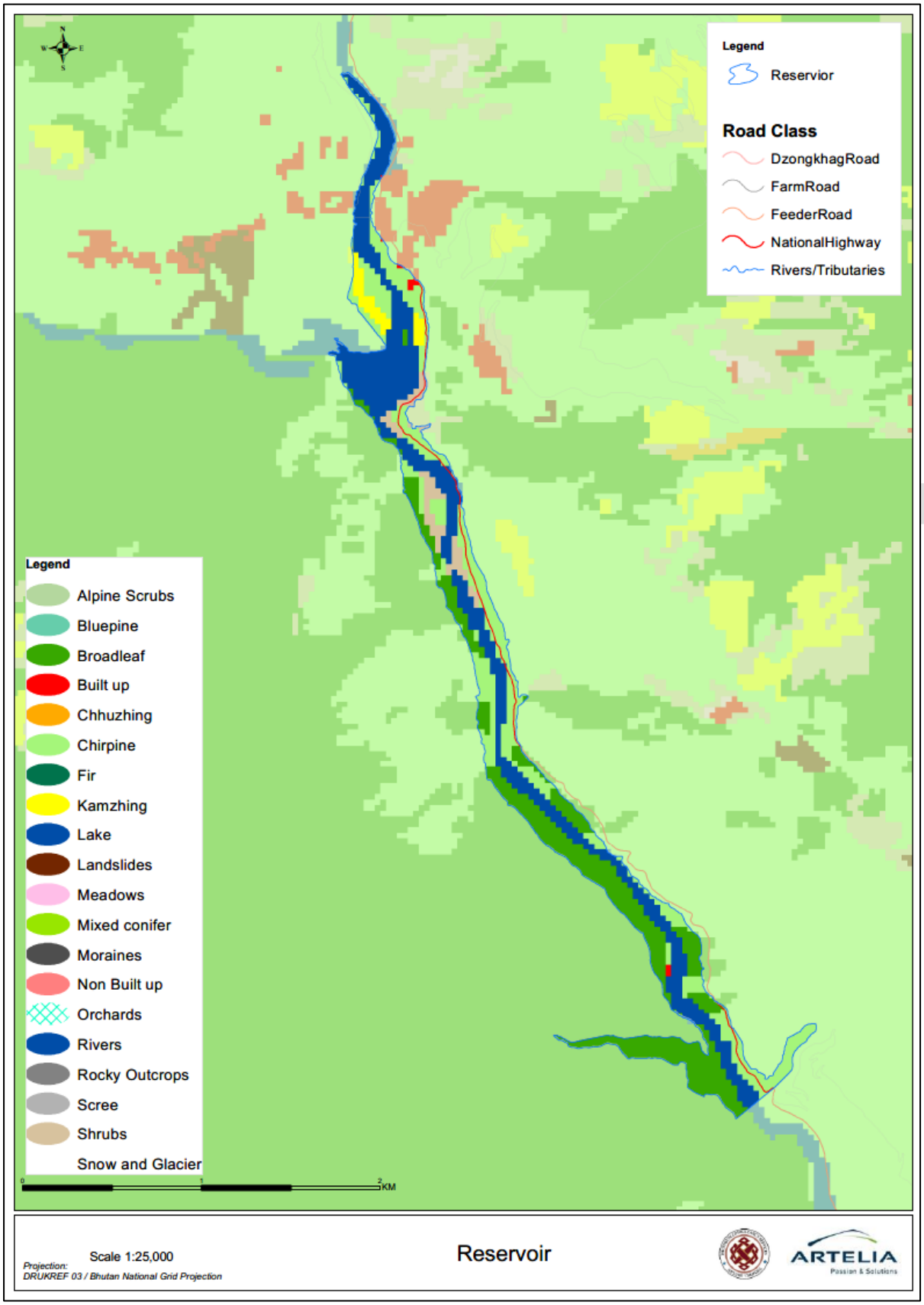


Figure 192: Land use in the reservoir area

10.2.2 Impacts on Physical Environment

Physical Environment impacts are not considered relevant to footprint. Impacts have been addressed in Section 10.4.

10.2.3 Impacts on Biological Environment

10.2.3.1 Natural Habitats losses by project footprint

10.2.3.1.1 Potential impacts

The habitat area losses by direct impact are summarized in the table below.

Table 174: Natural habitat losses in the project footprint (in acres)

Area in Acres	Type of losses	Natural habitats					Modified habitats					Total
		Rivers	Riparian forest	Broadleaf	Chirpine	Shrubs	Kamzhing	Chhuzhing	Orchards	Built up	Road and track with buffer	
Reservoir EL 850	Total (100%)	132.9	75.0	69.1	34.1	10.1	4.5	0.0	0.0	0.4	27.9	**359.89**
Dam works zone DWZ	Total (100%)	4.0	2.3	0.0	2.9	0.0	0.0	0.0	0.0	0.0	1.9	**11.1**
Contractor Construction Facilities CCF	Total (100%)	0.0	0.0	0.0	88.5	6.9	0.0	0.0	0.0	0.0	2.6	**101.13**
Muck Dumping Sites MD	Total (100%)	0.0	2.6	0.1	175.4	0.0	0.0	0.0	0.0	0.0	0.5	**198.74**
Quarries Ka	Total (100%)	4.3	3.0	0.1	47.0	2.2	1.4	0.0	0.0	0.0	0.2	**58.2**
Batching Plants BP	Total (100%)	0.0	0.1	0.1	12.5	0.0	0.0	0.0	0.0	0.0	0.2	**13.12**
Stock Yard SY	Total (100%)	0.0	0.0	0.1	18.4	0.0	0.0	0.0	0.0	0.0	1.0	**21.46**
Magazine EX	Total (100%)	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0	**2.8**
Office Of	Total (100%)	0.0	0.0	0.4	4.3	0.0	0.0	0.0	0.0	0.0	0.0	**4.7**
Portal Po	Total (100%)	0.0	0.0	0.3	1.3	0.0	0.0	0.0	0.0	0.0	0.0	**1.78**
Highway re-alignment	Total (100%)	0.0	0.0	5.9	17.6	0.2	0.1	0.0	0.0	0.0	1.1	**24.9**
New access for works	Total (100%)	0.1	0.7	6.4	110.0	1.1	0.8	0.0	0.0	0.0	0.2	**96.0**
Power line (Works)	Low vegetation: 0% High vegetation: 100%	0.4	0.9	10.7	65.4	5.0	4.0	0.0	0.0	1.2	0.6	**88.2**

Area in Acres	Type of losses	Natural habitats					Modified habitats					Total
		Rivers	Riparian forest	Broadleaf	Chirpine	Shrubs	Kamzhing	Chhuzhing	Orchards	Built up	Road and track with buffer	
Dewatered Impact Zone DeS	May change species composition of the banks	257.4	227.1	2.3	31.6	3.1	0.0	0.0	0.2	0.1	10.6	**532.4**
Downstream Impact Zone DoS		30.5	15.8	0.0	2.9	1.0	0.0	0.0	0.0	0.0	2.1	**52.3**
Total		**429.6**	**327.7**	**95.6**	**614.7**	**29.6**	**10.7**	**0.0**	**0.2**	**1.8**	**48.9**	**1559**
%loss Habitat in Footprint		27.6	21.0	6.1	39.4	1.9	0.7	0.0	0.0	0.1	3.1	100.0
Total Natural / Modified		**1497.2**					**61.5**					**1559**
% Natural / Modified		**96.1**					**3.9**					**100**

Note that, by convention, areas are projected in acres. The real surface (not projected) may be significantly higher as the slope increases.

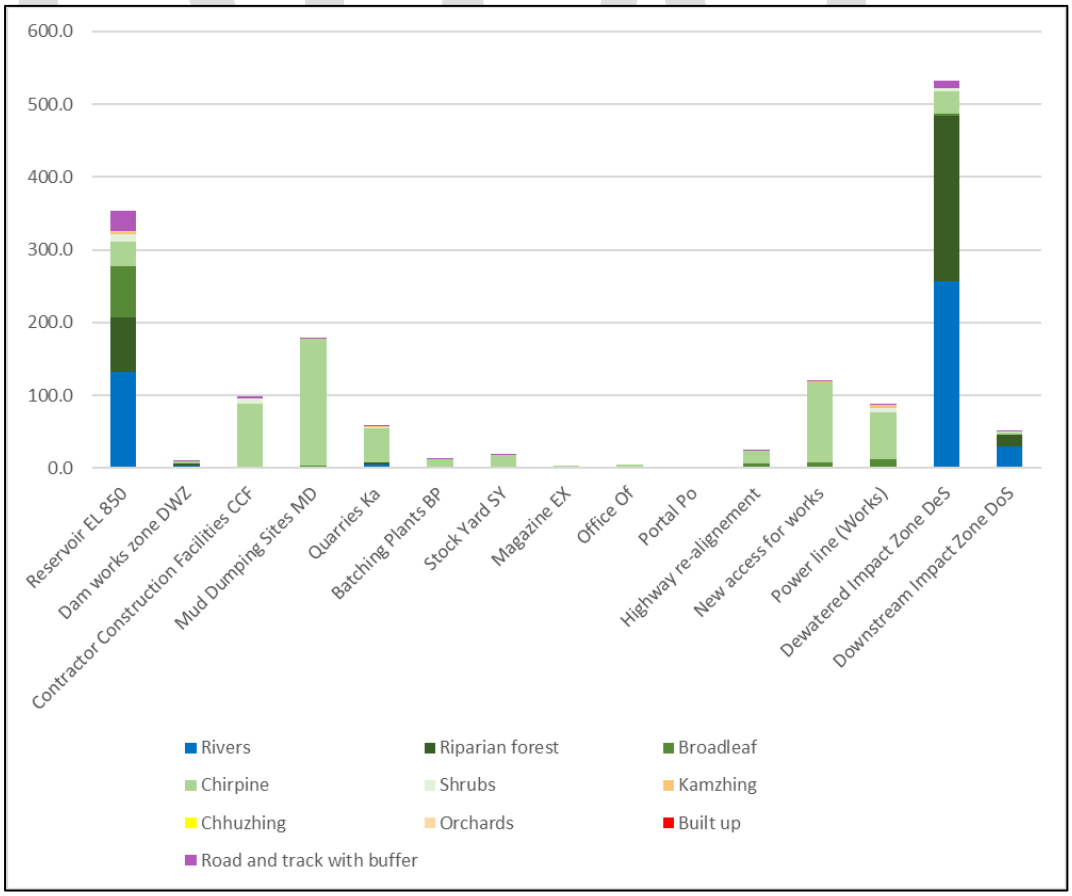


Figure 193: Project footprint by land cover classes

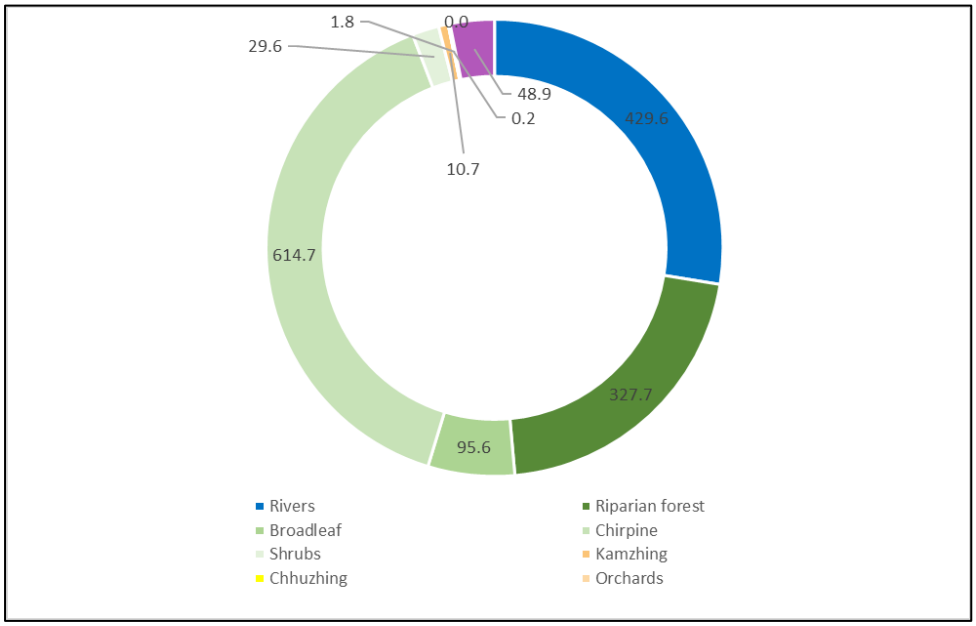


Figure 194: Land cover distribution in the project footprint

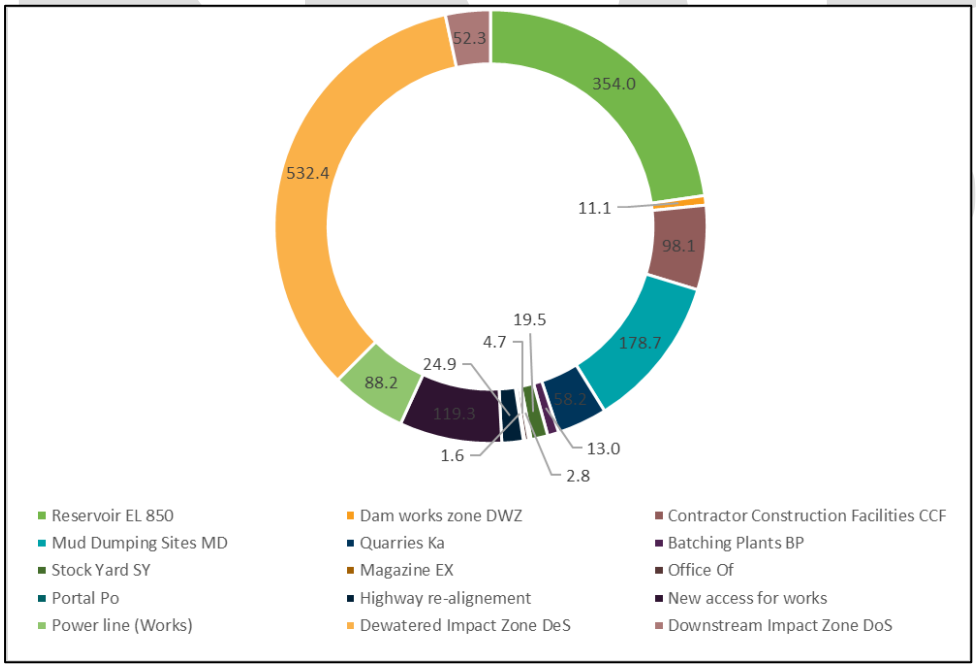


Figure 195: Habitat losses in the project footprint

The project AoA is in a natural environment (96.1%) mainly made of Broadleaf Forest (66%) and Chir pine forest (21% including riparian forest) and shrubs (3.6%).

About 96% of the project footprint is in a 'natural' environment with mostly Chir Pine Forest (39%), Broadleaf Forest (6.1), Riparian Forest (21%) and River (27.6%). Approximately 3.9% are in a 'built-up' environment.

Main impacting facilities on land clearing are reservoir (36%), Muck Disposal Sites (18%), access roads (12%), and Contractor Construction Facilities (10%).

The loss of these natural habitat is a **High** impact for the following aspects:

- Critical habitat by criteria a and b for flora, terrestrial fauna and aquatic fauna:
- These natural habitats have numerous sensitive species of plants, terrestrial fauna and aquatic fauna including emblematic species.

The impacts of the project on the different types of natural habitats are detailed in the table below. Note, habitat in the AoI is detailed in Section 7.1.

Table 175: Potential Global Risk on habitats in the project area

Habitats	Habitat in the AoI Area in acres % in AoI	Habitat losses (1) Project footprint (100% loss) (2) Dowstream, dewatered and powerline sections (3) Total Acres	%	Critical (criteria Ca and Cb)	Sensitivity	Potential global risk
River	1,300 0.7%	**(1) 141.3** (2) 288.3 (3) 429.6	11% 22% 33%	Yes (Ca and Cb 3 Fish and 4 birds)	Yes High endemicity level	High
Chir pine forest	38,457 21%	**(1) 514.9** (2) 99.8 (3) 614.7	1.3% 0.3 1.6%	Yes (Ca 3 mammals and 4 birds	Medium Forest type widely distributed in Bhutan	High
Broadleaf forest	123,213 65%	**(1) 82.8** (2) 13.0 (3) 95.6	0.1% 0.0% 0.1%	Yes (Ca 3 mammals and 4 birds) Ca and Cb one plant	Medium Forest type widely distributed in Bhutan	High
Riparian Forest	889 0.5%	**(1) 83.8** (2) 243.9 (3) 327.7	9.4% 27.4% 37%	Yes (Ca 3 mammals and 4 birds	Medium Forest type widely distributed in Bhutan	High
Shrubs	6,715 3.6%	**(1) 20.5** (2) 9.1 (3) 29.6	0.3% 0.1% 0.4%	May be use by mammals and birds including CHQ species but with less importance	Medium Widely distributed in Bhutan	Substantial
Agricultural land	8,210 4.4%	**(1) 6.7** (2) 4.2 (3) 10.9	0.08% 0.05% 0.13%	No	No, modified habitat with some	Low

Habitats	Habitat in the AoI Area in acres % in AoI	Habitat losses (1) Project footprint (100% loss) (2) Dowstream, dewatered and powerline sections (3) Total Acres	%	Critical (criteria Ca and Cb)	Sensitivity	Potential global risk
(Chhuzhing Orchards and Kamzing)					biodiversity value	

10.2.3.1.2 Mitigation measures and residual impacts

The 3 projects footprint alternatives have been evaluated based on technical considerations considering that the biodiversity gain between the 3 technically feasible alternatives was minor as they impact similar natural habitats.

The impact on footprint cannot be avoided and reduced once the alternative is chosen. The residual impact on natural habitat is Low as activities to mitigation these impacts will be undertaken through the biodiversity management plan to achieve the objective of no net loss along with offsetting measures.

To achieve the objective of no net loss and in accordance with good practices and national regulations, a reforestation program must be put in place and undertaken.

- **Afforestation program to offset the loss of natural habitat (OFM).** By adding 701.7 acres of forest and shrub lost by the footprints (100% loss) and the 77.0 acres of forest in the corridor of the construction power line, we obtain a loss of 778.7 acres of forest to be offset. With a replanting ratio of x2 we obtain a reforestation program of about 1,557 acres. The program will be financed by the project and developed with the relevant authorities, i.e. the DFPS of the MoENR and the NBC in conformity with the forest restauration strategy developed by Bhutan. The program will concern riverine broadleaf forest, broadleaf forest and chirpine forest.
- This offsetting is feasible but will require a high level of effort for the owner. This program will be associated to a long term adaptative monitoring program validating the completion of the actions and the results in term of natural habitat restoration.

Table 176: Objective of the afforestation program

Habitats	Riparian forest	Broadleaf forest	Chirpine forest	Shrub
Losses (Ha) (100% loss by footprint	83.8	82.6	514.9	20.5
Power line	0.9	10.7	65.4	Not considered
Dewatered section and downstream section	Not considered for offsetting/afforestation. EFlow mitigation measure will reduce enough the potential impact to consider that the residual impact will be negligible.			
Area of afforestation (Losses X2) (Ha)	171.2	186.6	1160.6	41
Note for habitat equivalence	The afforestation program should consider 16 km of riverine forest x 2 (river flooded by the reservoir) of Riparian forest to be included in the Area of afforestation program			To be converted in Broadleaf or Chirpine forest

Note that The Forest and Nature Conservation Act (FNCA) of Bhutan 2023" does not specify the requirement for compensatory plantation for double the area taken up by a project (Refer Section 70 of

FNCA 2023). The afforestation ratio may be discussed between owner, administration and lenders before implementation.

10.2.3.2 Natural habitat impacted in the dewatered reach

10.2.3.2.1 Potential impacts

In addition to the project footprints, the dewatered section may have a significant impact on the surrounding environment. In a buffer zone of 50 m around the axis of the river, the following habitats may be affected by the decrease in flow:

- River (287.9 acres): modifications of flow patterns that may impact the population of fish in the river and tributaries.
- Riverine forest (248.0), Chir pine forest (34.5 acres) and Broadleaf Forest (2.3 acres): modifications of solid transportation and river aquifer may impact the riparian forest. Note that in the first meters from the river, Chirpine forest gives way for riverine broadleaf forest. The riverine broadleaf forest depends on the abiotic factors induced by the presence of the river with air humidity, the level of the alluvial aquifer, the runoff on the slopes, the rocky conglomerate which borders the Kurichhu, the tearing force of the watercourses in flood zones during floods and the regular grinding of the banks of the minor bed by the pebbles moving in the flood waters.

Table 177: Potential natural habitat losses in the project footprint

Natural Habitat losses in acres	Rivers	Riparian forest	Broadleaf	Chirpine	Shrubs	Total
Dewatered and downstream sections	287.9	243.0	2.3	34.5	4.1	571.8

The loss of these natural habitats is a High impact, the river and the riparian forest are sensitive habitats which have CH qualifying species and sensitive species.

10.2.3.2.2 Mitigation measures and residual impacts

An effective avoiding measure will be the implementation of an EFlow to supply enough water and water level of the riparian broadleaf forest.

- **Implement an EFlow to maintain abiotic factors on the banks to preserve the riverine broadleaf forest. (RM).** Maintain low water in the alluvial aquifer at sufficient depth with a minimum depth of 10 to 20 cm in rapids and pools. Maintain flow peaks in the dry segment during the monsoon to conserve certain abiotic factors on the banks through significant and short flooding phases. Take advantage of annual and exceptional flood events and sediment emptying phases to form these flood peaks in the short-circuited section. As an order of magnitude, 3 to 5 one-day flood peaks per monsoon with a peak flow of 80% of the river flood flow should make it possible to maintain the abiotic conditions of the banks. The water intake for EFlow will be the highest possible to avoid the dead volume of the reservoir, two meters below the minimum operating level should be considered during project detail phase.

The residual impact should be Low for the riverine broadleaf forest and Low for the river habitat.

10.2.3.3 Loss of protected areas

10.2.3.3.1 Potential impacts

Phrumsengla National Park (also KBA). There is no direct impact on the PNP but 9% (83 km2) is inside the AoI. Social influx may increase the pressure on the natural environment. Direct impact on Corridor#7 may also induce changes in connectivity's. Potential impact is considered as Low.

Corridor #7. The reservoir is located inside Corridor 7. Changes in flow patterns may impact the connectivity for some species, but the river in its initial state is already a strong obstacle to connectivity. The project creates a barrier with different crossing methods, which can be an obstacle or an ease for the movement of species and the isolation of populations. It is possible that crossing the Kurichhu River will be easier in the reservoir. However, the widening of the watercourse from 50 to 200 m in the reservoir, even if the current speeds are very low compared to the river, could on the contrary limit the crossing of tigers in corridor no. 7. It is difficult to validate whether the impact will be positive or negative on the scale of corridor #7 without the implementation of a monitoring system over several years.

It should be noted that further downstream, the short-circuited segment will increase the connectivity between the two banks with numerous opportunities for crossing the river. The potential impact is Considered as Substantial for the Corridor #7.

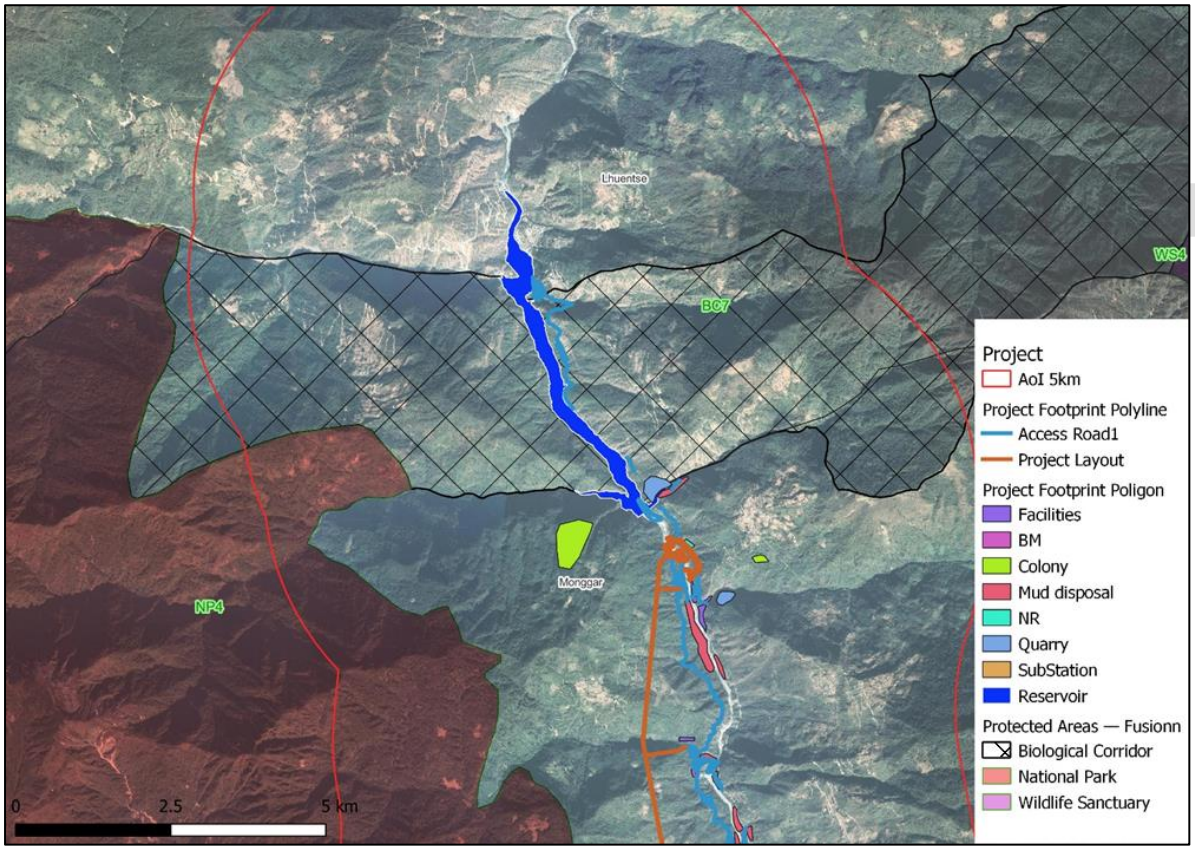


Figure 196: Biological Corridor # 7 in relation to the project components

KBA Pallas's Fish-eagle. It is impacted in its northern half by the dewatered segment and the powerhouse including restitution points. The known nesting area is located closed to the lake of the Kurichhu dam. Considering the feeding behaviour of this species (See Appendix L BIODIVERSITY ASSESSMENT BY CHQ SPECIES AND OTHER EMBLEMATIC SPECIES) there is a **Low** risk of fishing success loss thank to its capacity to target various terrestrial and aquatic species in various aquatic habitats. For this species, the most important feeding success occurs in lakes and wetlands and with a lesser importance in river and stream. There is also a **Medium** risk of modification of prey availability due to the dewatered segment and water level variations in the lake.

It is also expected that the new lake upstream de project dam may become a new feeding area as the most important feeding success occur in lake. The Potential impact is considered as Moderate.

10.2.3.3.2 Mitigation measures and residual impacts

Various mitigation measures seem feasible with:

- **Management plan of the social influx with avoidance and reduction measures to reduce social influx** in the vicinity of PNP, Corridor"7 and Pallas's Fish-eagle KBA (RM).
- **Implement an EFlow to maintain the watercourse and prey available in the dry segment allowing the Pallas eagle to feed (RM).** There is not a big difference in feeding success between rivers and streams, so this mitigation can be effective. The following value should be considered designing EFlow: minimum depth in the rapids 15 to 30 cm during low water season. Preserve the alternation of pools and rapids. The depth of the pools must be able to reach 1 m. The water intake for EFlow will be the highest possible to avoid the dead volume of the reservoir, two meters below the minimum operating level should be considered during project detail phase.
- **Installation of nesting platforms suitable for the Pallas Fish eagle downstream of the new project reservoir**.

The residual impact may be Low for the Phrumsengla National Park (also KBA) and **KBA Pallas's Fish-eagle**. such that general conservation measures preserving habitats of this area are acceptable to generate a net gain with:

- **Establishment of a partnership with the Phrumsengla national park and Mongar Territorial Division to support forest habitat preservation programs (OFM) in the and monitoring of mammals in the Corridor#7** and contribute to implementing programs for the management of BC #7 and the Pallas Fish Eagle Habitat.

The residual impact for the Park and Corridor"7 will be Low because the project will support towards actions within protected area management plans that enhance the conservation aims and effective management of the area and net Gain can be achieved for critical habitat wildlife species (Tiger, Wild Dog, Red Panda and other large mammals) through support to protected areas.

10.2.3.4 Loss of terrestrial critical habitat (Flora)

Potential impact

One station of an herb critical species (EN and RR, *Hoya bhutanica*) will be flooded by the project. As only a few stations are known for this species and thus the Potential impact is considered as **Moderate**

Mitigation measures and residual impacts

The loss of the station cannot be avoided or reduced as the station will be flooded by the reservoir. The expected residual impact will be Low as *Hoya* will be progpagated as described in the Biodiversity Management Plan.

10.2.3.5 Loss of critical terrestrial habitat (Birds)

10.2.3.5.1 Potential impact

There are 4 birds considered as CHQ species i.e. the Pallas's Fish-eagle (*Haliaeetus leucoryphus*), the White-rumped Vulture (Gyps *bengalensis*), the Red-headed Vulture (*Sarcogyps calvus*) and the Dark-rumped Swift (*Apus acuticauda*).

For the Pallas's Fish-eagle (*Haliaeetus leucoryphus*) see section 10.2.3.3 Loss of protected for the Pallas's Fish-eagle KBA.

For the two other vultures there is a **Low** risk of impacts on nests due to the project's footprint (no nests identified on the ground). Vultures do not like to build their nests at the bottom of valleys, but they are high up. There is also a **Low** risk of loss of favourable habitats and feeding success due to the impact of

the project given the size of the flight range of these species. However, the absence of a nest just before work cannot be certain even if it is unlikely.

The Dark-rumped Swift breeds in cliff and rocky area from March to May, the risk seems to be **Low** as limited to quarries and dam sites (cliffs). The species was not identified on site during field survey of May but its occurrence in cliff area of the quarry cannot be put away.

The intensity of the impact in case of nest presence is **High** and thus the potential impact is **Substantial**.

10.2.3.5.2 Mitigation measures and residual impacts

The presence of nests must be confirmed before work to adapt the project to the circumstances.

- Additional survey before work checking the presence of nests in and near the structures (100 m) (RM). If there are nests:

o optimize the footprint as much as possible to avoid the proximity of work (less than 100 m away).
o In all cases, it will be prohibited to cut down a tree with a nest of vultures during the nest building, egg laying and juvenile growing phase. This will be protected by a marked prohibition zone of 20 m around, without clearing the vegetation.
o Monitoring by a bird expert of the vultures during works
o Avoid the breeding periods if nests are found.

The residual impact will depend on the presence or not of nests just before the works and will be Low for the for all species because of the following:

- **Program to improve knowledge on all bird species** financing a research program with Universities or the DOFPS including monitoring of the species (AFM)

10.2.3.6 Loss of terrestrial critical habitat (Mammals)

10.2.3.6.1 Potential impact

There are 3 mammals CHQ species, the Capped Langur (*Trachypithecus pileatus* ssp. *Tenebricus*), the Chinese Pangolin (*Manis pentadactyla*) and the Tiger (*Panthera tigris*).

For the Chinese Pangolin, the risk of loss of habitat is **Low** as the presence of this species is not confirmed by the interview or camera trap data. The known location of the Pangolin in Bhutan is southeast and southwest of the AoA.

For Tiger the following impact factors are known.

- Habitat Loss and Fragmentation

o Dam construction: Floods large areas of land to create reservoirs, destroying existing tiger habitat (forests, grasslands) and displacing resident wildlife.
o Fragmentation: Residual forests become isolated patches due to the reservoir and associated infrastructure (roads, power lines). This reduces the total amount of usable habitat and isolates tiger populations, hindering movement and gene flow.

- Prey Availability:

o Reduced prey base: Loss of habitat due to flooding and fragmentation directly reduces the availability of prey species like deer, wild boar, and ungulates that tigers rely on for food.
o Prey disruption: Construction activities and human presence during dam construction can disturb prey behavior and make them less accessible to tigers.

- Disruption of Movement:

- Barriers: Dams and associated infrastructure can act as physical barriers, restricting tiger movement and hindering their ability to access essential resources like breeding grounds or prey populations.

For the Tiger, even if its presence was not highlighted during the 2020/2021 national inventory, a CT recording during the 2023/2024 inventory (6 km downstream at 2000 m altitude) confirms that it may be present in the project area. The highest population densities were known outside the project area of influence, but this new observation, considered good news in terms of conservation, likely shows a new Tiger hunting territory connected to Phrumsengla National Park. A Tiger territory is about 20 to 60 km2 for the female and up to 100 km² for male.

In the AoI the highest population densities are at the upper altimetric limits and the lowest populations at the lowest altitude, i.e. the altitude of the main footprint of the project. The known locations of Tiger concern the Phrumsengla National Park (PNP) and the Bumdeling Wildlife Sanctuary (BWS). (See Appendix L BIODIVERSITY ASSESSMENT BY CHQ SPECIES AND OTHER EMBLEMATIC SPECIES and 10.2.3.3 Loss of protected for Corridor#7). Given its current habitat and the location and altitude of the dam, reservoir, and major forest losses due to new access, the impact on the tiger from habitat loss and fragmentation appears limited, as the footprints are further north and at lower altitudes. However, the project may limit the expansion of new tiger territory within the area of influence of the project. A cumulative barrier to tiger range expansion is possible with existing settlements, existing works and existing development programs between the Kurichhu reservoir and Lingmethang. It is noted that the operation of the Kurichhu dam and the ongoing works in 2023 in this area have not prevented the presence of the tiger within 4 km distance but with a 1500 m difference in altitude.

Considering the indirect impact of the loss of prey availability on the Tiger, less than 0.7% of the forest is loss in the AoI mainly below 800 of altitude. The population and distribution of prey because of the project footprint seems to be lowly impacted. In addition, the project location is more north and lower in altitude.

For barrier effect, it is possible that the new access road, reservoir and forest loss area (dumping sites) have negative impact on Tiger movement, but this barrier is not in its existing territory.

For the Capped Langur, the field survey, camera trap and interview demonstrate that the population is well-established in the AoI of the project including closed to the footprint.

The favourable habitats of these species are mainly forests. If the absolute loss of favourable habitats remains significant, the relative loss, in relation to the available favourable habitats, remains low. The population decline resulting from the reduction in habitat may not be significant considering that the environment is not saturated.

For these two species, the intensity of the loss of their habitat is **Medium**, resulting in a High potential impact.

10.2.3.6.2 Mitigation measures and residual impacts

The main mitigation action for the CHQ terrestrial mammals is described in the biodiversity management plan. Net Gain can be achieved for critical habitat wildlife species (Tiger, Wild Dog, Red Panda and other large mammals) through support to protected areas thus reducing the residual impacts to the biodiversity management plan.

10.2.3.7 Loss of terrestrial critical habitat (Insect)

There is 1 insect CHQ species. *Bhutanitis ludlowi* the Bhutan Swallowtail will not be impacted by the project because of its altitudinal range of the species and its host plant.

Mitigation measures and residual impacts

As the potential and residual impacts on the loss of habitat for Bhutan Swallowtail is **Low**, general conservation measures preserving the habitat of this species are acceptable to generate a net gain with:

- **Program to improve knowledge of the Bhutan Swallowtail species** financing a research program with Universities or the DOFPS including monitoring of these species.

10.2.3.8 Loss of aquatic critical habitats (Fish)

10.2.3.8.1 Potential impacts

There are 4 fish CHQ. Creteuchiloglanis bumdelingensis, Parachiloglanis bhutanensis, Parachiloglanis dangmechuensis, these 3 torrent catfish species are restricted range and found in tributary of the AoA. The fourth species is Tor putitora.

The 3 restricted range torrent catfishes CHQs species have been identified. Creteuchiloglanis bumdelingensis, Parachiloglanis bhutanensis and Parachiloglanis dangmechuensis have been found in tributaries of the AoA and there is no evidence of their occurrence in the Kurichhu river.

The other CHQ is a threatened (EN) species known to occur downstream Kurichhu Dam. Tor putitora (Golden Mahseer) is not evidenced upstream the Kurichhu Dam which may be considered as the upper limit of the distribution of this species. It is strongly assumed that this species does not go through the fish ladder at Kurichhu Dam.

The creation of a reservoir upstream of the future dam will alter the hydromorphology (water depth and flow, water quality, …) of the river and, consequently, the habitat of aquatic flora and fauna. The creation of the reservoir will also lead to permanent flooding of the downstream part of a series of small tributaries.

The modification of flows with a reduction in speed and an increase in depth will considerably modify the aquatic habitat. 93.71 acres of aquatic river habitat will be converted in 309.15 acres a of lake habitat. During low water season, the project will be operated in peaking mode resulting in daily level variations in the reservoir of some meters (10 m maximum).

The creation of the reservoir impact on fish and other aquatic species such as otters will vary depending on the species. The bed of the watercourse will be deeper, morphologically less varied, more silted up, less luminous, less oxygenated, and therefore overall, less conducive to the reproduction of the most sensitive species. These changes, combined with the presence of large quantities of nutrients, tend to favor harder, less demanding species like catfish found in the study area, while sensitive riverine species may face challenges.

Lentic species will be favoured over rapid species. Otters will easily adapt to this new element of their range. The presence of a lake can slightly increases the fish biomass but can also reduce the habitat of endemic fish species whose biology is not known.

The hydraulic continuity of the two main tributaries will be modified by the flooding of their mouths. If connectivity appears improved, Kurichhu rapids habitats between tributaries will be modified by lentic habitats changing connectivity patterns. Connectivity success of the three restricted range catfishes may decay, if predator population is likely to increase in the reservoir.

Around 284 acres of river habitat may be suppressed by the dewatered section. Even if some tributaries contribute to providing some flow, the aquatic habitat will be lost as well as hydraulic continuity with and between the tributaries.

The two *Parachiloglanis spp* were found in tributary and are adapted to high flow environments; having striations on the leading rays of the paired fins aiding in adhesion to the substrate, as well as a mouth fit for scraping invertebrates from rocks (Thoni and Gurung, 2018). *Creteuchiloglanis bumdelingensis*, is also adapted to high flow and seems to prefer rock substrates and feed on benthic invertebrates (Thoni and Gurung,

2018). These 3 species have been found in tributary and not in the main streams of the Kurichhu, and considering the data, the population of this species in the Kurichhu is null to low comparing to the population in the tributary.

Potential impacts on the 3 CHQs restricted range torrent catfishes concern the flow pattern changes in the reservoir and the dewatered sections which will reduce the hydraulic continuity with the tributaries. Note that the project does not impact the tributary (except some manageable impacts of the works). It is not certain if these species use or not the Kurichhu river habitat at some stages of their development and if tributaries/Kurichhu hydraulic continuities are critical of not for these species. It is considered that mixing the population between tributaries is an important factor for the long-term preservation of these species.

For the Golden Mahseer (*Tor putitora*), this species is not in the AoI of the project but in the CAoI / AoA. The downstream area of influence (AoI) is limited downstream by the existing Kurichhu hydropower plant and dam. It is supposed that the existing Kurichhu hydropower plant will work as a demodulation dam during low flow, and in run of the river operation during high flow. It is unlikely that the project may have a significant influence on the flow downstream of the existing Kurichhu hydropower plant. The reservoir of Kurichhu dam will modulate the outflow during peaking at daily scale and the project reservoir has not the capacity to modulate the Kurichhu river at monthly or interseason scale. The sediment load and transport capacity downstream Kurichhu dam is not significantly impacted by the project as the Kurichhu reservoir already suppress rocks, gravels and sands transport load, decrease silt and mud load and have low impact on suspended solids.

Potential impact of loss of aquatic habitats for these 3 CHQ torrent catfish's species is considerate as **Substantial**.

Potential impact of loss of aquatic habitats for the Golden Masheer is considerate as **Low.**

Potential impact on other fish species ranges from **Low** positive to **Moderate** considering the species and (i) the affected area compared with their area of distribution and (ii) the sensibility of these species.

10.2.3.8.2 Mitigation measures and residual impacts

There is no mitigation measure feasible for the impact of the reservoir footprint once the operating level is selected. For the dewatered segment, an effective measure will be developed:

- **Implement an EFlow to maintain adequate lateral connectivity with the tributaries and minimum flow in the Kurichhu. (RM).** The EFlow should allow adequate lateral connectivity with the tributaries and minimum flow to maintain minimum water depth and velocity, as well as hydraulic continuities of the Kurichhu River in rapid areas. The following value should be considered designing EFlow: minimum depth in the rapids 15 to 30 cm during low water season. Preserve the alternation of pools and rapids. The depth of the pools must be able to reach 1 m. Maintain flow peaks during the monsoon to preserve biological signals that may be necessary for self-steered behavioural responses such as migration, mating and laying and displacements through significant and short flooding phases. Take advantage of annual and exceptional flood events and sediment emptying phases to form these flood peaks in the short-circuited section. As an order of magnitude, 3 to 5 one-day flood peaks per monsoon with a peak flow of 60 to 80% of the river flood flow should make it possible to maintain these types of signals. The water intake for EFlow will the highest possible to avoid the death volume of the reservoir, two meters below the minimum operating level should be considered during project detail phase.

With adequate flow management the 3 CHQ restricted catfish species can be expected to persist in their tributaries with adequate EFlow with similar biomass if adequate lateral connectivity is preserved.

However, even if EFlow significantly reduces the impact of the project on these 3 critical species, it is difficult to demonstrate an insignificant to minor residual impact without adequate monitoring. The residual impact will range from **Substantial** to Moderate. Additional offsetting measures are required.

- **Long term management plan dedicated the 3 CHQ restricted range catfish species** including:
    - Additional investigations before the project in other watersheds to assess the distribution of these species and validate its status as a restricted range species (Cb).
    - Additional assessments to understand the lateral movements of these species and the relationship with the main river down the tributaries to complete all life cycle and to preserve genetic diversity.
    - Dedicated monitoring to demonstrate the population level in the tributaries and validate that the residual impact remains insignificant to minority.
    - Additional assessments to define (i) preservation strategy of the upper watersheds and (ii) recommendation for hydropower projects to preserve lateral connectivities to be applied in Bhutan.
- **Program to improve knowledge on the 3 CHQ restricted range catfish species** financing a research program with Universities, NRCRLF, DOFPS and/or DoW including monitoring of the species.

If the residual impact is demonstrated to be moderate or even major after monitoring, the net gain in biodiversity may be difficult to obtain. Additional adaptative management measures may with a more ambitious conservation program.

- **The National conservation action plan is dedicated to these 3 species and other restricted range similar species**
    - Inventories and mapping of the restricted range species occurring in similar tributaries in Bhutan in priority in already protected areas.
    - Set up of a national strategy of conservation for these species.
    - Design a set of additional upper watersheds to be put in conservation (without hydropower equipment and others impacting activities on these species).
    - Long term management of the added protected areas.

10.2.3.9 Physical barrier to the ecological continuity in the Kurichhu River (natural river habitat)

Potential impacts

Dams serve as formidable obstacles to the natural movements of fish and other aquatic species. There will be two coffer dams, one upstream of dam and another downstream of Dam. Aquatic species often rely on specific routes for migration, either for breeding or seeking food, and sometimes, to escape from predators. These migrations can be categorized into two main types:

- Longitudinal Migrations: Some fish species, such as *Psilorhynchus homaloptera*, and *Neolissochilus hexagonolepis*, undertake longitudinal migrations within the main river channel. These migrations, often driven by the need for reproduction, involve moving upstream or downstream to specific spawning sites. Dams act as obstructions, preventing fish from accessing these critical spawning grounds. As a result, the natural migration patterns of these species are disrupted, potentially leading to reduced spawning success.
- Lateral Migrations: Lateral migrations involve the movement of fish from the main river channel to peripheral areas. Dams hinder these lateral migrations by altering the river's natural flow dynamics and blocking access to peripheral habitats. This disruption could affect species which may rely on these lateral movements for reproduction and survival.

Concerning spawning of fish in the tributaries of the upper course allows larvae to be entrained by drift with the floodwater over long distances downstream from the spawning site. Dams can interfere with this entrainment process by altering flow patterns and preventing the downstream movement of larvae. This disruption can impact the distribution of fish populations and their ability to colonize different habitats.

The construction of dams disrupts these intricate migration patterns and ecological cycles by impeding the natural movements of aquatic species. This interference could have significant effects on the behaviour and distribution of fish fauna with an impact on the population distribution and the biomass difficult to predict.

For Migratory fish species, the likelihood of the impact is **High**, and the severity is **High**. The significance of the potential impact is considered **High**.

Mitigation measures and residual impacts

Considering the height of the dam, a fish ladder is not feasible (usually not considered effective with more than 30 m height). Fish lifts have already been experimented in various countries which allow fish transportation to such heights. However, the return of experience is limited, and strong limitations are reported: very limited in term of biomass, some limitation in term of species, release of rapid species in lentic habitat, predators limit success for other species and strong maintenance effort.

The project offers easy access to various downstream and upstream sections of the river. The capture and release of migratory fishes with transportation by road may be a solution to maintain some species and population of migrators as well as genetic diversity of isolated population.

- **Program of capture and release of migratory fish with transportation by road (RM)** with
    - Assessment of the targeted fish, associated trapping technique to be implemented, associated trapping period and associated number of fish to be transported.
    - Assessment of transportation procedures and needed tools and capacity building.
    - Development of several capture zones, particularly at the foot of the dam.
    - Assessment of several realistic zones taking into consideration ecological pattern of each targeted species.
    - Long term capture and release operation by a dedicated team.
    - Monitoring of the targeted fish population.
    - Adaptive Management: Be prepared to adapt activities based on monitoring results and changing conditions.

However, even if capture and release significantly reduce the impact of the project on migratory species, it is difficult to demonstrate an insignificant to minor residual impact without adequate monitoring. The residual impact will range from **Substantial.** Additional offsetting measures are required to achieve no net loss of the migratory species (no migratory critical species evidenced).

- Fish Monitoring and Research (OFM/MM): Establish a comprehensive fish monitoring program to track the behaviour and movements of aquatic species. The program should assess in reference watershed without hydropower equipment and with hydropower equipment including but not limited to the project area. This program should include tagging and tracking studies to understand fish migratory patterns and their resilience to hydropower developments.

10.2.4 Impacts on Human Environment

A summary of the impact from the HPP on private land is shown below.

Physical Displacement

1 two-storied traditional house belonging to one household including an attached kitchen, toilet, cowshed, water tank, poultry (unused) and 2 storage sheds are impacted by reservoir and shall require relocation. The house is currently in use and the loss is permanent.

Other impacts

i. An unused poultry farm including barbed farm below Authso town (left bank) is closer to submergence and is identified as affected.

ii. Barbed wire fence around an agriculture land is affected by submergence.

iii. An automobile workshop (including 4 wooden sheds with CGI sheets, a concrete ramp for car wash, 2 wooden toilets and 2 servicing channels) currently operated on a leased land of a private individual will be affected by submergence.

iv. An automatic water level station located at old Authso suspension bridge is impacted by submergence.

v. Another traditional house, which is currently unused, falls under and will have temporary impact although relocation is not required.

vi. Barbed wire fence with wooden post and ruins of poultry farm (pillars and post) falling under CCF2 is temporarily affected.

vii. Sand collection area belonging to a private household.

Total Households Impacted

The project will affect **92 plots**, 34 of them through the construction power line. These 92 plots belong to **79 Project Affected Households (including 2 institutional land)**, as some PAHs have two or more plots affected. The **CENSUS** was able to cover all of PAH. Amongst these HH there are approximately **206 Project Affected Peoples**.

Loss of agricultural land

The Project will result in **the direct submergence or land clearing of 9.40 acres of agricultural land** (44.64% loss of Kamzhing assets, 55.36% loss of Chhuzhing assets including Institutional Land (kamzhing)).

A total of 20 HHs is affected by loss of agricultural livelihood resources. 16 with only agricultural use (1 affected by ADIT2 to ADIT 3; 3 by the reservoir and 12 by the transmission line); one with agricultural and residential use affected by the reservoir; and 3 with agricultural use and infrastructure (1 affected by CCF2 and 2 by the reservoir). 25 plots are permanently affected on more than 20% of their area.

12 HHs will have impacts though loss of trees. A total of 388 fruit trees was identified as lost because of the Project.

10.2.4.1 Physical Displacement

10.2.4.1.1 Physical Displacement

1 two-storied traditional house with associated structures (kitchen, toilet, water tank and sheds) to be physically displaced.

Other impacts include:

i. An unused poultry farm including barbed farm below Authso town (left bank) is closer to submergence and is identified as affected.

ii. Barbed wire fence around agriculture land is affected by submergence.

iii. An automobile workshop (including 4 wooden sheds with CGI sheets, a concrete ramp for car wash, 2 wooden toilets and 2 servicing channels) currently operated on a leased land of a private individual will be affected by submergence.

iv. An automatic water level station located at old Authso suspension bridge is impacted by submergence.

v. Another traditional house, which is currently unused, falls under and will have temporary impact although relocation is not required.

Total Households Impacted

The project will affect 58 plots, 5 of them through the construction power right of way. These 58 plots belong to 52 Project Affected Households (including 2 institutional land), as some PAHs have two or more plots affected. February 2024 and August 2024 CENSUS was able to cover all of PAH. Amongst these HH there are approximately 157 Project Affected Peoples.

The likelihood of the impact is **High,** and the severity is **High**. The significance of the potential impact is considered **High**.

The following measures are proposed to address the impact:

- Develop a Land Acquisition and Livelihood Restoration Plan (RES/EM). LALRP has been prepared for the project as a standalone document.

After proper development and implementation of these measures, the residual impact is considered as **Substantial**.

10.2.4.2 Loss of livelihood and assets

10.2.4.2.1 Loss of agricultural land

The Project will result in the direct submergence or land clearing of acres of agricultural land (44.64% loss of Kamzhing assets (including Institutional Land), 55.36% loss of Chhuzhing assets).

A total of 6 HHs is affected by loss of agricultural livelihood resources. 5 with only agricultural use; one with agricultural and residential use affected by the reservoir; and 3 with agricultural use and infrastructure (1 affected by CCF2 and 2 by the reservoir). 27 plots are permanently affected on more than 20% of their area.

12 HHs will have impacts though loss of trees A total of 342 fruit trees was identified as lost because of the Project.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Land Acquisition and Livelihood Restoration Plan (RES/EM). LALRP has been prepared for the project as a standalone document.

After proper development and implementation of these measures, the residual impact is considered as **Moderate**

10.2.4.2.2 Loss of forest and community forest

Forest

The Project will result in the direct submergence and land clearing of about:

- 95,6 acres of Broadleaf Forest.
- 614,7 acres of Chir Pine Forest.
- 29,6 acres of Scrub Forest.
- 327,7 acres of riparian forest

The total forest area lost because of the Project is about 1,0767.6 acres (re. Natural habitat losses in the project footprint).

Community Forrest

Within the project area of influence (5km) there are 10 community forest groups: 3 in Tsamang, 1 in Tsakaling, 1 in Saling, 2 in Chhaling, and 3 in Tsenkhar. Three Community Forest groups may be impacted by the Project, one from Construction Power Line, and two from road widening/realignment, however the full impact is not known at this stage.

The likelihood of the impact is **Low** severity is **Medium,** and the significance of the impact is **Moderate.**

The following measures are proposed to address the impact:

- Compensation for trees lost from the Community Forest will be paid by BPC based on commercial rate of royalty of standing trees as per the Forests and Nature Conservation Act and Rules and Regulations of Bhutan, 2023.
- Additionally, the Compensatory afforestation program will also include plantation of locally indigenous trees in degraded community forest areas.

After proper development and implementation of these measures, the residual impact is considered as **Low**

10.2.4.2.3 Loss of fisheries

The Project will alter water flows and cause loss of aquatic habitats in the dewatered section. However, the practice of fishing is illegal in the river and very rare so there will be no or low impacts on fisheries.

The likelihood of the impact is **High,** and the severity is **Medium.** The significance impact is considered as **High.**

The following measures are proposed to address the impact:

- Development and implementation of a Stakeholder Engagement Plan (MM/TM)
- Development and implementation of a Grievance Redress Mechanism (MM)
- Ensure Implementation of the EFlow Management Plan
- Establish a Fish Hatchery and Implement a Migratory Fish Catch-&-Release Protocol as detailed in the BMP.

After proper development and implementation of these measures, the residual impact is considered as **Moderate**.

10.2.4.2.4 Loss of community infrastructure and other assets

An NCHM automatic water level station will be affected.

The Project will result in the direct submergence of the disused suspension bridge near Autsho and four electric feeder poles. No other community asset has been identified as being flooded and impacted by reservoir submergence or land clearing requirements.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Compensation for the construction of a poles and line by Bhutan Power Corporation.
- Compensation for the removal and shifting of the NCHM automatic water level station.

After proper development and implementation of these measures, the residual impact is considered as **Low**

10.2.4.2.5 Loss of roads

The Project will result in the direct submergence of about 3.72 km of public roads near Autsho. The reservoir will also flood about 0.41 km of farm road to Takhambi village. New roads will be constructed to replace the impacted roads, with a total new road length of 5.4 km, and 1 km of tunnel.

The likelihood of the impact is **High,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Design and construction of new roads.

After proper development and implementation of these measures, the residual impact is considered as **Low**.

10.2.4.2.6 Loss of cultural sites

No known cultural site will be impacted by reservoir submergence or land clearing requirements. One stone bath in the dewatered section will lose interest as the water source will be farer, but it is not destroyed. One Chorten was noted to have already vandalised.

The likelihood of the impact is **Low,** and the severity is **Low.** The significance of the potential impact is **Low.**

The following measures are proposed to anticipate unexpected impacts:

- Cultural Resources Management Plan and Chance Find Procedure (AM/RM);
- Grievance Redress Mechanism (RM).

After proper development and implementation of these measures, the residual impact is considered as **Low.**

10.2.4.2.7 Direct loss of economic activities (business)

The Project will result in the submergence of one economic activity site. A small sand mining site in Autsho. It should be noted that this site is considered marginal and only includes a small sand borrow area on the riverbank (no permanent equipment or sand pumping operations). One automobile workshop will also be submerged.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Land Acquisition and Livelihood Restoration Plan (RES/EM). LALRP has been prepared for the project as a standalone document.

After proper development and implementation of these measures, the residual impact is considered as **Substantial**.

10.2.4.3 Risk for Public health

Incidence of waterborne or water related diseases is further detailed in the section related to impacts during operations.

The damming of rivers and alteration of water flow can contribute to the spread of waterborne diseases and poor water quality. These issues were not reported for the Kurichhu reservoir which has been impounded over 10 years ago.

The likelihood of the impact is **Low**, and the severity is **Low**. The significance of the potential impact is considered **Moderate**.

The following measures are proposed to address the impact:

- Liaise regularly with the local health authority, particularly Mongar Regional Referral Hospital, to monitor and identify any increasing trend in disease incidence.
- Communities Health and Safety Management Plan

After proper development and implementation of relevant measures, the residual impacts are **Low**.

10.2.4.4 Risk of drowning in the reservoir and from the restitution point to Kurichhu Reservoir

Risk of drowning is further detailed in the section about impacts during operations. However, the change in the river design with a reservoir- and its lake aspect- in place of a river with strong currents, could attract more people and increase the risk of drowning. It is understood that most of the local community do not how to swim and no one currently swims due to water temperature, strong current, and in general very little use of the river (no boat). There was no reported drowning for the Kurichhu reservoir which has been impounded over 10 years ago. There is no boat except those of the Kurichhu HPP on the reservoir and no one swim in the reservoir.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Implement targeted awareness campaign in the local schools / communities about drowning risks.
- Install regular drowning warning signage in key areas around the reservoir.
- Develop and implement emergency preparedness and response Plan.
- Communities Health and Safety Management Plan

After proper development and implementation of relevant measures, the residual impacts are **Low**

10.2.5 Summary of impacts and measures related to project footprint

The following summary table presents for each activity or component:

- The impacts based on description provided above.
- The significance of the impacts with the details of the severity and the likelihood.
- The list of the main corrective measures to manage the impacts.
- Consideration about the feasibility and difficulty of the proposed corrective measures rated from 1 (easy) to 3 (difficult).
- The significance of the residual impact.

It is noted that this table presents the residual impact without the implementation of offsetting measures. The purpose is to highlight (i) the significance of the residual impact with avoidance/reduction measures

only and (ii) the need for potential compensation measures. The compensation measures presented in this table are designed in a way to fully compensate the Substantial and significant residual impacts identified

Table 178: Summary of impacts and measures related to project location and footprint – Physical and Biological Environment

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure **AM= avoidance — RM = reduction** **R**ES = Restoration OFM = Offsetting measures **MM = monitoring –TM = training – EM = enhancement**	Implementation difficulty	
PHYSICAL ENVIRONMENT								
See section 10.4 and 10.5.5								
BIOLOGICAL ENVIRONMENT								
Project footprint, mainly from the reservoir, the dam, and associated infrastructures	Loss of protected / classified area, **Phrumsengla National Park** and **Corridor #7 are also considered as Critical habitat**	**Phrumsengla National Park** No direct impact. 9% (83 km²) is inside the AoI. Social influx may increase the pressure on the natural environment. Direct impact on Corridor#7 may induce changes in connectivity's. **Corridor #7** The reservoir is located inside Corridor 7. Changes in flow patterns may lightly impact the connectivity for some species, but the river in its initial state is already a strong obstacle to connectivity. It should be noted that further	Low Medium	Low Medium	Low Substantial	▪ Management plan of the social influx with avoidance and reduction measures to reduce social influx in the vicinity of PNP, Corridor"7 and Pallas's Fish-eagle KBA (RM). ▪ Implement an EFlow to maintain the watercourse and prey available in the dry segment allowing the Pallas eagle to feed (RM). There is not a big difference in feeding success between rivers and streams, so this mitigation can be effective. Preserve the alternation of pools and rapids. The water intake for EFlow	-	Low Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
		downstream, the short-circuited segment will increase the connectivity between the two banks with numerous opportunities for crossing the river. **KBA Pallas's Fish-eagle** It is impacted in its north half by the dewatered segment and the powerhouse including restitution points. It seems that the reservoir of the Kurichhu HPP is used by the species with nest close to the reservoir	Medium	Medium	Moderate	will the highest possible to avoid the death volume of the reservoir. ▪ Establishment of a partnership with the Phrumsengla national park and and Mongar Territorial Division to support forest habitat preservation programs (OFM) in the PNP and monitoring of mammals in the Corridor#7 and contribute to implementing programs for the management of BC #7 and the Palla Fish Eagle Habitat. ▪ Installation of nesting platforms suitable for the Pallas Fish Eagle downstream of the project reservoir.		Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Project footprint, mainly from the reservoir, the dam, and associated infrastructures	Loss of terrestrial critical habitat (Flora)	One station of an herb's species (EN and RR, *Hoya bhutanica*) will be flooded by the project	Medium	Low	Moderate	▪ Additional investigation before works in the project footprint to identify Hoya bhutanica stations. If new stations are evidenced in the AoI near the footprint: o Adjust as possible the project footprint 100 m away from the station. o Prohibition zone and protection of plants o If not, it is feasible to collect and multiplication in nurseries ▪ Search for sites favourable to reintroduction into the natural environment and proceed to a translocation program. (OFM). An experienced staff will oversee each step, increasing the chances of successful translocation. ▪ Improvement of the knowledge of this species financing a research program with Universities or the DOFPS including monitoring of the species in Bhutan (OFM/MM)	-	Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Loss of terrestrial critical habitat (Birds)	There are 4 birds considered as CHQ species i.e. the Pallas's Fish-eagle (*Haliaeetus* leucoryphus), the White-rumped Vulture (*Gyps bengalensis*), the Red-headed Vulture (*Sarcogyps calvus*) and the Dark-rumped Swift (*Apus acuticauda*). Low risk of impacts on nests due to the project's footprint (no nests identified on the ground). For vultures, there is Low probability of loss of favorable habitats and feeding success due to the impact of the project given the size of the flight range. For Pallas fish eagle, the feeding success will be Moderately impacted thank to its capacity to target various terrestrial and aquatic species in various aquatic habitats. For the Dark-rumped Swift the risk is limited in cliff / quarry area and during the breeding period from Marsh to May	Low	High	Susbtaintial	▪ Additional survey before work checking the presence of nests in and near the structures (100 m) (RM). If there are nests: ○ Optimize the footprint as much as possible to avoid the proximity of work (less than 100 m away). ○ In all cases, it will be prohibited to cut down a tree with a nest of vultures during the nest building, egg laying and juvenile growing phase. This will be protected by a marked prohibition zone of 20 m around, without clearing the vegetation. ○ Monitoring by a bird expert of the vultures and eagle ▪ Program to improve knowledge on the four CHQ species financing a research program with Universities or the DOFPS including monitoring of the species (AFM/MM)	Medium	Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Project footprint, mainly from the reservoir, the dam, and associated infrastructures	Loss of critical terrestrial habitat (Mammals)	There are three mammals CHQ species, the Capped Langur (*Trachypithecus pileatus* ssp. *Tenebricus*), Chinese Pangolin (*Manis p*entadactyla) and the Tiger (*Panthera tigris*) For the Chinese Pangolin the risk of loss of habitat is Low (not confirmed) For Tiger, the highest population densities are outside the project AoI but a new territory is evidence 6 km south of the project For Capped Langur, population well established in the AoI. If the absolute loss of favourable habitats remains significant, the relative loss to the available favourable habitats remains low. The population decline resulting from the reduction in habitat may not be significant.	Low	Medium	Moderate	▪ Program to improve knowledge of Capped Langur, Chinese Pangolin and Tiger species (OFM) financing a research program with Universities or the DOFPS of these species. ▪ Dedicated monitoring in the project area of Capped Langur, Chinese Pangolin and Tiger species (MM). In the project area, dedicated monitoring by camera traps and regular interviews will be performed ▪ Contribution to existing forest conservation program and taxon management program (Capped langur, Chinese Pangolin and Tiger) with authorities (DoFPS).	Low	Moderate
	Loss of terrestrial critical habitat (insect)	There is 1 insect CHQ species. *Bhutanitis ludlowi* the Bhutan Swallowtail No be impacted by the project because of its altitudinal range of species and its host plant.	Low	Low	Low	▪ Program to improve knowledge of the Bhutan Swallowtail species (OFM) financing a research program with Universities or the DOFPS including monitoring of these species	Low	Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure **AM= avoidance — RM = reduction** **R**ES = Restoration OFM = Offsetting measures **MM = monitoring –TM = training – EM = enhancement**	Implementation difficulty	
	Loss of natural terrestrial habitats and associated sensitive species.	Around 83.8, 82.6, 514.9 and 20.5 acres, respectively of riparian forest, broadleaf forest, chirpine forest and shrub will be lost. These losses may concern sensitive species, in addition to the CHQ species with 5 flora species, 11 mammal's species, 28 bird species, 6 herpetofauna species	High	Medium	High	▪ Afforestation program to offset the loss of natural habitat (OFM). The program of about 1,557 acres (Loss x2 ratio) will be financed by the project and developed with the relevant authorities, i.e. the DFPS of the MoENR and the NBC in conformity with the forest restauration strategy developed by Bhutan. The program will concern riverine broadleaf forest, broadleaf forest and chirpine forest.	High	High

Project footprint, mainly from the reservoir, the dam, and associated infrastructures	Modification of aquatic critical habitats and associated sensitive species.	3 CHQ restricted range torrent catfish species: *Creteuchiloglanis bumdelingensis, Parachiloglanis bhutanensis, Parachiloglanis dangmechuensis*, One EN CHQ species known to occur downstream Kurichhu Dam: *Tor p*utitora (Golden Mahseer) is not evidenced upstream the Kurichhu. The modification of flows with a reduction in speed and an increase in depth will considerably modify the aquatic habitat. Lentic species will be favored over rapid species. Potential impacts on the 3 CHQs torrent catfishes concern the flow pattern changes in the reservoir and the dewatered sections which will reduce the hydraulic continuity with the tributaries. For the Golden Mahseer (Tor putitora), this species is not in the AoI of the project but un the CAoI / AoA. Potential impact on this species is not expected	Medium	Medium	Substantial	▪ Implement an EFlow to maintain adequate lateral connectivity (RM) with the tributaries and minimum flow in the Kurichhu. (RM). The EFlow should allow adequate lateral connectivity with the tributaries and minimum flow to maintain minimum water depth and velocity, as well as hydraulic continuities of the Kurichhu River in rapid areas. Maintain flow peaks during the monsoon to preserve biological signals that may be necessary for self-steered behavioural responses. The water intake for EFlow will the highest possible to avoid the death volume of the reservoir. ▪ Long term management plan dedicated the 3 CHQ restricted range catfish species including (OFM) ▪ Program to improve knowledge on the 3 CHQ restricted range catfish species financing a research program with Universities, NRCRLF, DOFPS and/or DoW (OFM) ▪ Dedicated monitoring program (MM) ▪ If the residual impact is demonstrated to be substantial or high: o National conservation action plan dedicated to these 3 species and other restricted range similar species. o Design a set of additional upper watersheds to be put in conservation (without hydropower equipment and others impacting activities on these species).	Medium	Substantial

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Project footprint, mainly from the reservoir, the dam, and associated infrastructures	Physical barrier to the ecological continuity in the Kurichhu River (natural river habitat)	There will be two coffer dams, one upstream and the other downstream. Aquatic species that often rely on specific routes for migration, either for breeding or seeking food, and sometimes, to escape from predators. These migrations can be categorized into two main types	High	High	High	▪ Program of capture and release of migratory fish with transportation by road (RM) ▪ Fish Monitoring and Research (OFM/MM): Establish a comprehensive fish monitoring program to track the behaviour and movements of aquatic species.	High	Substantial
Dewatered segment and downstream (from restitution to Kurichhu lake)	Loss of riparian forest	Around 279.8 acres of forest may be impacted by the dewatered section. This forest type may be host of CH qualifying species and sensitive species	Medium	Medium	High	▪ Implement an EFlow to maintain abiotic factors on the banks to preserve the riverine broadleaf forest. (RM). Maintain low water in the alluvial aquifer at sufficient depth in rapids and pools. Maintain flow peaks in the dry segment during the monsoon to conserve certain abiotic factors on the banks through significant and short flooding phases. The water intake for EFlow will the highest possible to avoid the death volume of the reservoir	Low	Moderate
	Loss of aquatic natural critical habitats and associated sensitive species.	Around 287.9 acres of river may be impacted by the dewatered section. This river may be host of 3 CH qualifying species	High	High	High		Low	Moderate

Table 179 - Summary of impacts and measures related to project location and footprint – Human Environment

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significa
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
HUMAN ENVIRONMENT								
HPP facilities	Physical Displacement (household)	The Project requires the Physical Displacement of one HH. The HH assets include a house, a poultry barn and two huts.	High	High	High	Land Acquisition and Livelihood Restoration Plan (RES/EM).		Substantial
	Loss of livelihood – agricultural land,	The Project will result in the direct submergence or land clearing of about 19.37 acres of cultivated land	High	Medium	High	Land Acquisition and Livelihood Restoration Plan (RES/EM).		Moderate
	Loss of livelihood – crops and fruit trees	12 HHs will have impacts though loss of trees A total of 388 fruit trees was identified as lost as a result of the Project.	High	Medium	High	Land Acquisition and Livelihood Restoration Plan (RES/EM).		Substantial
	Loss of community forest	No community forest impact expected	Low	Medium	Moderate	Land Acquisition and Livelihood Restoration Plan (RES/EM).		Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significa
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
HUMAN ENVIRONMENT								
	Loss of economic activities (business)	The Project will result in the submergence of one economic activity site. The sand mining site in Autsho. It should be noted that this site is considered marginal and only including a small sand borrow area on the riverbank (no permanent equipment or sand pumping operations). One automobile workshop will also be submerged.	High	Medium	High	Land Acquisition and Livelihood Restoration Plan (RES/EM).		Substantial
	Loss of community infrastructure	The Project will result in the direct submergence of the disused suspension bridge near Autsho and four electric feeder poles. No other community asset has been identified as being flooded and impacted by reservoir submergence or land clearing requirements.	High	Medium	High	Design and construction of a poles and line by Bhutan Power Corporation. Land Acquisition and Livelihood Restoration Plan (RES/EM).		Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significa
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
HUMAN ENVIRONMENT								
	Loss of roads	The Project will result in the direct submergence of about 3.72 km of public roads near Autsho. The reservoir will also flood about 0.41 km of farm road to Takhambi. New roads will be constructed to replace the impacted roads, with a total new road length of 5.4 km, and 1 km of tunnel.	High	High	High	Design and construction of a new road.		Low
	Loss of cultural sites	No known cultural site will be impacted by reservoir submergence or land clearing requirements.	Low	Low	Low	Cultural Resources Management Plan and Chance Find Procedure (AM/RM); Grievance Redress Mechanism (RM).		Low
	Creation of a reservoir / public health	Potential increase in water borne disease following the creation of a reservoir.	Low	Low	Moderate	Liaise regularly with the local health authority, in particular Mongar Regional Referral Hospital, to monitor and identify any increasing trend in water borne disease incidence. Communities Health and Safety Management Plan		Low

Footprint	Potential impacts	Impact description	Impact assessment			Corrective measure		Significa
			Likelihood	Severity	Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
HUMAN ENVIRONMENT								
	Creation of a reservoir / public safety	Potential increase in drowning for local population	Low	High	Substantial	Implement targeted awareness campaign in the local schools / communities about drowning risks. Install regular drowning warning signage in key area around the reservoir. Develop and implement emergency preparedness and response Plan. Communities Health and Safety Management Plan		Low

10.3 Analysis of impacts related to the construction of the HPP

10.3.1 Impacts on Physical Environment

10.3.1.1 Impact from Blasting

10.3.1.1.1 Increased potential for landslides and rockfalls

The blasting activity carried out during the construction of the Dorjilung Hydropower Plant (HPP) can lead to an increased potential for landslides in the surrounding areas. Blasting involves the controlled use of explosives to break rock formations and create space for various construction activities. While blasting can have unintended consequences on the stability of the terrain. The study area is situated within the Daling-Shumar Group (also known as the Shumar Formation) of Precambrian age. This formation is composed of alternating layers of quartzite and phyllite/mica schist, along with carbonate and gypsum bands. The geological conditions seem favourable for the construction of the dam, due to the stable foundation provided by the phyllitic schist on both banks and the use of durable quartzite for critical structures.

However, the potential impact of blasting on the potential for landslides must be considered given the occurrence of faulting and thrusting, particularly in the southern part of the area, suggesting geological activity that has affected rock formations. Blasting can interact with these geological structures, potentially triggering localized instabilities. Furthermore, blasting can disturb the overburden and slope deposits, potentially increasing the risk of landslides and rockfalls in these areas.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Optimized Blasting Techniques (AM): Utilize controlled blasting techniques that minimize vibrations and rock fragmentation. Controlled blasting reduces the risk of dislodging large rock masses and helps maintain the stability of surrounding areas.
- Blast Monitoring (MM): Implement a monitoring system to track ground vibrations, rock movement, and other indicators during and after blasting. This real-time monitoring allows for immediate response if any adverse effects are detected.
- Blasting Design (AM): Develop precise blasting patterns that consider the geological characteristics of the site. This involves determining optimal drilling angles, hole depths, and explosive quantities to minimize disturbance to rock layers and structures.
- Blasting Sequence (AM/RM): Sequence the blasting operations carefully to prevent excessive loosening of rock material in a concentrated area. Spreading out the blasts over time can help distribute the effects more evenly.
- Rockfall Protection (AM/RM): Install rockfall protection measures, such as catch fences or barriers, in areas identified as potential landslide zones. These structures can intercept falling rocks and prevent them from reaching critical areas.
- Proper communication (AM): Prior to blasting, locals should be warned through proper communication either through village Tsogpa or an elected community representative. Timing should be made known to the nearby communities.
- Preparation and implementation of an Explosives and Blasting Management Plan and Construction Emergency Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial.**

10.3.1.2 Impact from Excavation and River Works

10.3.1.2.1 Changes in flows and potential flooding

During the construction phase of the Dorjilung HPP, the excavation and river works activities can potentially lead to changes in flows and alter the risk of flooding in the surrounding areas. These impacts arise due to the alteration of the natural river course and the disturbance of sediment and debris within the riverbed. Excavation activities can modify the river channel's geometry and alter the flow patterns. This might result in increased flow velocities in certain sections of the river, leading to erosion of the riverbanks and bed. Conversely, the construction activities could also temporarily obstruct the river's natural flow, causing water to pool upstream and potentially leading to localized flooding in areas that were previously unaffected. River works such as coffer dam construction, channel modifications, and diversion structures can alter the natural flow patterns of the river. These changes can include reduced or augmented flow rates, which might impact downstream ecosystems and communities.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Flow Diversion (AM/RM): During construction, consider the implementation of temporary flow diversion channels or bypasses. These structures can direct water around the construction site, minimizing disruptions to the natural flow and reducing the risk of flooding.
- Temporary Riverbank Protection (RM): Use temporary measures such as riprap, geotextiles, and vegetative cover to protect riverbanks from erosion during construction. This can prevent damage to nearby infrastructure and settlements.
- Emergency Preparedness and Response (AM): Develop emergency response measures in collaboration with local authorities. This plan should outline actions to take in case of sudden changes in flows or flooding, including communication strategies and evacuation plans.
- Preparation and implementation of a Construction Emergency Management Plan and Grievance Redress Mechanism.

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.2.2 Changes in sediment load and transport d/s

During the construction phase of the Dorjilung HPP, excavation and river works activities carry the potential to disrupt the natural landscape, leading to the erosion of soil and sediment. This soil can be entrained by rainwater or flowing water, initiating the process of sediment mobilization. Once set in motion, these sediment particles become suspended within the water and are transported downstream by the river's current. This transport can take place during rain events, snowmelt, or other natural runoff occurrences.

The increase in downstream transport of sediments can result in their accumulation and adverse impacts on Kurichhu reservoir with damage and increased wear to the intakes and turbines. This accumulation has the potential to hamper operational efficiency and necessitate more frequent maintenance activities.

As DGPC is both the operator of Kurichhu HPP and the proponent for Dorjilung HPP, communication and coordination are likely to be efficient between these two HPPs.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Sediment Control Structures (RM): Install sediment control structures such as silt curtains, sediment basins, and sediment traps strategically along the construction area. These structures can capture and manage sediment before it reaches downstream areas, minimizing the impact on water quality and aquatic ecosystems.
- Erosion and Sediment Control Plans (RM): Develop and implement comprehensive erosion and sediment control plans. These plans should outline strategies for preventing soil erosion and sediment dislodgement during construction. Measures such as revegetation, erosion-resistant materials, and proper construction sequencing can be employed to minimize soil disturbance.
- Sediment Monitoring (MM): Establish a sediment monitoring program to regularly assess sediment levels at key points downstream. This ongoing monitoring can provide valuable data on sediment transport patterns and deviations from baseline conditions, enabling prompt responses if needed.
- Selective Excavation Techniques (RM): Adopt selective excavation techniques that minimize the disturbance of fine sediments. This approach can help maintain the natural sediment balance and prevent excessive downstream transport.
- Vegetative Buffers (RM): Create vegetative buffers along the periphery of the construction area to stabilize soil and prevent sediment runoff. Healthy vegetation acts as a natural barrier against erosion and sediment transport.
- Regulated Release (AM): During construction activities (excavation), that could release a significant amount of sediment consider regulating the release to minimize sudden sediment influx downstream.
- Preparation and implementation of a Soil Erosion and Sediment Management Plan.

After development and implementation of relevant measures, the residual impacts are **Moderate**.

10.3.1.3 Impacts of Construction- Traffic

10.3.1.3.1 Air emissions

The increase in road traffic linked to the construction of the project to transport materials and personnel to/from the site will lead to an increase in atmospheric emissions, which will have an impact on the health of road users and people living around the access roads. This is mostly associated with dust (during the dry season) but also with direct vehicle exhaust fumes.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Mapping out itineraries for Project vehicles (RM): The itineraries used by the Project vehicles (light and heavy vehicles) will be mapped out for each route (from Thimphu, Mongar and from India) and between the different work sites.
- Liaison with local offices of the Department of Roads and Surface Transport (AM): The Contractor will liaise with the local offices of the Department of Roads and Surface Transport in Lingmethang and Mongar.
- Restrictions on night-time and school commute hours (AM): Except for exceptional circumstances, Project heavy vehicles will not use public roads at night between 10.00 pm and 06.00 am and will avoid using public roads during school commute times. No Project vehicles (light and heavy) will be allowed to circulate in local villages between 08.00 pm and 07.00 am).

- Enforcing speed limits (RM): The maximum speed for all Project vehicles will comply with the legal speed limits defined in Bhutan (50 km/h). When crossing villages and cities and close to buildings, the speed limit will be reduced to 30 km/h. On construction sites, the speed limit will be set at 20 km/h or 30 km/h. The contractor will consider using a GPS tracking device and will be required to undertake random speed checks of Project vehicles.
- Dust suppression measures (RM): During the dry season, the Contractor will use non-potable water to implement dust suppression measures. Typically, the road is sprayed in the morning and additional spraying is implemented as required during the day.
- Regular vehicle maintenance and checks (RM): Trailers, skips and haulage trucks will have their loads covered during transport and it is prohibited to remove the tailgate of trucks. All Project vehicles need to be in good working order and maintained as per the manufacturer's specifications. The Contractor will undertake regular checks of the vehicles fleet used on the Project.
- Preparation and implementation of a Traffic and Access Management Plan, inc. a Safe Driving Policy, and a Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are **Moderate**.

10.3.1.4 Impacts from Heavy machinery, Excavation and Earthworks

10.3.1.4.1 Air quality and dust impacts

Many construction activities generate dust (during the dry season) and to a lesser extent, direct vehicle exhaust fumes. In addition to vehicle movements (described in Section 10.3.3.1), land clearing activities, excavation, grading, earthworks and the operations of the crushing plants and batching plants all generate significant amounts of dust.

The impacts of air quality alteration and dust from heavy machinery, excavation, and earthworks on a construction site can have significant consequences for the workers and the surrounding communities, from impacts on the population's activities (visibility reduction during work potentially leading to hazardous driving conditions and accidents) to impact on people's comfort, safety and health (respiratory problems, allergies and irritations, etc).

Dust from construction activities on crops can be significant and detrimental to agricultural productivity, as it affects the crops by contaminating soils or the crops directly, by reducing photosynthesis and stunting growth and by interfering in pollination. Dust impacts on crops lead to the decrease of agricultural production quantity and quality, long-term soil degradation and loss of income for farmers.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Inform local populations of work activities (AM).
- Follow-up of dust and air quality complaints (MM) and implementation of the complaint management mechanism (RM).
- Implement covering stockpiles for a few weeks / months: Covering stockpiles is to create a physical barrier that prevents construction materials from being exposed to the wind and weather, thereby reducing the generation and dispersion of dust.
- Implementing temporary vegetation cover: For longer-term storage areas implement temporary vegetation cover is to stabilize the soil surface in storage areas, preventing the generation and dispersion of dust, and minimizing soil erosion. Vegetation cover reduces the potential for soil particles to become airborne, thus minimizing dust emissions.

- Reuse, composting and recovery of waste, including green waste (AM), reduction to the minimum possible of the burning of green waste.
- Develop and implement Revegetation (RES): Implement revegetation is to establish and maintain plant cover in areas where soil has been disturbed by construction, excavation, or other activities. Vegetation helps stabilize the soil, preventing erosion and reducing the potential for dust emissions.
- The monitoring of noise and dust emissions will be undertaken by construction contractors and the grievance mechanism will have to allow the population to express their concerns via complaints register (MM).
- Develop and implement an Air Quality Management Plan (AM), and a Waste Management Plan (AM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.1.4.2 Pollution associated with spills

Pollution associated with spills during the construction phase of a HPP occurs with accidental release of hazardous materials, chemicals, fuels, or other pollutants into the environment. These spills can occur due to various reasons, including equipment failure, human error, improper storage, or mishandling of materials.

The pollution associated with spills from construction works can impact workers and communities' health (respiratory issues, skin and eye irritation, displacement, and relocation in case of severe pollution) and economic activities as pollution can contaminate agricultural lands and water sources.

Spills can also lead to damage to nearby properties or public infrastructures and lead to financial losses for property owners as well as workers or tenants related to damaged properties.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Inform local populations of work activities (AM)
- Prohibit refuelling in the field (AM): all refuelling needs to be done in appropriate facilities with hardstand, drainage system and a de-oiler.
- Establishment of a program for the collection, monitoring, and treatment of waste (RM), including used oils in camps and on construction sites.
- Identify hydrocarbon storage sites (RM) with the company and organize this storage on dedicated secure platforms: waterproof concrete slab surrounded by a wall ensuring the retention of a volume at least equal to 110% of the largest container located on the platform (maximum to be authorized of 10,000 l for gasoline or diesel). The platform will be covered, and its evacuation equipped with an oil separator.
- Storage of chemicals in appropriate areas (RM) (with oils, for example) and the need to ensure their storage compatibility (information on toxicity and safety data sheets available for workers).
- Identify material deposition sites (RM) respecting a minimum distance (50 m) between material deposition and watercourse.
- Machinery and equipment maintenance area (RM). The maintenance and washing of machinery and equipment will be limited to areas defined for this use, equipped with a concrete slab and peripheral drainage evacuating runoff through an oil separator. In addition, sedimentation basins for the recovery of washing water rich in concrete, with pH readjustment (acid buffering) before discharge into the natural drainage will be set up.
- Define strict procedures for filling equipment tanks (RM) (type of equipment, mandatory dedicated areas).

- Prevention of pollution by toxic products (RM) by containment measures for hazardous products by the contractor and the establishment of an emergency plan in the event of accidental spills.
- Exclusive use of pesticides recognized by WHO (RM) or any other organization with authority in the matter.
- Establishment of a monitoring plan for the quality of water from worksite areas (MM). An initial document should make an inventory of the discharge points to be followed, in particular the discharges of wastewater after treatment, the discharges of water after the oil separators, the discharges after the sedimentation basins. The program should take as references, values validated by the EPA and based on IFC/ WHO standard to define the non-compliance of discharges, the following bacteriological and physicochemical indicators: Total coliforms, BOD5, COD, Total nitrogen, Total phosphorus, Total hydrocarbons, pH, SS. A periodicity, monthly for example, must be clearly defined.
- Establishment of an employee awareness and training program on all these aspects (TM).
- Develop and implement an Air Quality Management Plan, a Traffic and Access Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan, and a Grievance Redress Mechanism (AM).

After proper development and implementation of relevant measures, the residual impacts are **Moderate**.

10.3.1.4.3 Noise and vibration

The noise level will be modified by earthworks, rock clearing (hydraulic hammer), pile driving and drilling of foundations, crusher operations, concrete production, assembly of components and the various construction operations. Backup beepers of vehicles and machines present sound levels clearly audible from a large distance for safety reasons.

Table 180: Typical Noise Generators and Associated Noise Levels

Equipment	LAeq Sound Power Levels, dB(A) re. 1pW	Type of noise
Small pile driving rig	114	Impulse noise
Crane	110	Continuous noise
Forklift	90	Continuous noise
Dump truck	108	Continuous noise
Compactor / Vibratory Roller	103	Continuous noise
Bulldozer	109	Continuous noise
Excavator	106	Continuous noise
Mulcher	116	Continuous noise
Grader	108	Continuous noise
Trencher	104	Continuous noise
Generator	75	Continuous noise
Crusher	113	Continuous noise

Furthermore, activities are likely to generate vibrations perceived in two ways: tactile or auditory. The activities likely to cause vibrations that can impact nearby buried structures such as building foundations, are the following:

- Crushing.
- Earthmoving.
- Hydraulic hammering.
- Foundation treatment operations such as pile driving.
- Handheld electrical tools such as grinders, drills, jackhammers, etc.

- The transport of materials and equipment by truck, particularly when the road surface is uneven (deformation, potholes, etc.). The road passes close to villages, particularly the village of Raymond Camp (houses, clinics, market, etc.). The repeated vibrations induced by the heavy vehicles circulating on a non-adapted track can lead to the formation of cracks in the constructions and thus weaken them.

Whatever the origin, the generated vibrations propagate in the ground. The characteristics of these waves depend on:

- The nature of the soil crossed.
- The excitation frequency, influenced by the characteristics of the source (vehicle, machine...), its speed etc.
- The distance between the point of observation and the point of generation of the vibration.

The HPP, the base camp as well as important dam infrastructures (such as the intake) are in the immediate vicinity of the works and can be directly impact by noise and vibrations. However, massive structures such as HPP or intake (existing structures closest to the work areas) are not very sensitive to the range of vibrations induced by the planned construction activities. Nevertheless, the dam will be permanently monitored.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Periodic technical controls and maintenance of construction machines (RM) to maintain them in good working conditions.
- Unless instructed otherwise by DGPC, noise and vibration generating works are prohibited at night between 06.00 pm and 06.00 am and on Sundays in accordance with WHO Guidelines.
- Noise and vibration measurement at the start of noisy operations in a new area (MM): noise measurements will be conducted each time noisy operations begin in a new area (pile driving, hydraulic hammer, earthwork and grading) to verify that the noise emitted by the construction operations complies with the limits defined for the project.
- Limit the noise from fixed equipment (RM): fixed equipment such as generators and crushers will be housed in a technical room to reduce noise emissions.
- Provide information on the noisiest operations / operations involving significant vibrations to local communities (AM): information will be given on the noisiest operations to local people (presentation of the operation, type of noise, duration of the operation).
- Develop and implement a Noise and Vibration Management Plan.

After proper development and implementation of relevant measures, the residual impacts are **Substantial**.

10.3.1.5 Impacts associated with Muck Disposal Sites

Note: muck disposal sites have not been confirmed yet, the impact screening is only preliminary.

Increase sediment transport downstream.

During construction of the various components of the project, muck is generated both from soil or slide material and from rock excavation. The quantity of muck likely to be generated from different project components is as detailed below. A swell factor of 40% has been considered for calculation of muck generation from various project components.

Against the total quantity of 8.82 million m^3 of muck generated from various project sites and from the construction access roads, a total area of 259.70 acres in 16 sites in the project area, with an estimated total capacity 10.73 million m^3 have been identified in the vicinity of the project area for muck disposal. Potential

impacts associated with Muck Disposal site may include increase sediment transport d/s, significant traffic for MDS and the long-term stability of the MDS (safety / risk of failure).

The disposal of muck, which often contains soil, rock, and debris, and the Kurichhu reservoir, can increase sediment transport downstream. This sedimentation can negatively affect riverbed morphology, water quality, and aquatic habitats. The operation of an MDS requires the transportation of muck from the construction site to the disposal area. This can result in a significant increase in traffic to and from the MDS. The transportation of mucks may involve heavy trucks and equipment, which can lead to road congestion, dust emissions, and safety concerns for local communities.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation Measures and residual impact

- Preparation and implementation of a Muck Disposal Site Specific Management Plan (AM/RM).

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

Issues with long term stability of MDS

Muck disposal sites, especially if not properly managed, can pose various issues related to their long-term stability. These issues can have negative impacts on the environment and nearby communities. Ensuring the long-term stability and safety of the MDS is crucial. If not properly designed and managed, MDS can be at risk of failure, potentially leading to catastrophic consequences, including landslides, erosion, and further environmental damage. The stability of the disposal site needs continuous monitoring and maintenance.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Erosion Control Measures (RM): Implement erosion control measures such as sediment barriers, erosion control blankets, and vegetative covers to prevent soil erosion and sediment runoff from exposed slopes.
- Slope Stabilization Techniques (RM): Employ slope stabilization techniques such as terracing, slope regrading, and reinforcement with geotextiles or retaining structures to enhance slope stability.
- Drainage Management (RM): Design and install effective drainage systems to divert water away from slopes and prevent soil saturation, reducing the risk of slope failure.
- Revegetation (RES): After construction activities, promptly revegetate disturbed areas with native plants to establish root systems that stabilize slopes, prevent erosion, and restore natural habitat.

After development and implementation of relevant measures, the residual impacts are **Moderate**.

10.3.1.6 Impacts from Wastewater from CCF

10.3.1.6.1 Increase potential for water pollution

During the construction phase of the Dorjilung HPP, there is a potential for water pollution due to the generation of wastewater from the construction camp facilities (CCF). These facilities can produce various types of wastewaters, including domestic wastewater (sewage), kitchen and dining wastewater, and other sanitary discharges.

The generation of domestic wastewater is usually considered to represent up to 100 l / day / workers for a construction site. This represents between 500 m^3 – 600 m^3 of wastewater to be collected and treated daily during construction (with a likely split 2/3 – 1/3 between the dam camp and the powerhouse CCF; or about 325-390 m^3 / day for the dam CCF and about 175-210 m^3 /day for the powerhouse CCF.

There is also a risk associated with the rainfall runoff collecting pollutants on the surface, in the workshop, maintenance yard and technical installation areas. The exact volume of surface wastewater to be treated is unknown but this would likely be directly trapped and managed through an oil separator (i.e., it would not need to be collected and treated in a wastewater plant).

If not managed properly, these wastewaters can contain pollutants such as organic matter, nutrients, pathogens, and chemicals. Discharging untreated or improperly treated wastewater into nearby water bodies can lead to water pollution, degradation of water quality.

The likelihood of the impact is **medium,** and the severity is **medium**. The significance of the potential impact is considered **Substantial.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Wastewater Treatment (AM/RM): Set up appropriate wastewater treatment facilities within the construction camp to treat different types of wastewaters generated. Treatment methods could include primary treatment (sedimentation), secondary treatment (biological treatment), and disinfection. This can either include onsite treatment or on-site storage for pumping and disposal off-site at a licenced facility (least preferred option given the absence of wastewater treatment capacity in the Project area.
- Separation and Collection (AM): Ensure the proper separation and collection of different types of wastewater streams, such as sewage, kitchen wastewater, and sanitary waste. This prevents cross-contamination and facilitates more effective treatment.
- Greywater Reuse (AM): Implement systems for treating and reusing greywater (kitchen and dining wastewater) for non-potable purposes within the construction camp, such as irrigation and toilet flushing. This reduces the overall wastewater volume and minimizes environmental impact.
- Septic Tanks and Soakaways (AM): For domestic sewage, utilize septic tanks and soakaways that provide initial treatment and allow treated effluent to percolate into the soil, reducing the risk of contamination of water bodies.
- Chemical Management (RM): Properly manage and store chemicals used in CCF, ensuring they are stored in appropriate containers, labelled correctly, and handled according to safety guidelines to prevent accidental spills and contamination.
- Regular Maintenance (AM): Establish a regular maintenance schedule for wastewater treatment facilities, ensuring that equipment is in proper working condition and that treatment processes are effective.
- Effluent Monitoring (MM): Implement a program for monitoring the quality of treated wastewater effluent to ensure compliance with relevant water quality standards and guidelines.
- Training and Awareness (TM): Train CCF staff about proper wastewater management practices and the importance of pollution prevention. Create awareness campaigns to encourage responsible wastewater disposal habits among construction workers.
- Emergency Response Plan (RM): Develop a plan outlining actions to take in case of wastewater treatment system malfunctions or accidental releases. This plan should include steps for containment, reporting, and remediation.

- Stakeholder Engagement (AM): Engage with local communities and regulatory authorities to keep them informed about the wastewater management practices being implemented and address any concerns they may have.
- Preparation and implementation of a Water Quality and Effluent Management Plan and Camp and Technical Installations Site Specific Plan (AM).

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.7 Impact on Wastewater from crushing plant

10.3.1.7.1 Increase sediment load and potential for water pollution

The operation of a crushing plant during the construction phase can potentially lead to an increase in sediment load in river Kurichhu. Crushing, generating fine particles and dust that, when carried by stormwater runoff, contribute to higher sediment concentrations in the rivers. This elevated sediment load results in water pollution, degradation of water quality.

The likelihood of the impact is **High,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Sedimentation Basins and Erosion Control (AM): Implement sedimentation basins at the crushing plant site to capture and settle out suspended sediments from the wastewater before it enters the river. Use erosion control measures such as silt fences, gravel barriers, and vegetative cover to prevent sediment-laden runoff from leaving the construction area.
- Dust Suppression (RM): Employ effective dust suppression techniques, such as using water sprays, dust control agents, or enclosing crushing equipment to minimize the generation of airborne dust and help channeling the sediment in the management system.
- Scheduling and Planning (AM): Plan crushing activities during periods of lower rainfall to reduce the potential for stormwater runoff carrying sediment. Schedule crushing operations in a way that minimizes their impact on water bodies, especially during critical stages of river flow.
- Containment and Diversion (AM/RM): Create physical barriers to prevent sediment-laden water from reaching the river by constructing diversion channels or berms. Set up sediment barriers downstream of the crushing plant to capture any sediment-laden runoff before it enters the river.
- Wastewater Treatment (RM): Install sediment settling tanks and filtering systems to treat wastewater before it is released, reducing the concentration of suspended solids.
- Regular Monitoring and Inspection (MM): Implement a robust monitoring program to assess sediment levels and water quality downstream of the crushing plant. Conduct routine inspections to ensure that mitigation measures are properly implemented and effective.
- Preparation and implementation of a Water Quality and Effluent Management Plan and Camp and Technical Installations Site Specific Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.1.8 Impact from Wastewater from batching plant

10.3.1.8.1 Increase sediment load and potential for water pollution

During batching plant operations, various activities generate wastewater that contain suspended solids, cement particles, and chemicals utilized in the concrete mixing process. This wastewater can include runoff from equipment cleaning, concrete mixing, and general site maintenance. If not managed effectively, this wastewater has the potential to be carried by stormwater runoff into adjacent water bodies, in this case river Kurichhu. The concern arises from the fact that the suspended solids and cement particles present in the wastewater can easily be entrained by stormwater runoff. As runoff flows across construction sites, it can pick up these sediments and carry them into the river. The introduction of elevated sediment concentrations into water bodies can degrade water quality. Suspended solids can cloud the water, reducing clarity and light penetration.

The likelihood of the impact is **medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Sedimentation Basins and Settling Ponds (AM): Construct sedimentation basins and settling ponds near the batching plant to capture suspended solids and allow them to settle out before the water is discharged. These basins can be designed to accommodate the volume of wastewater generated during batching plant operations.
- Recycling and Reuse (AM/RM): Implement measures to recycle and reuse wastewater within the batching plant process, reducing the volume of wastewater requiring disposal. This approach can minimize the potential for sediment-laden runoff reaching the river.
- Treatment Systems (AM/RM): Install treatment systems, such as sediment filters and coagulation-flocculation units, to remove suspended solids and contaminants from the wastewater before discharge.
- Covering and Containment (AM): Cover storage tanks and mixing areas to prevent rainwater from meeting the concrete materials and generating sediment-laden runoff.
- Proper Drainage Design (AM): Design the site's drainage system to direct stormwater away from areas with potential contamination, routing it toward treatment systems or sedimentation basins.
- Regular Cleaning and Maintenance (AM/RM): Regularly clean and maintain the batching plant area to prevent accumulation of concrete residues and potential pollutants that could be washed into the river during rain events.
- Monitoring and Reporting (MM): Implement a monitoring program to assess the quality of wastewater generated by the batching plant before discharge. Regularly report the results of monitoring to ensure compliance with water quality standards.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial.**

10.3.1.8.2 Discharge of water with very high pH (Basic)

Batching plants during the construction phase can potentially lead to the discharge of wastewater with a very high pH (basic) into the environment. This elevated pH level in wastewater can result from the use of certain chemicals, additives, or cement in the batching process. If not properly managed, the discharge of highly basic wastewater can have several detrimental impacts on the environment. The alkaline nature of wastewater can disrupt the natural pH levels of receiving water bodies.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Wastewater Sampling (MM): Regularly sample and monitor the pH levels of wastewater before discharge to identify any deviations from acceptable ranges.
- pH Monitoring and Control (RM): Implement automated pH monitoring and control systems to ensure that pH levels are within permissible limits before wastewater is released.
- pH Adjustment Tanks (AM): Install pH adjustment tanks or systems to gradually adjust the pH of wastewater to acceptable levels before it is discharged.
- Training and Education (TM): Train staff in proper handling of chemicals and additives to minimize the risk of introducing highly basic substances into the wastewater.
- Containment and Spill Prevention (AM): Prevent spills of chemicals that contribute to elevated pH levels by implementing proper containment and spill prevention measures.
- Preparation and implementation of a Water Quality and Effluent Management Plan, Hazardous Materials / Waste Management Plan and Camp and Technical Installations Site Specific Plan.

After development and implementation of relevant measures, the residual impacts are considered to be Substantial.

10.3.1.9 Wastewater Impacts from Construction Activities

10.3.1.9.1 Impact of wastewater on water quality

Certain construction-related activities can influence water quality. Indeed, the risk of degradation of the chemical and biological quality of water can be induced by the temporary concentration of construction activities and the influx of workers. The water quality of river Kurichhu suggests that the water quality is typically satisfactory. The following table summarizes the various potential sources of pollution resulting from these activities and indicates the type of risks they are likely to generate, the environment affected and the possible impact.

Table 181: Potential sources of pollution resulting from

Source of risk	Risk	Receiving environment	potential impact
Wastewater from the construction site and living quarters	Discharges into the waters of the Kurichhu river and other tributaries and into the soils (mainly suspended solids, organic matter, and bacteria)	Surface and groundwater	Quality degradation of the natural aquatic environment (lack of oxygen, turbidity, presence of pathogenic bacteria) and impact on aquatic life. Risk to human health if polluted water is consumed.
Domestic waste in the construction site area and the living quarters	Waste spills directly into the waters of the river Kurichhu river and other tributaries. Leaching of waste storage areas (leachate) to surface and groundwater (mainly organic matter).	Surface water (for waste) and ground water (for leaching).	Visual degradation Contamination of surface water and/or groundwater by pathogens and hazardous substances that can be associated with the waste. Degradation of water quality (mainly due to lack of oxygen in connection with the degradation of organic matter).
Equipment washing water / concrete production	Discharges into the waters of the river Kurichhu and other tributaries.	Surface and ground water	Degradation of water quality (lack of oxygen, turbidity, chemical pollution). Possibility of acute toxicity to aquatic life depending on the concentrations.

Source of risk	Risk	Receiving environment	potential impact
Hydrocarbons, used oils, solvents, pesticides, and other hazardous products (storage and handling)	Leaks. Accidental spills. Leaching of polluted or treated areas (pesticides	Surface and ground water	Acute toxicity to aquatic life. Risk to human health if polluted water is consumed.

The likelihood of the impact is High, and the severity is High. The significance of the potential impact is considered High.

Mitigation measures and residual impact

The following measures are proposed to address the impact:

All these risks can be controlled by setting up services and infrastructures adapted to the needs from the start of the work: sanitation systems, waste management, management of hazardous substances and materials on the site. The proposed corrective actions are as follows:

- Establishment of wastewater treatment systems (RM): conventional sanitation network with wastewater treatment with (i) treatment facility at the operator's village level (long term), (ii) implementation conventional septic tanks at the level of all the health infrastructures of the main workers' camp (planned for the duration of the worksite) and (iii) installation of light systems of the dry latrine type at the level of the toilets of all the work areas.
- Establishment of a program for the collection, monitoring, and treatment of waste (RM), including used oils in camps and on construction sites.
- Identify hydrocarbon storage sites (RM) with the company and organize this storage on dedicated secure platforms: waterproof concrete slab surrounded by a wall ensuring the retention of a volume at least equal to 110% of the largest container located on the platform (maximum to be authorized of 10,000 l for gasoline or diesel). The platform will be covered, and its evacuation equipped with an oil separator.
- Storage of chemicals in appropriate areas (RM) (with oils, for example) and the need to ensure their storage compatibility (information on toxicity and safety data sheets available for workers).
- Identify material deposition sites (RM) respecting a minimum distance (50 m) between material deposition and watercourse.
- Machinery and equipment maintenance area (RM). The maintenance and washing of machinery and equipment will be limited to areas defined for this use, equipped with a concrete slab and peripheral drainage evacuating runoff through an oil separator. In addition, sedimentation basins for the recovery of washing water rich in concrete, with pH readjustment (acid buffering) before discharge into the natural drainage will be set up.
- Define strict procedures for filling equipment tanks (RM) (type of equipment, mandatory dedicated areas).
- Prevention of pollution by toxic products (RM) by containment measures for hazardous products by the contractor and the establishment of an emergency plan in the event of accidental spills.
- Exclusive use of pesticides recognized by WHO (RM) or any other organization with authority in the matter.
- Establishment of an employee awareness and training program on all these aspects (TM).

The residual risk of project construction will be Moderate.

10.3.1.10 Waste Impacts from Construction Activities

10.3.1.10.1 General aspects of waste issues

During the construction phase of a project, a range of general construction activities can generate diverse types of solid waste including:

- Domestic waste.
- Green waste.
- Inert construction waste.
- Hazardous waste (covered in section 10.3.1.11).
- Medical waste.

The quantity of domestic waste generated on a construction site is estimated at about 0.5-0.7 kg/person/day. This includes mostly waste associated with food and beverages, wrapping, office and cleaning consumables packaging and other personal items. The total waste generated during the peak construction could reach up to 3 t/day – 4.2 t/day. Considering a waste density of about 700 kg/m^3, this would represent between 4.3 $m^3$and 6 m^3 of domestic waste generated per day.

Activities involving excavation and earthworks, which entail digging, grading, and creating foundations and trenches, inherently yield excavated soil, rocks, and debris as waste by-products. Similarly, the process of pouring concrete into moles (formwork) for fabricating foundations, structures, and other components also yields waste, as formwork materials such as wood, metal, or plastic can turn into waste once they become no longer usable due to wear or damage. Furthermore, the erection of various structures such as dam walls, powerhouses, penstocks, and intake structures result in the generation of waste. This waste includes offcuts, leftover materials, and packaging materials from construction materials. Similarly, the installation of turbines, generators, transformers, electrical systems, and other mechanical and electrical equipment contributes to the accumulation of solid waste. This waste arises from items such as packaging materials, protective coverings, and discarded components of equipment.

Improper disposal of solid waste can lead to environmental degradation, soil contamination, and air and water pollution. Accumulation of solid waste can lead to unsightly conditions at the construction site, affecting the aesthetic appeal of the area and potentially causing community dissatisfaction. While waste burning is commonly undertaken on construction sites, it should be strictly prohibited on both air quality and safety grounds.

The likelihood of the impact is **medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The general waste management principles need to be reflected in all waste management activities, as outlined in the diagram below.

Figure 197: Waste Management Hierarchy (EU, nd)

The following measures are proposed to address the impact:

- Waste Minimization (AM): Prioritize waste minimization by carefully planning construction activities to avoid overordering of materials and excess production of waste. Ensure accurate material estimations and consider using prefabricated components to reduce on-site construction waste.
- Reuse and Recycling (RM): Establish a system to segregate and separate reusable and recyclable materials from general waste. Designate specific areas on-site for storing and sorting materials like metals, wood, and plastics for potential reuse or recycling.
- Material Management (MM): Control the inventory of construction materials to prevent unnecessary overstocking and material wastage. This includes proper storage and protection of materials from weather and damage.
- Optimized Formwork Design (AM): Plan formwork design to minimize the amount of waste generated from formwork materials. Use modular and adjustable formwork systems that can be reused across different phases of construction.
- Timely Removal of Debris (RM): Regularly clear construction debris and waste from the work area to prevent accumulation. Implement a waste collection schedule and provide designated disposal areas for different types of waste.
- Waste Sorting and Disposal (RM): Set up waste sorting stations with clearly labelled bins for different types of waste, such as metal, wood, plastic, and general waste. Establish partnerships with local waste management facilities for proper disposal and recycling.
- On-Site Recycling Facilities (RM): Consider establishing small-scale recycling facilities on-site for processing certain types of construction waste. For example, establish a crushing plant to recycle concrete debris into usable aggregates for future construction.
- Education and Training (TM): Provide construction workers with training and awareness programs on waste management practices. Encourage responsible behaviour and emphasize the importance of waste reduction and proper disposal.
- Supervision and Monitoring (MM): Assign dedicated personnel to oversee waste management on-site. Regularly monitor waste generation, segregation, and disposal practices to ensure compliance with waste management plans.
- Contractual Obligations (AM): Incorporate waste management requirements into construction contracts. Hold contractors and subcontractors accountable for adhering to waste reduction and disposal guidelines.

- Incentives for Waste Reduction (AM/RM): Implement incentives for workers and contractors who actively contribute to waste reduction and recycling efforts. Recognize and reward environmentally conscious practices.
- Regular Audits (MM): Conduct periodic waste audits to assess the effectiveness of waste management measures. Use audit results to identify areas for improvement and adjust strategies as needed.
- Preparation and implementation of a Waste Management Plan, Hazardous Materials / Waste Management Plan and Camp and Technical Installations Site Specific Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**

10.3.1.10.2 Green waste

Green waste from construction works refers to organic waste materials, such as tree trimmings, grass clippings, branches, leaves, and other plant matter generated during construction activities. The impacts of green waste on the human environment can be both positive and negative, depending on how it is managed. The main negative impacts are:

- Pollution of agricultural and grazing lands from illegal dumping and associated air and water pollution and/or the development and spread of pest and disease (improperly managed green waste may attract pests and spread plant diseases, affecting local ecosystems).
- Potential increase in fire hazards from composting heaps.
- Health and safety issues like respiratory issues or allergies and skin reactions can increase with the airborne particles released from decomposing green waste.
- Visual Pollution for the surrounding communities as marge piles of green waste left in public view can be unsightly and negatively impact the aesthetics of the surrounding area.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Green waste composting and recycling into mulch and organic fertilizers to enhance soil fertility, promote plant growth, prevent soil erosion and retain moisture in soil (EM).
- Creation of habitat such as brush piles from tree branches and logs for small animals and insects (EM).
- Preparation and implementation of a Waste Management Plan and Site Decommissioning and Rehabilitation Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.10.3 Construction and domestic waste

Impacts from construction and domestic waste generated during the construction of the hydropower plant can be significant and multifaceted if mismanaged or not managed at all. The main impacts concern workers and communities' health (development of diseases directly linked to the accumulation of waste or indirectly through contamination and pollution of air, water and soil), economic activities (degradation of agricultural lands from waste pollution of air, water and soil) and workers and communities' living conditions (litter and unsightly waste having aesthetic and visual impact).

The cement is assumed to be delivered in bulk and not in individual bags.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Development and implementation of a Waste Management Plan (AM/RM)
- Develop and implement a certified (e.g., ISO certification) Occupational Health and Safety Management Plan for Workers (AM/RM).
- Develop and implement a Community Health and Safety Management Plan (AM/RM).
- Develop and implement a Hazardous Materials / Waste Management Plan (AM/RM).
- Develop and implement a Water Quality and Effluent Management Plan (RM).
- Develop and implement a Soil Erosion and Sediment Management Plan (RM).

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.10.4 Medical waste

The contractor(s) will be required to have clinics and health facilities at their camps to avoid burdening the public health infrastructure. However, emergency cases may still be directed to local facilities, national workers families may use these facilities and there may be need for some cooperation (for instance for disposal of medical waste).

Medical waste on and nearby a construction site can have serious and far-reaching consequences for both the environment and human health. Medical waste, which includes potentially infectious materials, sharps, and other hazardous items generated from healthcare facilities, must be properly managed to prevent the spread of diseases and protect workers, nearby communities, and the environment. Improper handling and disposal of medical waste can expose workers and nearby communities to infectious agents leading to the spread of disease. Also, medical waste may contain sharps (e.g., needles, scalpels), which can cause injuries and potential transmission of infections to workers and waste handlers. If medical waste is not segregated and disposed of correctly, it can contaminate soil and water sources, posing health risks to humans and wildlife. Medical waste burning or incineration can release harmful gases and particulate matter into the air, contributing to air pollution.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- All medical waste is segregated and collected in adequately labelled bags (typically yellow bags marked with a 'biohazard risks).
- All medical sharps (e.g. needles and blades) are disposed of in sharp boxes.
- The Contractor will enter in an agreement with the Mongar Regional Referral Hospital for the safe disposal of medical waste (in an appropriate medical waste incinerator).
- Develop and implement a Waste Management Plan, a Hazardous Materials / Waste Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.10.5 Water consumption

During the construction phase of projects, such as Dorjilung HPP, various common construction tasks necessitate water use. These tasks encompass essential functions like mixing concrete, controlling dust, cooling machinery, and providing hydration for workers. While water is a crucial component for construction, its utilization can result in several noteworthy effects. The extensive use of water during

construction could lead to the depletion of local water resources. The water source includes the following streams Chimungri and Rewanchhu, Phelgangchhu, Chukchimeychu, Meralungchhu/ Shongarchhu and Gangolari. The act of withdrawing water from streams for construction activities has the capacity to disrupt the natural flow patterns and water levels of these water bodies. This disruption has the potential to disrupt the delicate balance of aquatic ecosystems, potentially affecting the health and well-being of aquatic organisms and their habitats.

Furthermore, construction activities can introduce pollutants into nearby water bodies. These pollutants can stem from actions like dust suppression techniques and machinery cooling processes. Unfortunately, this can result in the deterioration of water quality. Such degradation can negatively impact aquatic life, create challenges for downstream water users, and cast a shadow over the overall health of aquatic ecosystems.

The alteration of water courses for construction purposes is yet another concern. This can transpire through diverting water to construction sites, potentially leading to changes in the natural course of streams. Consequently, this could reshape the morphology of streams, disturb habitats that depend on the natural flow, and even contribute to erosion downstream.

Water consumption during construction may also have broader consequences for local environmental conditions. For example, heightened water usage could potentially influence local hydrological patterns, which might, in turn, trigger shifts in microclimates. Construction water estimates are provided in Section 3.

There is a negative precedent with the Mangdechhu HPP. In addition to the actual impacts and water consumption, the Project will need to manage perceptions around additional water consumption in a region where there is already stress on water resources.

The likelihood of the impact is **High,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Efficient Water Use (AM/RM): Implement water-efficient construction practices and technologies to minimize water consumption while maintaining construction quality. This includes fit for purpose water measures (e.g., using non potable water for dust suppression or vehicle cleaning) and water efficient fixtures at the camp (e.g., dual flush toilet, flow constrained showerhead, water efficient appliances, etc.).
- Prepare detailed estimates for construction and yield assessment.
- Recirculation and Reuse (AM): Develop systems to recirculate and reuse water where possible, such as recycling water used for concrete mixing.
- Environmental Monitoring (MM): Regularly monitor water sources, water quality, and downstream impacts to assess and address potential adverse effects.
- Community Engagement (AM): Involve local communities in water management discussions to address concerns and ensure equitable water allocation.
- Regulatory Compliance (AM/RM): Adhere to water usage regulations and permits to ensure responsible water consumption.
- Adaptive Management (AM/RM): Be prepared to adapt construction activities based on real-time water availability and changing conditions.
- Preparation and implementation of a Grievance Redress Mechanism, Water and Effluent Management Plan and Camp and Technical Installations Site Specific Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.1.11 Impact on Storage/ Transport / Use of hazardous products

10.3.1.11.1 Increase potential for soil pollution

During the construction of the hydropower plant, various hazardous wastes can be generated as a result of different construction activities and the materials used. The improper handling, storage, and disposal of hazardous waste can have significant impacts on the human environment, especially on the workers and communities' health (exposure to toxic substances, use of contaminated water or vegetables, breathing polluted air) as well as the local farming activities (soil, air and/or water contamination rendering land unsuitable for agricultural activities and contaminating crops and animals, leading to loss of income and subsistence products). The main areas with likely storage and use of hazardous products include (the most common hazardous products:

- Workshops and maintenance yards (solvents, batteries, lubricants, fuel, etc.).
- Fuel farms (petrol and diesel).
- Water and Wastewater treatment plans (treatment chemicals).
- On site labouratory (acid and other chemical testing).
- Kitchen (solvent and cleaning products).
- Batching plant (acid and additives).
- General storage facilities (cleaning products).

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Safe Handling and Storage in Workshops and Maintenance Yards (RM) Ensure proper handling and secure storage of hazardous products in workshops and maintenance yards, including solvents, batteries, lubricants, and fuel, to prevent leaks and spills.
- Fuel Farm Management (RM) Description: Implement safe practices for the storage and handling of petrol and diesel in fuel farms to prevent fuel leakage and contamination.
- Chemical Management for Water and Wastewater Treatment (RM) Establish strict protocols for the storage, transport, and use of treatment chemicals in water and wastewater treatment plants to minimize the risk of contamination.
- Safe Practices in On-Site Labouratory (RM) Enforce safe practices and protocols for handling and storing acid and other testing chemicals in the on-site labouratory to prevent accidents and chemical spills.
- Safe Handling and Storage in Kitchen (RM) Ensure the safe handling and storage of solvents and cleaning products in the kitchen area to prevent contamination of food and cooking equipment.
- Batching Plant Chemical Management (RM)
- Implement safe chemical management practices, including acid and additives, in the batching plant to prevent chemical spills and environmental contamination.
- General Storage Facility Safety (RM) Enforce safety measures for the storage of cleaning products and other hazardous materials in general storage facilities to prevent leaks, spills, and contamination.
- Development and Implementation of Hazardous Materials Management Plan (RM) Develop and implement a comprehensive Hazardous Materials Management Plan that outlines procedures for the safe storage, transport, and use of hazardous products across all areas of the construction site.

10.3.1.11.2 Increase potential for water and soil pollution

The storage, transport, and use of hazardous products during the construction phase can lead to an increased potential for water and soil pollution, resulting in several potential impacts as presented in the table below.

Table 182: Lists of potential impacts for water and soil pollution

Source of Risk	Risk	Receiving Environment	Potential Impact
Inadequate Storage and Handling	Poor storage practices and mishandling of hazardous products can result in spills or leaks.	Water Bodies (rivers, streams, groundwater)	Contamination of water sources with pollutants from hazardous products, impacting aquatic ecosystems.
Accidental Spills	Accidental spills of hazardous products during transportation or storage can lead to the release of pollutants.	Water Bodies, Soil	Leaching pollutants into water bodies and infiltration into soil, potentially harming water quality and leading to long term contamination.
Improper Disposal	Incorrect disposal methods of hazardous waste can lead to pollutants entering soil and water.	Soil	Contamination of soil with pollutants from improper disposal, affecting soil quality and nearby ecosystems.
Lack of Containment Measures	Insufficient containment measures can allow hazardous substances to spread, increasing the risk of pollution.	Water Bodies, Soil	Wider dispersion of pollutants in water bodies and soil, resulting in potential contamination.
Absence of Emergency Response Plan	Without a proper response plan, spill incidents may not be promptly contained, leading to prolonged pollution.	Surrounding Environment	Delays in addressing spills, increasing the duration of potential exposure to pollutants.

The absence of proper containment measures and emergency response plans can exacerbate the spread of pollutants and prolong pollution incidents.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Safe Handling and Storage (AM): Implement strict protocols for the proper handling, storage, and transportation of hazardous products. Provide training to workers on safe practices and emergency response procedures.
- Spill Prevention and Response Plans (AM): Develop spill prevention and response plans that outline procedures for preventing and containing accidental spills. These plans should include equipment, materials, and trained personnel to respond quickly to spills.
- Periodic technical controls and maintenance of construction machines (RM) to maintain them in good working conditions.
- Segregation and Labelling (AM): Properly segregate hazardous products to prevent cross-contamination. Ensure clear and accurate labelling of containers to identify hazardous materials and their associated risks through Material Safety Data Sheet (MSDS).
- Appropriate Storage Facilities (AM/RM): Store hazardous products in secure, designated areas with proper containment measures to prevent leakage or runoff into the environment. Install secondary containment systems to capture potential spills.

- Waste Management (AM/RM): Establish proper waste management procedures for hazardous products, including appropriate disposal methods and recycling options. Avoid improper disposal that could lead to pollution.
- Regular Inspection and Monitoring (MM): Regularly inspect storage areas and transportation routes for signs of leakage or potential hazards. Implement monitoring programs to detect any contamination promptly.
- Emergency Management (RM): Develop and communicate clear emergency response plans to address hazardous product spills. This also includes facilities such as eye rinsing fountains and chemical showers. Ensure that workers know how to respond effectively and safely in case of incidents.
- Community Awareness (AM/RM): Communicate with local communities about the presence of hazardous products, their potential risks, and the measures in place to prevent pollution. Encourage community involvement in reporting any unusual incidents.

- Develop and implement a Hazardous Materials / Waste Management Plan, Water and Effluent Management Plan, Community Health and Safety Management Plan, Occupational Health, and Safety Management Plan for Workers

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.1.12 Risk from Natural Hazards

Owing to its location in a mountainous environment, the Project is exposed to a wide range of natural hazards including:

- Landslides, rockfalls and debris flow.
- Floods (mostly torrential type floods).
- Glacial Lake Outburst Flooding events (GLOFs).
- Wildfire.
- Earthquakes.

Any major event has the potential to result in significant impacts on the Project. This could result in delays in project progress, losses, additional costs, and potentially compromised safety for workers, the community and equipment.

The construction activities are also likely to change and exacerbate existing natural hazards patterns. A significant natural hazard triggered by the Project could have catastrophic consequences in terms of loss and damage as well as reputational issues. This is particularly relevant for wildfire and landslide / rockfalls resulting from construction activities.

The following section outlines specific risks associated with natural hazards. The actual risk assessment would be undertaken as part of the construction activities and some aspects are already documented through the engineering works of the DPR update. Dam safety aspects are treated separately in Section 10.6.5.

10.3.1.12.1 Flooding event during construction

Flooding events caused by intensified monsoon rainfall and other natural hazards can pose several potential impacts during the construction phase of the Dorjilung HPP:

Table 183: Lists of potential impact from flooding

Source of Risk	Receiving Environment	Potential Impact
Floodwater during intense monsoon rainfall can damage construction infrastructure such	Construction Site and Infrastructure	Delays in project progress, increased repair costs, disruption of work,

Source of Risk	Receiving Environment	Potential Impact
as access roads, temporary facilities, and equipment.		hindered access to the construction site.
Swift and unpredictable floodwaters pose safety risks to workers and personnel on the construction site.	Workers and Personnel	Jeopardized safety, potential injuries or fatalities, hindrance to work continuity.
Flooding events can wash away or damage construction materials and equipment, leading to losses and project delays.	Construction Materials and Equipment	Financial losses, delays in project activities, increased procurement, and replacement costs.
Floodwater erodes soil, leading to sedimentation in nearby water bodies, potentially impacting aquatic ecosystems and water quality.	Downstream Aquatic Ecosystems	Water quality degradation, sedimentation in water bodies, potential harm to aquatic life and ecosystems. Risk is exacerbated by the potential for construction debris, hazardous materials, fuel and equipment to be washed off during flooding events.

Some areas (in the vicinity of the river) are exposed to flooding hazards. A design construction flood event of 25 years Average Return Interval (ARI) was selected for the Dorjilung HPP construction.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.** This impact is typically managed through the engineering work stream.

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Early Warning Systems (AM): Implement real-time monitoring and early warning systems that provide alerts about impending flood events. This allows workers to evacuate and secure the construction site promptly.
- Temporary Diversion Channels (RM): Construct temporary diversion channels or levees that redirect floodwater away from the construction site, reducing direct exposure to flood hazards.
- Secure Equipment (AM/RM): Ensure that construction equipment and materials are properly secured and anchored to prevent damage or displacement during flooding.
- Regular Training (AM): Conduct regular training and drills for workers to raise awareness about flood risks, safety protocols, and emergency response procedures.
- Collabouration with Authorities (RM): Coordinate with local authorities responsible for flood management to stay up-to-updated on weather forecasts and flood alerts.
- Develop and implement a Construction Emergency Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial.**

10.3.1.12.2 GLOF during construction

Glacial Lake Outburst Floods (GLOFs) are sudden releases of large volumes of water from glacial lakes, which can result in massive amounts of water, debris, and sediment rushing downstream. This can damage construction infrastructure such as access roads, temporary facilities, and construction equipment, leading to delays in project progress and increased costs for repairs. About 109 glacial lakes have been identified in Kurichhu catchment. The following types of glacial lakes were identified in the region: Glacial Erosion Lakes, Glacial Cirque Lakes, Interconnected Lakes, and Moraine-Dammed Lakes. Among these, Moraine-

Dammed Lakes located pose the highest risk due to their potential for GLOFs. The table below presents potentially dangerous glacial lakes.

Table 184: List of potential dangerous glacial lakes

Type of Glacial Lake	Description	Risk
End Moraine Dammed Glacial Lakes	L 107, L 7, L 215, L 105, L 210, L 48 and L204 with significant water spread area of about 74 to 247 acres. Located at the lower part of the glacier's ablation area near the end of the moraine. -	Risk of moraine dam breaches due to rapid glacier retreat and glacier mass falling into the lake. Potentially dangerous due to large surface areas and associated features.
Moraine Dammed Glacial Lakes	Lakes like L 209, L 208, L 203, and L 205 also have significant water surface areas (more than 74 acres). Located at the lower part of the glacier's ablation area near the moraine.	Similar risk factors like end moraine-dammed lakes, potentially dangerous due to their size and associated features.
Trough Valley Lake	Glacial lake L 107 is situated at a high elevation of about 4650 meters. Trough a valley lake occupying lowlands eroded by ancient glaciers. Surrounded by steep mountains and blocked by valley moraines.	High risk of massive surge waves and moraine dam overtopping or breaches during potential snow avalanches.
Supraglacial Lakes	Lakes like L 109, L 214, L 213, L 146, and L 176 are located on the glacier's surface and are of the cirque type. Vulnerable to bursting due to increased lake volume or seismic activity.	Risk of bursting and sudden release of water into the glacier
Interconnected Lakes	Some lakes like L208 and L209 are interconnected, discharging into each other, or having the potential for future combination. Increased complexity in lake interactions.	Risk of cascading impacts if one lake breaches, affecting the other interconnected lakes

Considering the lake surface area/water spread area and riverine distance of the lake from project site the following glacial lakes have been found to be the critical (in order of their severity) for an estimate of GLOF output at Dorjilung Hydro Project sites:

- End moraine dammed Lake L 107 with water spread area of about 247 acres and 140 km distance from the project site.
- Supraglacial Lake L 109 with water spread area of about 427 acres and 147.3 km distance from the project site.
- Combination of Lake L 208 & L 209 with combined water spread area of about 151 acres and at 174 km from the project site.

A Dam Break Analysis using the HEC RAS method was conducted to determine whether the dam at the Dorjilung HPP site could withstand potential GLOFs. The analysis concluded that the dam is capable of withstanding GLOFs, providing essential assurance for the project's safety and stability in the region.

The likelihood of the impact is **low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Early Warning System (AM): Implement an early warning system that can detect potential GLOFs and alert construction personnel well in advance. This system should include sirens, alarms, and communication methods.
- Emergency Evacuation Plan (RM): Develop and communicate an emergency evacuation plan to construction personnel. The plan should outline evacuation routes, assembly points, and steps to take in case of a GLOF event.
- GLOF Drills (RM): Conduct regular GLOF drills for construction personnel to ensure they are aware of the evacuation procedures and safety protocols.
- Remote Monitoring and Drainage (AM): Utilize remote monitoring systems to track the status of nearby glacial lakes and receive real-time data on their water levels. This information can help predict potential GLOF events. If the water level reach critical levels or the lake appear unstable, corrective action including slow drainage of the glacial lake, although this can be quite difficult at high altitude.
- Coordination with Authorities (AM/RM): Establish communication channels with local authorities and emergency services for coordinated response and support in case of a GLOF.
- Regular Updates (AM/RM): Stay informed about climate and glacier conditions to anticipate changes that could influence the risk of GLOFs.
- Develop and implement a Construction Emergency Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial.**

10.3.1.12.3 Increase risk of wildfires

The construction activities are very likely to increase fire hazards through:

- Sparks and fire are hazards from live electrical equipment, cutting and welding, heavy machinery and vehicles.
- Blasting.
- Hazard associated with waste disposal and management (fire hazard associated with batteries and composted green waste).
- Arson.
- Accidental fire hazards from negligence (cigarettes, cooking and recreational).

The Project area is relatively prone to fire events with very dry vegetation and high fuel levels during the drier season of the year. Fire events were relatively frequent (including with the artisanal collection of lemongrasses although this has largely declined) and major fire events still occur.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High**.

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Firebreaks and Clear Zones (AM): Create firebreaks and clear zones around the construction site to create a buffer against the spread of wildfires.
- Firefighting Equipment and Management (RM): Equip the construction site with firefighting equipment, such as hoses, water tanks, and fire extinguishers, to enable a swift response to contain and control any potential wildfires. Most vehicles should have portable fire extinguishers and specific facilities near dedicated firefighting resources (such as fuel farms, explosives storage buildings, accommodation, waste management sites and offices).

- Fire Awareness and Training (AM/RM): Provide training to all construction personnel on fire prevention, awareness, and proper firefighting techniques to ensure a coordinated response in case of wildfire.
- Communication and Coordination (AM/RM): Establish clear communication channels with local fire departments and authorities. This will help in coordinating efforts in case of wildfire and ensuring that response is timely and effective.
- Weather Monitoring (AM): Monitor weather conditions, particularly during dry months when the risk of wildfires is higher. Implement preventive measures, such as increased vigilance and readiness, during periods of elevated risk.
- Vegetation Management (RES): Implement measures to manage vegetation around the construction site, such as clearing dry and flammable materials, to minimize the potential fuel-load for wildfires.
- Develop and implement a Construction Emergency Management Plan.

After development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.1.12.4 Increase risks of landslides and rockfalls

The history of landslides in areas like Mongar and Lhuentse underscores the recurring nature of these events and their impacts on critical assets and services, roads, farm roads, and irrigation systems. The safety of on-site construction personnel is compromised by the abrupt onset of landslides and rockfalls.

The Project area is very prone to landslides and rockfalls. There are active landslide corridors being analysed as part of the engineering works on the updated DPR.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation Measures and residual impact

The following measures are proposed to address the impact:

- Engineering Measures (AM/RM): Implement engineering solutions such as slope stabilization techniques, rockfall protection structures, and retaining walls to minimize the risk of landslides and rockfalls affecting the construction site.
- Early Warning Systems (AM/RM): Establish early warning systems to detect signs of imminent landslides or rockfalls, enabling timely evacuation of personnel and equipment from high-risk areas.
- Training and Awareness (TM): Provide training to construction workers and personnel about the risks of landslides and rockfalls, as well as the necessary safety protocols to follow.
- Monitoring and Surveillance (MM): Continuously monitor the site for signs of slope instability and implement real-time surveillance systems to detect potential hazards.
- Emergency Response Plan (RM): Develop and implement an emergency response plan that outlines actions to take in the event of a landslide or rockfall, including communication, evacuation procedures, and first aid measures.
- Clearing and Restoration (RES): Establish protocols for quick response to clear debris and restore affected areas after a landslide or rockfall event.

After development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.2 Impacts on Biological Environment

Please refer also to the Appendix L BIODIVERSITY ASSESSMENT BY CHQ SPECIES AND OTHER EMBLEMATIC SPECIES.

This section describes additional impact resulting of works activities without double counting with the impact resulting of the project footprint and location. For example, impacts from clearing do not refer to the loss of the habitat because of the clearing (already included in impact from the footprint) but additional impact such as direct mortalities of some animals, nest destruction, behavioural modification resulting in decrease success of matting, feeding or breeding.

The impact factors may have two kinds of effects, (i) direct with direct loss of natural values (accidents, nest destructions, escape behaviours, or (ii) indirect with impact on the physical environment (water, air, soil degradation for example) which lead to loss of natural values.

Apart from the impacts linked to the project's footprint, the construction activities will have limited impacts on flora and fauna, if the site is properly managed. The impact factors in the construction on terrestrial flora are generic. The table below present the impact factor and give note on "impact by …". In the following section after the impact factor analysis in made with the logic of "impact on…" to focus on sensitive component of the environment.

In the last section, the mitigations measures are given with a logic of "impact by ..." more use during phase to present measure by impact factors.

10.3.2.1 Impact factors during work

Table 185: Main impact factors resulting from the works which may impact natural and critical habitats

Impact factor	Description
Alteration of water quality	Alteration of water quality may have an indirect impact on the aquatic habitats and sensitive associated species. If the alterations occur in the tributaries, the 3 CHQ catfishes may be impacted in addition to the other natural habitats and associated species including macroinvertebrate and plankton the basis of the food chain. The main risk of alteration of water quality is mainly related to the increase of turbidity resulting from earthworks and management of excess spoil and dump sites. A second risk of alteration is linked to discharge of polluted water of sanitation system for site personnel, pumping of excavation water, discharge from concrete plants and crushers. A last risk is linked to accidental spills of polluting products such as fuels, oils, paints, phytosanitary products and other polluting substances present on the construction site and during transportation.
Hydraulic discontinuity	Hydraulic discontinuity may also have direct and indirect impacts on sensitive species. If a stream is dewatered during work, the 3 CHQ catfishes may be impacted resulting in strong losses of population because of direct mortality. If an insurmountable obstacle results from work, a reduction in the movement capacity of species could also lead to a drop in populations. The main activities to have hydraulic discontinuity are related to the new permanent or temporary access and road, all the new muck disposal sites (dumpsites) and all the excavation and earthworks.

Impact factor	Description
Alteration of air quality and dust	Alteration of air quality and dust may have an impact on terrestrial plants and fauna including CQH species. The dust may block the growth of vegetation and disturb behavioural patterns such as feeding, matting, and breeding. Most mobile organisms will move away from dust emissions, however with possible losses of juvenile birds which will not be able to leave the nests, or which will be abandoned. Dust deposition remains at short distance of the zones ranging from a few meters to a few hundred meters depending mainly on the particle sizes, wind and emission intensities. The main activities responsive of dust emission are Excavation work and transport of excavated materials, storage of powdery excavated materials, traffic on unpaved tracks/roads
Alteration of soil quality	Soil alteration (compaction, removal of topsoil, pollution) can have an impact on the development of plants and species living in the soil. The main negative effect is to reduce the restoration capacities of temporary rights-of-way at the end of the works.
Sound emissions, vibration and blasting	Sound, vibration and blasting may perturb behavioural patterns such has feeding, matting, and breeding and communication, important for example, for birds whose perception distance of songs will be significantly reduced. As for dust, the impact decreases with source distance ranging from tens of meters for vibrations, hundreds of meters for sounds and 2 km for blasting. Noise and vibrations come from crushers, concrete plants, excavators, hydraulic rock breaker chisels, the circulation of construction equipment, generators and other excavation water pumps. Blasting will only be used in quarries.
Light emission	Light emission may have an impact on the orientation behaviour of nocturnal species and nocturnal migratory species. Feeding behaviours may also be disrupted. Light can be linked to night-time work, security lighting and base living lighting.
Circulation and other risk of accidents with fauna	During works fauna species will be subject to direct kill by accidents.
Presence of workers and work camps	The presence of the base camp and work force will increase pressure on flora and fauna. The important work force during several year with come and back mainly in India may allow the establishment of a poaching network and wildlife trafficking. The workforce may also result in additional food access to meals at living bases composed of wildlife collected by the workers themselves or by the population for money.
Social influx during the construction phase	The social influx may increase natural habitat conversion to modified habitat for crops and settlements. The increase of population adding work force and social influx may lead to an increase of human/wildlife conflicts mainly for dangerous or feared species such as felines, snakes, wild dogs, primates and other large fauna species.
Introduction of invasive species	The accidental or non-accidental introduction of invasive alien species, for flora. The biodiversity of the natural environment will decrease for plants. Indeed, the input of materials and the displacement of construction machinery increase the risks of introducing invasive species. The consequences of the introduction of invasive species vary according to the species introduced and the capacity of the environment to regulate them.
Land clearing activities	These activities can lead to significant mortalities of species with reduced mobility or species which cannot move due to behavioural or development stage reasons (juveniles, protection of the nest and feeding of the young, territorial species, etc..) and may not be able to run away from the construction machinery or flooding waters. Moreover, the project will create several islands in the reservoir and terrestrial fauna species may seek refuge on these islands during the impoundment of the reservoir. Such species would then be stuck in either a too small habitat or would be isolated from other individuals.
Reservoir filling stage	

The matrix below gives the probable interactions between the impact factors with the sensitive components of biological environments.

Table 186: Impact matrix between impact factors and sensitive elements of biodiversity

Sensible component/ Impact factor	Impact on protected area	Specific impact on CHQ plants	Specific impact on CHQ birds	Specific impact on CHQ mammals	Natural environment and associated sensitive species	Specific impact on CHQ fish	Specific impact on Natural aquatic environment
Alteration of water quality	0	0	1	1	1	2	3
Hydraulic discontinuity	0	0	0	0	1	2	3
Alteration of air quality and dust	0	0	1	1	2	0	0
Alteration of soil quality	0	0	0	0	1	0	0
Sound emissions, vibration and blasting	0	0	2	1	2	0	0
Light emission	0	0	1	1	2	0	0
Circulation of construction equipment and risk of accident	0	0	1	1	2	0	0
Presence of workers and colony	1	0	0	3	2	0	1
Social influx during the construction phase	1	0	0	3	2	0	1
Introduction of invasive species	1	0	1	1	2	0	0
Land clearing activities	0	0	1	1	1	2	2
Reservoir filling stage	0	0	0	2	2	1	2
Global	**1**	**0**	**2**	**3**	**3**	**3**	**3**

0: No interaction, 1: possible interaction but likely low potential impact, 2: likely interactions with moderate to substantial potential impacts and 3 : likely interactions with substantial to high potential impacts

10.3.2.2 Impacts on terrestrial habitats

10.3.2.2.1 Impact on protected area

There is low risk of impact in addition to those already describe in the project footprint and location.

The potential impact is considered as **Moderate** due to the presence of the workforce, the risk of the social influx in the risk of introduction of an alien invasive species. Even if the risk is **Low**, in case in influx or invasive species the intensity will be **Medium**.

10.3.2.2.2 Impact on CHQ plants

There is no impact of the works as the known station of *Hoya bhutanica* will be flooded by the reservoir.

10.3.2.2.3 Specific impact on CHQ birds

Vultures and Pallas fish eagle have no nest in the project area that were identified in field assessment before works described in section 10.2.3.5.2 . The impact of noise, vibration and blasting on this species will be Low as impact from clearing and filling reservoir activity (No other impact in addition to impact of the footprint). For these 3 CHQ species the potential impact from work phase is considered Low.

For the Dark-rumped Swift, the nesting is limited to the cliff areas which are potentially in or close to the quarry sites. Blasting and crushing may limit adequate habitat in a radius of 1 or 2 km around the blasting point depending on the sensibility of the species during breeding from March to May. The impact is considered as **Substantial** due to its low probability and its high intensity if occur.

10.3.2.2.4 Specific impact on CHQ mammals

There are 3 mammals CHQ species, the Capped Langur (*Trachypithecus pileatus* ssp. *Tenebricus*), the Chinese Pangolin (*Manis pentadactyla*) and the Tiger (*Panthera tigris*).

For the Chinese Pangolin and Tiger, these species may be present on the project area but with a low probability (Only one confirmation for *Panthera tigris since many years but in 2023 at 6 km downstream project and at an altitude of 2000m, project is between 500 and 1000 m in this area).*

The following impact factors are known to occur for Tiger and other mammals

- Direct Mortality:

o Construction accidents: Tigers and other wildlife can be injured or killed during construction activities (e.g., vehicle collisions, explosions).

- Disruption of Movement:

o Disturbance: Construction noise, vibrations, and increased human activity can disturb tiger behavior and disrupt their normal movement patterns. This may occur typicaly in a 1 km buffer zone around project construction activities

- Indirect mortality.

o Poaching: Increased human presence associated with construction can lead to increased poaching activity, impacting both tigers and their prey.

For the Capped Langur found at vicinity of some works area, the species will be impacted by works activities, in particular noise, vibration, dust, circulation and presence of the workforce. The impact will be (i) disruption of populations who will avoid work zones and (ii) risks of potentially fatal accidents such as the risk of electrocution, the risk of collision and the risk of conflict with workers with a **Medium** intensity.

For Pangolin and Tiger, considering the population level and area of occurrence / territory, direct impacts from works activities and physical environment alteration limited to the vicinity of the project have a **low** intensity.

Indirect impacts of the presence for the workers and the social influx may be **High** for the 3 species. The poaching is verry low in Bhutan due to cultural factors, strong awareness, and regulations. However, the presence of the workforce during a long period of several years will increase the risk of creating a poaching sector for the export and supply of bush meat to the workers.

10.3.2.2.5 Natural environment and associated sensitive species

Flora may be impacted by dust emission and hydraulic continuity but with a low intensity and in the vicinity of the works already considered in the impact analysis for footprint and location of the project. No significant additional impact is expected during construction.

For fauna, many works' activities will impact the natural environment and associate fauna species with various levels of probability, intensity and extend depending on the species and the impact factor considered. The main activities are alteration of air quality and dust, sound emissions, vibration and blasting, light emission, circulation of construction equipment and risk of accident, presence of workers and colony, social influx during the construction phase, introduction of invasive species, land clearing activities and

reservoir filling stage have substantial impacts on various taxons. Aggregating impact factors, the potential impact may be **High**.

Mammals and birds may be affected by the risk of accidents due to traffic and/or processes dangerous for wildlife (electrocution, entrapment, panic). Noise and light can have an impact on various species of birds, particularly nocturnal species and during the mating and feeding phases of juveniles (disruption of communication through songs).

Social influxes can increase the conversion of natural habitats to modified habitats, particularly in areas with limited slopes allowing cultivation and human settlements. The key point will be the availability of new access roads offering new opportunities for village development. This is a well-documented, long-term process whereby new access creates new development opportunities for communities. In Bhutan, although the population level is low and conservation and logging are well regulated, areas suitable for the establishment of crops and communities are limited.

10.3.2.3 Impacts on aquatic habitats

10.3.2.3.1 Impact on CHQ fish

There are 3 CHQ fish. *Creteuchiloglanis bumdelingensis*, *Parachiloglanis bhutanensis*, *Parachiloglanis dangmechuensis*, these 3 torrent catfish species are restricted range found in tributary of the AoA but with no evidence of occurrence in the Kurichhu.

The 3 CHQ catfishes are not evidenced in the Kurichhu river but in some tributaries. The strongest impact factor will be the risk of loss of hydraulic continuity and increase of turbidity. The tributaries, on the right bank, may be impacted by the access tracks crossings, by the earthworks and the spoil of the tunnel digging operations. Land clearing may also increase the turbidity of water and impact the population of the 3 CHQ catfishes. The potential impact is considered as **High.**

10.3.2.3.2 Impact on natural aquatic environment

Construction activities associated with the Dorjilung HPP can have adverse effects on aquatic ecosystems, particularly on water quality. Activities like land clearing, earthworks, temporary river diversion, cement manufacturing, and concrete pouring can degrade water quality. The extent of the impact depends on the degree of water quality degradation. Factors such as reduced oxygen levels, the presence of hydrocarbons, and increased turbidity can lead to fish mortality both at the project site and downstream. This can have significant consequences for many species living in the Kurichhu.

In the project area, a total of 11 fish species were identified, including those in the main Kurichhu River, its confluence, and tributaries. During the pre-monsoon season, 7 fish species were found in the mainstream Kurichhu River. These fish populations primarily consist of species like the torrent stone carp, Buduna, copper masher, Gadera, Khasi garra, snow trout, and Sucker throat catfish. The construction activities have a potential impact on these aquatic species, *Persicaria capitata,* semi-aquatic plant observed in the mainstream river and the riparian vegetation along the riverbanks. The relatively low fishing pressure and limited dependence on fish by the local population may somewhat mitigate these effects.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

10.3.2.4 Mitigation measures and residual impact

With an adequate ESMP, EFMP and BMP, the residual impact of the construction will be Low to Moderate.

Beyond the measures described in this section, the key elements for the success of preserving the biological environment are as follows:

- The selection of a competent and aware construction company that already has routine and corporate culture procedures in place.
- The contractualization of the elements of the ESMP and the BMP must clearly define the specifications of the measures to allow the anticipation of the budgets in proportion to the efforts and the personnel to be mobilized.
- The ability of the project owner and/or its consulting engineer to mobilize qualified personnel surrounded by a network of expertise is also an essential element of controlling impacts on biodiversity.
- A complete ESMP aimed at preserving all physical environments commensurate with the scale of the project.
- A complete BMP ensuring no net lost on natural habitat and net gain on critical habitat.
- A complete E-Flow Management Plan ensuring the physical and ecological conditions of the river are maintained and aimed at no net lost on natural habitat and net gain on critical habitat.

Following these main points, the residual impact of the construction will be Low to Moderate.

- Alteration of water quality
    - Drainage, Erosion and Sedimentation Control Plan
    - Muck Disposal Planning and Management Plan
    - Hazardous Substances and Explosives Management Plan
    - Waste Management Plan
    - Emergency Preparedness and Response Plan
    - No other specific measure from the BMP
- Hydraulic discontinuity
    - Drainage, Erosion and Sedimentation Control Plan
    - Water Quality Monitoring Plan
    - The specific measure from the BMP is:
        - Control all the water crossing to ensure hydraulic continuity of the tributaries allow fish movements.
- Alteration of air quality and dust
    - Emissions, Dust and Noise Management Plan
    - No other specific measure from the BMP
- Alteration of soil quality
    - Drainage, Erosion and Sedimentation Control Plan
    - Muck Disposal Planning and Management Plan
    - Hazardous Substances and Explosives Management Plan
    - Waste Management Plan
    - Emergency Preparedness and Response Plan
    - No other specific measure from the BMP
- Sound emissions, vibration and blasting
    - Emissions, Dust and Noise Management Plan
    - Quarry Management Plan
    - Specific measures from the BMP are:
        - Avoid basting activities from March to May anticipating aggregate needs to preserve the breeding period of the Dark-rumped swift.

- Avoid crushing activities at the vicinity of the cliffs from March to May to preserve the breeding period of the Dark-rumped swift.

- Light emission
  - Specific measures from the BMP are:
    - Develop a light management plan with the following:
    - Reduce the nigh works period to specific sites and operation to avoid fauna behavioural disturbance.
    - Install directional lighting for activity areas, security lighting and colony lighting.
    - For lighting other than that necessary for safety, limit the lighting duration to what is strictly necessary.

- Circulation of construction equipment and risk of accident
  - Road Traffic and Access Management Plan
  - The specific measure from the BMP is:
    - Signage at large wildlife crossing points, reporting collisions or injured animals.

- Presence of workers and colony and social influx
  - Management of Construction Worker Colonies (Camps)
  - ESHS Training for Construction Workers Plan
  - Influx management plan
  - Specific measures from the BMP are:
    - Convention with national polices forces, the DOFPS to avoid the risk of creating a poaching sector for the export and supply of bush meat to the workers.
    - Convention with national polices forces, the DOFPS to random control banning on detention of guns and traps, bushmeat consumption, capture and killing of wild animal.
    - Training in the Biodiversity Management Plan (BMP).
    - Raising awareness of biodiversity protection among construction companies and subcontractors
    - Code of conduct in case of interaction with wildlife such as primates, snakes, feline and other big fauna
    - Removal of the temporary road which will not be used for project maintenance.
    - Ban of the use of new access road dedicated for project maintenance.

- Introduction of invasive species
  - Specific measure from the BMP is:
    - Management of construction sites to control alien invasive species (Flora)

- Land clearing activities
  - Vegetation Clearing Plan
  - Ecological Protection Plan
  - Landscaping and Re-vegetation Plan of the temporary footprint
  - Specific measures from the BMP are:
    - Avoid the main period of birds breeding.
    - Emit sound and vibration signals in the areas to be cleared over several minutes before to facilitate the escape of mobile species such as snakes, lizards and other slow-moving species.

- Reservoir filling stage
  - Reservoir First Impoundment Management Plan

- Specific measures from the BMP are:
  - Avoid the main period of fish breeding.
  - Management flow during the reservoir filling period to be assessed in detail in the EFlow with the following: filling the reservoir during high flow period June to September.
  - Schedule a slow impoundment of the reservoir (4 weeks to be confirmed by EFlow assessment) to allow sensitive species to escape (RM).

- Other specific measures from the BMP are:
  - Prevention of animal mortality related to construction work.
    - Rescue procedure for trapped or injured animals
    - Regular inspection of dangerous sites to wildlife (electrical risk, risk of entrapment, risk of collision) for implementation of corrective action with awareness of site personnel for the identification of risks and reporting

- Specific measures from E-flow Management plan
  - River morphology MP
  - Research support MP
  - Native fish MP

10.3.3 Impacts on Human Environment

10.3.3.1 Impacts from Construction-Traffic

10.3.3.1.1 Risks of accidents and adverse road safety

Road and traffic accidents are one the main cause of injuries and fatalities on large construction projects. The general configuration of the Project area with narrow passage, sharp bends, steep slopes, and constrained road corridors in tight valleys further exacerbate the impacts. The current driving habits can be considered quite safe with generally low speed of travel and relatively safe and calm driving.

The resulting impacts affect both Project workers and the local community. Traffic accidents have the potential to injure or kill pedestrians, other drivers, drivers of a project vehicle and their passengers, and could also act as a local trigger for protests the project. Accidents can also lead to property damages. Children often take high-risks and tend to have a poor understanding of road safety. Women may also need to be informed about road safety risks as they could be less familiar than men in experiencing changes to their local road traffic conditions.

In addition to the local construction traffic of heavy vehicles (gross weight > 3.5 t) and light vehicle (gross weight < 3.5 t) in the Kurichhu valley, the Project will also very likely require the delivery of goods and materials from India. The main access road from India is relatively dangerous with very narrow roads and verges, evidence of active landslides and rockfalls, sheer drops and the absence of safety barriers in some section (damaged by rockfalls).

Night driving is also associated with higher risks due to reduced visibility and increase in fatigue of the drivers. Driving Under the Influence (DUI, from alcohol, drugs and medication) and speeding significantly increase the risks of crash and severe accidents.

While some of the bridges are rated at 40 tonnes, other bridges are only rated for 18 tonnes. The contractor will need to undertake a comprehensive audit of all bridges and roads and implement a bridge upgrade program to ensure the safe crossing of all areas.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- The itineraries used by the Project vehicles (light and heavy vehicles) will be mapped out for each route (from Thimphu, Mongar and from India) and between the different work sites.
- Prior to the deployment of the heavy vehicles, the Contractor will undertake a 'swept path analysis to demonstrate that the proposed itineraries can accommodate the movement of the largest and heaviest vehicles. The Contractor will also perform a comprehensive audit of all bridges to be used by Project traffic, check their load limit and implement corrective actions and upgrade as required.
- The contractor will also engage an independent Bailiff to document the state of public roads prior to the Project.
- The Contractor will liaise with the local offices of the Department of Roads and Surface Transport in Lingmethang and Mongar.
- Except for exceptional circumstances, Project heavy vehicles will not use public roads at night between 10.00 pm and 06.00 am and will avoid using public roads during school commute times. No Project vehicles (light and heavy) will be allowed to circulate in local villages between 08.00 pm and 07.00 am.
- In areas where traffic conflicts may result from the Project vehicles movements, the Contractor will install temporary traffic management which may include temporary signage and / or temporary traffic controllers.
- The maximum speed for all Project vehicles will comply with the legal speed limits defined in Bhutan (50 km/h). When crossing villages and cities and close to buildings, the speed limit will be reduced to 30 km/h. On construction sites, the speed limit will be set at 20 km/h, or 30 km/h. Lower speed limits can be implemented as required to accommodate local hazards and road conditions. The contractor will consider using a GPS tracking device and will be required to undertake random speed checks of Project vehicles.
- It is strictly prohibited for Project vehicles to transport local people, equipment or products other than those required for the construction activities.
- Trailers, skips and haulage trucks will have their loads covered during transport and it is prohibited to remove the tailgate of trucks. All Project vehicles need to be in good working order and maintained as per the manufacturer's specifications. The Contractor will undertake regular checks of the vehicles fleet used on the Project.
- The Contractor will organise random checks of drivers to verify that they hold the appropriate driving licence and perform random DUI checks.
- Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy, and a Grievance Redress Mechanism.

After proper development and implementation of these measures, the residual impact is considered as **Substantial**.

10.3.3.1.2 Livestock husbandry and risks of collisions

Increased traffic on roads crossing pastures and livestock farms can increase the risk of collisions between vehicles and livestock, which can injure drivers and their passengers as well as the animals hit. Such accidents can be caused by the free movement of herds close to roads, for example. Increased traffic can also lead to a deterioration in grazing conditions for livestock, due to the vibrations and dust caused by machinery, but also more generally to the stress caused to animals.

In the area husbandry is done on the verge of the roads- this is authorised by the Royal Decree.

The likelihood of the impact is **Medium**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- The itineraries used by the Project vehicles (light and heavy vehicles) will be mapped out for each route (from Thimphu, Mongar and from India) and between the different work sites. The area where there are recurring cattle grazing in the road verge will be marked.
- Except for exceptional circumstances, Project heavy vehicles will not use public roads at night between 10.00 pm and 06.00 am and will avoid using public roads during school commute times. No Project vehicles (light and heavy) will be allowed to circulate in local villages between 08.00 pm and 07.00 am).
- The maximum speed for all Project vehicles will comply with the legal speed limits defined in Bhutan (50 km/h). When crossing villages and cities and close to buildings, the speed limit will be reduced to 30 km/h. On construction sites, the speed limit will be set at 20 km/h or 30 km/h. The contractor will consider using a GPS tracking device and will be required to undertake random speed checks of Project vehicles.
- The Contractor will engage with each of the Gup and communities as relevant to raise awareness on potential risk of collisions with cattle grazing on the road verge and discuss the opportunity to identify alternative grazing solutions.
- Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy, and a Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.1.3 Congestion and travel times for road users

The increase in traffic on the roads through the villages leading to the dam site and power station may create traffic jams on these roads, considerably increasing the journey times of the local population to their destinations. Such congestion can have repercussions on people's living conditions (stress, difficulties reconciling professional and personal agendas, etc.) and have more serious consequences if they slow down or prevent medical treatment.

The likelihood of the impact is **Medium**, and the severity is **Low**. The significance of the potential impact is considered **Moderate.**

The following measures are proposed to address the impact:

- In areas where traffic conflicts may result from the Project vehicles movements, the Contractor will install temporary traffic management which may include temporary signage and / or temporary traffic controllers.
- The Contractor will schedule major deliveries to avoid peak construction traffic (i.e., dedicated time windows for major deliveries).
- The Contractor will develop and implement a procedure for rapid repair and recovery of vehicle suffering breakdown to limit road congestion.
- Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy, and a Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.1.4 Vibrations and cracks

The increase in road traffic associated with the construction of the project may lead to an increase in mechanical vibrations, whether from road defects (potholes, manhole covers, etc.) or from engine and heavy machinery movements. Where the weight of vehicles is heavier, as will be the case with construction and personnel transport equipment, vibrations are stronger and the inconvenience for road users and the surrounding population is bigger.

Vibrations caused by road traffic can lead to the formation and propagation of cracks in the road surface over time. The process is known as "fatigue cracking" or "mechanical fatigue." It occurs due to repeated loading and unloading of the road surface, causing stress cycles that weaken the material and eventually lead to the development of cracks. Road cracks pose various risks, both to road users and the infrastructure itself and increase the likelihood of traffic accidents and vehicle damage.

The various temples and tangible cultural heritage sites (e.g. Chortens) are also exposed to these impacts and are considered particularly sensitive.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

The following measures are proposed to address the impact:

- Buildings close to the roads used by Project vehicles will be subject to a dilapidation survey prior to the start of construction. This also includes temples and cultural heritage sites.
- The contractor will also engage an independent Bailiff to document the state of public roads prior to the Project.
- The Contractor will liaise with the local offices of the Department of Roads and Surface Transport in Lingmethang and Mongar.
- Except for exceptional circumstances, Project heavy vehicles will not use public roads at night between 10.00 pm and 06.00 am and will avoid using public roads during school commute times. No Project vehicles (light and heavy) will be allowed to circulate in local villages between 08.00 pm and 07.00 am).
- The maximum speed for all Project vehicles will comply with the legal speed limits defined in Bhutan (50 km/h). When crossing villages and cities and close to buildings, the speed limit will be reduced to 30 km/h. On construction sites, the speed limit will be set at 20 km/h, or 30 km/h. Lower speed limits can be implemented as required to accommodate local hazards and road conditions. The contractor will consider using a GPS tracking device and will be required to undertake random speed checks of Project vehicles.
- Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy, a Noise and Vibration Management Plan and a Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.2 Impacts from blasting

The headrace tunnel will likely be excavated using a Drill & Blast method; given the length of the tunnel and the configuration (almost 15 km long and 6 adits), there will be significant blasting activities for several years (2-3 years at least). This will directly affect the villages on the right bank, although the blast would clearly be heard across the valley by villages on the left bank. Rock extraction at the quarry may also require some blasting.

A specific blasting hazard assessment will need to be developed by a specialised company and will also inform you of the preparation of a dedicated Blasting Management Plan which will detail:

- Flying distance of individual rocks and safe distance.
- Safe distance for people due to the effects of shock waves caused by blasting and propagating in the air. For drilling and blasting works with large cross-section and using a lot of explosives, it is necessary to calculate the pressure of the shock wave in the air to check the durability and stability of the work.
- Specific procedures for safe transport, storage and handling of explosives.
- Estimate for individual large rocks to fall and roll as a result of blasting.

- Estimate of the direction of dispersion of dust and toxic gases generated during blasting and the safe distance in relation to concentration of toxic gas in the air.

All works relating to explosives and blasting must be carried out by a licenced and experienced contractor.

10.3.3.2.1 Vibrations and cracks

Blasting activities are likely to generate vibrations perceived in two ways: tactile or auditory. The activities likely to cause vibrations can also impact nearby buried structures such as building foundations.

There are at least 6-7 settlements (Ganghto, Upper/Lower Ban, Tokari, Tuensigh, Tepongwhog and Monjabi) on the right bank and in close proximity to the proposed headrace tunnel with some individual houses and structures directly above the proposed headrace tunnel (at least 5 houses). There are also a number of temples (inc. the main temple in Banjar) and community buildings.

It was noted during the various field surveys (inc. for the 2015 DPR) that a number of buildings currently present cracks, probably as a result of seismic activity and possibly ground movements. Repeated blasting has the potential to exacerbate these existing cracks and could potentially lead to significant structural damage.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Blasting will be prohibited at night between 06.00 pm and 06.00 am and on Sundays.
- The Contractor will engage an independent Bailiff to document the state of public community buildings and temples on the right bank prior to the Project.
- The population will be informed about upcoming blasting operation (as per SEP).
- Develop and implement a Blasting Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Security Management Plan.
- The GRM is to be activated by the affected households for reparation after valuation by a third party engaged by the Project.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.2.2 Hazards relating to transport, storage, and handling of explosives.

Handling, transporting and storing explosives is associated with significant hazards leading to explosion. Although the risk is considered low in Bhutan, there is always the potential for explosives theft.

The likelihood of the impact is **Medium**, and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

Develop an Explosives and blasting Management Plan including the following measures:

- The itineraries used to transport explosives will be mapped out and communicated to the relevant regulatory agency.
- Only accredited contractors with specialised vehicles will be used to transport explosives. By default, detonators and explosives are transported in separate vehicles.

At the warehouse storing explosives, strict control measures will be implemented by the Contractor including:

- Prohibit all forms of burning (cooking, heating ...) in the explosives warehouse and the area around the warehouse. Smoking and explosive objects are prohibited in the explosives warehouse. It is forbidden

to bring objects emitting sparks, flammable, radio transceivers such as cell phones, lighters, matches etc into the explosives warehouse.
- Locate the warehouse storing explosives away from inhabited areas.
- Explosives and detonators are stored in separate buildings.
- Regularly clearing, cleaning around the explosives warehouse.
- Dedicated fire-fighting arrangements must be developed and implemented at the explosives warehouse.
- Install and regularly check the lighting protection system around the explosives warehouses, detect and promptly repair electrical problems. On a monthly basis, the Contractor will measure the resistance value of the lighting protection system to ensure safety according to regulations.
- Arranging armed security forces (only armed guards on site, could be police/army personnel) to patrol and guard 24/24h the explosives warehouse.

After proper development and implementation of relevant measures, the residual impacts are considered to be Moderate.

10.3.3.2.3 Hazards relating to explosions.

Hazards related to explosions at a construction site of a hydropower plant can have severe impacts on the site, workers, nearby communities, and the overall project. During the blast, the shock wave can directly impact and injure individuals, buildings and equipment. Rocks can fly over great distances (sometimes hundreds of meters) and explosions can also trigger fires.

Blasting can also have adverse impacts in terms of perception and fears. Even if some communities are not directly impacted, they may still be perceived being impacted by blasting (for instance for the settlement on the left bank).

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Liaise with local authorities (Dzongaks and Royal Bhutan Police) on a regular basis to inform them of planned blasting events.
- Develop and implement strict blasting procedures.
- Develop and implement a Blasting Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Security Management Plan.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.3.3.2.4 Loss of water resources through impacts on groundwater

There is a known precedent with the construction of the Mangdechhu HPP for blasting and tunnel excavation activities to have adverse impacts on local water resources. Blasting and excavation have impacted groundwater resources and led to some springs and water supply points used by the community to dry out.

While the configuration at Dorjilung HPP is slightly different, with the headrace tunnel largely downslope of the settlement and the local community tapping water sources coming from upslope, it could occur. Regardless of the specific impacts, the perception that blasting will impact water resources exist in the community and was mentioned during public consultations.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Develop and implement a Blasting Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan, a Security Management Plan and Grievance Redress Mechanism.
- If there is a disruption to a groundwater supply used by villagers, the project will provide in emergency an alternate source of water (water trucks/water tanks) and look for durable options.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.3 OSH Risks for Workers

Workers engage in construction activities are exposed to a large range of Occupational Health and Safety hazards. The most common hazards are listed below:

- **Electrical Hazards:** electrocution risks when close to electrical wires or equipment, the contact with those leading to severe injuries or fatalities.
- **Falls and Trips Hazards** from trench, open pits and worksites: unprotected open pits or elevated worksites can pose fall hazards, leading to injuries or even fatalities if individuals fall from heights, and open trenches or excavations can collapse, leading to entrapment and suffocation risks.
- **Hazardous Materials.** Construction activities require storage, transport and the use of hazardous materials. Accidental spills and poor handling of hazardous materials can result in skin irritation and burns, eye damage, respiratory irritation, long term damage to organs such as lungs, liver and thymus, injuries and even fatalities.
- **Working at Height.** When working on elevated platforms, scaffolding, ladders, etc., they are at risks of falling. The most frequent incident occurs with workers falling between 2 m and 4 m (as they do not perceive that they are working at height). Generally, if a worker is 1.8 m above ground level, it is considered as "work at height".
- **Confined Space.** A confined space is one that is substantially enclosed (though not always completely), has no natural ventilation, a space not designed for living, and where serious injury could result from hazardous substances or lack of oxygen. This includes for instance: boiler, cargo compartment, cargo tank, oil tank, waste tank, pump room, compressor room, septic tank etc.
- **Crane and moving heavy equipment.** Crane, lifting equipment and heavy machinery can severely crush and injure workers. Workers can be hit directly by moving equipment or indirectly by the loads or through knocked on effects.
- **Burn, cuts, ear, eye and respiratory damage when using electrical tools and welding.** Workers using power tools such as grinders, drills, saw or welding can be injured. In worst cases, incidents can lead to fatalities.
- **Fire and Explosion Hazards**. Faulty electrical installations can lead to electrical fires, causing property damage and potential injuries to nearby communities, and worksites involving flammable substances can lead to explosions.

In addition, OH&S hazards and associated with hazardous materials and waste, road traffic, blasting. These are not repeated here as they were treated in dedicated sections.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- The Contractors has a ESHS manager and dedicated staff for OHS activities.

- Prior to deploying its workers at site, the Contractor will organise a health check of all workers to ensure that they are 'fit' for their work activities, without discrimination.
- Develop and implement a general OH&S site induction for all workers and visitors. Hold regular safety toolbox talks.
- Develop and implement job specific safe work method statement for each hazardous activity.
- Establish a Worker's Safety committee.
- Provide Personal Protective Equipment (PPE) for each worker. The PPE needs to be adequate and of the correct size for the individual worker.
- All hazardous areas and hazardous equipment must be clearly labelled. This may also include temporary and permanent fencing of hazardous areas and installations.
- The Contractor will install and maintain a First Aid station / small clinic at each of the main camp (at least one at the dam camp and one at the powerhouse camp). Each First Aid station / small clinic will be equipped with appropriate medical equipment for immediate response and stabilisation of patients. An ambulance with a driver will be on stand-by 24/7 at each camp. The contractor will also recruit a qualified medical doctor at the dam site and one at the powerhouse site.
- The Contractor will enter in an agreement with a specialised medical services company and / or Mongar Regional Referral Hospital to ensure that there is an adequate procedure in place for medical evacuation and medical treatment.
- First Aid Officers (FAOs) are present during working hours in sufficient numbers per shifts of workers (details figures to be determined by the Contractor for the non-objection of DGPC); ensuring that each worker can be attended to by a FAO in 5 minutes or less.
- Each work sites are equipped with an adequate number of Firs Aid Kits (FAKs), ensuring that each worker can access a FAK in 5 minutes or less.
- Develop and implement a strict working permit system for: working at height, working in confined spaces, welding, hot work permit, etc. Each worker must hold the relevant accreditation / have gone through the relevant training prior to undertaking these activities.
- Develop and implement an Occupational Health and Safety Management Plan.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.3.4 OH&S risks for local communities

Local communities are also exposed to various OH&S hazards. These are similar to the Workers OH&S hazards with a few notable exceptions: (i) the community members are not directly involved in construction and should not have access to the work site; their exposure to these hazards is either accidental or through trespassing (ii) they will not have received induction and will not wear PPE.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- At the beginning of the Project, implement specific awareness measures targeting local communities.
- The Contractor will ensure that the safety / hazard signage will be also made in local dialect and always with visual explicit symbols to ensure illiterate people can understand them.
- Develop and implement a Community Health and Safety Management Plan inclusive of OH&S risks and Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.5 Impacts associated with the main construction camps

10.3.3.5.1 General sanitary conditions

The installation of a workers' camp on a construction site can have various impacts on general sanitary conditions. The availability and quality of facilities directly affect the health and well-being of the workers, as well as the overall environmental conditions in the area. Some of the impacts on general sanitary conditions include:

- **Sanitation Facilities**: The availability and condition of sanitation facilities such as toilets and showers are crucial for maintaining proper hygiene. In a remote area, the provision of adequate and well-maintained sanitation facilities may be challenging, leading to potential issues with cleanliness and hygiene.
- **Waste Management**: The workers' camp generates a significant amount of waste, including solid waste and wastewater. Proper waste management is essential to prevent the accumulation of garbage and potential health hazards.
- **Water Supply**: Access to clean and safe drinking water is critical for maintaining good sanitary conditions. In remote areas, ensuring a reliable and clean water supply for the workers' camp can be a challenge.
- **Vector-Borne Diseases and Water-Borne Diseases**: Poor sanitary conditions and site untidiness (stagnant water in tyres, debrids, drums, etc.) can attract vectors like mosquitoes, flies, and rodents, increasing the risk of vector-borne diseases, such as malaria, dengue fever, and other illnesses.
- **Disease Outbreaks**: Inadequate sanitation and hygiene can contribute to the spread of infectious diseases, such as gastrointestinal infections and respiratory illnesses, among workers.
- **Worker Health and Productivity**: Poor sanitary conditions can negatively impact the health (physical and mental) and well-being of workers, leading to decreased productivity and an increase in absenteeism.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Occupational Health and Safety Management Plan and a Camp and Technical Installation Site Specific Plan.
- Develop and implement a Labour Accommodation Plan (AM/RM).
- Develop and implement an Occupational Health and Safety Management Plan (AM/RM).
- Develop and implement a Grievance Redress Mechanism for workers on their living conditions (RM).
- The Contractor shall audit the workers accommodation and living conditions on a regular basis (MM).
- The Contractor will regularly inspect the camps and technical installations and ensure their general tidiness. This includes clearing debris, removing litter, implementing anti-vermin measures and maintaining the work area clean.
- These plans have to be compliant with ESS2 para 28, i.e project workers will be provided with facilities appropriate to the circumstances of their work, including access to canteens, hygiene facilities, and appropriate areas for rest. Where accommodation services are provided to project workers, policies will be put in place and implemented on the management and quality of accommodation to protect and promote the health, safety, and well-being of the project workers, and to provide access to or provision of services that accommodate their physical, social and cultural needs. At least the minimum requirements set out in the last updated guidance note of the EBRD and IFC standards should apply.

After proper development and implementation of relevant measures, the residual impacts are considered to be Moderate.

10.3.3.5.2 Security Management

The installation of a camp and the concentration of workers and equipment close to the surrounding communities present security challenges that need to be addressed to ensure the safety and well-being of the workforce, protecting the communities while limiting adverse consequences on the Project. While the general security context in Bhutan is relatively calm and safe, these issues can occur during the Project.

The potential security risks include the following:

- **Thefts of goods and equipment**, either at the main construction camps or at the temporary work sites. Commonly stolen goods include fuel, portable tools, IT and office consumables or even food.
- **Vandalism and deliberate damage to vehicles and assets**. These actions can result from project opposition but also simply from unmotivated vandalism.
- **Activist and community opposition**. Opposition to the Project can be emanating from the local community but also from national and international groups. This can include sabotaging construction equipment, road blockage, verbal and written threats, tempering food and beverage or damaging sanitary equipment or power supply.
- **Unauthorised access to site**. This is usually associated with the other security risks. Intruders may try to gain entry through impersonating workers or through other means.
- **Criminal activities**. Criminal activities involving workers, trafficking construction sites, racketing, drug traffic, contraband, prostitution...
- **Terrorism and geopolitical risks**. Intelligence gathering by foreign organisations, terrorist attacks, unrest from geopolitical situations, etc.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an ID/tag system for Project workers and vehicles.
- The camps and mains installations should be fenced, with a double boom-gate / sas system to manage entry. There needs to be an automatic floodlight system with mention sensor in key areas of the Camp and Technical Installations.
- A sign-in/ sign-out system for official visitors, with safety induction session and visitors' escort.
- A CCTV system should be installed to cover the main areas and access (e.g., camp entry, office building entry, explosives warehouse, fuel farms, etc.).
- Any illegal contraband, poaching, trafficking, prostitution activity is strictly prohibited (zero tolerance policy). In addition to disciplinary measures and dismissal, offenders will be reported to the Royal Bhutan Police.
- Engage specialised company for security management. Guards are prohibited from wearing firearms and should restrain themselves from violent actions in their work.
- The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information.
- Develop and implement a Security Management Plan. All measures will need to abide by the Voluntary Principles on Security and Human Rights.

After proper development and implementation of relevant measures, the residual impacts are considered to be Moderate.

10.3.3.6 Impacts from population influx (Foreign workers, National workers and families, Camp followers)

The staff requirement for the peak construction period is estimated to be around 460 people for the national staff (only national staff would be allowed to bring their families, including children).

The Project is expected to recruit more than 6000 workers in addition to the 460 national staff, spread over various project locations, with the maximum at the dam site and the powerhouse locations.

The World Bank guidance note for managing the risks of adverse impacts on communities from temporary project induced labour influx indicates that the influx of workers and followers can lead to adverse social and environmental impacts on local communities, especially if the communities are rural, remote or small. Labour influx for construction works can lead to a variety of adverse social and environmental risks and impacts-listed and described below. While many of these impacts could have been present already or might occur regardless of the labour influx, they are likely to be exacerbated by it.

It is, however, important to recognize that appropriately managed labour influx can provide potential benefits for the community. These benefits are typically related to economic opportunities through employment and/or training by the project, or through selling goods and services. Other benefits include the provision of local infrastructure (e.g., access roads, power or water connection) which is developed for the project, and which serves the community beyond the project duration.

10.3.3.6.1 Public health impacts "increased risks of communicable diseases and burden on local health services"

An increase of the population is expected due to the influx of foreign workers, national workers and their families and camp followers as the Project may attract people seeking employment and other types of economic opportunities. Construction sites and international transit routes are associated with marked increase of transmittable diseases (in particular STIs).

New arrivals may bring with them diseases or infections that local populations are not usually confronted with or protected against. The incoming workers may be exposed to diseases to which they have low resistance. A sudden increase in population can overwhelm local healthcare facilities, leading to longer wait times, reduced quality of care, and limited access to medical services, with significant consequences in the event of an epidemic.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Locate CCF as far as possible from main settlements.
- Prior to deploying its workers at site, the Contractor will organise a health check of all workers, including for STI, to ensure that they are aware of potential disease and infections, without discrimination.
- Develop and implement a health and STI awareness program targeting both workers and the community.
- Access to the camps will be prohibited to community members. It is also prohibited for Project vehicles to give a lift to community members. Interactions between workers and community members will be limited and controlled as far as feasible. This includes for instance a buffer zone for the local business to provide goods and services for workers.
- Partially closed camps should be considered (with specific rules for entry/exit and recreational facilities on site).
- Condoms will be made available to workers free of charge through "condom boxes".

- Develop and implement a Community Health and Safety Management Plan, and Occupational Health and Safety Management Plan- including of the pandemic management plan.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.3.6.2 GBHV

The risks for gender-based violence and sexual exploitation and abuse as well as sexual harassment for surrounding communities and workers could increase during the construction phase due to the influx of workers and non-locals looking for work or economic opportunities. Construction workers are predominantly younger males. Those who are away from home on the construction job are typically separated from their family and act outside of their normal sphere of social control. This can lead to inappropriate and criminal behaviour, such as sexual harassment of women and girls, exploitative sexual relations, and illicit sexual relations with minors from the local community. A large influx of male labour may also lead to an increase in exploitative sexual relationships and human trafficking whereby women and girls are forced into sex work. Rapes involving foreign workers and associated with the construction of the highway have been reported during the consultations.

The issues of unwanted pregnancy with foreign workers are exacerbated by act on grant of citizenship in Bhutan: the child of a Bhutanese woman with a non-Bhutanese man (even married) will not be granted the Bhutanese citizenship. This may further push the single mother and her children to be ostracized by the local community.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered High.

The following measures are proposed to address the impact:

- The Project will have a zero-tolerance policy for any gender-based violence, sexual exploitation and abuse as well as sexual harassment. In addition to disciplinary measures and dismissal, offenders will be reported to the Royal Bhutan Police.
- The Project will include GBHV awareness as part of the workers' site induction.
- Develop and implement a GBV (gender-based violence), SH (sexual harassment) and SEA (sexual exploitation and abuse) Prevention and Response Action Plan (AM/RM) involving specialised services/ CSOs.
- Labour Management Plan (with a Code of Conduct);
- Develop and implement a Community Health and Safety Management Plan, and Occupational Health and Safety Management Plan.
- and a specific GBV-SEA/SH Grievance Redress Mechanism including confidential reporting with safe and ethical documenting of GBV/SH and SEA cases (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.3.3.6.3 General security and unrest disruptions

Camp followers can have various impacts on security and social unrest for both workers and local communities. These individuals often move from one construction site to another, seeking employment opportunities and accommodation. However, their presence can lead to challenges related to security, social dynamics, and potential disruptions, impacting both the construction site and the local community. The influx of workers and service providers into communities may increase the rate of crimes and/or a perception of insecurity by the local community. Such illicit behaviour or crimes can include theft, physical

assaults, substance abuse, prostitution, and human trafficking. Local law enforcement may not be sufficiently equipped to deal with the temporary increase in local population.

Also, the introduction of camp followers can lead to conflicts between them and the permanent workforce, especially if resources or jobs are perceived to be in competition, and they might pose a security risk to construction workers, particularly if tensions or conflicts arise. Camp followers may create tensions with local residents due to differences in values, behaviour, or expectations.

The population influx, including national and foreign workers can strain local law enforcement and security forces. The population influx can bring or increase issues such as the potential sale of drugs and increased alcohol consumption that can contribute to security concerns.

A larger population can lead to increased demand for drugs and prostitution, potentially attracting drug dealers and criminals looking to exploit this demand. If crime rates rise or security measures are insufficient, residents may feel unsafe, and demand increased security measures.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information.
- Develop and implement a GBV (gender-based violence), SH (sexual harassment) and SEA (sexual exploitation and abuse) Prevention and Response Action Plan (AM/RM).
- Labour Management Plan (with a Code of Conduct).
- Security management Plan, Develop and implement a Community Health and Safety Management Plan.
- and a Grievance Redress Mechanism.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.6.4 Cultural heritage and disruption of cultural values

Cultural heritage encompasses a community's traditions, customs, artifacts, languages, historic sites, and intangible practices that are passed down through generations. When an influx of people occurs-especially when the influx of foreign workers is significant- several impacts on cultural heritage can emerge, such as:

Cultural Erosion:

- Loss of Traditions: An influx of outsiders can dilute or overshadow local traditions and customs, potentially leading to a decline in their practice.
- Language Shift: Increased interaction with newcomers might lead to a decline in the use of the local language, potentially contributing to language loss.

Change in Lifestyle and Values:

- Adoption of Outsider Values: An influx can introduce new lifestyles and values, leading to changes in the community's traditional way of life.

Intangible Heritage Threats:

- Endangered Knowledge: The arrival of newcomers might threaten traditional knowledge and practices that are integral to the community's identity.
- Erosion of Oral Traditions: Intangible practices, such as storytelling and oral history, can be compromised if they're not passed down to the next generation.

Tangible heritage threats:

- Vandalism (however most sites have bene vandalised already and contains no more valuable items)

Loss of Identity:

- Identity Shift: An influx can alter the community's sense of identity and belonging, potentially leading to a disconnect with their cultural heritage.

Social Tensions:

- Cultural Clashes: An influx of people with differing cultural backgrounds can lead to tensions, potentially resulting in conflicts over values, practices, and resources.

Cultural Appropriation:

- Commodification of Culture: An influx might lead to the commercialization and appropriation of local cultural elements for profit.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Include awareness about the importance of cultural heritage and values as part of the site induction.
- Only national workers will be allowed to bring their immediate family. Foreign workers are not authorized to bring their families.
- Develop and implement a Labour Management Plan (AM/RM) including a Code of Conduct and a procedure for the demobilisation of the workforce at the end of the construction period.
- Cultural Heritage Management Plan (AM/RM) that promotes the preservation and promotion of cultural heritage while accommodating changes brought by the influx.
- and a Grievance Redress Mechanism (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be Moderate.

10.3.3.6.5 Poaching and illegal natural resources collection

Poaching and illegal collection of natural resources by newcomers can have significant negative impacts on communities, ecosystems, and biodiversity. These illegal activities can disrupt the delicate balance of natural environments and undermine the well-being of local communities that depend on these resources. These illegal activities may conduct to a loss of livelihoods for the communities, damage to cultural heritage and increase crime, resulting in social conflicts and safety risks.

Based on the field surveys, there are currently limited issues in the Project Area in terms of poaching or trafficking of species. Only moderate issues with illegal fishing were reported.

The likelihood of the impact is **Low,** and the severity is **Medium**. The significance of the potential impact is considered Moderate**.**

The following measures are proposed to address the impact:

- The Contractor will provide recreational facilities within the main camps.
- The Project will have a Zero Tolerance Policy for illegal poaching and illegal natural resources collection.
- The consumption of bush meat is strictly prohibited for Project workers.
- The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information.

- Develop and implement a Biodiversity Management Plan (AM/RM); a Labour Management Plan (AM/RM) including a Code of Conduct; a Security Management Plan and a Camp and Technical Installation Site Specific Plan.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.6.6 Disruption of social links and organization

Social influx (including foreign workers, national workers and their families as well as camp followers) can have various impacts on social links, relationships, and social organization within communities. The arrival of newcomers can disrupt existing social dynamics and structures, leading to changes in how communities interact and organize themselves. The presence of newcomers can sometimes lead to mistrust or suspicion within the community, impacting social cohesion. Cultural differences may challenge the existing sense of community identity and belonging, and sometimes escalate into conflicts, affecting social harmony (refer also to 10.3.3.6.4). Increased population might lead to competition for limited resources, potentially causing conflicts and tensions. Also, newcomers can influence existing power dynamics, potentially leading to shifts in community leadership and representation.

The likelihood of the impact is **Low,** and the severity is **Medium**. The significance of the potential impact is considered **Moderate.**

The following measures are proposed to address the impact:

- Develop and implement a Stakeholders Engagement Plan (AM/RM).
- Develop and implement Labour Management Procedures on which basis Contractor will prepare own Labour Management Plan (AM/RM) including a Code of Conduct.
- Develop and implement a Grievance Mechanism (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.6.7 Tension during demobilization

The demobilization of foreign and national workers from the construction site of the project can potentially lead to various impacts on the local communities by creating social changes in the local social and economic dynamics. The departure of workers can have economic impacts as the economic activity in the area can decrease, potentially leading to financial stress for businesses that rely on workers' spending. Also, as foreign workers contribute to cultural diversity and interaction within the community, their departure can lead to a reduction in cross-cultural experiences. Workers may have formed social bonds within the community and their departure could affect these relationships and interactions. Also, if infrastructure and social services were developed specifically to support foreign workers, such as accommodation facilities, it might not be fully utilized after their departure.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- The Contractor will be required to transport back the foreign workers at their original point of origin free of charge.
- DGPC will liaise with local authorities about the demobilisation of national workers.
- Develop and implement Labour Management Procedures on which basis Contractor will prepare own Labour Management Plan (AM/RM) including a Code of Conduct and a procedure for the

demobilisation of the workforce at the end of the construction period and a Grievance Redress Mechanism (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.6.8 Long-term settlement creating tensions

Long-term settlement of construction workers and camp followers in communities can have a range of impacts, both positive and negative, on the social, economic, cultural, and environmental aspects of the host communities. These impacts depend on factors such as the scale of settlement, the characteristics of the newcomers, the level of integration, and the community's capacity to absorb the population increase. The long-term settlement of workers and camp followers can create tensions among the local communities as an influx of settlers can strain existing infrastructure and services, leading to overcrowding and inadequate resources, and generate an increased demand for resources like water and energy might put additional stress on local ecosystems. Long-term settlement can also impact the housing and other living conditions for both locals and newcomers, affecting affordability for housing and other purchases. Also, the long-term settlement of workers and camp followers, even if they are nationals, can create imbalances in local social, political, economic and cultural systems.

On the other hand, both Mongar and Lhuentse Dzongkhags have been negatively affected by population exodus, in particular among the younger generation. During the consultations, population influx in the Project Area was considered as a potential benefit of the Project.

The likelihood of the impact is **Low,** and the severity is **Medium**. The significance of the potential impact is considered **Moderate** or **Positive.**

The following measures are proposed to address the impact:

- Undertake a survey among national workers 6 months prior to the end of the construction period, to register their intent in terms of long-term settlement in the Project Area.
- Develop and implement a Labour Management Plan (AM/RM) including a Code of Conduct and a procedure for the demobilisation of the workforce at the end of the construction period.
- and a Grievance Redress Mechanism (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.7 Impacts from procurement and purchase of local goods

10.3.3.7.1 Opportunities for local supply and local businesses

Social influx into local communities will create opportunities for local suppliers to meet the increased demand for various goods and services. Local supply of resources to accommodate newcomers can have positive economic and social effects on the community, promoting local businesses, generating employment, and contributing to the overall development of the area.

This usually includes a range of opportunities such as the provision of food and materials but also opening of small shops and restaurants.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to support and enhance the impact:

- Preference for local business licences will be attributed in order to: PAPs, local residents from the Project Area, local resident from Mongar / Lhuentse and Bhutanese nationals and foreigners.

- The Contractor will engage with the Gups and local authorities to ascertain the potential to source good and services form local areas.
- Develop and implement a Local Procurement Procedure.

10.3.3.7.2 Opportunities for maintaining local services

The provision of basic services can also be maintained or increased by the social influx, as workers, camp followers and their families will need those services (healthcare, education, transportation, etc). As local communities have pointed out, they are worried about class closures, and the arrival of national workers' families and camp followers could help preserve schools. It is anticipated that the children of the national workers (460 workers expected at the peak of the construction period) will be enrolled in the schools in the project area, primarily at the dam site and the powerhouse but potentially also at other locations (e.g. secondary colonies).

The schools in Gyelpozhing and Lingmethang would probably be most impacted in terms of student admissions as these would be closest to the Powerhouse area. Towards the dam sites, the closest schools are Tsakaling, Chhaling and Autsho.

With the project, the general expectations are that with the increase in demand for student admissions, the schools can be reopened (Banjar), upgraded (Chhaling) and provided with facilities to cater to additional students. Gyelpozhing HSS has only arts students now and hopes to accommodate other streams and that through improved infrastructure benefits from the project the school can provide education for numerous villages that are located far away (boarding facilities).

Regarding health services, the contractor(s) will be required to have clinics and health facilities at their camps to avoid burdening the public health infrastructure with the expected 5000 to 6000 foreign workers and 466 national workers. However, emergency cases may still be directed to local facilities, national workers families may use these facilities and there may be need for some cooperation.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to support and enhance the impact:

- Engage with local authorities and schools about the enrolment of additional students in the local schools.

10.3.3.7.3 Inflation risks

Social influx into local communities can indeed bring about inflation risks. Inflation refers to the general increase in prices of goods and services over time, leading to a decrease in purchasing power and potential economic instability. This inflation risk can impact housing costs, leading to rising property prices and rental rates and, if housing supply does not keep up with demand, it can contribute to a lack of affordable housing options, driving up costs. This inflation might also impact demand on basic goods and services, potentially causing prices to rise and, if local supply chains cannot cope with increased demand, it might lead to price increases for essentials. Local communities and newcomers may be faced with prices that are too high and no longer be able to afford certain goods, thus seeing their standard of living decline.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Local prices will be monitored by the local regulatory authorities.
- The vast majority of the workforce will be housed in the main camp. Only a limited number of national workers and consultants are likely to be housed in local guesthouses.

- The Contractor will source some of its main good from outside of the Project Area (for instance in terms of fuel, cement, construction materials) while also considering opportunities for local procurement bringing benefits to the community.
- The labour management procedures frame local hiring procedure (to avoid unmanaged labour influx)
- Develop and implement a Local Procurement Procedure.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.7.4 Competition for water resources

This impact has already been described under Section 10.3.1.10.5

10.3.3.7.5 Competition for energy resources

As for the water, the increased population during construction can lead to higher energy demand for construction works, workers and newcomers' accommodation, and various other purposes. Currently, the local community mostly uses LPG for cooking needs and the use of firewood is very limited. The LPG cannisters are bought from the local service station.

The Project will have its own fuel farms, power supply and will only seldomly source energy from the local area. During the pre-construction and preparatory stages, the Contractor may use some of the local service to refuel vehicles, but it should be very limited and temporary.

The likelihood of the impact is **Low,** and the severity is **Low**. The significance of the potential impact is considered **Low.**

No specific measures are required.

10.3.3.7.6 Creation of Guesthouse for Project workers

The creation of guest house for Project workers has an impact on local communities, as this accommodation creates jobs for its construction, management and stewardship. This job creation helps to diversify employment opportunities for the local population, and to improve skills. This accommodation could become permanent by accommodating workers during the project's operational phase but could also contribute to a wider diversification of the local economy by offering a tourism conversion.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to support and enhance the impact:

- Develop and implement a Local Procurement Procedure.

10.3.3.7.7 Leasing / renting land for Project facilities

The leasing and renting of land by the local communities for the Project facilities can enable local communities to increase and/or stabilize their income. If the land was already used for economic activities (agricultural, pastoral or other), the income generated by renting out the land must cover the losses incurred. Also, the activities carried out by the tenant on the land must not pollute or deteriorate the land, so as to enable the owners to resume the original activity they carried out prior to their lease.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to support and enhance the impact:

- Develop and implement a Local Procurement Procedure.

After proper development and implementation of these measures, the residual impact is considered as **Positive**.

10.3.3.7.8 Significant drop-in activities and opportunities at the end of construction

The significant drop-in activities and opportunities at the end of construction can have various risks and negative impacts on local communities, bringing economic, social, and infrastructural challenges as construction workers and their families and camp followers leave the area. Many jobs in construction-related industries, as well as supporting sectors like hospitality and retail, might be lost as construction activities wind down. The departure of construction workers and camp followers can also lead to reduced income for businesses that relied on their patronage.

Some businesses might struggle to continue and may close due to a reduced customer base. Property owners might lower rent prices to attract new occupants, potentially affecting their revenue and, if they converted agricultural or pastoral land to rent those land, not be able to convert those land back to their initial purpose. Infrastructure and services that were scaled up to accommodate the construction phase might now be overcapacity and the services procurement can lower accordingly or be discontinued.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Develop and implement Labour Management Procedures (AM/RM) including a procedure for the demobilisation of the workforce at the end of the construction period; and a Grievance Redress Mechanism (RM).
- Develop and implement a Local Procurement Procedure.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.8 Land use

10.3.3.8.1 Increased pressure to access flat land in the valleys.

The construction activities and the construction facilities, as well as the influx of people (workers, their families and camp followers) will increase the existing pressure to access flat land in the valleys.

As mentioned in the baseline, flat land is already a scarce resource for local communities to both house local families and agricultural or pastoral activities. The increased pressure on flat land can lead to local communities being unable to invest in land for subsistence activities, or even selling it for a quick return without reinvesting this income in sustainable subsistence investments. Also, the occupation of land for the construction site and its facilities shall not lead to any kind of pollution that could spread to surrounding land, including flat land, and thus increase pressure on flat land, as some of it would be contaminated.

This may be quite challenging in particular for Autsho as it is also earmarked as a development centre for Lhuentse.

The likelihood of the impact is High, and the severity is Medium. The significance of the potential impact is considered High.

The following measures are proposed to address the impact:

- Engage experienced architects, urban planners, and engineers to design the construction project with minimal disruption to the valley's natural landscape, consider alternative construction methods, such as building vertically or using innovative designs that require less flat land, especially regarding the construction facilities (workers accommodation sites for example) (AM/RM).
- Use temporary access roads, bridges, or platforms during construction to reduce the impact on flat land. Once the project is complete, these structures can be removed or repurposed (AM/RM).

- Promote public transportation, carpools, and other alternative commuting options for the workers and some materials' transportation to reduce the demand for flat land for parking lots and road expansions (RM).
- Involve local communities in the decision-making process to ensure their concerns are addressed, and their input is considered in the construction project by developing and implementing a Stakeholders Engagement Plan (EM).
- The Project facilities built during construction should be decommissioned and rehabilitated at the end of the construction period to release some flat land (AM/RM/EM).

After proper development and implementation of these measures, the residual impact is considered as **Substantial**.

10.3.3.9 Access to CSO/NGOs

10.3.3.9.1 Improved access to CSO/NGOs

The construction phase, including the social influx of population, can bring Civil Society Organizations (CSOs) and Non-Governmental Organizations (NGOs) to develop their activities in the area and have a positive impact for local communities. CSOs and NGOs often play a vital role in advocating community needs, providing services, and promoting social change.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to maximise the benefits:

- Develop and implement a Stakeholders Engagement Plan (EM).
- Gender and Vulnerability Action Plan (TM/EM)

10.3.3.10 Capacity building

10.3.3.10.1 Opportunities to do capacity building of local governmental agencies.

Local government agencies lack the experience and capacity to deal with many aspects of large infrastructure projects. They may be exposed to new issues (as detailed under the various impacts) caused or exacerbated by the project but also to new development potentials for which they'd need to be prepared.

Capacity building of local governmental agencies in the context of the Project involves enhancing their skills, knowledge, resources, and institutional capabilities to effectively plan, manage, and oversee construction activities. This approach can lead to improved project outcomes, better governance, and sustainable development.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to maximise the benefits:

- Borrower's capacity assessment and capacity building plan (TM/EM)
- Develop and implement a Stakeholders Engagement Plan (EM).
- Develop and implement the Gender, SEA/SH and Vulnerability Action Plan (TM/EM)

10.3.3.11 Direct employment

The project will positively impact short-term employment by creating jobs for the civil workers. The construction project will mobilize up to 460 national workers and more than 6000 foreign workers.

The individuals employed during the construction stage, and their household members, will benefit from increased income that is likely to increase their overall standard of living, access to healthcare and educational resources, and reduce their socio-economic vulnerability. Job opportunities and training have repeatedly been mentioned during stakeholder engagement activities as key expectations of the local

population concerning the project. However, due to the rarity of skilled technical workers in the area the economic benefit from this project for the local population will be limited as inhabitants' level of skills may not match the level and type of qualifications required for the project, unless internal training is provided. In addition, as observed with other infrastructure projects, related jobs usually benefit more to men, contributing to women getting more works and responsibilities in low paid jobs in the farms.

The impact is direct because the individuals and their household members will benefit from increased income and from training and skill development opportunities. The impact is reversible, as the income generated from local employment shall cease at the end of their employment as the number of workers needed decreases.

The significance of the potential impact is considered **Positive.** But it is not going to benefit all if no enhancement measures are taken.

The following measures are proposed to support and enhance the impact for local men/women and vulnerable:

- Develop the Gender and Vulnerability Action Plan to contribute to local skill building and employment for women, youths and People with Disabilities (PwDs) (EM).
- Develop and implement a Labour Management Procedure (AM/RM) including a procedure for "No at the gate hiring" and the demobilisation of the workforce at the end of the construction period.
- and a Grievance Redress Mechanism (RM).

10.3.3.12 Employment of workers and subcontractors

10.3.3.12.1 Labour conditions, contract and payments

The Project is expected to recruit more than 6000 workers in addition to the 460 national staff, spread over various project locations, with the maximum at the dam site and the powerhouse locations.

Workers can be exposed to many risks related to their Labour conditions:

- unsafe working environments posing risks to their health and safety (exposure to hazardous materials, lack of proper safety equipment, unsafe working conditions),
- work related accidents and injuries resulting in physical harm and potential legal liabilities for the employer,
- health hazards (exposure to toxic chemicals, poor ventilation, or excessive noise levels can lead to long-term health issues for workers, including respiratory problems, hearing loss, or chronic illnesses),
- exploitative labour practices: forced labour, child labour, excessively long working hours, or underpayment of wages can lead to exploitation of workers and violations of labour laws and ethical standards. Labour conditions in the supply chain, including subcontractors and suppliers, can pose risks to businesses, including reputational damage, legal liabilities, and disruptions to the supply chain. Poor labour conditions can result in low employee morale, dissatisfaction, and high turnover rates, leading to recruitment and training costs, as well as loss of institutional knowledge.
- discriminatory practices based on factors such as race, gender, age, or disability, as well as harassment or bullying in the workplace, can create hostile environments and negatively impact employee well-being and morale.
- lack of Labour Rights: Denial of basic labour rights such as the right to organize, collective bargaining, or fair wages can lead to discontent among workers and potential labour disputes. Failure to comply with labour laws and regulations, including minimum wage laws, working hour restrictions, or health and safety standards, can result in legal penalties, fines, and reputational damage.
- The project will employ a majority of migrant workers who are often victims of stigma and potential violations of Human Rights Laws and Body Integrity and Dignity (ex. from ILO: notification of medical

results such as HIV/AIDS can take place in non-private settings under which no emotional or medical counselling is provided, ILO reports that in many of these cases, the fired person frequently "disappear" and is never seen again.)

The labour conditions shall ensure that both foreign and national workers on the construction site are working in a safe environment, inhibiting the risk of accidents, injuries and legal liabilities. The workers contract and labour conditions shall be compliant with labour laws and regulations to avoid penalties.

Contracts shall also specify payments modalities and timing so both parties (the worker and the employer) are aware of the contractual terms to help avoid ambiguity and misunderstanding. Disputes over work quality, delays, or change of orders can lead to payment disputes. Contracts should outline dispute resolution mechanisms.

The likelihood of the impact is **High,** and the severity is **Medium**. The significance of the potential impact is considered **High.**

The following measures are proposed to address the impact:

- Develop and implement Labour Management Procedures that shall apply to the Contractor and any subcontractor (AM/RM);
- Develop and implement an Occupational Health and Safety Management Plan (AM/RM);
- Develop and implement a Grievance Redress Mechanism for workers in their working conditions (RM);
- The Contractor shall audit the Labour conditions, contract and payments of foreign and national workers on the construction site, ensuring it is compliant with local laws (MM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.3.3.12.2 Accommodation and living conditions

Considering the scale of the project and the number of foreign and national workers coming on site for the construction phase, there are significant impacts resulting from workers' accommodation and living conditions, especially for those who need to be on-site for extended periods. Ensuring adequate and safe living conditions for workers is not only an ethical consideration but also essential for productivity, morale, and compliance with labour regulations. The workers' accommodation and living conditions comprise the following points:

- **Temporary Housing**: On larger or remote construction sites, temporary housing facilities may be provided for workers. The quality and availability of these accommodations can have a significant impact on the worker's well-being. Impacts include:
    - Housing Quality: Substandard housing can lead to health and safety issues, as well as lower morale among workers. Quality housing should include proper sanitation, heating/cooling, and security.
    - Occupancy Density: Overcrowding can lead to discomfort, increased stress, and potential health risks, including the spread of diseases.
    - Amenities: Access to basic amenities like clean water, sanitation facilities, cooking areas, and recreation spaces can greatly affect living conditions.
    - Privacy: Workers need personal space and privacy for rest and relaxation. Lack of privacy can lead to stress and decreased satisfaction.

- **Health and Safety**:
    - Sanitation and Hygiene: Adequate sanitation facilities, clean drinking water, and hygiene measures are essential for preventing the spread of diseases.

- Safety: Workers' accommodations should meet safety standards to protect against fire hazards, structural failures, and other safety risks.

- **Accessibility**: Consider the proximity of accommodation to the construction site. Workers should not face lengthy commutes or difficult transportation options, as this can lead to fatigue and reduced productivity.
- **Cultural and Social Considerations**: the project involves a diverse workforce with 5,000 to 6,000 foreign workers. Accommodation should respect workers' cultural and social norms, providing spaces for relaxation, religious practices, and social interaction.

The likelihood of the impact is **High,** and the severity is **Medium.** The significance of the potential impact is considered High.

The following measures are proposed to address the impact:

- Develop and implement a Labour Accommodation Plan) ("The management of the construction workers colonies, (IFC standards) (AM/RM)
- Develop and implement an Occupational Health and Safety Management Plan (AM/RM)
- Develop and implement a Grievance Redress Mechanism for workers on their living conditions (RM)
- The Contractor shall audit the workers accommodation and living conditions on a regular basis (MM).

After proper development and implementation of relevant measures, the residual impacts are considered to be Moderate.

10.3.3.13 Cultural heritage

The impacts related to cultural heritage are already addressed in section 10.2.4.2.6.

However, there is a potential risk of impact on cultural heritage sites that may not be identified at this stage during the project construction works. For the case of unexpected encounter of Cultural and Historical Sites a Chance Find Procedure will need to be developed and implemented.

The likelihood of the impact is **Low,** and the severity is **Medium**. The significance of the potential impact is considered Moderate**.**

The following measures are proposed to address the impact:

- Develop and implement a Cultural Heritage Management Plan, inc. a Chance Find Procedure (AM/RM).

After proper development and implementation of these measures, the residual impact is considered as **Low**.

10.4 Summary of impacts during construction phase

The following summary table presents for each activity or component:

- The impacts based on description provided above.
- The significance of the impacts with the details of the severity and the likelihood.
- The list of the main corrective measures to manage the impacts.
- Consideration about the feasibility and difficulty of the proposed corrective measures rated from 1 (easy) to 3 (difficult).
- The significance of the residual impact.

It is noted that this table presents the residual impact without the implementation of compensation measures. The purpose is to highlight (i) the significance of the residual impact with avoidance/reduction measures only and (ii) the need for potential compensation measures. The compensation measures

presented in this table are designed in a way to fully compensate the Substantial and significant residual impacts identified.

Table 187: Summary of impacts during construction phase – Physical Environment

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
PHYSICAL ENVIRONMENT								
Blasting	Increased potential for landslides	Due to the occurrence of faulting and thrusting, particularly in the southern part of the area, blasting can interact with these geological structures, potentially triggering localized instabilities. Blasting can disturb the overburden and slope deposits, potentially increasing the risk of landslides in these areas.	Medium	High	High	○ Implement optimized blasting techniques (AM). ○ Establish blast Monitoring program (MM). ○ Implement and develop effective Blasting Design (AM). ○ Implement blasting Sequence (AM/RM). ○ Provide rockfall Protection measures (AM/RM). ○ Provide Proper communication (AM). ○ Preparation and implementation of an Explosives and Blasting Management Plan and Construction Emergency Management Plan.		Substantial
Excavation and river work	Changes in flows and potential flooding	The impacts may arise due to the alteration of the natural river course and the disturbance of sediment and debris within the riverbed. Excavation activities can modify the river channel's geometry and alter the flow patterns.	Medium	Medium	Substantial	○ Implement Flow Diversion (AM/RM). ○ Establish temporary riverbank protection (RM). ○ Develop and implement emergency preparedness and response (AM). ○ Preparation and implementation of a Construction Emergency Management Plan and Grievance Redress Mechanism		Moderate

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Excavation and river work	Changes in sediment load and transport d/s	Activities such as excavation and river work have the capacity to disturb the existing natural landscape, causing soil and sediment to erode. This loosened soil is susceptible to being carried away by rainwater or the movement of flowing water, kickstarting the process of sediment mobilization. Once mobilized, these sediment particles become suspended in the water and are then transported downstream by the current of the river.	Medium	Medium	Substantial	○ Implement sediment Control Structures (RM). ○ Develop and implement comprehensive erosion and sediment control plans (RM) ○ Develop and execute a comprehensive sediment monitoring program (MM). ○ Selective Excavation Techniques (RM). ○ Establish vegetative buffers by planting native vegetation (RM). ○ Develop strategies for controlled release of water from the construction site (AM). ○ Preparation and implementation of a Soil Erosion and Sediment Management Plan.		Moderate

ACTIVITY OR COMPONENT CONSTRUCTION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
Construction Traffic	Air Emissions	The increase in road traffic linked to the construction of the project to transport materials and personnel to/from the site will lead to an increase in atmospheric emissions, which will have an impact on the health of road users and people living around the access roads. This is mostly associated with dust (in particular during the dry season) but also with direct vehicle exhaust fumes.	Medium	Medium	Substantial	○ Implement itineraries for Project vehicles. ○ Develop liaison between contractors and local offices of the Department of Roads and Surface Transport. ○ Project heavy vehicles will not use public roads at night and during school commute times. ○ Implement specific reduce speed limit. ○ Implement dust suppression by using non-potable water. ○ Trailers, skips and haulage trucks will have their loads covered during transport. ○ Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy; and a Grievance Redress Mechanism.		Moderate

ACTIVITY OR COMPONENT CONSTRUCTION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
Heavy machinery, Excavation and Earthworks	Air quality / Dust impacts	The impacts of air quality alteration and dust can have significant consequences for the workers and the surrounding communities, from impacts on the population's activities (visibility reduction during work potentially leading to hazardous driving conditions and accidents) to impact on people's comfort, safety and health (respiratory problems, allergies and irritations, etc).	High	High	High	○ Inform local populations of work activities (IM). ○ Follow-up of dust and air quality complaints (MM) and implementation of the complaint management mechanism (RM). ○ Implement covering stockpiles. ○ Implementing temporary vegetation cover. ○ Develop and implement an Air Quality Management Plan, a Traffic and Access Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Grievance Redress Mechanism. ○ Reuse, composting and recovery of waste, including green waste (AM). ○ Develop and implement Revegetation (RES). ○ Implement monitoring of noise and dust emissions (MM)		Substantial

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Pollution associated with spills	The pollution associated with spills and erosion from construction works can impact on workers and communities' health (respiratory issues, skin and eye irritation, displacement and relocation in case of severe pollution) and economic activities as pollution can contaminate agricultural lands and water sources.	Low	High	Substantial	○ Inform local populations of work activities (IM). ○ Prohibit refuelling in the field (AM). ○ Establishment of a program for the collection, monitoring, and treatment of waste (RM). ○ Identify hydrocarbon storage sites (RM). ○ Storage of chemicals in appropriate areas (RM). ○ Identify material deposition sites (RM). ○ Machinery and equipment maintenance area (RM). ○ Define strict procedures for filling equipment tanks (RM) ○ Prevention of pollution by toxic products (RM) ○ Exclusive use of pesticides recognized by WHO (RM) ○ Establishment of a monitoring plan for the quality of water from worksite areas (MS). ○ Establishment of an employee awareness and training program on all these aspects (MF). ○ Develop and implement an Air Quality Management Plan, a Traffic and Access Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Grievance Redress Mechanism.		Moderate

Activity or component	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
CONSTRUCTION	Noise and vibration	The noise level will be modified by earthworks, rock clearing (hydraulic hammer), pile driving and drilling of foundations, crusher operations, concrete production, assembly of components and the various construction operations. Furthermore, activities are likely to generate vibrations perceived in two ways: tactile or auditory. The activities likely to cause vibrations can impact nearby buried structures such as building foundations.	High	Medium	High	○ Periodic technical controls and maintenance of construction machines (RM) ○ Unless instructed otherwise by DGPC, noise and vibration generating works are prohibited at night between 06.00 pm and 06.00 am and on Sundays in accordance with WHO Guidelines. ○ Noise and vibration measurement at the start of noisy operations in a new area (MM) ○ Limit the noise from fixed equipment (RM) ○ Provide information on the noisiest operations / operations involving significant vibrations to local communities (IM) ○ Develop and implement an Air Quality Management Plan, a Traffic and Access Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Grievance Redress Mechanism		Substantial

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Changes in erosion and increased risk of slope instability	The removal of vegetation and soil disturbance during these activities can weaken the natural stability of slopes, making them more susceptible to erosion and landslides.	High	High	High	○ Erosion Control Measures (RM) ○ Slope Stabilization Techniques (RM) ○ Drainage Management (RM) ○ Establish procedures for managing material deposits, particularly loose material (RM). ○ Limit areas accessible to vehicles (RM) ○ Rehabilitation of areas used for temporary infrastructure (RM) ○ Revegetation (RES) ○ Preparation and implementation of a Soil Erosion and Sediment Management Plan and Site Decommissioning and Rehabilitation Plan.		Moderate

ACTIVITY OR COMPONENT CONSTRUCTION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
Muck Disposal Sites	Issues with long term stability of MDS	During construction of the various components of the project, muck is generated both from soil or slide material and from rock excavation. Potential impacts associated with Muck Disposal site may include increase sediment transport d/s, significant traffic for MDS and the long-term stability of the MDS (safety / risk of failure).	Medium	High	High	○ Preparation and implementation of a Muck Disposal Site Specific Management Plan		Substantial

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Wastewater from CCF	Increase potential for water pollution	There is a potential for water pollution due to the generation of wastewater from the construction camp facilities (CCF). These facilities can produce various types of wastewaters, including domestic wastewater (sewage), kitchen and dining wastewater, and other sanitary discharges.	Medium	Medium	Substantial	○ Implement and develop Wastewater Treatment (AM/RM). ○ Implement separation and Collection (AM). ○ Promote Greywater Reuse (AM) ○ Utilise Septic Tanks and Soakaways (AM) ○ Implement measure to manage chemical (RM). ○ Perform regular maintenance (AM). ○ Monitor effluent quality (MM). ○ Provide training and awareness for construction personnel (TM). ○ Develop an Emergency Response Plan (RM). ○ Stakeholder Engagement (AM) ○ Preparation and implementation of a Water Quality and Effluent Management Plan and Camp and Technical Installations Site Specific Plan.		Moderate

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Wastewater from crushing plant	Increase sediment load and potential for water pollution	Crushing, generating fine particles and dust that, when carried by stormwater runoff, contribute to higher sediment concentrations in the rivers. potentially lead to an increase in sediment load in river Kurichhu.	High	High	High	○ Implement Sedimentation Basins and Erosion Control (AM). ○ Apply Dust Suppression (RM). ○ Develop Scheduling and Planning Strategies (AM). ○ Implement Containment and Diversion measures (AM/RM). ○ Develop and Implement Wastewater Treatment (RM). ○ Conduct Regular Monitoring and Inspection (MM). ○ Preparation and implementation of a Water Quality and Effluent Management Plan and Camp and Technical Installations Site Specific Plan.		Substantial
Wastewater from batching plant	Increase sediment load and potential for water pollution	Wastewater can include runoff from equipment cleaning, concrete mixing, and general site maintenance. If not managed effectively, this wastewater has the potential to be carried by stormwater runoff into adjacent water bodies, in this case river Kurichhu.	Medium	High	High	○ Implement Sedimentation Basins and Settling Ponds (AM). ○ Implement method for Recycling and Reuse (AM/RM). ○ Install Treatment Systems (AM/RM). ○ Implement Covering and Containment (AM). ○ Design Proper Drainage Design (AM). ○ Perform Regular Cleaning and Maintenance (AM/RM). ○ Conduct Monitoring and Reporting (MM).		Substantial

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Discharge of water with very high pH (Basic)	Batching plants during the construction phase can potentially lead to the discharge of wastewater with a very high pH (basic) into the environment. This elevated pH level in wastewater can result from the use of certain chemicals, additives, or cement in the batching process.	Medium	High	High	○ Conduct Wastewater Sampling (MM). ○ Implement pH Monitoring and Control (RM/MM). ○ Develop and Implement pH Adjustment Tanks (AM). ○ Provide Training and Education to construction personnel (TM). ○ Implement Containment and Spill Prevention (AM). ○ Preparation and implementation of a Water Quality and Effluent Management Plan, Hazardous Materials / Waste Management Plan and Camp and Technical Installations Site Specific Plan.		Substantial

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Waste from Construction Activities	General aspect of waste issues	Improper disposal of solid waste can lead to environmental degradation, soil contamination, and air and water pollution. Accumulation of solid waste can lead to unsightly conditions at the construction site, affecting the aesthetic appeal of the area and potentially causing community dissatisfaction. While waste burning is commonly undertaken on construction sites, it should be strictly prohibited on both air quality and safety grounds	Medium	High	High	○ Implement Waste Minimization strategies (AM). ○ Develop and implement Reuse and Recycling (RM). ○ Implement effective Material Management (MM). ○ Develop and implement an optimized Formwork Design (AM). ○ Implement timely Removal of Debris (RM). ○ Implement proper waste sorting and disposal (RM). ○ Develop and establish on-site Recycling Facilities (RM). ○ Provide Education and Training for construction personnel (TM). ○ Develop Supervision and Monitoring (MM). ○ Implement Contractual Obligations (AM). ○ Develop Incentives for Waste Reduction (AM/RM). ○ Conduct Regular Audits (MM). ○ Preparation and implementation of a Waste Management Plan, Hazardous Materials / Waste Management Plan and Camp and Technical Installations Site Specific Plan.		Substantial

Activity or component	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
CONSTRUCTION	Green waste	The impacts of green waste on the human environment can be both positive and negative, depending on how it is managed.	Medium	Medium	Substantial	○ Develop Green waste composting and recycling (EM) ○ Creation of habitat such as brush piles from tree branches and logs for small animals and insects (EM). ○ Preparation and implementation of a Waste Management Plan and Site Decommissioning and Rehabilitation Management Plan.		Moderate

Activity or component	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
CONSTRUCTION	Construction and domestic	The main impacts concern workers and communities' health, economic activities and workers and communities' living conditions	Medium	Medium	Substantial	○ Development and implementation of a Waste Management Plan (AM/RM) ○ Develop and implement a certificate (e.g. ISO certification) Occupational Health and Safety Management Plan for Workers (AM/RM). ○ Develop and implement a Community Health and Safety Management Plan (AM/RM). ○ Develop and implement a Fuels, Chemical and Hazardous Materials Management Plan (AM/RM). ○ Develop and implement a Liquid Effluent Management Plan (RM). ○ Develop and implement a Soil and Erosion Management Plan (RM). ○ Develop a Contaminated Soils Management Plan to manage polluted soil in case of accidental pollution from construction and domestic waste (RM).		Moderate

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Medical waste	Medical waste on and nearby a construction site can have serious and far-reaching consequences for both the environment and human health.	Medium	High	High	○ All medical waste is segregated and collected in adequately labelled bags (typically yellow bags marked with a 'biohazard risks). ○ All medical sharps (e.g. needles and blades) are disposed off in sharp boxes. ○ The Contractor will enter in an agreement with the Mongar Regional Referral Hospital for the safe disposal of medical waste (in an appropriate medical waste incinerator). ○ Develop and implement a Waste Management Plan, a Hazardous Materials / Waste Management Plan.		Moderate

ACTIVITY OR COMPONENT	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
CONSTRUCTION	Reduction of water resources	The extensive use of water during construction could lead to the depletion of local water resources. Construction activities can introduce pollutants into nearby water bodies. These pollutants can stem from actions like dust suppression techniques and machinery cooling processes. This can result in the deterioration of water quality. Such degradation can negatively impact aquatic life, create challenges for downstream water users, and cast a shadow over the overall health of aquatic ecosystems.	High	High	High	○ Efficient Water Use (AM/RM): showerhead, water efficient appliances, etc.). ○ Recirculation and Reuse (AM). ○ Environmental Monitoring (MM). ○ Community Engagement (AM). ○ Regulatory Compliance (AM/RM). ○ Adaptive Management (AM/RM). ○ Preparation and implementation of a Grievance Redress Mechanism, Water and Effluent Management Plan and Camp and Technical Installations Site Specific Plan.		Substantial

ACTIVITY OR COMPONENT CONSTRUCTION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
Storage/ transport/ use of hazardous products	Increase potential for water and soil pollution	Poor storage practices and mishandling of hazardous products can result in spills or leaks. Accidental spills of hazardous products during transportation or storage can lead to the release of pollutants. Incorrect disposal methods of hazardous waste can lead to pollutants entering soil and water.	Medium	High	High	○ Safe Handling and Storage (AM). ○ Spill Prevention and Response Plans (AM). ○ Periodic technical controls and maintenance of construction machines (RM) ○ Segregation and Labelling (AM). ○ Appropriate Storage Facilities (AM/RM). ○ Waste Management (AM/RM). ○ Regular Inspection and Monitoring (MM). ○ Emergency Management (RM). ○ Community Awareness (AM/RM). ○ Develop and implement a Hazardous Materials / Waste Management Plan, Water and Effluent Management Plan, Community Health and Safety Management Plan, Occupational Health and Safety Management Plan for Workers		Substantial
Natural Hazards	Flooding event during construction	Floodwater during intense monsoon rainfall can damage construction infrastructure such as access roads, temporary facilities, and equipment. Flooding events can wash away or damage construction materials and equipment, leading to losses and project delays.	Medium	High	High	○ Implement Early Warning Systems (AM). ○ Construct Temporary Diversion Channels (RM). ○ Secure Equipment (AM/RM). ○ Conduct Regular Training (AM). ○ Collabouration with Authorities (RM). ○ Develop and implement a Construction Emergency Management Plan.		Substantial

Activity or component	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
CONSTRUCTION	GLOF during construction	Three types of glacial lakes were identified in the region: Glacial Erosion Lakes, Glacial Cirque Lakes, and Moraine-Dammed Lakes. Among these, Moraine-Dammed Lakes located pose the highest risk due to their potential for GLOFs which can result in massive amounts of water, debris, and sediment rushing downstream.	Low	High	Substantial	○ Implement Early Warning System (AM). ○ Develop Emergency Evacuation Plan (RM). ○ Organize regular training sessions to practice response actions and evacuation procedures for GLOF events. (RM). ○ Utilize Remote Monitoring (AM). ○ Establish Coordination with Authorities (AM/RM). ○ Regular Updates about changing climate and glacier conditions to anticipate and respond to potential GLOFs effectively. (AM/RM). ○ Develop and implement a Construction Emergency Management Plan.		Substantial
	Increase risk of wildfire	The construction site and its infrastructure, such as access roads, temporary facilities, and construction equipment, could be at risk of damage or destruction in the event of wildfire. This could result in delays in project progress, additional repair costs, and potentially compromised safety for workers and equipment.	Medium	High	High	○ Develop and establish Firebreaks and Clear Zones (AM). ○ Provide Firefighting Equipment (RM). ○ Conduct Fire Awareness and Training (AM/RM). ○ Establish communication and coordination protocols (AM/RM). ○ Monitor weather monitoring (AM). ○ Implement measures to control and manage vegetation (RES). ○ Develop and Implement Emergency Response Plan.		Moderate

ACTIVITY OR COMPONENT CONSTRUCTION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
	Increase risks of landslides and rockfalls	The history of landslides in areas like Mongar and Lhuentse underscores the recurring nature of these events and their impacts on vital infrastructure, roads, farm roads, and irrigation systems. The safety of on-site construction personnel is compromised by the abrupt onset of landslides and rockfalls.	Medium	High	High	○ Implement engineering solutions such as slope stabilization techniques, rockfall protection structures, and retaining walls Engineering Measures (AM/RM). ○ Establish early warning systems to detect signs of imminent landslides or rockfalls (AM/RM). ○ Provide training for construction workers and personnel about the risks of landslides and rockfalls (TM). ○ Implement real-time surveillance systems to detect potential hazards (MM). ○ Implement an emergency response plan (RM). ○ Establish protocols for quick response to clear debris and restore affected areas after a landslide or rockfall event (RES).		Substantial

Table 188 - Summary of impacts during construction phase – Biological Environment

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significan
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
BIOLOGICAL ENVIRONMENT								
Presence of workers and colony Social influx Invasive species	Impact on protected area	No direct impact Works and colony away from the protected area	Low	Medium	Moderate		Low	Low
Works activities	Impact on CHQ plant	No additional impact resulting of works activities	No	No	No			No
Sound emissions, vibration and blasting	Impact on CHQ birds	Main impact on the Dark-rumped Swift. The nesting is limited to the cliff area and is potentially in or closed the quarry sites. Blasting and crushing may limit adequate habitat in a radius of 1 or 2 km	Medium	Medium	Substantial		Medium	Moderate
Presence of workers and colony Social influx Filling stage	Impact on CHQ Mammals	The poaching is verry low in Bhutan due to cultural factor and strong sensibilisation and regulation. However, the presence of the work force during a long period of several years will increase the risk of creating a poaching sector for the export and supply of bush meat to the workers.	Medium	High	High		Low	Low

Dust, Light, noise vibration **Risk of accident** **Presence of workers** **Social influx** **Invasive species** **Land clearing** **Reservoir filling** **Access**	Impact on terrestrial natural environment and associated species	Mammals and birds may be affected by the risk of accidents due to traffic and/or processes dangerous for wildlife (electrocution, entrapment, panic). Noise and light can have an impact on various species of birds, particularly nocturnal species and during the mating and feeding phases of juveniles (disruption of communication through songs). Social influxes can increase the conversion of natural habitats to modified habitats. key point will be the availability of new access offering new opportunities	Medium	High	High	Specific measure from the BMP in addition to all other ESMP plans ○ Control all the water crossing to ensure hydraulic continuity of the tributaries allow fish movements. ○ Avoid basting Marsh to May anticipating aggregate needs to preserve the breeding period of the Dark-rumped swift. ○ Avoid crushing activities at the vicinity of the cliffs from Marsh to May to preserve breeding period of the Dark-rumped swift. ○ Reduce the nigh works period to specific sites and operation to avoid fauna behavioural disturbance. ○ Install directional lighting for activity areas, security lighting and colony lighting. ○ For lighting other than that necessary for safety, limit the lighting duration to what is strictly necessary. ○ Signage at large wildlife crossing points, reporting collisions or injured animals. ○ Convention with national polices forces, the DOFPS to avoid the risk of creating a poaching sector for the export and supply of bush meat to the workers. ○ Convention with national polices forces, the DOFPS to random control banning on detention of guns and traps, bushmeat consumption, capture and killing of wild animal. ○ Training to the BMP (biodiversity Management Plan	Low	Low

Activity or component CONSTRUCTION	Potential impacts	Impact description	Impact assessment			Corrective measure		Signi fican
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
						○ Raising awareness of biodiversity protection among construction companies and subcontractors ○ Code of conduct in case of interaction with wildlife such as primates, snake, feline and other big fauna ○ Removal of the temporary road which will not be used for project maintenance		
Land clearing **Alteration of water quality** **Hydraulic discontinuity**	Impact on CHQ fish species	The 3 CHQ catfishes are no evidenced in the Kurichhu river but in some tributaries. The strongest impact factor will be the risk of loss of hydraulic continuity and increase of turbidity. The tributaries, in particular in right bank, may be impacted by the access tracks crossings, by the earthworks and the spoil of the tunnel digging operations. The land clearing may also increase the water turbidity and impact on the population of the 3 CHQ catfishes	Medium	High	High	○ Ban of the use of new access road dedicated for project maintenance. ○ Management of construction sites to control alien invasive species (Flora) ○ Avoid the main period of birds breeding for vegetation clearing and reservoir filling. ○ Emit sound and vibration signals in the areas to be cleared over several minutes before to	Low	Low

Land clearing **Alteration of water quality** **Hydraulic discontinuity** **Land clearing** **Reservoir filling**	Impact on natural aquatic environment and associated species	Construction activities associated with the Dorjilung HPP can have adverse effects on aquatic ecosystems, particularly on water quality. Activities like land clearing, earthworks, temporary river diversion, cement manufacturing, and concrete pouring can degrade water quality. Hydraulic discontinuity may result in a habitat area and loss of the population in tributaries. The main activities to have hydraulic discontinuity is related to the new permanent or temporary roads access and road, all the muck disposal sites (dumpsites), all the excavation and earthworks.	Medium	High	High	facilitate the escape of mobile species such as snakes, lizards and other slow-moving species. ○ Reservoir filling stage ○ Reservoir First Impoundment Management Plan ○ The specific measure from the BMP is: ○ Avoid the main period of fish breeding filling the reservoir. ○ Management flow during the reservoir filling period to be assessed in detail in the EFlow with filling the reservoir during high flow period June to September and schedule a slow impoundment of the reservoir (4 weeks to be confirmed by EFlow assessment) to allow sensitive species to escape (RM). ○ Prevention of animal mortality related to construction work. ○ Rescue procedure for trapped or injured animals ○ Regular inspection of dangerous sites to wildlife (electrical risk, risk of entrapment, risk of collision) for implementation of corrective action with awareness of site personnel for the identification of risks and reporting	Low	Low

Table 189: Summary of impacts during construction phase – Social Environment

Activity or component	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of resid
			Likelihood	Severity	Significance	Description and classification of the measure Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
CONSTRUCTION								

Social ENVIRONMENT								
Construction traffic	Risks of accidents and adverse road safety	Traffic accidents have the potential to injure or kill pedestrians, other drivers, drivers of a project vehicle and their passengers, and could also act as a local trigger for protests against the project.	High	Medium	High	○ Implement specific itineraries for the Project vehicles. ○ Comprehensive audit of road network. ○ The contractor will also engage an independent Bailiff to document the state of public roads prior to the Project. ○ The Contractor will liaise with the local offices of the Department of Roads and Surface Transport in Lingmethang and Mongar. ○ Project heavy vehicles will not use public roads at night and during school commute times. ○ Temporary traffic management. ○ Implementation of specific reduced speed limits. ○ It is strictly prohibited for Project vehicles to transport local people, equipment or products other than those required for the construction activities. ○ Trailers, skips and haulage trucks will have their loads covered during transport. ○ The Contractor will organise random checks of drivers to verify that they hold the appropriate driving licence and perform random DUI checks. ○ Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy; and a Grievance Redress Mechanism.		Substantial

	Livestock husbandry and risks of collisions	Increased traffic on roads crossing pastures and livestock farms can increase the risk of collisions between vehicles and livestock, which can injure drivers and their passengers as well as the animals hit.	Medium	Medium	Substantial	○ Implement specific itineraries for the Project vehicles. ○ The Contractor will liaise with the local offices of the Department of Roads and Surface Transport in Lingmethang and Mongar. ○ Project heavy vehicles will not use public roads at night and during school commute times. ○ Implementation of specific reduced speed limits. ○ The Contractor will engage with each of the Gup and communities as relevant to raise awareness on potential risk of collisions with cattle grazing on the road verge. ○ Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy; a Grievance Redress Mechanism.		Moderate
	Congestion and travel times for road users	The increase in traffic on the roads through the villages leading to the hydroelectric power station may create traffic jams on these roads, considerably increasing the journey times of the local population to their destinations.	Medium	Low	Moderate	○ In area where traffic conflicts may result from the Project vehicles movements, the Contractor will install temporary traffic management which may include temporary signage and / or temporary traffic controllers. ○ The Contractor will schedule major delivered to avoid peak construction traffic (i.e., dedicated time windows for major deliveries). ○ The Contractor will develop and implement a procedure for rapid repair and recovery of vehicle suffering breakdown to limit road congestion. ○ Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy; a Grievance Redress Mechanism.		Moderate

	Vibrations and cracks	The increase in road traffic associated with the construction of the project leads to an increase in mechanical vibrations, whether from road defects (potholes, manhole covers, etc.) or from engine and heavy machinery movements. Where the weight of vehicles is heavier, as will be the case with construction and personnel transport equipment, vibrations are stronger and the inconvenience for road users and the surrounding population is bigger.	Medium	Medium	Substantial	○ Buildings close to the roads used by Project vehicles will be subject to a dilapidation survey prior to the start of construction. ○ The contractor will also engage an independent Bailiff to document the state of public roads prior to the Project. ○ The Contractor will liaise with the local offices of the Department of Roads and Surface Transport. ○ Implement specific itineraries for the Project vehicles. ○ Project heavy vehicles will not use public roads at night and during school commute times. ○ Implementation of specific reduced speed limits. ○ Develop and implement a Traffic and Transport Management Plan, inc. a Safe Driving Policy; a Noise and Vibration Management Plan and a Grievance Redress Mechanism.		Moderate
Blasting	Vibrations and cracks	Blasting activities are likely to generate vibrations perceived in two ways: tactile or auditory. The activities likely to cause vibrations can impact nearby buried structures such as building foundations.	Medium	High	High	○ Blasting will be prohibited at night between 06.00 pm and 06.00 am and on Sundays. ○ The Contractor will engage an independent Bailiff to document the state of public community buildings and temples on the right bank prior to the Project. ○ Develop and implement a Blasting Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan and a Security Management Plan.		Moderate

	Hazards relating to transport, storage and handling of explosives	Handling, transporting and storing explosives is associated with significant hazards leading to explosion. Although the risk is considered low in Bhutan, there is always the potential for explosives theft.	Medium	High	High	○ The itineraries used to transport explosives will be mapped out and communicated to the relevant regulatory agency. ○ Only accredited contractors with specialised vehicles will be used to transport explosives. By default, detonators and explosives are transported in separate vehicles. ○ Prohibit all forms of burning (cooking, heating ...) in the explosives warehouse and the area around the warehouse. ○ Explosives and detonators are stored in separate buildings. ○ Regularly clearing, cleaning around the explosives warehouse. ○ Dedicated fire-fighting arrangements must be developed and implemented at the explosives warehouse.		Moderate
	Loss of water resources through impacts on groundwater	Construction activities can lead to environmental pollution, impacting groundwater resources in particular. The populations using this water for their agricultural activities and other varied uses may find themselves short of water if the resources are used for construction or polluted by it.	Medium	High	High	○ Develop and implement a Blasting Management Plan, a Community Health and Safety Management Plan, an Occupational Health and Safety Management Plan, a Security Management Plan and Grievance Redress Mechanism.		Moderate

OSH Risks for Workers		Workers engage in construction activities are exposed to a large range of Occupational Health and Safety hazards. The most common hazards are listed below: - Electrical Hazards. - Falls and Trips Hazards. - Hazardous Materials. - Working at Height. - Confined Space. - Crane and heavy moving equipment. - Burn, cuts, ear, eye and respiratory damage when using electrical tools and welding. - Fire and Explosion Hazards.	Medium	High	High	○ Organise a Health check of all workers. ○ Develop and implement a general OH&S site induction for all workers and visitors. ○ Develop and implement job specific safe work method statement for each hazardous activity. ○ Establish a Worker's Safety committee. ○ Provide, free of charge, job specific Personal Protective Equipment (PPE) to each worker. ○ All hazardous areas and hazardous equipment must be clearly labelled. ○ Provide a First Aid station / small clinic at each of the main camps. ○ The Contractor will enter in an agreement with a specialised medical services company and / or Mongar Regional Referral Hospital. ○ First Aid Officers (FAOs) are present during working hours in sufficient numbers. ○ Each work sites are equipped with an adequate number of Firs Aid Kits (FAKs). ○ Develop and implement a strict working permit system for: working at height, working in confined spaces, welding, hot work permit, etc. Each worker must hold the relevant accreditation / have gone through the relevant training prior to undertaking these activities. ○ Develop and implement an Occupational Health and Safety Management Plan.		Substantial

OH&S risks for local communities		Local communities are also exposed to various OH&S hazards. These are similar to the Workers OH&S hazards with a few notable exceptions: (i) the community members are not directly involved in construction and should not have access to the work site; their exposure to these hazards is either accidental or through trespassing (ii) they will not have received induction and will not wear PPE.	Medium	High	High	○ At the beginning of the Project, implement specific awareness measures targeting local communities. ○ The Contractor will ensure that the safety / hazard signage will be also made in local dialect and always with visual explicit symbols to ensure illiterate people can understand them. ○ Develop and implement a Community Health and Safety Management Plan and Grievance Redress Mechanism.		Moderate
Camp	General sanitary conditions	The availability and quality of facilities directly affect the health and well-being of the workers, as well as the overall environmental conditions in the area. Some of the impacts on general sanitary conditions include availability of sanitation facilities, waste management, water supply, vector borne diseases, disease outbreaks and workers' health and productivity.	Medium	Medium	Substantial	○ The Contractor will regularly inspect the camps and technical installations and ensure their general tidiness. This includes clearing debris, removing litter, implementing anti-vermin measures and maintaining the work area clean. ○ Develop and implement an Occupational Health and Safety Management Plan and a Camp and Technical Installation Site Specific Plan.		Moderate

	Security Management	Workers living in the camp may face safety risks due to the remote location, such as exposure to wildlife, extreme weather conditions, or hazardous terrain. Workers also risk potential crimes, conflicts, theft or vandalism within the camp, whether caused by other workers or any individual who entered the camp, resulting for workers to be in an unsafe and an unsuitable living environment. Workers and other camp residents may also face domestic risks in the camp, such as fire, flooding, electrocution, etc.	Medium	Medium	Substantial	○ Develop and implement an ID/tag system for Project workers and vehicles. ○ The camps and mains installations should be fenced, with a double boom-gate / sas system to manage entry. There needs to be an automatic floodlight system with mention sensor in key areas of the Camp and Technical Installations. ○ A CCTV system should be installed to cover the main areas and access (e.g., camp entry, office building entry, explosives warehouse, fuel farms, etc.). ○ Any illegal contraband, poaching, trafficking, prostitution activity is strictly prohibited (zero tolerance policy). In addition to disciplinary measures and dismissal, offenders will be reported to the Royal Bhutan Police. ○ Engage specialised company for security management. Guards are prohibited from wearing firearms and should restrain themselves from violent actions in their work. ○ The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information. ○ Develop and implement a Security Management Plan. All measures will need to abide by the Voluntary Principles on Security and Human Rights.		Moderate

Population influx – Foreign workers, National workers, Camp followers	Public health impacts	The important social influx can lead to the increase in the risk of diseases or epidemics among the surrounding communities, as high population density resulting from an influx can increase the risk of communicable diseases, especially if sanitation and hygiene measures are inadequate. Also, new arrivals may bring with them diseases or infections that local populations are not usually confronted with or protected against. A sudden increase in population can overwhelm local healthcare facilities, leading to longer waiting times, reduced quality of care, and limited access to medical services, with significant consequences in the event of an epidemic.	High	Medium	High	○ Prior to deploying its workers at site, the Contractor will organise a health check of all workers, including for STI, to ensure that they are aware of potential disease and infections, without discrimination. ○ Develop and implement a health and STI awareness program targeting both workers and the community. ○ Access to the camps will be prohibited to community members. It is also prohibited for Project vehicles to give a lift to community members. Interactions between workers and community members will be limited and controlled as far as feasible. This includes for instance a buffer zone for the local business to provide goods and services for workers. ○ Partially closed camps should be considered (with specific rules for entry/exit and recreational facilities on site). ○ Condoms will be made available to workers free of charge through "condom boxes". ○ Develop and implement a Community Health and Safety Management Plan, and Occupational Health and Safety Management Plan.		Substantial

	GBHV	The risks for gender-based violence and sexual exploitation and abuse as well as sexual harassment for surrounding communities and workers could increase during the construction phase due to the influx of workers and non-locals looking for work or economic opportunities.	Medium	High	High	○ The Project will have a zero-tolerance policy for any gender-based violence, sexual exploitation and abuse as well as sexual harassment. In addition to disciplinary measures and dismissal, offenders will be reported to the Royal Bhutan Police. ○ The Project will include GBHV awareness as part of the workers' site induction. ○ Develop and implement a GBV (gender-based violence), SH (sexual harassment) and SEA (sexual exploitation and abuse) Prevention and Response Action Plan (AM/RM); Labour Management Procedures (with a Code of Conduct); Develop and implement a Community Health and Safety Management Plan, and Occupational Health and Safety Management Plan; and a Grievance Redress Mechanism including confidential reporting with safe and ethical documenting of GBV/SH and SEA cases (RM).		Substantial
	General security and unrest disruptions	The population influx, including national and foreign workers can strain local law enforcement and security forces. The population influx can bring or increase issues such as the potential sale of drugs and increased alcohol consumption that can contribute to security concerns. If crime rates rise or security measures are insufficient, residents may feel unsafe, and demand increased security measures.	Medium	High	High	○ The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information. ○ Develop and implement a GBV (gender-based violence), SH (sexual harassment) and SEA (sexual exploitation and abuse) Prevention and Response Action Plan (AM/RM); Labour Management Procedures (with a Code of Conduct); Security management Plan, Develop and implement a Community Health and Safety Management Plan; and a Grievance Redress Mechanism.		Moderate

	Cultural heritage	Cultural heritage encompasses a community's traditions, customs, artifacts, languages, historic sites, and intangible practices that are passed down through generations. When an influx of people occurs, several impacts on cultural heritage can emerge such as theft or vandalism committed by non-locals, but also cultural erosion, change in lifestyle and values, intangible heritage threats, loss of identity, social tensions or cultural appropriation.	Medium	Medium	Substantial	○ Include awareness about the importance of cultural heritage and values as part of the site induction. ○ Only national workers will be allowed to bring their immediate family. Foreign workers are not authorized to bring their families. ○ Develop and implement Labour Management Procedures (AM/RM) including a Code of Conduct and a procedure for the demobilisation of the workforce at the end of the construction period; Cultural Heritage Management Plan and Chance Find Procedure (AM/RM) that promotes the preservation and promotion of cultural heritage while accommodating changes brought by the influx; and a Grievance Redress Mechanism (RM).		Moderate
	Poaching and illegal natural resources collection	Poaching and illegal collection of natural resources by newcomers can have significant negative impacts on communities, ecosystems, and biodiversity. These illegal activities can disrupt the delicate balance of natural environments and undermine the well-being of local communities that depend on these resources.	Low	Medium	Moderate	○ The Contractor will provide recreational facilities within the main camps. ○ The Project will have a Zero Tolerance Policy for illegal poaching and illegal natural resources collection. ○ The consumption of bush meat is strictly prohibited for Project workers. ○ The Project Manager and Security Manager will liaise regularly with the Royal Bhutan Police and other agencies to share information. ○ Develop and implement a Biodiversity Management Plan (AM/RM); a Labour Management Procedures (AM/RM) including a Code of Conduct; a Security Management Plan and a Camp and Technical Installation Site Specific Plan.		Moderate

	Disruption of social links and organization (family and community cohesion)	The arrival of newcomers can disrupt existing social dynamics and structures, leading to changes in how communities interact and organize themselves. The presence of newcomers can sometimes lead to mistrust or suspicion within the community, impacting social cohesion. Cultural differences may challenge the existing sense of community identity and belonging, and sometimes escalate into conflicts.	Low	Medium	Moderate	○ Develop and implement a Stakeholders Engagement Plan (AM/RM) ○ Develop and implement Labour Management Procedures (AM/RM) including a Code of Conduct ○ Develop and implement a Grievance Mechanism (RM).		Moderate
	Tension during demobilization	The departure of workers can have economic impacts as the economic activity in the area can decrease, potentially leading to financial stress for businesses that rely on workers' spending. Also, as foreign workers contribute to cultural diversity and interaction within the community, their departure can lead to a reduction in cross-cultural experiences. Workers may have formed social bonds within the community and their departure could affect these relationships and interactions.	Medium	Medium	Substantial	○ The Contractor will be required to transport back the foreign workers at their original point of origin free of charge. ○ DGPC will liaise with local authorities about the demobilisation of national workers. ○ Develop and implement Labour Management Procedures (AM/RM) including a Code of Conduct and a procedure for the demobilisation of the workforce at the end of the construction period; and a Grievance Redress Mechanism (RM).		Moderate

	Long term settlement creating tensions	Long-term settlement of construction workers and camp followers in communities can have a range of impacts, both positive and negative, on the social, economic, cultural, and environmental aspects of the host communities. These impacts depend on factors such as the scale of settlement, the characteristics of the newcomers, the level of integration, and the community's capacity to absorb the population increase.	Low	Medium	Moderate	○ Undertake a survey among national workers 6 months prior to the end of the construction period, to register their intent in terms of long-term settlement in the Project Area. ○ Develop and implement Labour Management Procedures (AM/RM) including a Code of Conduct and a procedure for the demobilisation of the workforce at the end of the construction period; and a Grievance Redress Mechanism (RM).		Moderate
Procurement and purchase of local goods	Opportunities for local supply and local businesses	Local supply of resources to accommodate newcomers can have positive economic and social effects on the community, promoting local businesses, generating employment, and contributing to the overall development of the area.	+	+	+	○ Preference for local business licences will be attributed in order to: PAPs, local residents from the Project Area, local resident from Mongar / Lhuentse and Bhutanese nationals and foreigners. ○ The Contractor will engage with the Gups and local authorities to ascertain the potential to source good and services form local areas. ○ Develop and implement a Local Procurement Procedure.		
	Opportunities for maintaining local services	The provision of basic services can be maintained or increased by the social influx, as workers, camp followers and their families will need those services (healthcare, education, transportation, etc).	Positive	Positive	Positive	○ Engage with local authorities and schools about the enrolment of additional students in the local schools		

	Inflation risks	The inflation risks can impact housing costs, leading to rising property prices and rental rates and, if housing supply does not keep up with demand, it can contribute to a lack of affordable housing options, driving up costs. Local communities and newcomers may be faced with prices that are too high and no longer be able to afford certain goods, thus seeing their standard of living decline.	High	Medium	High	○ Local prices will be monitored by the local regulatory authorities. ○ The vast majority of the workforce will be housed in the main camp. Only a limited number of national workers and consultants are likely to be housed in local guesthouses. ○ The Contractor will source some of its main good from outside of the Project Area (for instance in terms of fuel, cement, construction materials) while also considering opportunities for local procurement bringing benefits to the community. ○ Develop and implement a Local Procurement Procedure.		Moderate
	Competition for energy resources	The Project will have its own fuel farms, power supply and will only seldomly source energy from the local area. During the pre-construction and preparatory stages, the Contractor may use some of the local service to refuel vehicles, but it should be very limited and temporary	Low	Low	**Low**			
	Creation of guest house for Project workers	The creation of guest house for Project workers has an impact on local communities, as this accommodation creates jobs for its construction, management and stewardship. This job creation helps to diversify employment opportunities for the local population, and to improve skills.	Positive	Positive	Positive	○ Develop and implement Local Procurement Procedure		

	Leasing / renting of land for Project facilities	The leasing and renting of land by the local communities for the Project facilities can enable local communities to increase and/or stabilize their income.	Positive	Positive	Positive	○ Develop and implement Local Procurement Procedure.		
	Significant drop-in activities and opportunities at the end of construction	The significant drop-in activities and opportunities at the end of construction can have various risks and negative impacts on local communities, bringing economic, social, and infrastructural challenges as construction workers and their families and camp followers leave the area. Many jobs in construction-related industries, as well as supporting sectors like hospitality and retail, might be lost as construction activities wind down.	High	Medium	High	○ Develop and implement Labour Management Procedures (AM/RM) including a procedure for the demobilisation of the workforce at the end of the construction period; and a Grievance Redress Mechanism (RM). ○ Develop and implement a Local Procurement Procedure.		Moderate
Land use	Increased pressure to access flat land in the valleys	Flat land is already a scarce resource for local communities to both house local families and agricultural or pastoral activities. The increased pressure on flat land can lead to local communities being unable to invest land for subsistence activities, or even selling it for a quick return without reinvesting this income in sustainable subsistence investments.	High	Medium	High	○ The Project facilities built during construction should be decommissioned and rehabilitated at the end of the construction period to release some flat land.		Substantial
Access to NGOs/CSOs	Improve access to CSO/NGOs	The construction phase, including the social influx of population, can bring Civil Society Organizations (CSOs) and Non-Governmental Organizations (NGOs) to develop their activities in the area and have a positive impact for local communities.	Positive	Positive	Positive	○ Develop and implement a Stakeholders Engagement Plan (EM). ○ Gender and Vulnerability Action Plan (TM/EM)		

Capacity building	Opportunities to do capacity building of local Gvt agencies	Capacity building of local governmental agencies in the context of the Project involves enhancing their skills, knowledge, resources, and institutional capabilities to effectively plan, manage, and oversee construction activities.	Positive	Positive	Positive	○ Capacity assessment and capacity building plan (TM/EM) ○ Gender and Vulnerability Action Plan (TM/EM) ○ Develop and implement a Stakeholders Engagement Plan (EM).		
Direct employment	Employment of local skilled and unskilled labour	The individuals employed during the construction stage, and their household members, will benefit from increased income that is likely to increase their overall standard of living, access to healthcare and educational resources, and reduce their socio-economic vulnerability.	Positive	Positive	Positive	○ Develop and implement Labour Management Procedures (AM/RM) including a procedure for the demobilisation of the workforce at the end of the construction period; and a Grievance Redress Mechanism (RM).		
Employment of workers and subcontractors	Labour conditions, contract and payments	Potential risks of an unsafe environment, risk of accidents, injuries and legal liabilities. Non-compliance with labour laws and regulations. Ambiguity and misunderstanding with the contractual terms. Disputes over work quality, delays, or change of orders can lead to payment disputes.	Medium	High	High	○ Develop and implement Labour Management Procedures that shall apply to the Contractor and any subcontractor (AM/RM). ○ Develop and implement an Occupational Health and Safety Management Plan (AM/RM). ○ Develop and implement a Grievance Redress Mechanism for workers in their working conditions (RM). ○ The Contractor shall audit the Labour conditions, contract and payments of foreign and national workers on the construction site, ensuring it is compliant with local laws (MM).		Moderate

	Accommodation and living conditions	Low quality and availability of accommodation can have a significant impact on worker well-being, low sanitation and hygiene are prone to the spread of diseases, and Lack of compliance with safety standards increase of fire hazards, structural failures, and other safety risks. Lengthy commutes or difficult transportation options led to fatigue and reduced productivity. No respect for workers' cultural and social norms, no spaces for relaxation, religious practices, and social interaction.	Medium	High	High	○ Develop and implement a Labour Accommodation Plan) ("The management of the construction workers colonies, (IFC standards) (AM/RM). ○ Develop and implement an Occupational Health and Safety Management Plan (AM/RM). ○ Develop and implement a Grievance Redress Mechanism for workers on their living conditions (RM). ○ The Contractor shall audit the workers accommodation and living conditions on a regular basis (MM).		Moderate
Cultural heritage	Direct damage or destruction of tangible cultural heritage	There is a potential risk of impact on cultural heritage sites that may not be identified at this stage during the project construction works.	Low	Medium	Moderate	○ Develop and implement a Cultural Heritage Management Plan including a Chance Find Procedure (AM/RM) ○ Develop and implement a Stakeholder Engagement Plan (AM/RM) ○ Develop and implement a Grievance Mechanism (RM).		

10.5 Analysis of impacts related to the operation of the HPP

10.5.1 Impacts on Physical Environment

10.5.1.1 Impact on hydrology and hydraulics

The Dorjilung Hydroelectric Power Project features a diurnal storage system encompassing a gravity dam with a height of 85m. The reservoir's water levels are strategically managed, with an FRL set at 850m asl and a MDDL of 840m asl. This configuration allows for a live storage capacity of approximately 12.62 Mm^3, facilitating continuous peaking operations for up to 8 hours.

The proposed Dorjilung dam will be built at an elevation of 768m above sea level. The dam site's authorized Kurichhu sub-basin has an area of 8,782 km^2. The Dorjilung dam receives an average annual flow of 281.87 cumecs and the annual inflow volume is substantial, averaging at 8,895.38 MCM, with a peak flow reaching 1,348.14 cumecs, signalling the potential for flood events.

The maximum gross head stands at 306 m, while the minimum gross head is 296m, resulting in a head loss of 25m under full plant load. The reservoir itself offers substantial storage capacity, with approximately 44.17 Mm^3 available at the Full Reservoir Level and 31.55 Mm^3 at the Minimum Draw Down Level.

Design flood studies reveal the likelihood of encountering high-volume flood events. The calculated Probable Maximum Flood (PMF) for the Dorjilung HPP stands at a considerable 11,885 m^3/s (draft DPR 2024 update, accounting for GLOF). The operation of a hydropower project can lead to several potential impacts on the physical environment, particularly related to the reservoir and its interaction with the hydrology and hydraulic flows of the area. This impact can include:

- Fluctuating water levels, influenced by differences between FSL and MOL, as well as the diurnal storage approach, introduce variability. During periods of intense precipitation or rapid snowmelt, the reservoir may face difficulties in managing excess water, increasing the likelihood of spilling during the period of June to September.
- The impoundment of the dam will induce the rise of water surface elevation in the reservoir area. This impact will be systematically observed once the dam is built. It is a significant change for the local environment and will occur during the entire lifespan of the dam.
- The operation of the dam has an impact on the river flow caused by the regulation capacity of the reservoir. Nevertheless, the project is a small storage scheme and the potential impact of the project on annual modifications of hydraulics flows is limited.
- The impoundment of the reservoir will reduce the flow downstream of the dam. Therefore, reservoir filling might have a severe impact on downstream flow. The severity of the impact directly depends on the duration of the impoundment.
- Rapidly released water during periods of high inflow can alter downstream water levels, potentially contributing to flooding.
- The modification of hydrochemical conditions between upstream and downstream of the dam can have several significant impacts on the aquatic ecosystem and water quality.

The likelihood of the impact is **Medium,** and the severity is **High**. The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Efficient Reservoir Management Strategies (AM): Implementing effective reservoir management strategies involves optimizing the operation of the reservoir to manage inflow and outflow during various conditions, including flood events. This can be achieved through the controlled release of water from the reservoir in anticipation of or during heavy rainfall periods. By carefully managing the

reservoir's water levels, the risk of sudden overflow and downstream flooding can be minimized. This might involve real-time monitoring of weather forecasts, inflow rates, and water levels to make informed decisions about releasing excess water gradually.

- Proper Flood Forecasting and Warning Systems (AM): Establishing accurate flood forecasting and warning systems is crucial to alert downstream communities and relevant authorities about potential flood events. These systems use advanced meteorological and hydrological data to predict and monitor rising water levels and the likelihood of flooding. Timely alerts enable affected communities to take precautionary measures and evacuate if necessary, reducing the risk of casualties and property damage.
- Adequate Maintenance of Spillways (AM/RM): Regular maintenance of spillways ensures that they remain functional and capable of safely channelling excess water away from the reservoir. Damaged or blocked spillways can impede the controlled release of water, increasing the chances of uncontrolled overflow and downstream flooding. Maintenance procedures should include routine inspections, repairs, and clearing debris to ensure spillways are ready to handle increased water flow during flood events.
- Establishing Emergency Response Protocols (RM): Developing well-defined emergency response protocols outlines the steps and responsibilities to be taken in the event of a flood. These protocols encompass coordination among relevant authorities, communication plans, evacuation routes, and procedures for mobilizing resources and assistance to affected areas. Having a clear plan in place helps minimize confusion and ensures a swift and organized response to mitigate flood impacts.
- Careful Planning and Ongoing Monitoring (MM): Careful planning involves considering potential flood impacts from the initial stages of project design. By incorporating flood risk assessments and mitigation measures into the project plan, potential impacts can be identified and addressed proactively. Ongoing monitoring involves continuous tracking of hydrological and meteorological data to detect changing weather patterns and rising water levels.
- Adaptive Management Practices (AM): Adaptive management practices involve a flexible approach that allows adjustments to mitigation strategies based on changing conditions and new information. This could include modifying reservoir release patterns, updating flood forecasting models, or enhancing emergency response plans based on lessons learned from previous flood events. Adaptive management ensures that mitigation measures remain effective and relevant over time, even as environmental conditions evolve.
- Flow Regulation (RM): Develop a flow regulation strategy that considers the seasonal variations in water discharge. This can help in managing the release of water from the reservoir, especially during the monsoon season, to mitigate sudden and extreme changes in downstream flow.
- Reservoir Operation Protocol (RM): Establish a well-defined reservoir operation protocol that considers the inflow-outflow dynamics to maintain a stable and gradual change in water levels. This can help in minimizing abrupt fluctuations that could impact downstream ecosystems.
- Environmental Flow Releases (AM/RM): Implement environmental flow releases that mimic natural flow patterns, particularly during low-flow periods. This can contribute to maintaining downstream ecosystems and supporting aquatic life.
- Sediment Management (RM): Design and implement sediment management strategies to prevent excessive sediment build-up within the reservoir. Regular sediment flushing or controlled releases can help in maintaining reservoir storage capacity and reducing downstream sedimentation.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial**.

10.5.1.2 Degradation of the water quality in the reservoir and downstream

The reservoir area will be around 6.80 km² with about 44.17 Mm³ of gross storage and 12.62 Mm³ of live storage. The creation of the reservoir may increase the retention time of the water at the dam site.

The risk of water pollution is mostly related to the retention time of the water in the reservoir (relation between inflow, outflow, and reservoir's volume), to the reservoir's depth, to the organic matter flooded during the reservoir filling and to the water's temperature. Retention time leads to the alteration of the physicochemical water quality in the reservoir and downstream due to project: evaporation in the reservoir, low temperatures during periods of low flow, silt concentrations in the streams and low levels of dissolved oxygen. Given the relatively small volume and anticipated low retention time of the Dorjilung reservoir, the potential issues related to water quality, stratification, and long-term impacts should indeed be limited compared to larger reservoirs.

The likelihood of the impact is **Low,** and the severity is **Medium.** The significance of the potential impact is considered **Moderate**.

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Sediment Management (RM): Implement sediment management strategies to reduce sedimentation in the reservoir. This may include installing sediment basins, regular dredging, and erosion control measures in the catchment area.
- Temperature Regulation (AM/RM): Develop strategies to regulate water temperature in the reservoir. This can involve adjusting release rates to mimic natural flow patterns and maintain suitable temperature ranges for aquatic life.
- Nutrient Control (RM): Implement watershed management practices to control nutrient inputs into the reservoir. This may involve promoting sustainable land use practices and vegetation cover to reduce nutrient runoff.
- Algae Monitoring and Control (MM): Establish monitoring programs to detect early signs of algal blooms. Implement control measures if necessary, such as the application of algaecides, aeration, or nutrient reduction strategies.
- Water Quality Monitoring (MM): Continuously monitor water quality parameters such as temperature, dissolved oxygen, turbidity, and nutrient levels. This allows for timely intervention and adjustment of reservoir operations if water quality deteriorates.
- Flow Management (AM): Manage flow releases from the reservoir to minimize abrupt changes in downstream water quality. Gradual releases that mimic natural flow patterns can help maintain water quality consistency.
- Erosion Control (AM/RM): Implement erosion control measures in the catchment area to minimize sediment input into the reservoir. This includes vegetative cover, buffer zones, and sediment traps.
- Public Awareness and Education (TM): Raise awareness among local communities and stakeholders about the importance of maintaining water quality. Encourage responsible waste disposal practices and sustainable land management.
- Emergency Response Plan (RM): Develop an emergency response plan to address sudden water quality degradation events, such as chemical spills or harmful algal blooms.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.1.3 Modification of sediment transport and erosion

The dam constitutes a physical and permanent obstacle to sediment continuity and will alter sediment transport by the Kurichhu River. The reservoir functions as a settling zone for suspended matter.

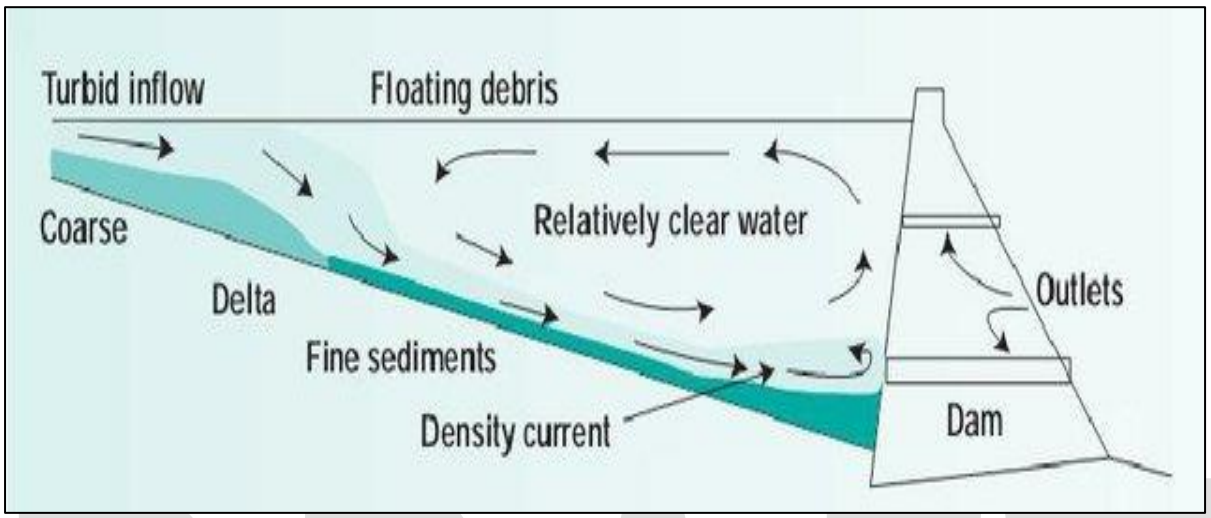


Figure 198: Conceptual diagram of sediment trapping in reservoirs (Ketelsen T. 2013)

As a river flows into a reservoir, its velocity abruptly decreases, causing a significant reduction in sediment transport capacity. Consequently, the sediment load, comprising both bedload and suspended particles, is deposited within the reservoir. Coarser sediments carried as bedload tend to settle towards the reservoir's tail, while finer sediments accumulate nearer to the dam. This can potentially trigger gravity currents depending on sediment size, concentration, and characteristics. The degree of sediment trapping varies based on particle size, with coarser particles (medium to coarse sand) being more effectively trapped within the reservoir. Finer particles (fine sand and smaller) can pass through the dam.

The trapping efficiency in for medium and coarser particles reaches 100% for discharges lower than approximately 500 m^3/s. Numerical model results demonstrate that, for drawdown flushing from FSL to MOL, trapping efficiency decreases over the initial years: 94% (2 years), 73% (4 years), 62% (6 years), 53% (8 years), and 43% (10 years). Similarly, for drawdown up to Conservation Level (CL), trapping efficiency is 89%, 66%, 57%, 48%, and 39% for the same timeframes. Sensitivity analysis confirms that the designated intake and spillway crest level are suitable for flushing and ensuring the reservoir functions as a desilting basin. Sedimentation in the reservoir therefore has no impact on the life of the project.

Evaluation of the spillway crest level and intake location reveals that the scour cone, even after 50 years of reservoir sedimentation, will extend approximately 900 m and 1150 m upstream of the power intake location for MOL and CL drawdowns, respectively. The 2D model shows that bed shear stress remains below 0.05 N/m^2 in the main reservoir area for an initial discharge of 500 m^3/s, suggesting that particles larger than 0.2 mm should settle in this region. Considering the targeted particle size (0.2 mm and coarser), results from both 1D and 2D simulations indicate that the reservoir will inherently function as a desilting basin. However, its effectiveness in this role is anticipated to diminish over time.

Table 190: Overview of sediment related impacts

Source of impacts	Impacts	Receiving environment	Potential impact
Reservoir presence	The reservoir's presence can disrupt the natural flow and distribution of sediment downstream, impacting river morphology and geomorphology.	Downstream rivers and tributaries	Changes in river morphology and habitat.

Source of impacts	Impacts	Receiving environment	Potential impact
	This can affect aquatic habitats, riverbanks, and ecosystem dynamics.		
Changes in sediment transport	Changes in sediment transport can affect species relying on specific riverbed conditions for survival and reproduction. Fish spawning grounds and breeding habitats might be altered, impacting fish and other aquatic populations.	Riverbeds and aquatic habitats	Decline in fish and aquatic species.
Various downstream changes	Various downstream changes might occur, including alterations in channel width, depth, slope, meander wavelength, sinuosity, current velocity, and maximum depth, impacting local ecosystems and habitat.	River morphology and habitats	Changes in channel characteristics.
Variation of Discharge Rates	Sudden release of "clear" water from the reservoir, along with varying discharge rates, can trigger erosion downstream due to sediment supply disruption	Surface and ground water	Increased erosion and instability
Reservoir shape	The reservoir will initially act as a desilting basin, removing coarser particles. However, efficiency will decrease over time due to sediment accumulation.	Reservoir inflow and water quality	Efficiency of Desilting Action
Controlled Water Release	The reservoir's presence and controlled water release for sediment management can alter downstream flood dynamics, impacting local communities and ecosystems.	Downstream areas and communities	Altered Downstream Flood Dynamics

The likelihood of the impact is **High,** and the severity is **High.** The significance of the potential impact is considered **High.**

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Maximizing Dam Transparency (AM/RM): The fundamental strategy to mitigate sedimentary impact involves minimizing the trapping of sediments within the reservoir. Rather than relying on sediment flushing, it's more effective to prevent sediments from being trapped in the first place. This approach focuses on maintaining the reservoir's transparency to sediment flow.
- Critical Period Management: Certain periods are particularly crucial for sediment management. High sediment occurs during peak flows, often coinciding with the beginning of the wet season. Being aware of these critical periods allows for proactive management strategies.
- Integrated Sediment Management (RM): Define and implement environmental measures to accompany sediment management for dam operation; ideally, the whole sediment management strategy should be designed with environmental sustainability in mind.
- Sediment Flushing (AM/RM): Sediment flushing is the controlled release of water to mobilize and carry sediments downstream. It's recommended to investigate this method as a primary approach, effectively preventing sediment buildup near the water intake.
- Dredging (RM): Dredging involves physically removing trapped sediments from the reservoir. This technique can be considered as a supplementary measure to sluicing, focusing on targeted areas with high sediment accumulation.
- Localized Sediment Management (MM): In areas where sediment accumulation is a concern, localized measures like dredging or sediment flushing can be used to maintain clear pathways for water intake and reduce sediment impact.

- Monitoring and Adaptive Management (MM): Regular monitoring of sediment accumulation and water quality allows for timely adjustments to sediment management strategies. Adaptive management ensures that mitigation measures remain effective as conditions evolve.
- Long-term monitoring (MM): Implement a sustained monitoring program that tracks hydromorphological shifts of the Kurichhu River from its source to its estuary. This long-term monitoring ensures the prompt identification of any changes, allowing timely corrective actions.
- Unforeseen Impacts (RM): Corrective measures may be required to compensate for unidentified impacts on aquatic environments (clogging of habitat zones, for example) or on the human environment (for example, or access to water, even though this activity has not yet been identified in the region).
- Public Awareness and Community Engagement (TM): Informing local communities about sediment management strategies, their benefits, and potential impacts fosters a sense of involvement and cooperation, enhancing the overall success of the mitigation efforts.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Substantial.**

10.5.1.4 GHG Emissions

10.5.1.4.1 Bhutan hydropower GHG

The Power System Master Plan 2040 in Bhutan, prepared in November 2019 (JICA, 2019) included consideration of the potential to reducing GHG emission through hydropower developments in Bhutan.

This report notes the following on the value of GHG emission reductions:

- A hydropower plant is a power generation system that does not generate CO2 at all during power generation. Therefore, it is possible to reduce CO2 emissions in neighbouring countries by developing a hydropower plant in Bhutan and selling the power generated to neighbouring countries. According to the CO2 Baseline Database for the Indian Power Sector, CEA (2016), the CO2 emissions factor in 2016 in the power sector in India is 0.82 t-CO2/MWh, due to the high proportion of coal-fired thermal power plants. In India, it is a policy to promote the development of renewable energy, and it is assumed that this emission factor will gradually decrease. (Section 4.6).
- If the power generated in Bhutan is exported to India, it will be possible to reduce the amount of thermal power generation in India and reduce CO2 emissions by about 0.7 tons per MWh. This will contribute to reducing CO2 emissions by about 20 million tons annually. (Section 8.3).

Based on this report it is considered that the GHG emitted in development of Dorjilung HPP would be considered to contribute to an overall reduction in GHG emitted as this energy would replace energy from coal fired production in India.

10.5.1.4.2 Project GHG Calculations

This section provides a summary of the Green House Gas (GHG) emissions assessment for the Project. The full GHG assessment was provided in the Task IV.3_Climate Resilience Assessment prepared for the Dorjilung HPP by Studio Pietrangeli (December 2023, see ESIA Volume 3 Appendix P).

Greenhouse gases are those gases in the atmosphere that raise the surface temperature of the Earth. Human activities have increased the concentration of Carbon Dioxide (CO2), Methane (CH4) and other greenhouse gases (GHG) in the atmosphere. This is the reason for the Kyoto Protocol, an international treaty that commits signatory states to reduce greenhouse gas emissions. Bhutan signed the Kyoto Protocol on August 26, 2002.

The vast majority of greenhouse gases emissions by humans come from the combustion and production of fossil fuels. However, hydropower plants also generate GHG emissions. In fact, freshwater reservoirs emit GHGs because the flooded land beneath freshwater reservoirs provides a new source of organic matter available for decomposition and because they create new environments favourable to the production of methane, a more potent GHG than CO2.

The GHGs potentially present in the footprint of the HPP include gases listed in the Kyoto Protocol, such as:

- carbon dioxide (CO2)
- methane (CH4)
- nitrous oxide (N2O)

from the reservoir area, and

- sulphur hexafluoride (SF6)

a potentially fugitive gas from electrical equipment of substations.

10.5.1.4.3 G-Res Methodology

The Climate Resilience Assessment calculated GHG emissions for the Project using the G-res tool provided by the International Hydropower Association (IHA). The inputs needed for the G-Res tool were taken mainly from the DPR (2015-2016 INFRATECH MAIN REPORT). Some other data like land cover data were taken from the European Space Agency (ESA), Annual wind speed and Reservoir Mean Global Horizon Radiance were calculated from measured data from Tamachu stations and from ERA5 temperatures.

10.5.1.4.4 G-Res Results

Using the G-Res tool, calculations are provided for emissions per m^2 of reservoir, for the total reservoir, and also the total lifetime emissions (estimated to be over 100 years using GWP100 of 34).

The Total Emissions per m2 of Reservoir was 1039 gCO2e/m^2/yr. The Total Reservoir Emissions per year was 6782 tCO2e. The Total lifetime emissions in 662,852 tCO2e. The estimated GHG emissions factor for the Project is 1.4 g $CO2_{eq}$/kWh.

It is noted that the construction phase is the main source of GHG emissions. The construction phase module in G-Res provides an indicative estimate of the construction phase emissions which includes the manufacture of raw materials, transportation of materials to, from and around the site, and the energy used from plant used for installation of reservoir infrastructure. The quantities are categorized as follows: Earthworks, Fill, Concrete works, Steelworks, Roads and Bridges, and Equipment. Emissions are calculated in the tool based on values provided for quantities of material and the distance each material travelled to/from site.

This data is presented in further detail in Table 191 and Table 192., and in full in the Climate Resilience Assessment.

Table 191: Results of G-Res Analysis for Reservoir GHG Footprint

	Post Impoundment	-	Pre-Impoundment	-	Unrelated Anthropogenic Sources	=	Net GHG Footprint
Emissions Rate	968	-	-175	-		=	1143

	Post Impoundment	-	Pre-Impoundment	-	Unrelated Anthropogenic Sources	=	Net GHG Footprint
(tCO_2e/yr)							
Of which CO_2	97	-	-182		n/a	=	278
Of which CH_4	872	-	6	-		=	865
Emissions Rate ($gCO_2e/m^2/yr$)	880	-	-159	-		=	1039
Of which CO_2	88	-	-165		n/a	=	253
Of which CH_4	792	-	6	-		=	786

Table 192: Results of G-Res Analysis for Total GHG Footprint

	Post Impoundment	-	Pre-Impoundment	-	Unrelated Anthropogenic Sources	+	Construction (Reservoir)	=	Net GHG Footprint
Emissions per m^2 of Reservoir in $gCO2e/m^2/yr$	880	-	-159	-		+	n/a	=	1039
Total Reservoir Emissions per year in tCO2e	968	-	-175	-		+	5485	=	6 628
Total lifetime emissions in tCO2e	96802	-	-17 530	-		+	548 521	=	662 852

10.5.1.4.5 Comparison of Alternative Energy Sources

Artelia used the information provided on Dorjilung HPP in the Climate Resilience Assessment to prepare a comparison of theoretical alternative considerations. The international practice is to express GHG in CO_2 equivalents (CO_2e). Emissions of gases other than CO_2 are translated into CO_2e by multiplying by the respective global warming potential (GWP).

Comparison of theoretical alternative considerations for energy production (diesel, gas, charcoal, wind and solar) range between 10 to 1000 gCO_{2eq}/ kWh as shown in Table 193. These estimations are taken from the comparison of life-cycle emissions from thermal power generation (IPCC, 2014). In accordance with IPCC (2006), the lifetime assessment period for net GHG emissions is 100 years.

The alternatives discussed in Table 193 should be read with the understanding that these are theoretical alternatives. It is noted that for Bhutan, some of the theoretical alternatives may not be feasible due to constraints posed by the landscape. For example, wind and solar would be difficult as there is little flat land available for solar and installing wind turbines on the mountain/ridge crests would be difficult as the terrain is extremely steep.

Table 193: Comparison of energy alternatives to produce 4 558 GWh/year installed capacity

	Units	DORJILUNG HPP	Diesel	Gas	Charcoal	Wind	Solar
Annual Production	GWh/yr	4504	4504	4504	4504	4504	4504
Total Lifetime emission	kT CO_{2eq}	663	364,640	182,320	455,800	4558	18,232
Total Emission per year	kT CO_{2eq}/yr	6.63	3646.40	1823.20	4558	45.58	182.32
GHG Emission Intensity	g CO_{2eq}/kWh	1.4	800	400	1000	10	40

10.5.1.4.6 Comparison to other Hydropower developments

Comparison of the GHG Emission Intensity of Dorjilung HPP to other hydropower projects showed Dorjilung HPP is well below the median value. A study of nearly 500 global hydropower reservoirs using the G-res Tool published in Water Security and Climate Change: Hydropower Reservoir Greenhouse Gas Emissions (2021) found the median value for hydropower to be 23 gCO2-eq/kWh.

10.5.1.4.7 GHG over the life of reservoir

The concession period or expected operating lifespan of Dorjilung HPP is yet to be determined. To allow comparisons to alternative energy sources the lifetime assessment period for net GHG emissions used is 100 years in accordance with IPCC (2006).

Over 100 years, the calculated total lifetime emission for Dorjilung HPP is 663 kT $CO_{2eq.}$ Over the same period, the emissions of thermal alternatives with equivalent production would be between 4,558 ktCO_{2eq} (for wind) and 455,800 ktCO_{2eq} (for coal). This estimation is assuming constant emissions for these means, without considering possible technical improvements likely to reduce their GHG footprint.

Thus, over 100 years, the development of Dorjilung HPP would save up to 455,137 kt$CO_{2eq,}$ depending on the alternatives. From the point of view of avoiding CO2 emissions, this is therefore an excellent project.

10.5.1.4.8 Conclusion regarding GHG

The GHG impact of the Project is considered low.

The impact on GHG emissions, and therefore on the global climate, is estimated as very positive when comparison is made to a thermal alternative.

The significance of the potential impact is considered **Positive**.

10.5.1.5 Induced seismicity from the reservoir

Large hydropower scheme can be associated with Reservoir Triggered Seismicity (RTS). If RTS is considered relevant, it needs to be considered in the actual design of the dam and civil structure. It can also result in impacts on the local community. As the region may be exposed to some seismic activity, small earthquakes may be associated with RTS by the local community, regardless of the actual nature of the event.

RTS was not explicitly considered in the DPR, and it is not considered a major concern for the Dorjilung HPP.

The likelihood of the impact is **Low**, and the severity is **High**. The significance of the potential impact is considered **Substantial**.

Mitigation measures and residual impact

The following measures are proposed to address the impact:

- Comprehensive Seismic Assessment (AM): Conduct a thorough seismic hazard assessment using the latest geological and geophysical data. This assessment should identify potential fault lines, geological structures, and areas of higher seismic activity that could be impacted by the reservoir's impoundment.
- Monitoring and Early Warning Systems (AM/MM): Implement a robust seismic monitoring system that continuously tracks ground vibrations and seismic activity in and around the project area. Early warning systems can provide advanced alerts about changes in seismic activity, allowing for timely responses and precautionary measures.
- Reservoir Filling Management (AM): Manage the reservoir filling process carefully and gradually. Avoid rapid and excessive impoundment of water, as this can exacerbate stress changes in the subsurface and increase the risk of inducing seismic events.
- Water Level Adjustment (AM): Maintain flexibility in reservoir water levels. Adjustments can be made to the water levels to alleviate stress on faults and geological structures that might be triggered by sudden changes in load.
- Collabouration with Seismic Experts (AM): Collabourate with seismic experts and geologists to develop a comprehensive understanding of the geological and tectonic conditions in the project area. Their expertise can guide the design, construction, and operation of the reservoir to minimize the risk of inducing seismicity.
- Risk Management Plan (RM): Develop a detailed risk management plan that outlines procedures and actions to be taken in the event of any seismic activity. This plan should address the safety of the dam, reservoir, infrastructure, and communities downstream.
- Public Awareness and Preparedness (AM): Educate local communities about seismic risks and safety measures. Prepare communities for potential seismic events, ensuring they are aware of evacuation plans and emergency response protocols.
- Adaptive Management (AM): Implement an adaptive management approach that considers any changes in seismic activity over time. Regularly review and update mitigation strategies based on ongoing monitoring and new scientific insights.
- Regular Reporting (MM): Provide regular reports to relevant authorities, stakeholders, and communities about the monitoring of seismic activity and the effectiveness of mitigation measures. Transparency and communication are key in ensuring trust and cooperation.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.2 Impacts on Biological Environment

10.5.2.1 Variation of water quality in the reservoir and downstream

10.5.2.1.1 Potential impact

In the section 10.5.1.2 the impact on the water quality has been considered as **Moderate**. During the first years of operation, the organic matter in the reservoir will change the water quality in the reservoir. However, taking into consideration the rate of renewal of water in the reservoir and the risk of stratification, it is unlikely that the quality should significantly alter the parameters essential to the development of aquatic life, in particular with a limited decrease in oxygen and a limited increase in nutrient. This needs to be monitored. In the section 10.2.3, the impact of the footprint has been already described. There is no additional impact in the reservoir area on the river habitat already considered as modified. However, the

water quality is an important parameter in habitat restauration and biodiversity preservation in the reservoir during operation.

The downstream impact is induced by the design of the water intakes, for the tunnel intake on one hand and, for the E-Flow on the other hand. Water is mainly impacted in the dead volume of the reservoir, particularly during the first years of operation. At the first meters from the surface, the water quality is less impacted and has the highest oxygen concentration. To preserve the water quality downstream, the water intake should be as much as possible in the first meters. As the project has a tidal amplitude of 10 m it is feasible to design intake in the best water layer. This will also preserve the E-flow water quality.

The likelihood of the impact of water alteration on fish population downstream and in the reservoir is **Medium**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

10.5.2.1.2 Mitigation measure and residual impact

See 10.5.1.1 and design water intake for tunnel and E-Flow as close as possible of the surface (part of the reservoir with the best water quality).

After mitigation measures the residual impact will be **Moderate**.

10.5.2.2 Effects of the variations of the sediment load on aquatic fauna

10.5.2.2.1 Potential impact

The creation of the dam will generate a decrease in the sediment load downstream. Indeed, the sediment load corresponds to the quantity of sediment transported and is therefore linked to the flow rate. Flow rate that will decrease with the creation of the dam.

The sediments are important for the aquatic fauna because they create a diversity of substrates that offer different habitats and conditions for their life cycle, such as spawning area. However, the lake of Kurichhu dam is located just downstream, at the exit of Dorjilung dam. The river flow is already affected by this dam, as well as the sediment transport.

The likelihood of the impact of water alteration on fish population downstream and in the reservoir is **Medium**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

10.5.2.2.2 Mitigation measure and residual impact

See 10.5.1.1 and 10.5.1.3

After mitigation measures the residual impact will be **Moderate**.

10.5.2.3 Sediment flushing

10.5.2.3.1 Potential impact

Management flushing to remove sediments accumulated upstream of the dam will partially restore sediment continuity and de-silt the water body. If these manipulations do not comply with certain rules, they can lead to downstream habitat degradation and a net loss of aquatic species, including endangered species. They can be the cause of

Individuals are being carried downstream by the sudden increase in flow. This can displace fish and their offspring, especially species like *Schizothorax richardsonii*, which continue to spawn until late autumn.

An influx of fine sediments that can obstruct fish gills.

Habitat changes such as the partial or destruction of spawning grounds and the clogging of the riverbed.

A risk of reduced dissolved oxygen levels in the water, which could lead to fish mortality.

The release and dispersal of sediments potentially containing contaminants of industrial (e.g. quarries located upstream), domestic, agricultural or natural origin.

The likelihood of the impact is **High**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

10.5.2.3.2 Mitigation measure and residual impact

To mitigate this impact, it is necessary to improve knowledge of the tolerance threshold of the species present, and to prepare sediment hunts carefully (AM/RM): assess the quality and quantity of the sediment, determine the best time and frequency for flushing, particularly in relation to reproduction periods, monitor water quality throughout the flushing operation, and if necessary, provide refuge areas for fragile species.

See 10.5.1.3 for more measure.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

It will be essential to pair this operation with the operation of the downstream dam.

10.5.2.4 Risk of fauna being trapped and drowns during reservoir impoundment.

10.5.2.4.1 Potential impact

During the filling stage, some species could be trapped and drowned as the water level rises. The primates will be able to escape using high trees and leave the area easily. Even if the area is known as steep with rocky slopes, medium mammals can cross from one side to another (biological corridor known for its role of connectivity). With topography analysis, no significative island should be created during the filling, which does not create additional traps. The most impacted taxons that have a low dispersion capacity, such as the insects, the small mammals, and the plants. Concerning the fish, there are no escape routes.

The likelihood of the impact is **Medium**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

10.5.2.4.2 Mitigation measure and residual impact

To mitigate this impact, specific measures can be implemented:

- Schedule a slow impoundment of the reservoir to allow sensitive species to escape (RM). The speed to be confirmed by E-flow assessment should be about 4 weeks.
- The correct implementation of the first impoundment management plan (RM). Some measures can be added to this plan such as avoiding the breeding period for fish (AM) and the management flow during the filling period must be assessed in detail in the e-flow. The filling period must fit with the high flow period, from June to September, to be smoother.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Low**.

10.5.2.5 Risk of fish mortality related to the operation.

10.5.2.5.1 Potential impact

The operation could pose certain risks to fish populations, including the potential for fish mortality. The water catchment at the dam is likely to carry fish to the penstock and then to the turbines at the plant, as well as the instream flow. Turbine mortality and injury rates are not uniform and can significantly differ based on several factors. These factors include the species in question, the type of turbine used, and the location of the water intake. Some fish species (such as the Crayfish), that swim downstream, may

experience notably high mortality rates in specific turbine setups. It's important to note that while these concerns exist, none of the fish species in the area are currently classified as threatened according to the IUCN.

The likelihood of the impact is **High**, and the severity is **Low**. The significance of the potential impact is considered **Substantial**.

10.5.2.5.2 Mitigation measure and residual impact

General measures on the HPP operation can be applied here 10.5.1.1. Some grids / screens can also be installed to limit fish passage to the turbines.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.2.6 Impacts of peaking activities

10.5.2.6.1 Potential impact

The Dorjilung HPP Scheme will be operated in peaking mode which will create significant and rapid changes in water levels between the tailrace tunnels and the tail of Kurichhu reservoir. The estimates of water levels changes are not available, but they are likely to be sudden and significant.

In the reservoir

See previous impact 10.5.2.4

In the reservoir, the impact on fauna (fishes and invertebrates) will be essentially linked to the drifting of species, swept away with the water. The average time of a peaking operation is estimated to be 3 hours. The tidal effects should not have an impact on the fauna as the water quality is good on the first 10 meters and the loss of water during the peaking event will not go above this value. The quality of the water in the reservoir will remain good.

The likelihood of the impact is **High**, and the severity is **Low**. The significance of the potential impact is considered **Substantial**.

Downstream

The Kurichhu dam is located 1km downstream Dorjilung project. Kurichhu dam will play the role of a demodulation basin. The impact of peaking will thus have several impacts on a short section:

- On aquatic fauna: loss of stable habitat and spawning area, tearing off the macroinvertebrates which will not be properly fixed to the substrates.
- On aquatic flora: constant modifications of the habitat on the riverbanks.
- On terrestrial flora: constant modifications of the water level on the riverbanks and increase of the erosion.

The restitution points after peaking events are at the end of the short-circuited section. The peaking will thus not have an impact on the implementation of the e-flow.

The likelihood of the impact is **Medium,** and the severity is **low**. The significance of the potential impact is considered **Moderate**.

10.5.2.6.2 Mitigation measure and residual impact

For fish mortality in the reservoir, see 10.5.2.5.2

Because the Kurichhu dam plays the role of demodulation basin, the short-circuited section is not impacted and the impacted section is very short, it is considered that the peaking operation is possible for such

project. When a peaking scheme is planned for an operation, it is not possible to implement mitigation measures.

The residual impact will be **Moderate**.

10.5.2.7 Risk of invasive species proliferation

10.5.2.7.1 Potential impact

The proliferation of terrestrial invasive species, both in terms of fauna (animals) and flora (plants), is a potential impact associated with reservoir creation. The reservoir's altered hydrology and water quality can create a habitat that is more suitable for certain invasive species especially during the first years of operation. Invasive species can be introduced during the construction phase, machinery, vehicles, and equipment used during the construction phase can inadvertently transport invasive species. Mud and debris on equipment can contain invasive plant seeds, insect eggs, or small aquatic organisms. The potential consequences of the proliferation of invasive species, from the construction phase through to the operational phase, can lead to a reduction in native biodiversity, disrupt the natural balance of ecosystems, and elevate the overall costs associated with ecosystem management and restoration.

The likelihood of the impact is **Medium**, and the severity is **Medium**. The significance of the potential impact is considered **Substantial**.

10.5.2.7.2 Mitigation measure and residual impact

See general measures to prevent the proliferation of invasives species.

After proper development and implementation of relevant measures, the residual impacts are considered **Moderate**.

10.5.2.8 Impacts of accidental turbines shut down on biodiversity

10.5.2.8.1 Potential impact

In the event of a turbine shutdown, the downstream consequences can be significant on aquatic organisms and on riparian environments with a drop in water levels and possible degradation of water quality.

With an active storage of 16.62 hm^3, an average low flow of 60 m^3/s and a minimum environmental flow of 10 m^3/s, the maximum reservoir filling duration is approximately 4 days during which the flow in downstream of the discharge point will be the minimum environmental flow. In the stretch between the discharge point and Kurichhu reservoir, the flow and water level will reduce significantly. The drop in water levels at the banks will be the main cause of mortality by stranding fish, particularly juveniles.

No impact is expected on vegetation considering the shutdown frequency, the maximum possible duration before overflow and the affected area.

For fishes the likelihood of the impact is **low**, and the severity is **Medium** as the impacted area is limited. The significance of the potential impact is considered **Moderate**.

10.5.2.8.2 Mitigation measure and residual impact

As part of the design, the following measures must be put in place:

- Maintain environmental flow (RM): the previous sections have already provided environmental flow requirements for riparian vegetation and fish population, which will also be effective in mitigating the impact of an accidental shutdown.

With an adequate environmental flow, the accidental shutdowns will not have additional residual impact.

10.5.3 Impacts on Human Environment

10.5.3.1 Community Health and Safety issues

10.5.3.1.1 Incidence of waterborne or water related diseases.

The damming of rivers and alteration of water flow can impact aquatic ecosystems, potentially leading to changes in water quality and the spread of waterborne diseases. Poor water quality can result in reduced access to safe and clean drinking water, forcing communities to rely on contaminated sources and perpetuating the cycle of disease. Stagnant water in reservoirs can create breeding grounds for disease-carrying vectors like mosquitoes, potentially increasing the risk of diseases like malaria and dengue.

These issues were not reported for the Kurichhu reservoir which has been impounded over 10 years ago about 15 km downstream of the future Dorjilung reservoir. Given the relatively short retention time, it is not expected to be an issue for the Project.

The likelihood of the impact is **Low,** and the severity is **Low**. The significance of the potential impact is considered **Moderate**.

The following measures are proposed to address the impact:

- Liaise regularly with the local health authority, in particular Mongar Regional Referral Hospital, to monitor and identify any increasing trend in waterborne disease incidence.
- Develop and implement an Operational ESMP.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Low**.

10.5.3.1.2 Risk of drowning during reservoir impoundment

During the reservoir impoundment phase of a hydropower plant's operation, there can be a risk of drowning for individuals who are not adequately informed or prepared for the changes in water levels. Reservoir impoundment involves filling the reservoir behind the dam, which can result in rapidly rising water levels and changes in currents that may catch people off guard.

Local communities, and recreational users might not be fully aware of the impoundment schedule or the potential hazards it brings. As it is proposed to have the reservoir vegetation partially cleared prior to impoundment, this also increases the risks of community members collecting wood products being caught by rising waters.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial**.

The following measures are proposed to address the impact:

- Develop and implement a targeted awareness program at least 1 month prior to first impoundment.
- Install temporary signage informing local communities about the upcoming reservoir filling at least 1 month prior to first impoundment.
- Undertake an onsite patrol just before and throughout impoundment to directly identify persons being exposed, warn / rescue them. This measure would be coupled with the similar actions targeting fauna being trapped and drowning.
- Develop and implement a Reservoir Impoundment Plan (AM/RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.3.1.3 Risk of drowning in the reservoir

Deeper reservoirs with strong currents can pose higher risks, especially for individuals who are not strong swimmers. Submerged objects, debris, and structures in the reservoir can pose risks to swimmers and boaters. If the reservoir is easily accessible and attracts recreational users, the risk of drowning might be even higher due to increased human activity around the water.

It is understood that most of the local community do not how to swim. There was no reported drowning for the Kurichhu reservoir which has been impounded over 10 years ago about 15 km downstream of the future Dorjilung reservoir.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial**.

The following measures are proposed to address the impact:

- Implement targeted awareness campaign in the local schools / communities about drowning risks.
- Install regular drowning warning signage in key areas around the reservoir, including a floating boom with warning signage upstream of the power intake.
- Develop and implement an Operational ESMP.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.3.1.4 Risk of drowning between the restitution and Kurichhu reservoir

The Dorjilung HPP Scheme will be operated in peaking mode which will create significant and rapid changes in water levels between the tailrace tunnels and the tail of Kurichhu reservoir. The estimates of water levels changes are not available, but they are likely to be sudden and significant. This brings potential drowning risks. 4 main types of users exposed to EFlow-related safety issues are (i) Fishers, (ii) Gravel collectors, (iii) People performing ritual/religious ceremonies, and (iv) People likely to cross the watercourse.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial**.

The following measures are proposed to address the impact:

- Establish of fencing of the riverbanks at the Gyelzhung estate to prevent people from approaching the river in the hydropeaking section.
- Implement targeted awareness campaign in the local schools / communities about drowning risks.
- Install regular drowning warning signage in key area around the reservoir with a potential warning system (flashing light / siren).
- Develop and implement an Operational ESMP.
- Implement an E flow Management Plan for the downstream area (see Community Safety Management Plan in EFMP).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.3.2 OH&S Impacts during Operation and Maintenance activities.

The OH&S impacts are significantly reduced compared to the construction stage. The activities will be limited to regular operation and maintenance activities. However, this still represents a risk for workers as operating hydropower schemes still have some localised hazards (e.g., working at height, falls, etc.). The following key OH&S hazards are relevant:

- Electrical Hazards.
- Falls and Trips Hazards.
- Hazardous Materials.
- Working at Height.
- Confined Space.
- Crane and moving heavy equipment.
- Burn, cuts, ear, eye and respiratory damage when using electrical tools and welding.
- Fire and Explosion Hazards.
- Traffic Hazards.

As the HPP Scheme will be closed to the public (in particular access to the dam and powerhouse will be prohibited to the public and patrolled).

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial**.

The following measures are proposed to address the impact:

- Implement security arrangements to prohibit public access to the HPP Scheme during operations.
- Develop and implement an Operational ESMP.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate**.

10.5.3.3 Loss of Business

Following the commissioning of the Dorjilung HPP Scheme, there will be significant changes to sediment transport, and, after a few years, there will likely be drastic reduction in sand materials available for extraction. In addition, the current Natural Resources Development Corporation Limited (a public autonomous body) sand mining site in Gyelpozhing will be directly exposed to the safety hazards associated with the peaking operations (rapid changes of water levels) which will likely be not acceptable for safe working conditions.

Considering the above mechanism, the current NRDCL sand mining site in Gyelpozhing will likely need to close rapidly after commissioning.

The likelihood of the impact is **High,** and the severity is **High**. The significance of the potential impact is considered **High**.

The following measures are proposed to address the impact:

- The NRDCL, the National Land Commission and the Ministry of Energy and Natural Resources and DGPC will investigate this issue as it involves only public bodies. NRDCL to be allocated another sand mining site as replacement.

The residual impacts are considered to be **High**.

10.5.3.4 Dam Safety

10.5.3.4.1 Spillway not evacuating floods correctly and leading to flooding.

The failure of a hydropower plant's spillway to effectively evacuate floods can have serious consequences, potentially leading to flooding, dam breaches, and other significant risks. The spillway is a critical component of a dam that allows excess water to be safely released from the reservoir during periods of high-water flow. If the spillway is unable to release water in a controlled manner, there is a risk of sudden, uncontrolled releases of water downstream. This can lead to rapid and severe flooding that can endanger

communities, infrastructure, and natural habitats. Flooding resulting from a spillway failure can damage roads, bridges, buildings, and other infrastructure downstream, leading to significant economic losses and potential loss of life. Flooding can force people to evacuate their homes, leading to temporary or long-term displacement.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.4.2 Dam failure leading to sudden and extensive flooding downstream.

If the dam breaches, there is a risk of sudden, uncontrolled releases of water downstream. This can lead to rapid and severe flooding that can endanger communities, infrastructure, and natural habitats. Flooding resulting from a spillway failure can damage roads, bridges, buildings, and other infrastructure downstream, leading to significant economic losses and potential loss of life. Flooding can force people to evacuate their homes, leading to temporary or long-term displacement.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.4.3 GLOFs leading to wave and overtopping.

Glacial lake outburst floods (GLOFs) pose significant risks and consequences to hydropower plant projects, particularly in regions where glaciers and glacial lakes are present. A GLOF occurs when a glacial lake dammed by ice or moraine suddenly breaches or releases a large volume of water. These events can have severe impacts on hydropower infrastructure, local communities, and the environment. A GLOF can damage or destroy intake structures, dams, powerhouses, transmission lines, and other components of a hydropower plant, disrupting its operation and potentially leading to significant financial losses. Floodwater can wash away access roads, bridges, and other transportation infrastructure, hindering emergency response and repair efforts. Workers on-site during a GLOF event may be at risk of injury or death due to the sudden inundation of floodwaters. The occurrence of a GLOF can lead to negative public perception of the project and its safety measures, affecting community trust and support.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.4.4 Landslide leading to wave and overtopping.

Landslides near a hydropower plant can have significant risks and impacts for local communities, particularly if they lead to waves and overtopping of reservoirs or water bodies created by the dam. If a landslide occurs near a dam, it can potentially destabilize the dam structure, leading to dam failure and catastrophic flooding downstream. The sudden release of a large volume of water due to overtopping or dam failure can result in massive floods downstream, causing widespread destruction to communities, infrastructure, and agriculture. The rapid and forceful floodwaters resulting from a landslide-induced overtopping event can pose a significant threat to human life, leading to casualties and injuries. Communities located downstream of the hydropower plant could experience severe property damage, loss of homes, businesses, and infrastructure, forcing residents to evacuate their homes, leading to temporary or long-term displacement and homelessness for affected individuals and families. Disasters like landslides and floods can have lasting social and psychological impacts on affected communities, including trauma, stress, and loss of a sense of security.

The likelihood of the impact is **Low,** and the severity is **High**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.5 Occupational Health and Safety issues during Operations

Maintenance operations in a hydropower plant carry various risks for workers involved in the maintenance tasks:

- Mechanical Hazards: Working with heavy machinery, equipment, and moving parts can pose risks of crush injuries, entanglement, and other mechanical accidents.
- Electrical Hazards: Maintenance tasks often involve working with electrical systems, which can lead to electric shocks, burns, and other electrical accidents if not handled properly.
- Falls: Maintenance tasks may require working at heights, such as on scaffolding or elevated platforms, increasing the risk of falls.
- Confined Spaces: Entering confined spaces within the plant can expose workers to risks such as poor ventilation, toxic gases, and the potential for being trapped.
- Chemical Exposure: Maintenance operations might involve handling chemicals, lubricants, and cleaning agents, which can lead to skin irritation, respiratory issues, or other health problems if not used safely.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement an Operational – ESMP.

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.6 Improved access and road conditions

The improved access roads to the hydropower plant and the improved road conditions thanks to the project will have significant positive impacts for the surrounding communities. Indeed, better roads enable easier transportation of goods and products to and from the remote communities, boosting local trade and commerce. This can lead to increased economic opportunities and income generation for businesses and individuals. Improved roads provide local farmers and producers with better access to markets, allowing them to sell their products more easily and profitably.

This has an impact as well on the procurement and access to services, including healthcare, education and other services for local communities. It can also diversify the local economy by promoting tourism and providing an additional source of income for the local community and, regarding roads maintenance activities, create temporary and permanent employment opportunities for local residents.

The significance of the potential impact is considered **Positive.**

10.5.3.7 Employment and Economic Opportunities

The project will positively impact long-term employment by creating jobs for the operation and maintenance of the HPP, mobilizing up to 125-150 specialized skilled workers and technicians. The Project will be mostly staffed by DGPC employees during operations with a few opportunities for unskilled labour employment (such as local helpers, guards or cleaners). Due to the specific skills requirement, the job opportunities for the local population will be limited unless internal training is provided. In addition, as observed with other infrastructure projects, related local jobs usually benefit more to men, contributing to women getting more works and responsibilities in low paid jobs in the farms.

The DGPC operational staff will settle in the area with their families and create an 'anchor' development; similar to the trend observed with Gyelpozhing (associated with the Kurichhu HPP operations). This will likely benefit Autsho for the staff located near the dam and Gyelpozhing / Lingmithang for the staff operating the powerhouse.

The significance of the potential impact is considered **Positive**, but it is not going to benefit all if no enhancement measures are taken.

The following measures are proposed to support and enhance the impact for local men/women and vulnerable:

- Develop the Gender and Vulnerability Action Plan to contribute to local skill building and employment for women, youths and people with disabilities (EM)

10.5.3.8 Construction facilities

10.5.3.8.1 Handover of landfills / waste management

The handover of landfills and waste management after the hydropower plant construction phase can have several significant impacts on the local communities as waste management is currently insufficient, and the overall sustainability of the project. Inadequate waste management can lead to health risks for nearby communities due to pollution and the potential release of hazardous substances into the environment. Poor waste management practices can also pose risks to workers involved in waste handling and disposal. Improperly managed landfills can negatively impact the visual aesthetics of the area, reducing the quality of life for local residents. Also, as nearby communities rely on the natural environment for their livelihoods (e.g., agriculture, fishing).

The significance of the potential impact is considered **Positive.**

The following measures are proposed to address the impact:

- The design and location of the construction phase landfills / waste management facilities need to be made in consultation with the Mongar/Lhuentse Dzongkhags administration.
- About 6 months prior to construction demobilisation, DGPC and Contractor will start engaging with the Mongar/Lhuentse Dzongkhags administration to plan for a handover. Prior to the formal handover, the Contractor will undertake an asset condition assessment and provide it to the Mongar/Lhuentse Dzongkhags administration.

10.5.3.8.2 Handover of access roads

The handover of access roads to local communities after the construction phase can come with certain risks and challenges. One of the primary risks is that local communities might not have the resources, expertise, or funding to properly maintain and repair the access roads. Over time, this could lead to deterioration and unsafe conditions. If the access roads are not well-maintained, they could become hazardous to vehicles and pedestrians, increasing the risk of accidents and injuries.

In the remote areas where the project is constructed, access roads are crucial for connecting communities to essential services, markets, and healthcare facilities. Poor road conditions or lack of maintenance could isolate these communities, making it difficult for them to access necessities. If the access roads deteriorate and transportation becomes challenging, it could impact local economies by hindering the movement of goods, services, and people. This can lead to reduced economic opportunities and growth for the communities.

Finally, disputes might arise within communities over responsibilities for road maintenance, potentially causing conflicts and straining social relationships.

The significance of the potential impact is considered **Positive.**

The following measures are proposed to address the impact:

- The design and location of the access road will be shared with the Mongar/Lhuentse Dzongkhags administration and Department of Roads.
- About 6 months prior to construction demobilisation, DGPC and Contractor will start engaging with the Mongar/Lhuentse Dzongkhags administration to plan for a handover. Prior to the formal handover, the Contractor will undertake an asset condition assessment and provide it to the Mongar/Lhuentse Dzongkhags administration and Department of Roads.
- The contractor to repair the road prior to demobilization and hand it over in a roadworthy condition.

10.5.3.9 Continuity of the Local Development Programs

Insufficient funding, planning, and capacity for the continuation of a local development program during the operation phase of the hydropower plant project can have many negative impacts on the local community, as insufficient funding can lead to the discontinuation of community development programs that provide essential services, such as education, healthcare, and infrastructure improvements. This can negatively impact on the overall well-being of the local population. It can also result in the deterioration of social infrastructure projects that were initiated during the construction phase, such as schools, community centers, and health clinics. This can hinder access to essential services and hinder the creation of economic opportunities, such as job training, vocational programs, and entrepreneurship initiatives. This can limit the potential for income generation and sustainable livelihoods for community members. The discontinuation of local development programs can erode the positive benefits that the project initially promised to the community, leading to disillusionment and resentment among residents.

The likelihood of the impact is **Medium,** and the severity is **Medium**. The significance of the potential impact is considered **Substantial.**

The following measures are proposed to address the impact:

- Develop and implement a Removal and Rehabilitation Plan at the end of the Construction phase (AM/RM).
- Develop and implement an Institutional Capacity Building Plan (AM/RM/TM/EM)
- Develop and implement a Stakeholders Engagement Plan (AM/RM)
- Develop and implement a Community Benefits Management Plan (AM/RM)
- Develop and implement a Grievance Mechanism (RM).

After proper development and implementation of relevant measures, the residual impacts are considered to be **Moderate.**

10.5.3.10 Power generation

10.5.3.10.1 Generation of green power

Information on the economics project was not available during the ESIA preparation.

During operation, the project will generate up to 5265 GWh per year of renewable energy that will feed the national grid. The hydropower plant will contribute from a portion of the national electricity production once operational. The impact is expected to be positive, both direct and indirect because the project will provide energy to the national grid which will benefit other electricity users (households, businesses, and government buildings), pay taxes, purchase materials and services which will lead to the growth of small and medium businesses. Also, hydropower is a renewable energy source that generates electricity by harnessing the energy of flowing water. It produces minimal greenhouse gas emissions, helping to mitigate climate change and reduce reliance on fossil fuels. The avoided amount of GHG, over 100 years, would save up to 455,137 $ktCO_{2eq}$ depending on the alternative considered (see also Section 10.5.1.4).

The significance of the potential impact is considered **Positive**.

10.5.3.10.2 Income in hard currencies

Exporting power produced by the new hydropower plant can generate significant foreign exchange earnings for a country. Revenue generated from the sale of electricity in hard currencies can contribute to the country's foreign reserves and stimulate economic growth by providing resources for investment in infrastructure, development projects, and other sectors of the economy. Also, power exports can help improve a country's balance of payments by increasing export revenue and reducing trade deficits. The revenue generated from power exports can be used to service external debt, reducing the financial burden on the country.

The significance of the potential impact is considered **Positive.**

10.5.3.10.3 Energy security

While power exports generate income, it is important to balance energy exports with domestic energy needs to ensure energy security and stability. Many hydropower plants can provide consistent baseload power, which stabilizes the grid and contributes to a reliable supply of electricity, and hydropower plants located domestically provide a stable source of energy that is less susceptible to international supply chain disruptions. Also, hydropower plants have long lifespans, providing a consistent and predictable energy source over many decades.

The significance of the potential impact is considered **Positive**.

10.5.4 Impacts on River Flow (Eflow)

The high resolution Eflow assessment, prepared as a standalone report to this ESIA, **concluded that in a dry season flow rate of 6 m^3/s should be maintained in the dewatered reach**, with sufficient variation to follow early monsoon freshes and the gradual decrease in the autumn, to reflect the natural pattern of

the river and trigger biological changes. This base value of 6 m^3/s is determined from a 1-D hydraulic model. Beyond this flow rate, the overall habitat value increases very slowly, because whilst the wetted area increases, the velocity and to a lesser extent depth become less suitable. This minimum flow will be supplemented by several tributaries located in the dewatered stretch and will depend on the rainfall and timing of the monsoon and, as a result, EFlow releases may not always be according to a predetermined monthly schedule. **During the 3-day duration of the fresh, the minimum flow released in the dewatered stretch should be increased to 15 m^3/s.**

The Kurichhu dam acts as an ideal demodulation dam and is located a short distance from the restitution. The short reach affected by hydropeaking is channelised laterally with riprap on the right bank and the road on the left bank, reducing the effects of fish stranding. The presence of a right bank tributary immediately downstream of the Dorjilung tailrace will, to some extent, help maintaining the flow outside of hydropeaking. In the hydropeaking reach, the focus should be on eliminating configurations such as draining pools that can trap fish.

10.5.5 Summary of impacts during operation phase

The following summary table presents for each activity or component:

- The impacts based on description provided above.
- The significance of the impacts with the details of the severity and the likelihood
- The list of the main corrective measures to manage the impacts.
- Consideration about the feasibility and difficulty of the proposed corrective measures rated from 1 (easy) to 3 (difficult).
- The significance of the residual impact.

It is noted that this table presents the residual impact without the implementation of compensation measures. The purpose is to highlight (i) the significance of the residual impact with avoidance/reduction measures only and (ii) the need for potential compensation measures. The compensation measures presented in this table are designed in a way to fully compensate the Substantial and significant residual impacts identified.

Table 194: Summary of impacts during operation phase- Physical Environment

Activity or component OPERATION	Potential impacts	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	IMPACT SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
PHYSICIAL ENVIRONMENT								
Reservoir	Impact on hydrology and hydraulic flows	The impoundment of the dam will induce the rise of water surface elevation in the reservoir area. During low-flow conditions, typically in the non-monsoon period (October to May), the river experiences an average flow volume is 2,862 MCM. The average monsoon flow (June to September), volume is 6,255 MCM, indicating a substantial increase in water discharge compared to other periods. The maximum annual flow volume of 13,163 MCM highlights the potential for intense water flow during peak rainy seasons. The maximum 10-daily discharge values (1,578 m^3/s for monsoon and 682 m^3/s for non-monsoon) reflect short-term surges in water flow, which could occur due to heavy rainfall.	Medium	High	High	○ Develop a flow regulation strategy that considers the seasonal variations in water discharge (RM). ○ Establish a well-defined reservoir operation protocol that considers the inflow-outflow dynamics (RM). ○ Implement environmental flow releases that mimic natural flow patterns, particularly during low-flow periods (AM/RM). ○ Develop a flood forecasting system that provides early warnings about potential high-water discharges (AM/RM). ○ Design and implement sediment management strategies to prevent excessive sediment build-up within the reservoir (RM).		Substantial

	Degradation of the water quality in the reservoir and downstream	The risk of water pollution is mostly related to the retention time of the water in the reservoir (relation between inflow, outflow, and reservoir's volume), to the reservoir's depth, to the organic matter flooded during the reservoir filling and to the water's temperature. The operation of the dam will increase the retention time of the water in the reservoir and can therefore potentially deteriorate the quality of the water both in the reservoir and downstream.	Medium	Medium	Substantial	○ Implement sediment management strategies to reduce sedimentation in the reservoir (RM). ○ Develop and implement strategies to regulate water temperature in the reservoir AM/RM). ○ Implement watershed management practices to control nutrient inputs into the reservoir (RM). ○ Establish monitoring programs to detect early signs of algal blooms (MM). ○ Develop and implement continuous water quality Monitoring (MM) ○ Flow Management (AM): Manage flow releases from the reservoir to minimize abrupt changes in downstream water quality. ○ Implement erosion control measures in the catchment area to minimize sediment input into the reservoir (AM/RM). ○ Public Awareness and Education (TM): Raise awareness among local communities and stakeholders about the importance of maintaining water quality. ○ Develop and implement an Emergency Response Plan (RM)		Moderate
Operation of the hydropower plant	Modification of sediment transport and erosion		Low	High	Substantial	○ Maximized sediment trapping within the reservoir (AM/RM). ○ Develop and implement specific strategies tailored to critical periods when sediment management is most essential (AM/RM). ○ Implementing Sediment Flushing (AM/RM): Actively carry out controlled		Substantial

Activity or component OPERATION	Potential impacts	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANCE OF RESIDUAL IMPACT
			LIKELIHOOD	SEVERITY	IMPACT SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
						○ water releases to mobilize and transport sediments downstream. ○ Supplementary Dredging (RM): Consider targeted dredging as a supplementary measure to sluicing, concentrating on areas with significant sediment accumulation. ○ Implement localized Sediment Management (MM). ○ Implement regular monitoring of sediment accumulation and water quality for timely adjustments to sediment management strategies (MM). ○ Raising awareness Among Local Communities About Sediment Management Strategies (TM).		
Energy production and dam operation	Emission of GHG	Construction and operation of reservoirs will cause GHG emissions, however these emissions are expected to be lower than total emission from alternative energy sources.			Positive	○ Develop and implement a Reservoir Impoundment Plan (AM/RM) including the removal of vegetation prior to impoundment to reduce organic matter available for decomposition.		Positive

Table 195: Summary of impacts during operation phase- Biological Environment

ACTIVITY OR COMPONENT OPERATION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		SIGNIFICANC
			LIKELIHOOD	SEVERITY	IMPACT SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	
BIOLOGICAL ENVIRONMENT								
Impact from hydropower operation	Variation of water quality in the reservoir and downstream	The impoundment of water can lead to changes in water chemistry, including alterations in pH, nutrient levels, and the concentration of various chemicals. These changes can disrupt the balance of the aquatic ecosystem and negatively affect the growth and survival of aquatic organisms.	Medium	medium	Substantial	○ Measure to preserve water quality in the reservoir and downstream (RM) ○ Maintain an environmental flow (RM): The E-flow will allow to reduce the impacts of the dam on aquatic ecosystems. ○ Establishment of sediment monitoring on all impacted sections (MM) ○ Develop and implement strategies to avoid the intrusion of invasive species (fish) (RM). ○ Installation of grid / screens to limit fish mortality (RM) ○ Implementation of general measures to avoid terrestrial invasive species (RM) ○ Monitoring of fish populations downstream, in the reservoir, in side streams and upstream, migratory/mobile species and species with limited distribution (MM).		Moderate
	Variation of the sediment load	The creation of the dam will generate a decrease in the sediment load downstream. This will lead to a modification of habitat downstream for aquatic fauna such as loss of spawning area.	Medium	Medium	Substantial			Moderate
	Flushing sediment from the reservoir	Management flushing to remove sediments accumulated upstream of the dam will partially restore sediment continuity and de-silt the water body. If these manipulations do not comply with certain rules, they can lead to downstream habitat degradation and a net loss of aquatic species, including species of concern.	High	Medium	Substantial			Moderate

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Risk of fish mortality related to the operation.	The operation could pose certain risks to fish populations, including the potential for fish mortality. The water catchment at the dam is likely to carry fish to the penstock and then to the turbines at the plant, as well as the instream flow.	High	Low	Substantial	○ Monitoring impacts to define adaptive management measures (MM). ○ See also all offsetting measures indicated in the section 10.2.3		Moderate
	Impacts of peaking activity	The Dorjilung HPP Scheme will be operated in peaking mode which will create significant and rapid changes in water levels between the tailrace tunnels and the tail of Kurichhu reservoir. The estimates of water levels changes are not available but they are likely to be sudden and significant. In the reservoir, the impact on species will essentially be drifting and mortality (see above). Downstream, the impact will be on a short section (1km), on aquatic fauna, aquatic flora and terrestrial (riparian) flora.	Medium	Low	Substantial			Moderate

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Signif icanc
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Risk of invasive species proliferation	The reservoir's altered hydrology and water quality can create a habitat that is more suitable for certain invasive species especially during the first years of operation. Invasive species can be introduced during the construction phase, machinery, vehicles, and equipment used during the construction phase can inadvertently transport invasive species	Medium	Medium	Substantial			Moderate
	Impacts of operation shutdown and outage	In the event of a turbine shutdown, the downstream consequences can be significant on aquatic organisms and on riparian environments with a drop in water levels and possible degradation of water quality.	Low	Medium	Moderate			Low

Table 196: Summary of impacts during operation phase- Human Environment

ACTIVITY OR COMPONENT OPERATION	POTENTIAL IMPACTS	IMPACT DESCRIPTION	IMPACT ASSESSMENT			CORRECTIVE MEASURE		
			LIKELIHOOD	SEVERITY	IMPACT SIGNIFICANCE	DESCRIPTION AND CLASSIFICATION OF THE MEASURE AM= AVOIDANCE — RM = REDUCTION RES = RESTORATION OFM = OFFSETTING MEASURES MM = MONITORING –TM = TRAINING – EM = ENHANCEMENT	IMPLEMENTATION DIFFICULTY	SIGNIFICANCE OF RESIDUAL IMPACT
HUMAN ENVIRONMENT								
Community health and safety issues	Increased incidence of waterborne or water-related diseases	The damming of rivers and alteration of water flow can impact aquatic ecosystems, potentially leading to changes in water quality and the spread of waterborne diseases. Poor water quality can result in reduced access to safe and clean drinking water, forcing communities to rely on contaminated sources and perpetuating the cycle of disease. Poor water quality resulting from pollution and contamination can harm aquatic ecosystems, leading to the decline of fish populations and making fish improper for consumption.	Low	Low	Moderate	○ Liaise regularly with the local health authority, particularly Mongar Regional Referral Hospital, to monitor and identify any increasing trend in waterborne disease incidence. ○ Develop and implement an Operational ESMP		Low

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Risk of drowning during reservoir impoundment	Deeper reservoirs with strong currents can pose higher risks, especially for individuals who are not strong swimmers. Submerged objects, debris, and structures in the reservoir can pose risks to swimmers and boaters, increasing the potential for accidents.	Low	High	Substantial	○ Develop and implement a targeted awareness program at least 1 month prior to first impoundment. ○ Install temporary signage informing local communities about the upcoming reservoir filling at least 1 month prior to first impoundment. ○ Undertake an onsite patrol just before and throughout impoundment to directly identify persons being exposed, warn / rescue them. This measure would be coupled with the similar actions targeting fauna being trapped and drowning. ○ Develop and implement a Reservoir Impoundment Plan (AM/RM).		Moderate
	Risk of drowning in the reservoir	Reservoir impoundment involves filling the reservoir behind the dam, which can result in rapidly rising water levels and changes in currents that may catch people off guard.	Low	High	Substantial	○ Implement targeted awareness campaign in the local schools / communities about drowning risks. ○ Install regular drowning warning signage in key areas around the reservoir. ○ Develop and implement an Operational ESMP.		Moderate

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Risk of drowning between the restitution and Kurichhu reservoir	The failure of a hydropower plant's spillway to effectively evacuate floods can lead to rapid and severe flooding that can endanger communities, infrastructure, and natural habitats. Flooding resulting from a spillway failure can damage roads, bridges, buildings, and other infrastructure downstream, leading to significant economic losses and potential loss of life. Flooding can force people to evacuate their homes, leading to temporary or long-term displacement.	Low	High	Substantial	○ Implement targeted awareness campaign in the local schools / communities about drowning risks. ○ Install regular drowning warning signage in key area around the reservoir with a potential warning system (flashing light / siren). ○ Develop and implement an Operational ESMP.		Moderate
OH&S Impacts during Operation and Maintenance activities	Risk of hazards during Operation and Maintenance activities	The OH&S impacts are significantly reduced compared to the construction stage. The activities will be limited to regular operation and maintenance activities. However, this still represents a risk for workers as operating hydropower scheme still has some localized hazards (e.g., working at height, falls, etc.).	Low	High	Substantial	○ Implement security arrangements to prohibit public access to the HPP Scheme during operations. ○ Develop and implement an Operational ESMP.		Moderate

Activity or component Operation	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Loss of Business	Loss of the NRDCL sand mining sites in Autsho and Gyelpozhing	Following the commissioning of the Dorjilung HPP Scheme, there will be significant changes to sediment transport, and, after a few years, there will likely be drastic reduction in sand materials available for extraction. In addition, the current NRDCL sand mining site in Gyelpozhing will be directly exposed to the safety hazards associated with the peak operations (rapid changes of water levels) which will likely be not acceptable for safe working conditions.	High	High	High	○ Land Acquisition and Livelihood Restoration Plan (RES/EM).		High
Dam Safety	Spillway not evacuating floods correctly and leading to flooding	The failure of a hydropower plant's spillway to effectively evacuate floods can lead to rapid and severe flooding that can endanger communities, infrastructure, and natural habitats. Flooding resulting from a spillway failure can damage roads, bridges, buildings, and other infrastructure downstream, leading to significant economic losses and potential loss of life. Flooding can force people to evacuate their homes, leading to temporary or long-term displacement.	Low	High	Substantial	○ Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).	○	Moderate

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Dam failure leading to sudden and extensive flooding downstream	If the dam breaches, there is a risk of sudden, uncontrolled releases of water downstream. This can lead to rapid and severe flooding that can force people to evacuate their homes, leading to temporary or long-term displacement.	Low	High	Substantial	○ Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).	○	Moderate
	GLOFs leading to wave and overtopping	A GLOF can damage or destroy intake structures, dams, powerhouses, transmission lines, and other components of a hydropower plant, disrupting its operation and potentially leading to significant financial losses. Floodwater can wash away access roads, bridges, and other transportation infrastructure, hindering emergency response and repair efforts. Workers on-site during a GLOF event may be at risk of injury or death due to the sudden inundation of floodwaters.	Low	High	Substantial	○ Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).	○	Moderate

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Landslide leading to wave and overtopping	Landslides near a hydropower plant can have significant risks and impacts for local communities, particularly if they lead to waves and overtopping of reservoirs or water bodies created by the dam such as dam failure, massive floods, loss of life and injuries, property damage and loss, and physical displacement.	Low	High	Substantial	○ Develop and implement an Operational - Emergency Management Plan (AM/RM/TM).	○	Moderate
Occupational health and safety issues	Risk due to maintenance operations	Maintenance operations in a hydropower plant carry various risks for workers involved in maintenance tasks such as mechanical hazards, electrical hazards, falls, confined spaces and chemical exposure.	Medium	Medium	Substantial	○ Develop and implement an Operational – ESMP.		Moderate
Traffic	Improved access and road conditions	Better roads enable easier transportation of goods and products to and from the remote communities, boosting local trade and commerce. This can lead to increased economic opportunities and income generation for businesses and individuals. This has an impact as well on the procurement and access to services, including healthcare, education and other services for local communities.			Positive			

Activity or component Operation	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Employment	Local Labour	The individuals employed during the operation and maintenance phase, and their household members, will benefit from increased income that is likely to increase their overall standard of living, access to healthcare and educational resources, and reduce their socio-economic vulnerability.			Positive			
Construction facilities	Handover of landfills / waste management	Inadequate waste management can lead to health risks for nearby communities due to pollution and the potential release of hazardous substances into the environment. Poor waste management practices can also pose risks to workers involved in waste handling and disposal.			Positive	○ The design and location of the construction phase landfills / waste management facilities need to be made in consultation with the Mongar/Lhuentse Dzongkhags administration. ○ About 6 months prior to construction demobilisation, DGPC and Contractor will start engaging with the Mongar/Lhuentse Dzongkhags administration to plan for a handover. Prior to the formal handover, the Contractor will undertake an asset condition assessment and provide it to the Mongar/Lhuentse Dzongkhags administration.		

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
	Handover of access roads	Local communities might not have the resources, expertise, or funding to properly maintain and repair the access roads. Over time, this could lead to deterioration and unsafe conditions. If the access roads are not well-maintained, they could become hazardous to vehicles and pedestrians, increasing the risk of accidents and injuries.			Positive	○ The design and location of the access road will be shared with the Mongar/Lhuentse Dzongkhags administration and Department of Roads. ○ About 6 months prior to construction demobilisation, DGPC and Contractor will start engaging with the Mongar/Lhuentse Dzongkhags administration to plan for a handover. Prior to the formal handover, the Contractor will undertake an asset condition assessment and provide it to the Mongar/Lhuentse Dzongkhags administration and Department of Roads. ○ Contractor to repair the road prior to demobilization and hand it over in a roadworthy condition.		

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Local Developments Programs	Continuity of the Local Development Programs	Insufficient funding, planning, and capacity for the continuation of a local development program during the operation phase of the hydropower plant project can have many negative impacts on the local community, as insufficient funding can lead to the discontinuation of community development programs that provide essential services, such as education, healthcare, and infrastructure improvements, affecting the overall well-being of the local population.	Medium	Medium	Substantial	○ Develop and implement a Removal and Rehabilitation Plan at the end of the Construction phase (AM/RM) ○ Develop and implement an Institutional Capacity Building Plan (AM/RM/TM/EM) ○ Develop and implement a Stakeholders Engagement Plan (AM/RM) ○ Develop and implement a Community Benefits Management Plan (AM/RM) ○ Develop and implement a Grievance Mechanism (RM).		Moderate
Power generation	Generation green power	The project will provide energy to the national grid which will benefit other electricity users and, as hydropower is a renewable energy source, it produces minimal greenhouse gas emissions, helping to mitigate climate change and reduce reliance on fossil fuels			Positive			

Activity or component OPERATION	Potential impacts	Impact description	Impact assessment			Corrective measure		Significance of residual impact
			Likelihood	Severity	Impact Significance	Description and classification of the measure AM= avoidance — RM = reduction RES = Restoration OFM = Offsetting measures MM = monitoring –TM = training – EM = enhancement	Implementation difficulty	
Power generation	Income in hard currencies	Revenue generated from the sale of electricity in hard currencies can contribute to the country's foreign reserves and stimulate economic growth by providing resources for investment in infrastructure, development projects, and other sectors of the economy. Also, power exports can help improve a country's balance of payments by increasing export revenue and reducing trade deficits.			Positive			

10.6 Impacts on Ecosystem Services

10.6.1 Principles for the evaluation of ecosystem services

Ecosystem services are the benefits or advantages that humans (people, communities, businesses) derive from ecosystems. In the IFC/WB system, the way in which the Project must take ecosystem services into account is mainly dealt with in ESS6, but is also references in ESS4, ESS5, ESS7 and ESS8. The ESS apply only to ecosystem services that the project can directly control and/or over which it has a significant influence. ESS1 defines four categories of ecosystem services:

- **Provisioning services**, which are the products people obtain from ecosystems, and which may include food, freshwater, timber, fibres, and medicinal plants.
- **Regulating services**, which are the benefits people obtain from the regulation of ecosystem processes, and which may include surface water purification, carbon storage and sequestration, climate regulation, protection from natural hazards.
- **Cultural services**, which are the nonmaterial benefits people obtain from ecosystems, and which may include natural areas that are sacred sites and areas of importance for recreation and aesthetic enjoyment.
- **Supporting services**, which are the natural processes that maintain the other services, and which may include soil formation, nutrient cycling and primary production.

10.6.2 Classification of ecosystem services

For the ecosystem services assessment of the Dorjilung project the four categories of ecosystem services have been further refined into two types:

- **Type I:** those for which project impacts may adversely affect communities. These services will be considered a priority in the following circumstances:

o The Project is likely to have a significant impact on the ecosystem service.
o This impact will result in a direct negative impact on the livelihoods, health, safety and/or cultural heritage of the affected communities.
o The Project has direct management control or significant influence over the ecosystem service.

- **Type II:** those on which the project is directly dependent on its activities. These services will be given priority in the following circumstances:

o The Project is directly dependent on the ecosystem service for its primary operations.
o The Project has direct control over the management of the ecosystem service or significant influence.

10.6.3 Identification of Priority Ecosystem Services and Impacts

10.6.3.1 Provisioning ecosystem services

Arable land:

Cash crops, vegetable and fruit production are the main activities of communities in the project AoI. Production is predominantly used for own consumption and surplus are sold. The project will impact on some agricultural land currently used for orchard, kitchen garden and pasture- this impact is already covered under the LALRP. Dust produced by construction activities, blasting and traffic can also impact agricultural production quantity and quality, and lead to long-term soils degradation. This impact is also addressed as part of the impact assessment on the physical environment. The project has direct control on loss of agricultural lands and loss of productivity of agriculture**: ES priority Type I.**

Grazing areas:

Livestock raising for dairy and meat production is also a main activity. Cows are usually grazing along the main roads. Increased traffic will increase stress and risks of collision with cattle, affecting punctually the ecosystem service. Measures to address livestock husbandry and risks of collision are addressed in other parts. The project has a partial influence on this service (risks of collision) considered as **ES Priority Type I.**

Aquatic resources:

Fishing in the river is illegal and thus very rare. It is only occasionally performed by a few villagers. The project will create some modification on aquatic fauna and flora, and impact particularly those species that are sensitive to fluctuations in water levels and flow dynamics. This ES is considered as an **ES priority Type I.**

Biochemicals, natural medicines and pharmaceuticals:

Medicinal plants and herbs such as Aconitum, Gentiana, Nardostachys, Delphinium, Rhodiola, Meconopsis, Osnoma, Dactylorhiza, Ophiocordyceps sinensis, Picrorhiza and Fritillaria can be found in the Alpine zone which includes alpine meadows and scrub areas above 4000masl. These areas are not affected by the project. Communities consulted do not collect medicinal plants anymore as they rely on modern medicine.

Wood and other wood fibres:

Wood is used in local construction. Villagers are allowed to collect a standard and well-defined quantity of timber for the construction of their house and then every ten years for the repair or extension of their house. Timber extraction is managed and controlled. Currently, the local community mostly uses LPG for cooking needs and the use of firewood is very limited. Some villagers produce baskets and ropes out of cane fiber, especially in Tsamang and Banjar villages.

The project has partial control over the loss of land where timber and construction materials can be collected. The impacts are covered in the LARP and biodiversity conservation measures. The influx of population could also increase pressure on these resources. **This ES is priority Type I.**

10.6.3.2 Cultural ecosystem services

Areas used for religious purposes:

Numerous sacred sites are scattered in the Project area, they have been listed and geolocated and the project will avoid those sites. The project design was revised to avoid the impoundment of area used for religious purposes and ERC measures are planned.

Aesthetic value:

The aesthetic value of the river will be degraded by the construction sites, the dam itself (unless considered as a point of attraction) and low water level in the dewatered section. The powerhouse being underground will however have less impact on the landscape aesthetic than open air powerhouse. The reservoir may be considered pleasant lake scenery.

Recreational values:

Stone baths along the river are valued for their healing properties and represent potential for local tourism. They are geolocated and won't be physically impacted. The bath localised in the dewatered section will however be less convenient as the source of water will be reduced and distant from the current bath. The project influence is marginal and related to the location and operation of this unique site.

10.6.3.3 Regulating ecosystem services

Purification of air:

The purification of air is a crucial ecosystem service that supports human health and biodiversity by removing pollutants from the atmosphere, regulating air quality, and providing clean oxygen for breathing. Construction processes, such as land clearing and earth-moving, often result in vegetation loss, thereby reducing the area's innate ability to filter the air. This can lead to the release of dust, emissions, and various pollutants, adversely affecting this essential ecosystem service. **This ES is priority Type I.**

Climate regulation and carbon storage and sequestration – Global/Regional/Local:

Local ecosystems, like forests, water bodies, and soil, naturally regulate and stabilize the climate. These services are crucial for maintaining a balanced environment and can significantly influence local weather patterns, temperatures, humidity, and air quality.

The construction process, including the use of heavy machinery, can lead to increased carbon emissions. Additionally, changes in land use and vegetation cover can alter the carbon balance of the area.

Water regulation:

The natural flow patterns of rivers help to disperse and dilute pollutants, maintaining water quality. Seasonal flows and flood pulses also contribute to the ecological health of water systems. Aquatic plants and microorganisms in water bodies play a vital role in breaking down organic materials and pollutants, further aiding in water purification.

Construction activities can increase the sediment load in water bodies, leading to higher turbidity. This can affect aquatic life, reduce light penetration, and alter the aesthetic and recreational value of the water. The dam can also lead to changes in water temperature, especially if it involves deep-water release. Temperature is a critical factor for aquatic life and can influence chemical processes in the water. **This ES is priority Type I.**

Erosion control:

The land cover, especially forests, plays a crucial role in controlling erosion by stabilizing the soil with their root systems in the project area. During the construction phase, activities will disrupt this natural process by removing vegetation cover, leading to increased erosion and sedimentation in nearby water bodies. This disruption will temporarily impact water quality and aquatic habitats. **This ES is priority Type I.**

Purification of water and waste decomposition:

The forests naturally filter water and break down pollutants, including organic waste. The presence of such ecosystems within the project area would contribute to maintaining water quality. Construction activities might temporarily compromise this service by introducing pollutants and disrupting water flow patterns.

Disease Control and Pest Control:

The Biodiverse ecosystems in the project area regulate diseases and pests through natural predator-prey relationships. The disruption of these habitats through construction phase could temporarily alter these natural controls, potentially leading to increased populations or disease vectors.

Pollination:

Pollinators like bees, birds, and insects present in the study area and are essential for the reproduction of many plant species, including crops vital for food production. The presence of pollinators is crucial for agricultural productivity and biodiversity.

10.6.3.4 Supporting ecosystem services

Nutrients capture, recycling, and Primary production:

These zones support a rich diversity of flora and fauna, contributing to nutrient capture and recycling through the decomposition and regeneration of biomass. The forests across these zones are crucial for primary production, acting as significant carbon sinks through photosynthesis.

The construction phase in the Dorjilung area is likely to have a low impact on primary production and forest coverage, given that the extent of vegetation and forest clearance is limited. The construction activities have been planned to minimize environmental disruption, maintaining a significant portion of the natural habitat and, by extension, the processes of primary production within the ecosystem.

Pathways for genetic exchange:

Protected areas and biological corridors (BC#7) are present in the AoI of the project, which are essential pathways for genetic exchange among species, maintaining biodiversity and ecosystem health. These corridors facilitate the movement of species between fragmented habitats, ensuring genetic diversity and the resilience of ecosystems against environmental changes. The project cut in two the Biological Corridor (BC#7) because of the reservoir footprint which widens the river about 200 m while the actual width is about 50 m.

Measures have been proposed to ensure connectivity between the protected areas (see Section 10.5.2).

10.6.4 Summary of Priority Ecosystem Services and Impacts

The table on the next page provides an assessment of the ecosystem services present in the project area and highlights the priority of ecosystem services. In the table, the "Service Presence" column gives information on the actual presence of the service in the study area, while the "Service Use" column details the actual use that is made of the service.

For each type I service, when the columns "Impact of the Project on the Service", "Consequences for Communities", and "Management or Influence of the Service by the Project" contains the mention Yes, then the service is considered as a type I priority.

For each type II service, when the columns "Dependence of the Project on the Service" and "Management or Influence of the Service by the Project" are marked yes, then the project is considered as a type II priority.

Table 197: Identification of priority ecosystem services

	Presence of the service	Use of the service	Impact of the project on the service	Consequence for communities	Dependence of the project on the service	Management or influence of the service by the project	Service priority and priority type
Provisioning ecosystem services							
Grazing areas	**Yes**	**Yes**	**Yes**	**Yes**	No	No	Type I
Arable land	**Yes**	**Yes**	**Yes**	**Yes**	No	No	Type I
Wild foods: gathering and hunting	No	No	No	No	No	No	No
Sand and gravel	No	No	No	No	No	No	No
Aquaculture	No	No	No	No	No	No	No
Aquatic resources	**Yes**	**Yes**	**Yes** Extremely low (illegal fishing)	No	No	No	Type I
Biochemicals, natural medicines and pharmaceuticals	**Yes**	No	No	No	No	No	No
Wood and other wood fibers	**Yes**	**Yes**	**Yes**	**Yes**	No	No	Type I
Other fibers, for example, cotton, hemp, silk	**No**	**No**	**No**	**No**	No	No	No
Cultural ecosystem services							
Sacred or spiritual sites	No	No	No	No	No	No	No
Areas used for religious purposes	**Yes**	No	No	No	No	No	No
Recreational activities and tourism / ecotourism areas	**Yes**	**Yes**	No	No	No	No	No

	Presence of the service	Use of the service	Impact of the project on the service	Consequence for communities	Dependence of the project on the service	Management or influence of the service by the project	Service priority and priority type
Aesthetic values	**Yes**	**Yes**	May become a local tourism attraction.	No	No	No	No
Regulating ecosystem services							
Purification of air	**Yes** Primary forests have a role in air purification	**Yes**	**Yes**	**Yes**	No	No	Type I
Climate regulation and carbon storage and sequestration - Global	**Yes** The quantity of carbon in the vegetation and forest within the project footprint is limited	No	No (negative) The extent of vegetation and forest clearance is limited.	No	No	No	No
Climate regulation and carbon storage and sequestration – Regional/Local		No	**Yes** (positive) On a 25-year scale, the project will save GHGs compared to a thermal alternative	No	No	No	No
Water regulation	**Yes**	No	**Yes** Modification of the physical conditions	**Yes**	No	No	Type I
Erosion control	**Yes**	No	**Yes** Low: Part of the project site will be cleared during construction, which increases the risk of wind and water erosion	**Yes** Very low Indirectly, through the impacts on the physical quality of water during construction	No	**Yes**	Type I
Purification of water and waste decomposition	**Yes**	No	No	No	No	No	No

	Presence of the service	Use of the service	Impact of the project on the service	Consequence for communities	Dependence of the project on the service	Management or influence of the service by the project	Service priority and priority type
Disease Control and Pest Control	**Yes**	No	No	No	No	No	No
Pollination	**Yes**	No	No	No	No	No	No
Natural hazard mitigation	No	No	No	No	No	No	No
Supporting ecosystem services							
Nutrient capture and recycling	**Yes**	No	No	No	No	No	No
Primary production	**Yes** Forests	**Yes**	**Yes** Low: as the extent of vegetation and forest clearance is limited.	**Yes**	No	**Yes**	Type I
Pathways for genetics Exchange	**Yes** Biological corridor	No	**Yes**	No	No	No	No

10.6.5 Corrective Measures and Residual Impact

This analysis highlights that there are several priority type I ecosystem services in the study area.

Priority type I ecosystem services are:

10.6.5.1 Provisioning ecosystem services:

Grazing areas: Implement land rehabilitation measures in disturbed areas once construction phases are complete. This can include reseeding with native grass species, soil stabilization practices, and the restoration of access to natural water sources for livestock.

Arable land: The project will impact on some agricultural land currently used for orchard, kitchen garden and pasture- this impact is already covered under the LALRP.

Aquatic resources: Measures included in (i) the Liquid Effluent Management Plan, mainly to control and monitor wastewater; (ii) the Chemical and Hazardous Materials Management Plan to avoid pollution.

Wood and other wood fibres: The project will develop and implement a reforestation plan for areas cleared during construction, along with afforestation efforts in areas that can benefit from increased tree cover, to compensate for the loss of wood resources.

10.6.5.2 Regulating ecosystem services:

Purification of air: Implement dust suppression techniques such as water spraying on construction sites, especially during dry conditions, to prevent dust from becoming airborne. Plant trees and vegetation around the project site and in adjacent areas to absorb pollutants and provide natural air filtration. This can also help compensate for vegetation loss due to construction activities.

Erosion control: Implement erosion control measures such as sediment barriers, erosion control blankets, and vegetative covers to prevent soil erosion and sediment runoff from exposed slopes.

Water regulation: Establish and maintain vegetated buffer zones along waterways to naturally filter runoff, absorb nutrients, and reduce sedimentation into rivers and streams.

10.6.5.3 Supporting ecosystem services:

Primary production: Compensation measures with afforestation program.

10.6.5.4 Cultural ecosystem services

No impact on cultural ecosystems services was acknowledged.

A set of mitigating measures against negative project impact on these ecosystems services has already been presented in the previous sections, whether related to the project footprint, the construction phase, or the operation phase, and aim to avoid, reduce, and compensate for the impact on provisioning, regulating, and supporting ecosystem services. The measures planned for social aspects also respond to these challenges. The residual impact is considered **Minor.**

In conclusion, no additional measures are identified as necessary.

10.7 Dam Safety

Artelia was provided with the Dam Break Analysis report in August 2024. This report dated July 2024 was prepared by Studio Pietrangeli (SP) who performed hydraulic calculations performed downstream of the Dorjilung dam in the event of a dam failure. The study area for dam break analysis extends from the dam toe to approximately 110 km downstream along the river, reaching the boundary with India and encompassing the Kurichhu dam.

A catastrophic flash flood occurs when a dam is breached, and the impounded water escapes through the gap into the d/s channel. Therefore, identifying areas prone to flooding due to the breaching of the Dorjilung Dam is crucial for developing an effective flood management plan and implementing appropriate preventive measures to mitigate significant damage. SP analysed the possibility of a cascading breach of the Dorjilung and Kurichhu dams. This scenario is plausible, as a failure of the Dorjilung Dam could generate a flood wave that could also collapse the Kurichhu Dam, located about 22 km downstream.

To thoroughly assess the potential failure of the existing Kurichhu Dam due to the failure of the upstream Dorjilung dam, the analysis was conducted by implementing the following two numerical models:

- Upstream model - from Dorjilung Dam to Kurichhu Dam Reservoir.
- Downstream model - from Kurichhu Dam to the Indian boundary.

10.7.1 Upstream Model

The upstream model simulates the river reach extending 19 km from Dorjilung Dam to Kurichhu Reservoir. This model was implemented to simulate the collapse of the Dorjilung Dam and the subsequent propagation of the resulting flood wave discharged by the instantaneous breach.

The maximum flood discharged by the breach is 31'531, recorded at the instant in which the dam collapsed. The reduction of the peak flood downstream of the Dorjilung dam is about 20'081 m3 /s along about 19 km of the stretch of the river investigated. In correspondence with the dam section, the peak flood goes from 31'531 m3/s to 11'450 m3/s in the last section. The attenuation of the flood peak is mainly attributable to the topographical features of the area investigated, characterised by natural constrictions that the current encounters along the watercourse.

The peak flood at Kurichhu reservoir is about 11'450 m3 /s smaller than the PMF value at the Kurichhu reservoir and of the design and check flood used for this dam. Therefore, the flood wave reaching the Kurichhu dam can be safely evacuated through the existing spillway. The risk of overtopping failure of the Kurichhu dam due to the breach of the Dorjilung dam, located approximately 22 km upstream, can thus be considered negligible.

The arrival time of the peak, which is the difference between the peak at the dam toe and the peak of the flood hydrograph simulated in the last downstream cross-section, is equal to about 45 min. This time is considered adequate by SP to issue a warning and take appropriate mitigation measures to protect downstream areas, including fully opening the Kurichhu dam gates to prevent a domino effect.

10.7.2 Downstream Model

This second model focuses on the flood wave propagation from the Kurichhu reservoir to the Indian border.

The reduction of the peak flood downstream of the Kurichhu dam is about 8'253 m3 /s along about 89 km of the stretch of the river investigated. In correspondence with the dam section, the peak flood goes from 11'450 m3 /s to 3'197 m3 /s in the last section. The attenuation of the flood peak is mainly attributable to the topographical features of the area investigated, characterised by natural constrictions that the current encounters along the watercourse.

10.7.3 Assessment of Impact

SP considered the results of the hydraulic numerical analysis for the dam break scenario, including assessing the consequences and impact of the flooding in the downstream valley regarding the number of people, villages, and infrastructures involved.

In the reach between the Dorjilung dam and section 15, for a development of about 13 km, there are no villages near the flooded area.

Houses

The flooded area located 14 to 16 kilometres downstream of the Dorjilung dam includes scattered houses. Bridge 2, also known as the Kuri Zampa Bridge, is entirely submerged and inaccessible. The area containing isolated houses may experience minor flooding. As a precautionary measure, it is recommended that a temporary evacuation order be issued during alert conditions to prioritise the safety of residents in these houses.

The inundated area immediately upstream of the existing Kurichhu reservoir includes several houses in the town of Gyelpozhing, Mongar district, near the riverbanks. Based on the results of the analysed scenario, these houses may not be directly impacted by the flood generated by the breach of the Dorjilung Dam under sunny day conditions. The flood is contained within the river and does not seem to inundate the areas where these houses are located. However, in the event of a dam breach, it is recommended that a warning be issued to stay away from the riverbanks for safety reasons.

In the river stretch downstream of the Kurichhu dam up to the Indian border, the flood was not considered by SP to potentially impact any cities or villages. There are some isolated houses for which it is recommended that an order be issued to stay away from the riverbanks in case of dam breaking, and all activities along the riverbanks should be prohibited.

Bridges

SP considered the potential flooding impacts on bridges across the river, with 7 bridges identified within the study area ranging from 4 km d/s of Dorjilung Dam to 98 km d/s. The table below summarizes the freeboards calculated for all bridges in the investigated areas, with 4 bridges being flooded.:

Bridge Name	Distance d/s Dam (km)	Bridge Freeboard (m)	Flood arrival time (hh:mm)	Peak Flood arrival time (hh:mm)
BanjarZam	4.0	3.7	00:05	00:09
Kuri-Zam	14.1	0	00:20	00:28
Raysa-Zam	47.8	0	01:31	02:10
Wangchhuk-Zam	58.2	0	02:18	02:55
Panbari_zam	62.8	0	02:39	03:13
Pangbang_suspension	98.0	0.9	05:16	05:58
Pangbang Zam	98.0	7.0	05:16	05:58

In order to manage an emergency in the event of the collapse of the Dorjilung dam, it is recommended that bridges that are completely flooded, with no freeboard, should not be used. These bridges will be impassable in the event of a flood caused by the breach of the Dorjilung dam under Sunny Day scenario conditions. On the other hand, bridges with a safety clearance of less than one meter must be monitored and used only if strictly necessary. Alternative solutions are recommended to ensure connectivity and passage of emergency services in areas affected by the flood.

The outcomes of the dam break analysis with each scenario are described in detail in Emergency Preparedness Plan.

11 CUMULATIVE IMPACT ASSESSMENT

11.1 CIA ADDENDUM Background

At the watershed scale, hydropower projects can exert cumulative impacts due to interactions with other water-dependent projects, affecting ecosystems, ecosystem services, and communities reliant on these resources for various activities.

The Cumulative Impact Assessment (CIA) is an integral component of the ESIA for the Dorjilung Project. Compliant with the standards set forth by the World Bank's Environmental and Social Framework and the IFC's Good Practice Handbook on Cumulative Impact Assessment and Management, this assessment comprehensively evaluates the collective effects of existing, under construction, and planned projects over the next two decades.

The Cumulative Impact Assessment (CIA) for the Dorjilung Hydropower Project (HPP) has been prepared as an addendum to the original CIA for the Kuri-Gongri Basin (SWECO, 2018). This was prepared due to the need to specifically address the cumulative impacts associated with this project, which were not comprehensively covered in the original CIA. The initial CIA provided a broad assessment of the cumulative impacts of multiple hydropower projects within the Kuri-Gongri basin, but it lacked detailed, project-specific data on the Dorjilung HPP. This addendum aims to bridge that gap by incorporating recent data and analysis for the environmental and impact assessment of Dorjilung HPP, ensuring a thorough evaluation of Dorjilung HPP's potential cumulative impacts on the basin's environment and communities.

The Dorjilung HPP is a significant project within the Kuri-Gongri Basin, and its cumulative impacts need specific attention. This addendum allows for a detailed examination of these impacts, particularly in relation to other hydropower projects in the basin. It provides a focused assessment on how Dorjilung HPP interacts with existing and planned projects, which is essential for understanding the full scope of environmental and social changes regarding conduction perspectives and river basin perspectives.

By adding this specific addendum, the assessment ensures that all relevant environmental and social factors are considered. This includes impacts on biodiversity, water resources, local communities, and cultural heritage sites, which may be uniquely affected by the Dorjilung HPP. The addendum updates the CIA with recent field surveys and additional analyses, making the impact predictions more accurate and reliable.

Importantly, this addendum does not alter the content and conclusions of the original CIA concerning other hydropower projects or parts of the Kuri-Gongri Basin. Instead, it complements the original assessment by adding depth and detail to the analysis of the Dorjilung HPP. This ensures that stakeholders have a clear and complete understanding of all potential cumulative impacts without changing the established findings related to other projects.

The addendum also responds to stakeholder concerns and requirements for more detailed information about Dorjilung HPP. It aligns with IFC Good Practices for cumulative impact assessments, ensuring that all potential impacts are thoroughly evaluated and managed. This detailed approach supports informed decision-making and helps to mitigate any adverse effects on the environment and local communities.

The CIA addendum for the Dorjilung HPP is essential for providing a complete and accurate assessment of the project's cumulative impacts within the Kuri-Gongri Basin. It ensures that all relevant environmental and social factors are considered, complementing the original CIA, and addressing specific project-related impacts comprehensively. This section of the ESIA presents a succinct summary of the CIA addendum.

11.2 CIA Summary

The cumulative impact assessment adopts two distinct perspectives: a **construction perspective** and a **river basin perspective**. From the construction viewpoint, it addresses the cumulative impacts of the Dorjilung Project with other large construction endeavours in the local area (six regional developments

projects in the next 20 years were identified and confirmed in consultation with government officials). The river basin perspective delves into the broader impacts, specifically examining the cumulative effects of the Dorjilung Project and other hydropower initiatives within the Kuri-Gongri Basin. For the river basin perspective, the cumulative impact assessment strongly builds on the previous Kuri-Gongri Cumulative Impact Assessment Report (SWECO, June 2018).

For the Dorjilung Project, three VECs have been identified as experiencing beneficial cumulative impacts, while two VECs are assessed to face negligible or no cumulative impact. The other seven VECs are expected to undergo slight negative cumulative impacts which could be effectively mitigated with the application of suitable mitigation strategies. Below is a summarization detailing the significance of cumulative impacts for each of the specified VECs.

Table 198: Cumulative impacts to selected VECs

Selected VECs	Cumulative Impact Significance (CIA 2018)	Update (2024) with Dorjilung Construction perspectives
Forest Cover	Slight negative impact.	Slightly negative impact
Slope Stability	Slight negative impact	Slight negative impact
Migratory Fish	Major negative impact	**Moderate negative impact**
Scenery and Landscapes	Moderate negative impact	**Slight negative impact**
Protected Areas	Major negative impact	**Slight negative impact**
Livelihood Opportunities	Positive impacts	Positive impacts
Community Quality of Life	Significant negative impact	Slight negative impact
Access to Markets and Services	Positive impacts	Positive impacts
Cultural Heritage	Moderate negative impact	Slight negative change
Downstream Public Safety	slight negative impacts	slight negative impacts
Economic Growth	Positive impact	Positive impact
Domestic Electricity Supply Security	Positive impact	Positive impact

The 2018 Kuri-Gongri CIA evaluated strategies like avoidance, minimization, mitigation, and enhancement to address the impacts across the entire Kuri-Gongri Basin and its management. For the Dorjilung HPP specifically, the ESMP and the BMP have introduced specific mitigation measures to tackle its environmental, biological, and social effects. The project has developed various management plans designed to modify the extent of its cumulative impacts. This includes:

The Stakeholders Engagement Plans and related Community GRM, the Labour Management Plan and related Code of Conduct and demobilization plan, as well as the Gender Based Violence/ SEA-SH and Vulnerability Action Plan, the community Health, and Safety Plan. These initiatives are designed to mitigate the project's adverse effects on community quality of life.

The GSVAP and Local Development Plan are looking forward to enhancing local economic opportunities and local economic development with mid- and long-term vision, integrated with local development projections.

The main recommendation for the management of cumulative impacts emphasizes the importance of developing a program for aquatic and fish species, which complements the mitigation plans for the Dorjilung HPP and contributes to a larger, state-wide strategy for managing aquatic habitats. This program would not only serve the needs of individual projects of Dorjilung but also contribute to a broader, coordinated effort at the regional level, enhancing the knowledge and conservation of longitudinal migratory species, lateral migratory species, and species with restricted range. the following are key recommendations to be established:

- An Aquatic and Fish Management Plan aims to address the conservation and monitoring of aquatic life, with a particular focus on migratory species. The goals of this plan are to improve the understanding of species behavior, population dynamics, and the effects of hydropower operations on aquatic ecosystems. Additionally, a Cascade Management Plan is proposed to coordinate the operation of Kurichhu, Dorjilung, and other small hydropower projects (HPPs) within the catchment. This plan will focus on managing flood risks, optimizing sediment transport and flushing strategies, maintaining riverine health, and ensuring effective fish monitoring and ecological management to support biodiversity.
- Strategies for River Connectivity are crucial for maintaining or enhancing river connectivity, which is essential for migratory species. The goals include ensuring that species can complete their life cycles without significant disruption from hydropower operations. This will involve engaging in knowledge sharing with other hydropower projects and relevant agencies to build a comprehensive understanding of the regional ecosystem. The strategy includes developing shared databases, research initiatives, and capacity-building programs. Collaboration with environmental agencies and local communities is also recommended to develop and implement conservation programs, integrating various perspectives and expertise into management strategies for more effective and sustainable outcomes.
- The Long-Term Management Plan for Restricted Range Catfish Species includes several key objectives. Additional investigations are necessary to assess the distribution of restricted catfish species in other watersheds to validate their status. Assessments of lateral movements are needed to understand the relationship between species and the main river downstream of the tributaries, ensuring all life cycles are completed and genetic diversity is preserved. Dedicated monitoring is required to track population levels in tributaries, ensuring that residual impacts remain insignificant to minors. A preservation strategy for upper watersheds must be defined, along with recommendations for hydropower projects to maintain lateral connectivity.
- To further support these efforts, a research program should be financed in collaboration with universities, the National Research Center for Riverine and Lake Fisheries (NRCRLF), the Department of Forest and Park Services (DOFPS), and the Department of Water (DoW). This program will aim to improve knowledge of the restricted range catfish species. Additionally, a National Conservation Action Plan should be created, dedicated to these species and other similar species. Inventories and mapping of restricted range species in similar tributaries in Bhutan should be prioritized, especially in already protected areas. A national strategy for the conservation of these species should be developed, which includes designating additional upper watersheds for conservation, free from hydropower equipment and other activities that could impact these species and ensuring long-term management of these newly protected areas.

By incorporating these additional measures and recommendations, the Dorjilung HPP can effectively mitigate its cumulative impacts, not only at the project level but also contribute positively to larger-scale ecological management and conservation efforts across the Kuri-Gongri Basin.

D. ADDITIONAL INFORMATION

12 STAKEHOLDER ENGAGEMENT AND PUBLIC CONSULTATIONS

12.1 Previous ESIA

Consultations were conducted during the previous ESIA preparation phase in 2015-2016 with a) affected households, b) local communities' people in the villages and urban settlements, c) local government at the gewog level in Mongar and Tsaenkhar in Lhuentse). The objective of the consultations was to inform the public about the project, project components, the activities, the size, labour and equipment that would be employed, the positive impacts that the project will bring to the local and national economy; possible negative impacts that the people have to accommodate with that is associated with the project and invite public opinion, issues and concerns in the ESIA and RP Report.

Participant list from Saleng, Tsaenkhar, Tsakaling gewogs was prepared. This list includes a statement/summary stating that the consultation on the project was conducted and that the participants were informed that they will be provided with compensation if their land or property is acquired by the project and that they do not have any reservations against the project.

Formal meetings were held with government agencies such as the National Environment Commission, National Library, National Referral Hospital, Ministry of Health, Forest Ranger, Gyelpozhing, and with the Dzongkhag Administration in Mongar and Lhuentse.

In terms of disclosure, the project was initially presented at a national workshop on the ESIA on 18 November 2015 wherein representatives from the following agencies participated.

- Druk Green Power Corporation (8),
- Ministry of Agriculture and Forest (1),
- World Wildlife Fund Bhutan (1),
- Department of Forest and Park Services (1),
- National Biodiversity Centre (1),
- Ministry of Health (2),
- Department of Geology and Mines (2),
- Bhutan Power Corporation (2),
- Tangsibji HEP (1),
- Bhutan Electric Authority (1),
- National Research Centre for Riverine and Lake Fisheries (1),
- Ministry of Home and Cultural Affairs (1)

It is not clear if outreach activities were undertaken in earlier phases of the Project (2011-2015).

Summary of consultations with dates, locations, primary audience, key issues / concerns raised, and responses from project proponent are provided in appendices to the SEP.

12.2 Updated ESIA 2023-2024

A chronological summary of the stakeholder consultation and/or engagement carried out during the ESIA Update is provided in the table below. This information is also included with minutes of meeting in ESIA Volume VIIIB Appendices - Appendix H and Appendix P, and the SEP and appendices.

Table 199: Summary of consultation/engagement carried out during ESIA Update.

Date	Participants	Gender	Key topic of consultation / Key message received
7 February 2023	Chief and staff Water Resources Division (now the Department of Water (DoW),		Discussion for the meeting held between Department of Water (DoW), Ministry of Energy & Natural Resources (MoENR), Druk Green Power Corporation Limited (DGPC) and ARTELIA (Consultant) regarding Environmental Flow

Date	Participants	Gender	Key topic of consultation / Key message received
			Assessment (EFA) for 1,125 MW Dorjilung Hydropower Project (HPP).
20 February 2023	Chief, National Statistics Bureau (NSB)		To discuss the process for conducting household surveys and seek data on the project area from NSB to plan for the social surveys and field data collection.
2 March 2023	Department of Environment and Climate Change (DoECC), Ministry of Energy & Natural Resources (MoENR)		Following the discussion between PCS & DGPC on Feb 10, 2023, regarding the ESIA ToR issued for Dorjilung HPP (for ESIA Update), the DGPC discussed and sought clarifications on the scopes that were flagged for discussion with the DoECC.
17 April 2023	Director, Department of Culture and Dzongkha Development, Ministry of Home Affairs		Informed the Director about the project and the SEP and sought clarification on the preliminary list of PCR sites for all the gewogs and requested guidance to confirm whether all significant sites have been included.
27 April 2023	Offtg. Director, Department of Forest and Park Services		The consultant briefed the Offtg. Director about the Project and the SEP indicating the various project components on the map and discussing various points as listed in the Record of discussions that were reshared with the DOFPS for their review and comments.
17 May 2023	Introductory meeting at Mongar Dzongkhag	6 M, 0 F	Key concern: Autsho community is very concerned about the impact of the submergence/reservoir on the township and the chorten and enquired about the possibility of shifting the dam further downstream.
17 May 2023	Banjar community, Tsamang Gewog	2 M, 13 F	Concerns about the blasting- The community expressed their worries about their homes' walls cracking because of vibration from the blasting.
17 May 2023	Primary Health Care Centre, Banjar	1M, 0 F	The HA expressed that the occurrence of violence between community people and foreign workers is expected when the project starts. The other concern is the increase in the number of STIs in the local community.
17 May 2023	Tsamang Primary School	1M, 0 F	School is at maximum capacity.
18 May 2023	Primary Health Care Centre Tsamang	1M, 0 F	
18 May 2023	Primary Health Care Centre, Lingmaythang	1M, 0 F	
18 May 2023	Lingmaythang Middle Secondary School	1M, 0 F	Cannot accommodate more now.
18 May 2023	Tokari community, Tsamang Gewog	2 M, 15 F	There were no comments, clarifications, or concerns in the large group meeting. During the smaller group meetings. One serious social concern is the use of Marijuana by the youth and its sale to both locals and outsiders from as far as Thimphu. There is a risk that this could increase with the project.
19 May 2023	Gyelpozhing Hospital	0 M, 1 F	
19 May 2023	Gyelpozhing Higher Secondary School	0 M, 1 F	It is below capacity, can accommodate a maximum of 780 students.

Date	Participants	Gender	Key topic of consultation / Key message received
19 May 2023	Dangaling community, Tsamang Gewog	3 M, 8 F	Welcome
18 May 2023	Lingmaythang town and community, Saleng Gewog	7 M, 16 F	**Location of muck disposal sites.** The community had recently had a meeting with Park officials and were informed that the area between Kurichhu bridge and the Kurichhu HEP dam should not be disturbed as it was the habitat for eagles
19 May, 2023	Gyalsuung Project	3 m, 1 F	Main concern was the surgeshaft area, its access road, and if there are any structures overlooking the Gyalsuung project.
19 May, 2023	NRDCL, Gyelpozhing	1 M, 0 F	When the project is confirmed to commence, the GM will apprise his General Manager who will write to DOT for approval to import additional fuel to cater to the increased requirement.
20 May 2023	Druk Petroleum Corporation Limited (DPCL), Gyelpozhing	1 M, 0 F	
20 May 2023	Primary Health Care Centre, Chaling	1 M, 0 F	Before when the school had till class 8 they could accommodate more students but now that it is downgraded, they cannot.
20 May 2023	Chaling Gewog	14 M, 6 F	The community has expectations that the project will generate employment for the locals.
20 May 2023	Chaling Lower Secondary School	2 M, 0 F	
21 May 2023	Gyelpozhing town and community	6 M, 14 F	
22 May 2023	Mendroling Monastry, Autsho	1 M, 0 F	Project impact. He believes that project will benefit the Autsho township because in recent times, only the monks and old people seem to be left in the rural communities. The principal said that he had met with the community, and they had expressed their happiness to him with the project being initiated.
22 May 2023	Tsenkhar and Jarey Gewog and Autsho town	27 M, 27 F	The Gup said that they had heard about the Dorjilung project a while ago and most people were curious to know whether the project would start and if so when.
22 May 2023	Autsho Hospital	1 M, 0 F	
22 May 2023	Autsho Central School	1 M, 0 F	The school can accommodate an additional 30-40 students based on incoming teachers.
22 May 2023	Introductory meeting at Lhuentse Dzongkhag	16 M, 3 F	Key Concern: Impacts on Autsho town. Dasho was concerned about the project location, as Autsho has been identified as the future town and the livable city for Lhuentse Dzongkhag.
22 May 2023	Lingmaythang Range Office, under Mongar Forest Division	1 m, 0 F	Critical habitat – The forest is mostly broadleaf and chirpine but there are no critical habitats in the area, except the KBA area.
22 May 2023	Tsenkhar Forest Office under Mongar Forest Division	2 M, 0 F	There are no endangered species in the area, only common species such as sambar, capped langur, giant squirrel, and barking deer.

Date	Participants	Gender	Key topic of consultation / Key message received
22 May 2023	Autsho Range Office under Phrumsengla National Park	1 M, 0 F	
23 May 2023	Primary Health Care Centre, Takhambi	1 M, 0 F	No questions
23 May 2023	Primary Health Care Centre, Tsakaling	2 M, 0 F	The Health Assistant replies that he sees both positive and negative effects of the project when asked what some of the issues are. He asserted that there would undoubtedly be an increase in population along with an increased number of workers; as a result, he feels the PHC will be updated and that further advancements in the health services may be expected. He also sees air pollution from the project area; thus, he anticipates a rise in COPD cases in the community. There is no shortage of equipment and medicines for now. But if the projects come then he feels that there will be a need to increase the quantity of medicines and equipment.
23 May 2023	Tsakaling Primary School	1 M, 0 F	
23 May 2023	Tsakaling Gewog	17 M, 11 F	There were no comments, clarifications, or concerns in the large group meeting, However, during the interview with the Gup, it was expressed that the affected communities should be given first priority in terms of benefits (employment, opportunities to earn income). There is interesting to operate stone quarries as a community and supply materials to the project and that the project will respect and follow the gewog by-laws.
24 May 2023	Tokari community, Tsamang Gewog	1 M, 14 F	
24 May 2023	Mongar Gewog	8 M, 0 F	Impacts of Transmission line. The farmers do not get compensation for the land under the transmission line, which while being retained under the farmers.
24 May 2023	Forest Range office, Gyelpozhing under Mongar Forest Division	1 M, 0 F	
25 May 2023	Bhutan Power Corporation Office	1 M, 0 F	Requested further information to assess the layout.
25 May 2023	Mongar Forest Division	3 M, 0 F	Areas inside the PNP- The project layout was discussed, and it was clarified that the area under Tsamang does not fall inside the PNP, but that Tsamang gewog is included for administrative purposes.
25 May, 2023	Mongar Regional Referral Hospital	2 M, 0 F	
25 May, 2023	Bhutan Construction and Transport Authority under the Ministry of Information and Communication (MoICE)	1 M, 0F	The BCTA has submitted the annual report on road accidents, data requested.

Date	Participants	Gender	Key topic of consultation / Key message received
25 May, 2023	Department of Surface Transport (DOST) under the Ministry of Infrastructure and Transport (MoIT)	1 M, 0F	Plans for road widening need to be developed
25 May, 2023	Royal Bhutan Police	1 M, 0F	Regarding social conflicts, expat workers normally do not engage in local festivities and religious occasions so there is no issue. The workers have their own festivals, wherein support is provided by the RBP.
26 May 2023	Phrumsengla National Park	1 M, 0F	The CFO overlayed the park kmz on Dorjilung HPP and found that the project components are falling outside the Park area but in the buffer zone, which is under the management of PNP, and the project components are not falling in BC 7 on park side.
26 May 2023	Debrief at for both Mongar and Lhuentse Dzongkhags	4 M, 0 F	Key concern: Dasho mentioned that Menchugang is the only water source for the area and the settlement is also growing with many offices and the school has been upgraded. The consultant informed the meeting that the technical team is still exploring suitable locations for PH, and this is yet to be finalized, so that accordingly drinking water sources to be tapped can be ascertained.
9 June, 2023	Department of Environment and Climate Change, MoENR	1 M, 0 F	Some of the concerns with landfill sites are the cost of transportation and the landfill site maintenance issues in the future.
18 July, 2023	Competition & Consumer Affairs Authority (CCAA)	1 M, 0 F	Whether the project would impact Autsho town in terms of submergence- The reservoir extent and dam location 6km downstream of Autsho was clarified
16 August, 2023	Consultation with National Biodiversity Centre (NBC), Ministry of Agriculture and Livestock	1 M, 0 F	The PD expressed that given the extent of the reservoir area, the primary concerns would be more on aquatic species, compared to terrestrial species, due to the dewatered section, and on sustainability of the water source.
18 August, 2023	First Consultation with Department of Culture and Dzongkha Development (DoCDD), Ministry of Home Affairs (MoHA)	1 M, 1 F	Meeting to present the project background, objectives and activities as well as the field survey findings.
28 August, 2023	Ministry of Education and Skills Development	6 ppl	Since only a skeletal crew would be manning the station after the completion of the project, certain schools would need to be closed off unless the project is willing to fund.
22 September 2023	Consultation with Ministry of Infrastructure and Transport	11 ppl	The feasibility study of the road and site survey was inquired upon.
31 October 2023	Department of Forest and Park Services	4 ppl	Presentation on field survey and CHA findings and discussion mitigation measures including compensatory afforestation

Date	Participants	Gender	Key topic of consultation / Key message received
3 January 2024	Second Consultation with MoIT a	7 ppl	Threat of Glacial Lake Outburst Flood (GLOF) upstream and its impact. The Ministry added that for future road development projects in the area, mitigation measures would need to be carried out.
3 January 2024	Second Consultation with Ministry of Education and Skills Development	3 ppl	The main concern of the Ministry is to ensure that the infrastructure and facilities required can be assessed and the possibilities of working with the project in terms of building infrastructure and cost-sharing.
15 April 2024	Gyelpozhing, Mongar Gewog	19 M, 2 F	Providing the opportunity for the locals to rent their apartments is very good because as seen in other projects, construction of colonies results in lots of permanent structures that are not required. The project must think of long-term benefits to the communities, and not just for the project term, as it is obvious that the benefit e.g. employment only lasts for a short while
16 April 2024	Banjar community, Tsamang Gewog	11 M, 19 F	The people have been waiting for the project and have high expectations that the project will commence soon and that they will benefit through income generation.
16 April 2024	Tokari community, Tsamang Gewog	5 M, 33 F	Whether there will be an impact on their irrigation water due to the project. For land compensation, there was a query about where the land would be provided from. Since they have limited land, they are worried about the impact on private land due to the transmission lines and towers.
17 April 2024	Tsaenkhar and Jarey Gewogs	22 m, 22 F	As the study is very detailed, there is strong support from the community for the project, and even if there are impacts on private plots, there are provisions for compensation.
17 April 2024	2nd consultation with Lhuentse Dzongkhag	7 m, 4 F	Dasho mentioned that since religious ceremonies are held at Autsho town, air pollution could impact the masses.
18 April 2024	2nd consultation with Mongar Dzongkhag	6 M, 1 F	Waste is the responsibility and accountability of Dzongkhag. As segregation will be very difficult- should focus on hazardous waste management- It is preferred to have separate landfill site per dzongkhag as there may be an issue during operation time as waste is increasing every year. An independent landfill is better administratively for O & M and ownership.
18 April 2024	Tsakaling Gewog	96 M, 139 F	Include requirement to provide opportunities to the three affected gewogs first. For example, job opportunities for unemployed youth, contracts for wall construction.
19- April 2024	Chaling Gewog	18 M, 6 F	During the lean season, the river flow is very low due to less flow from the source with reduced exports. Moreover, to meet domestic need- we import from India. What measures are in place to overcome production during the lean season
20- April 2024	Saleng Gewog	41 M, 55 F	Clarification on why the areas previously proposed by the Tsogpa do not seem to have been selected, which would have allowed town expansion, and the lack of facilities such as CCFs in Lingmethang resulting in reduced economic opportunities for the town.

Date	Participants	Gender	Key topic of consultation / Key message received
23 April 2024	National Stakeholder Consultation including: • National Commission for Women & Children (NCWC) • Respect, Educate, Nurture and Empower Women (RENEW) • Department of Environment and Climate Change (DECC) • Department of Water • Department of Culture • Natural Resources Development Corporation Limited (NRDCL) • Dept of Surface Transport • Dept of Labour • National Research Centre for Riverine And Lake Fisheries	22 M, 7 F, 5 n/a	• One of the key concerns is insecurity for women and children- especially youth crime, work-based abuse such as discrimination, bullying, gender-based violence and disaster's that impact women and children more than men and local business (NCWC). • Preventive measures in place for air and dust pollution, in terms of monitoring as well as social well-being aspect or benefit for local communities, preventive measures during the peak flow especially when children are on vacation to ensure children do not go to the riverside. (NCWC) • Is there a mechanism to ensure that whoever is being recruited does not have criminal background (NCWC). • How the implementation of this project addresses existing and future gender-based violence issues. She also asked to add sexual reproductive health to health concerns (inform) and partnerships with health workers and and to have monitoring and evaluations happen by NGOs, CSOs. (RENEW). • Enquired on assessment of cultural heritage sites (DECC). • The assessment of the existing scenario as a baseline, along with projected impacts during and after construction assessment be carried out as a comparative assessment. (Department of Water). • Questioned if the potential impact on sand mining business has been considered (NRDCL). • Enquired how construction and demolition waste will be handled (Dept of Surface Transport)
16 May 2024	Meeting with Department of Forestry and Park Services	5 M, 2 F	• Discussion on feasibility of biodiversity management measures proposed.

12.3 Considerations in ESIA

Key aspects raised during consultations have been addressed within this ESIA and supporting documentation. At a high level this includes:

- Project Layout and Footprint, including location of facilities and new & upgraded roads (Section 3 of ESIA)
- Alternatives considered (Section 5 of ESIA).
- Impact on human environment from footprint including loss of livelihood and assets (Section 10.2.4 of ESIA and standalone LALRP.
- Impacts from construction including noise, traffic, dust and waste (Section 10.3.1 of ESIA).
- Impact on water during operation including Eflow (Section 10.5.1 of ESIA)
- Impact on the human environment during operation including community health (Section 10.5.3).

13 KEY MEASURES AND ACTIONS FOR THE ENVIRONMENTAL AND SOCIAL COMMITMENT PLAN

13.1 Overview

An Environmental and Social Commitment Plan (ESCP) has been prepared as a standalone document for the project following the World Bank Template. The ESCP is required by the World Bank ESF. It forms part of the legal/financing agreement between the World Bank and Borrower for the investment on Dorjilung Hydro-electric Power Project in the future. The ESCP will be agreed between the two parties during the future project preparation, and it is therefore subject to changes to align with the project design and implementation readiness.

Section 13.2 provides a summary of the material measures and actions, timeframe, and responsible entity as detailed in the ESCP.

13.2 Summary of ESCP Actions

For full details please refer to the standalone ESCP.

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
MONITORING AND REPORTING			
A	REGULAR REPORTING Prepare and submit to the Association regular monitoring reports on the environmental, social, health and safety (ESHS) performance of the Project, including but not limited to the implementation of the ESCP, status of preparation and implementation of E&S instruments required under the ESCP, stakeholder engagement activities, and functioning of the grievance mechanism(s) [specify other aspects that the reporting would need to consider, as relevant].	Submit quarterly reports to the Association throughout Project implementation, commencing after the Project implementation Effective Date. Submit each report to the Association no later than 20 working days after the end of each reporting period.	DGPC
B	INCIDENTS AND ACCIDENTS Promptly notify the Association of any incident or accident related to the Project which has, or is likely to have, a significant adverse effect on the environment, the affected communities, the public or workers, including, inter alia, cases of sexual exploitation and abuse (SEA), sexual harassment (SH), accidents that result in death, serious or multiple injury, impacts to critical habitats and species, and pollution of watercourses exceeding set limits. Provide sufficient details regarding the scope, severity, and possible causes of the incident or accident, indicating immediate measures taken or that are planned to be taken to address it, and any information provided by any contractor and/or supervising firm, as appropriate. Subsequently, at the Association's request, prepare a report on the incident or accident and propose any measures to address it and prevent its recurrence.	Notify the Association no later than 48 hours after learning of the incident or accident. Provide subsequent report to the Association within 10 working days after learning about the incident or accident.	DGPC
C	CONTRACTORS' MONTHLY REPORTS Ensure that the construction contractor(s) provides monthly monitoring reports on ESHS performance in accordance with the metrics specified in the respective bidding documents and contracts and submit such reports to the Association.	Submit the monthly reports to the Association as annexes to the reports to be submitted under section A.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
D	NOTIFICATIONS RELATING TO DAAB COMPLIANCE REVIEW OF CONTRACTOR COMPLIANCE WITH SEA/SH PREVENTION AND RESPONSE OBLIGATIONS Notify the Association of any referral submitted to the Dispute Avoidance and Adjudication Board (DAAB) to initiate a process of compliance review in relation to a contractor's obligations to prevent and respond to sexual exploitation and abuse (SEA), and/or sexual harassment (SH) specified in the respective works contract with such contractor; and, in the event of any such referral, notify the Association of: (i) the DAAB's decision on such referral; (ii) the contractor's Notice of Dissatisfaction, if any, with such DAAB decision; (iii) any notification received on the commencement of an emergency arbitration proceeding or full arbitration proceeding in relation to the DAAB's decision; and (iv) the resulting emergency arbitration order and/or full arbitration order, if any.	No later than 7 days after the issuance or receipt, as applicable, of the relevant document (i.e., referral to the DAAB, issuance of DAAB decision, Notice of Dissatisfaction, notice of commencement of emergency/full arbitration, emergency/full arbitration order, as applicable).	DGPC
ESS 1: ASSESSMENT AND MANAGEMENT OF ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS			
1.1	ORGANIZATIONAL STRUCTURE Establish and maintain a PMU with qualified staff and resources to support management of ESHS risks and impacts of the Project including: 1 ESHS Manager, 1 Environmental Specialist, 1 Biodiversity Specialist, 1 Social Specialist, 1 Gender/GBV/SEA/SH Specialist, 1 Community Liaison Officer, 1 GIS/Documentation Specialist as well as 3 ESHS inspectors acceptable to the Association. The ESHS Manager reports directly to the Project CEO/Director. As required, recruit additional key staff to ensure effective management of ESHS risks and impacts depending on factors such as the type, number, complexity of activities etc.	Establish and maintain a PMU as set out in the Financing Agreement prior to Project Appraisal. Submit the terms of reference of the E&S positions for prior review and clearance by the Association. Hire or appoint the Biodiversity Specialist prior to appraisal. Hire or appoint the the 3 ESHS inspectors at least 2 months prior to the Main Works phase. Thereafter maintain all positions throughout Project implementation.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
1.2	ENVIRONMENTAL AND SOCIAL INSTRUMENTS Consult, finalize based on consultations and the Association's feedback, disclose, adopt and implement the Environmental and Social Impact Assessment (ESIA), and corresponding Environmental and Social Management Plan (ESMP) as well as all associated E&S Documentation that have been prepared for the Project. The standalone associated E&S Documentation include EFlow Assessment (high resolution) and Eflow Management Plan (EFMP), Biodiversity Action/Management Plan (BAP/BMP), Environmental and Social Commitment Plan (ESCP), Stakeholder Engagement Plan (SEP), E&S Borrower Capacity Assessment, Gender, GBV-SEA/SH and Vulnerability Action Plan (GSVAP), Land Acquisition and Livelihood Restoration Plan (LALRP), Cultural Heritage Management Plan (CHMP) and Labour Management Procedures (LMP). Implement an E&S Change Management Procedure to evaluate and address any significant departure to the design or construction of the Project.	Disclose the ESIA and ESMP no later than 120 days before Board Date, and thereafter finalize, redisclose, adopt and implement the ESIA and ESMP throughout Project implementation. Adopt the ESMP before launching the bidding process for the Project. Once adopted, implement the ESMP throughout Project implementation.	DGPC BPC
1.3	MANAGEMENT OF CONTRACTORS Ensure the construction contractor(s) and all its sub-contractors and service providers adopt the ESIA and ESMPs and in turn develop a construction, commissioning and operational stages ESMPs. Incorporate the relevant aspects of the ESCP, including, inter alia, the relevant E&S instruments, the ESMP, CHMP, the Labor Management Procedures, the GSVAP and code of conduct, into the ESHS specifications of the procurement documents and contracts with contractors and supervising firms. Ensure that the intent and objectives of all aspects of the E&S documentation are maintained as contractual obligations for the contractors and supervising firms. Thereafter ensure that the contractors and supervising firms comply and cause subcontractors to comply with the ESHS specifications of their respective contracts.	As part of the preparation of procurement documents and respective contracts. Supervise contractors throughout Project implementation.	DGPC BPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
1.4	TECHNICAL ASSISTANCE Ensure that the consultants, studies (including feasibility studies, if applicable), capacity building, training, and any other technical assistance activities under the Project are carried out in accordance with terms of reference acceptable to the Association, that are consistent with the ESSs. Thereafter ensure that the outputs of such activities comply with the terms of reference.	Throughout Project implementation.	DGPC
1.5	NATIONAL APPROVALS / Project Obtain national approvals from Department of Environment and Climate Change for the Project.	Prior to the Project implementation Effective Date.	DGPC
1.6	NATIONAL APPROVALS / Power Evacuation Line Prepare separate ESIA including ESMP for the Power Evacuation Transmission line (PETL) (See commitment 1.8). Obtain national approvals from the Department of Environment and Climate Change for the power evacuation required for the Project.	Prior to the Project implementation of Power Evacuation Transmission Line.	BPC and DGPC
1.7	NATIONAL APPROVALS / Quarries and other sites Obtain national approvals from the Department of Environment and Climate Change for the quarries or other facilities for the Project.	Prior to the Project implementation Effective Date.	DGPC
1.8	ASSOCIATED FACILITIES Prepare separate ESIA including ESMP for the Power Evacuation Transmission line (PETL), following the Environmental and Social Management Framework presented in Section 13 of Project ESIA. Ensure that the activities for the PETL are carried out in accordance with the applicable requirements of this ESCP and all ESSs including preparation or	All relevant E&S documentation to be prepared and non-objected prior to any construction activities taking place for the power evacuation line. Throughout implementation.	Bhutan Power Corporation and DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	amendment to the ESIA, ESMP, LMP, BMP, RAP, SEP and management of contractors.		
1.9	ENGAGE ES PANEL OF EXPERTS (ESPoE) The project requires an ES panel of experts (ESPoE) during the preparation phase of Dorjilung HPP under the World Bank Technical Assistance project. It is expected that the role of the ESPoE will continue through the construction phase and into the operations phase of the project. However, as the project preparation evolves and when decisions on its future investment and construction are made, the role and composition of the ESPoE will be revisited, and the ESPoE will be reconstituted under new Terms of Reference	During the preparation phase and expected to continue throughout construction and implementation.	DGPC
ESS 2: LABOR AND WORKING CONDITIONS			
2.1	LABOR MANAGEMENT PROCEDURES Consult, finalize based on consultations and the Association's feedback, disclose, adopt and implement the Labor Management Procedures (LMP) developed for the Project, including, inter alia, provisions on working conditions, management of workers relationships, occupational health and safety (including personal protective equipment, and emergency preparedness and response), code of conduct (including relating to SEA and SH), forced labor, child labor, grievance arrangements for Project workers, and applicable requirements for contractors, subcontractors, and supervising firms.	Adopt the LMP prior to engaging any project workers, and thereafter implement the LMP throughout Project implementation.	DGPC
2.2	GRIEVANCE MECHANISM FOR PROJECT WORKERS Operate the grievance mechanism for Project workers, as described in the LMP and consistent with ESS2.	Adopt the grievance mechanism prior to engaging Project workers and thereafter maintain and operate it throughout Project implementation.	DGPC Construction contractor(s)
2.3	CONTRACTOR OCCUPATIONAL HEALTH AND SAFTEY	Ensure the contractor develops standalone Occupational Health and Saftey documentation prior to construction and implements during construction.	DGPC Construction contractor(s)

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	Ensure the contractor develops standalone Occupational Health and Saftey documentation following international standards and documentation prepared in ESIA, ESMP and standalone documents including LMP.		
ESS 3: RESOURCE EFFICIENCY AND POLLUTION PREVENTION AND MANAGEMENT			
3.1	WASTE MANAGEMENT and HAZARDOUS SUBSTANCES Ensure the EPC Contractor develops, adopts and implements detailed management plans as part of the Contractor ESMP to minimize waste and manage hazardous and non-hazardous waste, consistent with ESS3. This should include a Waste Management Plan (WMP) along with (inter alia) a Hazardous Substances Management Plan and an Explosive And Blasting Management Plan. Ensure the EPC Contractor stores, transports and disposes of hazardous waste as per the Hazardous Substances Management Plan. Storage and disposal to be detailed in contractor ESMP to be at appropriate facilities (inc. in accordance with the Basel Convention). A plan for the management of chemical substances will be prepared by the Contractor, detailing the measures planned for minimizing pollution risks. Ensure the EPC Contractor implements Waste Minimization strategies and promotes waste segregation, reuse and recycling. Ensure the EPC Contractor establishes appropriate waste management sites in accordance with Project ESMP without using public facilities (unless with prior agreement of DGPC) and enters into a commercial agreement to manage recycled waste as far as feasible. Monitor the WMP, Hazardous Substances Management Plan, Explosive and Blasting Management Plan, implementation.	Develop and adopt the WMP, Hazardous Substances Management Plan, Explosive And Blasting Management Plan, no later than one month prior to the start of Construction, and thereafter implement the WMP, Hazardous Substances Management Plan, Explosive And Blasting Management Plan, throughout Project implementation.	DGPC
3.2	RESOURCE EFFICIENCY AND POLLUTION PREVENTION AND MANAGEMENT Ensure the contractor develops and implements detailed resource efficiency and pollution prevention and management measures as part of the C-ESMP and in line with the Project ESMP prepared under action 1.2 above. This should include (inter alia): minimization of surplus volumes of muck at the detailed design stage or maximize	Same timeframe as for the adoption and implementation of the ESMP.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	their reuse for fill which does not require specific geotechnical characteristics, deposit materials resulting from removal of the surface soils (topsoil) separately to reuse them during restoration works, reuse of concrete and plaster debris and/or appropriately stored chemicals as possible. Ensure contractors develop and implements detailed measures that avoid or minimize water quality impacts including (inter alia): Erosion and Sediment Control Plan and Water Quality Monitoring Plan (by CC). Ensure OE develops and implements detailed measures that avoid or minimize water quality impacts including (inter alia): Water Quality Monitoring Plan (by OE) and Control of CC Water Quality Monitoring (OE).		
ESS 4: COMMUNITY HEALTH AND SAFETY			
4.1	TRAFFIC AND ROAD SAFETY Ensure the contractor develops, submits for the supervising engineer's approval, adopts and implements a detailed Traffic Management Plan (TMP) to manage traffic and road safety risks as required in the ESMP prepared under action 1.2 above.	Develop and adopt the TMP no later than one month prior to the start of Construction, and thereafter implement the TMP throughout Project implementation.	DGPC
4.2	COMMUNITY HEALTH AND SAFETY Adopt and implement the Community Health and Safety Management Plan and other relevant sub-plans of the ESMP pertaining to community health and safety (including LMP, GSVAP), to assess and manage the health and safety risks to the community. Ensure the contractor develops and implements detailed plans in line with the Project ESMP including the Communities Health and Safety Management Plan. Supporting this plan contractor will also be required to prepare the following management plans (inter alia): Waste Management Plan, Hazardous Substances Management Plan, Explosive and Blasting Management Plan, Emissions, Dust and Noise Management Plan, Road Traffic Management Plan, Construction Sites Access and Security Management Plan, Management of Construction Worker Colonies (Camps), Reservoir First Impoundment Management Plan.	Same timeframe as for the adoption and implementation of the ESMP.	DGPC
4.3	SEA AND SH RISKS	Adopt the GSVAP from the Project implementation Effective Date, and	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	Adopt and implement the Gender, SEA/SH and Vulnerability Action Plan, to assess and manage the risks of SEA and SH.	thereafter implement the GSVAP throughout Project implementation.	
4.4	SECURITY MANAGEMENT Prepare a Security Risk Assessment to provide inputs to a construction phase Construction Sites Access Management Plan and Security Force Management Plan, building on the outline provided in the operational phase ESMP. Assess and implement measures to manage the security risks of the Project, including the risks of engaging security personnel to safeguard project workers, sites, assets, and activities. This is to follow the Construction Sites Access, Security and Security Force Management Plan provided in the Project ESMP and be guided by the principles of proportionality and GIIP, and by applicable law, in relation to hiring, rules of conduct, training, equipping, and monitoring of such personnel.	Prepare a Security Risk Assessment during pre-construction to build on the Project ESMP and inform the preparation of construction phase Construction Sites Access Management Plan and Security Force Management Plan. Prepare and implement pre-construction a Construction Sites Access, Security and Security Force Management Plan.	DGPC
4.5.a	DAM SAFETY (FOR ANNEX A, PARA. 2. ESS4) / Large Dam Establish and maintain an independent dam safety panel of experts (DSPoE), with terms of reference and composition acceptable to the Association, to, inter alia, review and advise on matters related to safety and other critical aspects of the Dorjilung dam, its appurtenant structures, the catchment area, the area surrounding the reservoir, and downstream areas, as relevant. Implement the recommendations made by the Panel, unless otherwise agreed to in writing by the Association.	Prior to the finalization of the Detailed Project Report and throughout Project implementation and operations.	DGPC
4.5.b	DAM SAFETY (FOR ANNEX A, PARA. 2. ESS4) / Large Dam Recruit a Supervising Engineer (SE), based on the terms of reference agreed by the Association, that comprises experienced and competent professionals for the supervision of the design and construction of Dorjilung dam, and adopt and implement dam safety measures during the design, bid tendering, construction, operation, and maintenance of the Dorjilung dam and associated works.	Prior to the finalization of the Detailed Project Report and throughout Project implementation and operations.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
4.5.c	DAM SAFETY (FOR ANNEX A, PARA. 2. ESS4) / Large Dam Adopt and implement the following Dam Safety Plans: (i) a plan for construction supervision and quality assurance (CSQAP); (ii) an instrumentation plan (IP); (iii) an operation and maintenance plan (O&MP); and (iv) an emergency preparedness plan (EPP).	The Dam Safety Plans are non-objected by the Association and dam safety specialist, as required. Each Dam Saftey Plan has different timeline: CSQAP: submit within six months of Project Effective Date building on the TOR for SE to be developed and submitted per action 4.5b. IP: submit before bid tendering. O&MP: submit outline of the O&MP prior to Project Appraisal and final O&MP not less than six months before starting reservoir filling EPP: Submit the Framework EPP prior to appraisal and final EPP not less than twelve months prior to starting reservoir filling. The EPP preparation should involve adequate stakeholders' engagement and consultation, including with disadvantaged or vulnerable groups, based on detailed consequence assessments.	DGPC
4.5.d	DAM SAFETY (FOR ANNEX A, PARA. 2. ESS4) / Large Dam Engage the Panel to carry out a safety inspection of the Dorjilung dam at intervals of not less than once every year during Project implementation, by independent experts whose terms of reference shall be acceptable to the Association.	First inspection within the first 6 months of construction. At least once per year throughout Project implementation and for the first 3 years of operations.	DGPC
4.6	DAM SAFETY / Impoundment Prepare, adopt and implement a reservoir impoundment plan.	The reservoir impoundment plan is non-objected by the Association and dam safety	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
		specialist, as required, at least 3 months prior to first impoundment.	
ESS 5: LAND ACQUISITION, RESTRICTIONS ON LAND USE AND INVOLUNTARY RESETTLEMENT			
5.1	RESETTLEMENT PLANS / LALRP Surveys for the Project Adopt and implement the Land Acquisition and Livelihood Restoration Plan for each activity under the Project and consistent with ESS5. Carry out any subsequent LALRP revision before construction	Adopt and implement the respective LALRP, including ensuring that before taking possession of the land and related assets, full compensation has been provided and, as applicable, displaced people have been resettled and moving allowances have been provided.	DGPC and BPC
5.2	GRIEVANCE MECHANISM Adopt and implement the grievance mechanism (GM) to address resettlement, land acquisition and livelihood restoration related complaints as described in the LALRP.	Same timeframe as for the adoption and implementation of the LALRP.	DGPC and BPC
5.3	Power Evacuation Transmission Line Resettlement Plans Carry out surveys to assess the private plots impacted by the Power Evacuation Transmission Line (PETL). A standalone Resettlement Plan (RP) or Resettlement Plans (RPs) will be prepared to cover the power evacuation line for the Project once field surveys have been completed. The Social Policy Framework as presented in the ESIA should be followed (as prepared in Section 13 of ESIA the PETL Environmental and Social Management Framework (ESMF)).	Adopt and implement the respective RP/RPs prepared for the Power Evacuation Transmission Line.	DGPC and BPC
ESS 6,: BIODIVERSITY CONSERVATION AND SUSTAINABLE MANAGEMENT OF LIVING NATURAL RESOURCES			
6.1	BIODIVERSITY RISKS AND IMPACTS / BMP Adopt and implement mitigation measures documented in the planning level Biodiversity Management Plan (BMP) including Organizational measures, information and training measures, avoid and reduce measures, offsetting measures and monitoring measures (including adaptive management). Measures include (inter alia): Management	Adopt and implement the measures presented in the planning level BMP Project implementation Effective Date.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	of construction sites to control invasive species, Additional surveys for CHQ nest birds and adaptive management, Additional surveys for CHQ H. bhutanica and adaptive management, EFlow implementation, Afforestation program for natural forest habitats and associated species. Measures also include an offsetting program. Prepare, adopt and implement operational level BMP and Biodiversity Offset Management Plan (BOMP), in accordance with the guidelines of the ESIA and BMP (planning level) prepared for the Project, and consistent with ESS6. Conduct additional surveys for the offset and afforestation sites.	Prepare, adopt and implement the Operational BMP and BOMP at the Project implementation Effective Date. Implement the Operational BMP and BOMP during construction and operation.	
6.2	BIODIVERSITY RISKS AND IMPACTS / Biodiversity Surveys for the power evacuation line for the Project Undertake biodiversity surveys for the power evacuation line for the Project. Amend and update the BMP to also cover the power evacuation line for the Project once field surveys have been completed.	Surveys to be undertaken to cover the power evacuation line for the Project. Amend and update the BMP following survey.	DGPC and BPC
6.3	Environmental Flow (Eflow) Follow the implementation and operation requirements presented in the Eflow Management Plan. Follow the provisions for general adaptive management presented in the Eflow Management Plan. This includes measures on the Biodiversity No Net Loss/ Net Gain Approach and Social Adaptive Management. Prepare and implement the specific environmental and social thematic management plans during construction and operation. This includes Dam Eflow Operation Management Plan, Eflow Commissioning Management Plan, Community Safety Management Plan, River Morphology Management Plan, Research Support Management Plan, Native Fish Management Plan, Prevention of pollution, and Cultural Heritage Management Plan.	During construction and operation prepare and implement the specific environmental and social thematic management plans. Implement the Eflow management requirements during operation.	DGPC
ESS 8: CULTURAL HERITAGE			

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
8.1	CULTURAL HERITAGE RISKS AND IMPACTS Adopt and implement the Cultural Heritage Management Plan (CHMP), in accordance with the guidelines of the ESIA prepared for the Project, and consistent with ESS8.	Adopt the CHMP before launching the bidding process for the Project. Once adopted, implement the CHMP throughout Project implementation.	DGPC
8.2	CHANCE FINDS Adopt and implement the chance finds procedure, as part of the CHMP of the Project.	Adopt the CHMP before launching the bidding process for the Project. Once adopted, implement the CHMP throughout Project implementation.	DGPC
ESS 10: STAKEHOLDER ENGAGEMENT AND INFORMATION DISCLOSURE			
10.1	STAKEHOLDER ENGAGEMENT PLAN PREPARATION AND IMPLEMENTATION Adopt and implement a Stakeholder Engagement Plan (SEP) for the Project, consistent with ESS10, which shall include measures to, inter alia, provide stakeholders with timely, relevant, understandable and accessible information, and consult with them in a culturally appropriate manner, which is free of manipulation, interference, coercion, discrimination and intimidation.	Adopt the SEP prepared during ESIA revision, and thereafter implement the SEP throughout Project implementation.	DGPC
10.2	PROJECT GRIEVANCE MECHANISM Establish, publicize, maintain, and operate an accessible grievance mechanism, to receive and facilitate resolution of concerns and grievances in relation to the Project, promptly and effectively, in a transparent manner that is culturally appropriate and readily accessible to all Project-affected parties, at no cost and without retribution, including concerns and grievances filed anonymously, in a manner consistent with ESS10. The Project grievance mechanism is complemented by a dedicated Workers' grievance mechanism and a separate GBV-SEA/SH SPECIFIC GRM.	Adopt the grievance mechanisms from the finalization of the ESIA, and thereafter throughout Project implementation.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	The GBV-SEA/SH SPECIFIC GRMshall be equipped to receive, register, and facilitate the resolution of SEA/SH complaints, including through the referral of survivors to relevant gender-based violence service providers, all in a safe, confidential, and survivor-centred manner.		
CAPACITY SUPPORT			
CS1	SUPPORT FROM INTERNATIONAL E&S SPECIALISTS DURING THE EARLY PHASES Mobilize an international E&S specialist (either an individual or a firm) for the first six months of the pre-construction and preparatory phase to focus on two elements: (i) train DGPC (ii) work alongside DGPC in the preparation of the ESHS Contractor's specifications and the development of the E&S implementation framework for the Project. The international specialist (individual or firm) should have prior experience with World Bank ESF, as well as E&S management during construction.	Mobilize pre-construction for engagement during first six months of the pre-construction and preparatory phase.	DGPC
CS2	TRAINING to build the capacity of DGPC The following targeted training is recommended to help build the capacity of DGPC (further details provided in Borrower E&S Capacity Assessment): Training in Labour Management. Training in implementing and monitoring a Worker's Grievance Redress Mechanism. Training in Workers' OH&S. Training in Community OH&S. Training on implementing and monitoring a Project's Grievance Redress Mechanism. Training in Communication and Stakeholder Engagement	Carry out training prior to pre-construction phase.	DGPC
CS3	DEVELOP TEMPLATES AND SYSTEMS Develop templates and protocols for the monitoring of E&S activities to be implemented under the Project. This includes the development of the following templates: Data management for key information to be stored, database organization, registers, non-compliance reports, photographic records, etc.	Commence now to be available during the pre-construction and preparatory stage.	DGPC

MATERIAL MEASURES AND ACTIONS		TIMEFRAME	RESPONSIBLE ENTITY
	Structure and content of weekly, monthly, and semi-annual progress and monitoring reports. Protocols and checklist for the weekly and monthly ESHS inspections. Protocols and checklist for the daily ESHS inspection. Detailed procedure for handling ESHS non-compliant events. Permit Register.		
CS4	SPECIFIC EQUIPMENT TO BE SOURCED FOR THE PROJECT Source specific equipment for the Project including: At least three (3) digital cameras with memory cards. At least four (4) 4WD vehicles (one for the ESHS Manager, one for the team at the dam site, one for the team at the powerhouse site and one for the adits, ancillaries and transportation to local townships). At least eight (8) personal computers – one for each specialist and one shared computer for the inspectors. Each computer should be recent, in good working order with basic software installed. One of the computers will need to be powerful enough to run GIS. At least one (1) air quality monitoring system. At least one (1) water quality sampling probe. Establishment of a commercial agreement for laboratory services (mostly in relation to water quality monitoring). Some equipment could be requested through the EPC Contractor (vehicles and associated fuel and maintenance)	Sourced (acquired) for the Project prior to construction and maintained throughout its delivery.	DGPC Construction contractor(s)

14 POWER EVACUATION TRANSMISSION LINE ESMF

14.1 ESMF Introduction

This section of the ESIA presents the Environmental and Social Management Framework (ESMF) for the Power Evacuation Transmission Line (PETL) connection from the Dorjilung HPP powerhouse to the regional grid. This PETL is for power evacuation, not construction power supply. The ESMF is a high-level document and serves as a basis for future detailed studies.

This ESMF is developed to support the environmental and social due diligence provisions for activities financed by the World Bank. This ESMF is targeted at the PETL of the Dorjilung HPP project, as the wider project activities (see ESIA Section 3) are covered in the EISA separately. DGPC will be implementing the PETL activities.

Preparation of the ESMF has been based on the two route options provided by DGPC in September 2023. As the final alignment has not been decided at the time of ESIA preparation the ESMF has been designed to provide an overall guideline for the detailed E&S planning for the PETL that will need to occur at a later stage once the PETL alignment is finalised. The ESMF includes analysis of these two alternative routes and assessment of the E&S pros and cons of each route.

This ESMF has been prepared to identify the potential environmental and social risks and impacts of proposed PETL activities and propose suitable mitigation measures to manage these risks and impacts. It maps out the World Bank policies appliable to the PETL, and describes the principles, approaches, implementation arrangements, and environmental and social mitigation measures to be followed.

The objective of the ESMF is to assess and mitigate potential negative environmental and social risks and impacts of the PETL consistent with the Environmental and Social Standards (ESSs) of the World Bank ESF and national requirements. More specifically, the ESMF aims to (a) assess the potential environmental and social risks and impacts of the proposed PETL and propose mitigation measures; (b) to establish terms of agreement between relevant authorities in DGPC and the World Bank regarding principles and procedures to be used in subsequent preparation of a Resettlement Plan (RP) in accordance with the Resettlement Policy Framework (RPF); (c) establish procedures for the environmental and social screening, review, approval, and implementation of activities; (d) specify appropriate roles and responsibilities, and outline the necessary reporting procedures, for managing and monitoring environmental and social issues related to the activities; (e) identify the staffing requirements, as well as the training and capacity building needed to successfully implement the provisions of the ESMF; and (f) address mechanisms for public consultation and disclosure of project documents as well as redress of possible grievances.

This ESMF follows the World Bank Environmental and Social Framework (ESF). While national laws and regulations of Bhutan have not been considered in this ESMF, any relevant approvals will need to be determined and obtained by DGPC prior to construction activities. This would include any national environmental and social impact assessment documentation.

Consideration with the ESMF also includes similar aspects to those assessed in the ESIA but focussed on the PETL. This includes environmental impact assessment, alternative analysis, and environmental and social management. An initial consideration of potential risks, impacts, and mitigation measures has been presented in this ESMF. This initial consideration will need to be further developed during later PETL stages. Also included is a social policy framework covering social aspects (e.g. resettlement, labour, gender etc.). Specifically, a Resettlement Policy Framework (RPF) has been prepared following the principles, criteria and entitlement matrix as per the LALRP.

This ESMF should be read together with other plans prepared for the project, including the wider ESIA and ESMP and associated separate plans including SEP, ESCP, BMP, E&S Borrower Capacity Assessment, LALRP, CHMP and LMP.

14.2 PETL Description

14.2.1 Background on PETL Route Options

In August 2023, DGPC approached the Department of Energy (DoE) under the Ministry of Energy and Natural Resources for the National Transmission Grid Master Plan (NTGMP). Information was requested on the potential corridors of the PETL to support the ESMF preparation, and DGPC were informed that the existing NTGMP 2018 was being updated.

In September 2023, information was shared from DoE to Artelia via DGPC, providing the Associated Transmission System (ATS) information which included a map showing Dorjilung HPP and the wider grid from the latest NTGMP report. The ATS information included two routes from Dorjilung HPP to Durungri Power Station (PS) where connection to the wider grid is proposed. This wider grid is proposed to then connect to other parts of Bhutan as well as Rangia, India, via an additional 37 km route. The map provided is shown in Figure 199. The proposed connections from Durungri PS to other areas have not been considered in this ESMF screening, only the two routes from Dorjilung HPP to Durungri PS.

As detailed GIS information was not provided with this update, Artelia subsequently converted this information into .kmz files. The separate PETL options were labelled TL1 and TL2 for this ESMF. Each PETL was calculated based on the distance and position shown in the maps in the ATS information and extrapolated on Google Earth. These corridors are relatively crude, but they give an indication of the main features of the area to be crossed by the TL. As the exact position of the Durungri PS was also unknow, Artelia placed it in a position with the effort to not affect the nearby village of Amshingwoong. As more precise information (i.e. the actual location of the corridor) was not provided Artelia used this .kmz file to do a comparative analysis and inform the ESMF for TL. The approximate route options are shown on Figure 16.

14.2.2 Other PETL route options

It is noted that the ATS documents provided a short description of the routes which included information that there are other studies being conducted to realign the route or the entire ATS in Bhutan. The information from these studies was not known when the updated ATS route was shared. It is therefore feasible that the final PETL for Dorjilung HPP is on either of the routes considered in this ESMF. The E&S screening of the two routes should be understood in this context. This highlights the importance of the ESMF as a framework for future studies.

14.2.3 Summary of Route Options for Dorjilung HPP

Option-I proposes a 2xD/C 400 kV ACSR Moose twin configuration line from Dorjilung HEP to Durungri pooling station (PS), with power transmitted to India via a 1xD/C 400 kV ACSR Moose quad line. It includes a contingency 1xD/C 400 kV twin line for power evacuation to Phuntshothang and further transmission to India through the Nyera-Amari ATS. The route avoids sensitive areas and protected zones, ensuring minimal disruption, with a 52-meter Right-of-Way (RoW) covering seven Gewogs in Monggar and Pemagatshel dzongkhags. However, it intersects with the RoW of existing 132 kV lines at two points, which could potentially be avoided with rerouting.

Option-II proposes a 1xD/C 400 kV ACSR Moose twin line from Dorjilung HEP to Durungri PS and Gongri HEP, interconnecting hydroelectric plants. The pooled power from Durungri PS would be transmitted to India via a 1xD/C 400 kV ACSR Moose quad line. This option also avoids sensitive areas

and follows existing road networks, maintaining a 52-meter RoW. However, it intersects with the RoW of 132 kV lines, and rerouting is not possible within Monggar.

While Option-II offers flexibility for interconnecting Dorjilung and Gongri HEPs and optimizing the ATS for Kholongchhu, Dorjilung, and Gongri, it is more expensive by Nu. 4,376 million compared to Option-I. Based on feasibility and cost assessments, Option-I is recommended for the 1,125 MW Dorjilung hydroelectric project, though Option-II may be considered if issues arise with tower/circuit alignment or space at Durungri PS. Based on the PETL standards available online from Bhutan Power Commission, it is expected the PETL Right of Way (RoW) would be 52 m. Within the RoW the maximum tree height is 5.5 m. Towers are assumed to be required approximately every 350 m (300-500 m for 400 kV).

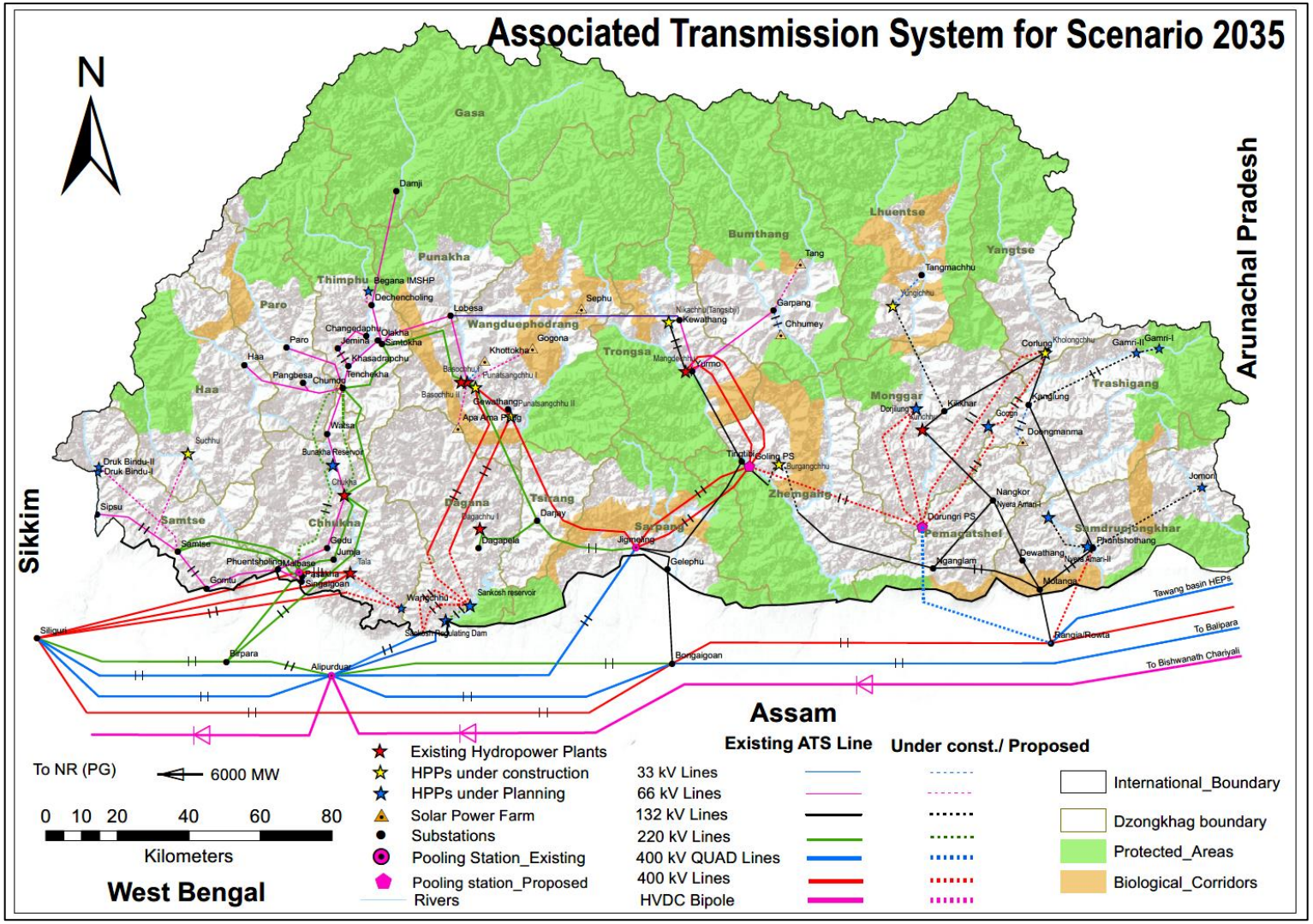


Figure 199: Associated Transmission System for Scenario 2035. Source Department of Energy

Note: map based on information provided in September 23 and extrapolated by Artelia – locations very approximate.

14.3 Environmental and Social Policies, Regulations, and Laws

14.3.1 Legal Framework

The legal framework includes the following acts, rules and regulations in relation to the Power Evacuation Transmission Line.

14.3.1.1 The Constitution of Bhutan, 2008

Article 7 provides all Bhutanese the right to life, liberty and security, freedom of speech, opinion and expression, right to information, right to freedom of thought, conscience and religion.

Article 9(3) ensures protection of fundamental human rights, freedom, dignity, and freedom from discrimination, oppression, and violence of all people.

Article 5(2) requires the Government to ensure a safe and healthy environment.

14.3.1.2 Electricity Act

The objective of the Act is to promote a safe and reliable supply of electricity throughout the country, enhance revenue generation through export of electricity, promote socio-economic development and self-reliance and to promote efficiency in management and service delivery. The Act requires that environmental considerations are considered when developing the electricity supply industry.

The Electricity act allows for the restructuring of the electricity supply industry; establishment of the Electricity Regulatory Authority and the National System Operator, regulation of the electricity supply industry; private sector participation in the electricity supply industry; and empowers the Government to form any company for the purpose of carrying out the purpose of the Act.

The National System Operator coordinates and regulates power system operation and outages and monitors export and import of power.

The responsibility for the survey and construction of transmission facilities for power evacuation lies with Bhutan Power Corporation (BPC). Power evacuation is guided by the National transmission grid master plan for Bhutan (NTGMP) developed for the country.

14.3.1.3 The Grid Code Regulation of Bhutan 2024

This regulation repeals the Bhutan Electric Authority grid code of Bhutan 2008.applies to all entities (system operator, transmission licensee, generation licensee and users) connected to the transmission system. It establishes the rules, standards and procedures governing the operation, maintenance, and development of the transmission system to ensure safe, secure, reliable and efficient operation of the power systems.

According to this regulation the national transmission grid master plan issued by the Ministry is the basis for planning and development of the transmission system. While policies, targets and strategies and approval of the power system expansion plans are the mandate of the Ministry, the Electric Regulatory Authority is responsible for developing relevant standards, codes and procedures related to performance standards including the minimum technical and safety requirements for the operation maintenance of generation transmission and distribution systems. It is also responsible for ensuring the reliability, quality, security and efficiency of the electricity supply. It issues licenses, approves generation tariffs and monitors the performance of licenses and their compliance with the legislative provisions as well as settles disputes and grievances between licensees and customers.

14.3.1.4 Safety Regulation and Safety Code (2008)

The relevant provisions given in BEA's/ERA's Safety Regulation (2008) and Safety Code (2008) must be adhered to and referenced during the DPR, in the Tender Documents and during Construction. Bhutan Hydropower Guidelines

Section A- DPR Preparation, Technical Aspects, of the guidelines describe the requirements to be met for Power transmission lines.

This includes the following

- Detailed surveys include route alignment and profiling, right of way identification and clearance, tower spotting, optimization of tower locations with consideration of the existing ones, soil resistivity measurement, investigation of the site, topographical and geotechnical investigation, with information on wind and weight span for each tower.
- Access roads for tower erection and further service road.
- Consideration of all accessories and components (uts and bolts, washers, phase, circuit, number and danger plates, circuit and conductors, insulators, OPGW/OFC, hardware & fittings).
- Requires that all materials, conductors, OPGW, OFC, insulators, strings and accessories have to be manufactured in compliance with IEC/EN standards.
- The design and construction of transmission corridors in accordance with the relevant IEC standards IEC 60826 / EN 50341.
- Integration of the new power plant into the power system through existing or new pooling stations and requirement of new evacuation lines.

14.3.1.5 Environmental Assessment Act (EA Act), 2000 and Regulation for Environmental Clearance of Projects, 2016 (RECOP, 2016)

The process for Bhutanese E&S Approvals, known as Environmental Clearance (EC) is separate to the International EISA process. Under the EA act and the ECOP, an ESIA is required to be prepared for transmission lines above 33 kV, based on an approved Terms of Reference.

After issuance of EC the proponent is obliged to prepare and submit Detailed Implementation Plan after 3 months of EC issuance, carry out self-monitoring to ensure compliance to EC terms and conditions, Environmental Standards 2020, and other environmental norms, submit monitoring reports as stipulated in the EC terms and conditions, apply for renewal at least three months prior to the expiry of EC, and seek prior approval should there be modification to the approved design/location/project.

14.3.1.6 Forest and Nature Conservation Act (FNCA) of Bhutan, 2023 and the Forest and nature conservation rules and regulations of Bhutan 2023.

Under this Act, any inclusion into or exclusion from State Reserved Forest Land (SRFL) must follow the provisions of the Land Act of Bhutan.

The Act empowers the Department of Forest and Park Services to issue for forestry clearance for construction of transmission line and associated facilites in areas containing high forests based on impact assessment. Forest clearances are valid for a period of project or activity.

Community Forest Management Groups (CFMG) can allow developmental activity within and through the CF on condition that the CFMG are compensated for the damage caused to the resources based on the guidelines developed and issued by the Department.

All mega projects must provide funds for compensatory plantation for double the SRFL impact. The areas selected for compensatory plantation program will not be limited to project area but may also extend to other potential SRF areas and the plantation may be outsourced by the Department but must be executed as per terms and conditions of the outsourcing guideline and technical approval issued by the Department. The respective Chief Forest Officer is responsible for supervising, monitoring and evaluating and reporting on the state of the plantation to the Department.

The Act and regulation restrict hunting, killing, trapping, transporting, capturing, breeding, cultivating, possessing or keeping as pet any totally protected species listed in Schedule I except if a special permit has been issued by the Ministry or in self-defense due to a direct threat to a person life or safety.

Agencies responsible for power lines and substations are required to construct adequate fire lines around substations and other installations, carry out regular maintenance of transmission corridors and power lines and remove overhanging branches over the transmission lines.

14.3.1.7 Protected Area Zonation Guidelines 2020

Protected areas may be delineated into core zone (Key (High) Biodiversity Areas (KBAs), Areas of high endemism, Critical Freshwater Habitats, Areas serving as wildlife refuge, Key wildlife habitats such as salt licks and water holes and Migratory routes of wild animals and birds), transition zone (important habitat patches or contiguous habitat that serves as an important refuge for wildlife or for movement of wildlife from core to other zones where traditional and legal rights for sustainable use of natural resources is permitted for a certain period of time), buffer zone (500m around multiple use zones; campsites, religious sites and hot springs, 150m on both sides of national highway measured from the center of the road, 50m on both sides from the center of the farm roads, 20m buffer from the center of trails, 500m for the settlement that lies right outside the park boundary, towards a core or transition zone) and multiple use (may include settlements, built-up areas, private registered lands and resource allocation areas).

The act requires that if any infrastructure development in the biological corridor is unavoidable and critical for the benefit of the community, wildlife underpasses or overpasses shall be constructed to facilitate the movement of animals.

14.3.1.8 The Biodiversity Act of Bhutan, 2022 and the Biodiversity Rules and Regulations, 2023

The Biodiversity Act and regulation covers conservation and sustainable use of biodiversity, access to genetic resources, access to traditional knowledge associated with genetic resources, fair and equitable sharing of benefits, Bhutan access and benefit sharing fund, and registry, records, and disposal of genetic resources. The National Focal Point to implement this legislation is the National Biodiversity Centre under the Ministry of Agriculture

14.3.1.9 Labour and Employment

Labour administration in the country is guided by the Labour and Employment Act of the Kingdom of Bhutan, 2007 and its regulations such as:

- Regulations on Working Conditions, 2022.
- Regulation on Foreign Workers Management, 2022.
- Regulation on Occupational Health, Safety and Welfare, 2022.
- Regulation on Occupational Health and Safety for Construction Industry, 2022.

The Labour and Employment Act of Bhutan 2007 prohibits any form of child or forced labour, discrimination, sexual harassment or gender-based violence. It also requires employers to provide and maintain a safe working environment for their employees, through hazard identification, instituting management, systems and procedures for implementation, monitoring and recording and reporting to the Chief Labor Administrator. All contractors are required to abide by the Regulation on Occupational Health and Safety for the Construction Industry, 2022. It requires contractors to prepare a health and safety (HS) policy, appoint both an HS committee, a Safety Officer, and a Safety Representative, an Emergency Action Plan, and provision for Personal Protective Equipment for its workers. The Regulation also requires measures to ensure safety to the neighbouring community and measures to minimize both environmental and social impacts.

14.3.1.10 The Local Government Act of Bhutan, 2009

The Local Government Act of Bhutan (2009) requires that all national agencies conduct periodic consultations with the Local Government before any project or program is implemented in their area and involve Local Governments both in the planning and implementation of national projects. This is particularly relevant where there are project components impacting private land requiring compensation, ancillary facilities such as road construction and waste management.

14.3.1.11 Road Act 2013

This Road Act applies to all road and road issues. The national authority for all roads is the Department of Surface Transport (DoST) under the Ministry of Infrastructure and Transport. For any access road taking off from the national secondary highways, require the approval from DoST.

14.3.1.12 Road Safety and Transport Act 1999 and Road Safety and Transport Regulations, 2021

This Act applies to all vehicles plying within the country. The Act establishes systems and procedures for the licensing of drivers and registration of motor vehicles and aims to ensure an efficient and safe public transport system. The Bhutan Construction and Transport Authority is responsible for updating all regulations concerning the safety with respect to surface transport, through enforcement of speed limits, requirement of vehicular emission testing of all vehicles and requirement of the Pollution under Control Certificate (PUC).

14.3.1.13 Draft Cultural Heritage Bill of Bhutan 2016.

This repeals the Movable Cultural Property Act of Bhutan 2005. The bill pertains to the conservation and protection of cultural heritage and cultural landscapes as well as movable cultural property owned by government, community, or private individuals

The nodal agency for implementation of this bill is the Department of Culture and Dzongkhag Development (DCDD), Ministry of Home Affairs. Within each Dzongkhag, there are Cultural Officers that must be consulted for matters pertaining to heritage sites. If archaeological remains are found during excavation of land, the operator/contractor must cease all operation immediately, secure the site against possible damage or unauthorized access and inform the Dzongkhag Administration and the Department of Culture (DCDD) of the discovery within ten days from the day of discovery and take actions based on the instructions in writing from the DCDD. The DCDD may conduct studies to determine if the archaeological remains are of cultural heritage value or coordinate rescue excavations or determine ownership of the discovery. Any development activity in a buffer zone of a Designated Heritage Building or an Important Cultural Site must seek developmental permit from the Dzongkhag and comply with the development control regulations if notified by the DCDD.

14.3.1.14 Acts pertaining to land acquisition, exchange and compensation

The primary legal instrument for Land Acquisition and Resettlement in Bhutan is the Land Act (amended in 2007), which regulates ownership, sales, and the land acquisition by the RGoB when land is acquired. The Land Act of Bhutan 2007 provides the acquisition mechanism for land and other property falling under the eminent domain whenever required for a public purpose.

The National Land Commission Secretariat (NLCS) is the apex agency for all matters pertaining to land registration, sale, exchange, or compensation. The NCLS, based on the land classifications and regulations, will pay compensation, or provide alternative land.

As per the act, private registered land shall be acquired only if unavoidable and can be acquired only once the substitute land is registered or cash compensation has been paid. This Act only recognizes legal title holders and does not consider assessing socio-economic aspects (livelihood restoration) or vulnerability as a requirement during land acquisition.

In the case of landless people, the land can be allotted free of cost by the Government as a Kidu (assistance/welfare provided by His Majesty)

Land acquisition and compensation is guided by the Land Acquisition and Compensation Rules and Regulations (LACRR), 2022, and the Property Assessment & Valuation Compensation Rates (2022), Cash Compensation Rates 2022 for Cash crops/Fruit trees/Annual crops, and the Bhutan Scheduled Rates (BSR 2022) for the affected structures.

The Land Exchange Rules and Regulations 2022 provides the mechanism of exchanging private registered land with State Land (SL). This is only applicable if private registered plots affected by Natural Calamities fall within the Critical Watershed area and Natural Wetland; and in case of scattered private registered plot(s) located within State Forests.

14.3.1.15 Gender and Social inclusion

The Royal Government of Bhutan has adopted several international and national laws, policies and frameworks that are relevant from a gender and social inclusion perspective.

National Gender Equality Policy (NGEP) 2020: The NGEP provides an effective framework within which legislations, policies, programmes and practices ensure equal rights, opportunities and benefits for women and men in the family, community, workplace and in society at large

The National Youth Policy, 2011 sets out goals to provide youth proper education and training opportunities, provide access to information in respect of employment opportunities and to other services, including entrepreneurial guidance, financial credit and strengthening of private sector.

The National Policy for Persons with Disabilities of Bhutan, 2019 ensures that the vulnerable and marginalized group enjoy the same rights and opportunities as the rest of the population and seeks to improve the lives of persons with disabilities through empowerment, ensuring participation and mainstreaming disability initiatives in plans, policies, and programs in all sectors.

The Domestic Violence Prevention Act of Bhutan, 2013, covers the prevention of physical, sexual, psychological, and economic and emotional violence.

14.3.2 Key E&S Guidelines and standards

There are several guidelines for health and medical waste management, education, environmental assessment, planning and development of human settlements, construction of buildings and disaster management planning.

Table 200: Power Evacuation Key E&S Guidelines and standards

Guideline	Prepared by	Description
Occupational health and safety: Guidelines for health professionals	Occupational Health and Safety Program Department of Public Health	Management and certification of occupation related issues and medical certification processes pertaining to medical screening for employment, immigration and disability compensation purposes
National guideline on infection control and medical waste management	Health Care & Diagnostic Division Department of Medical Services Ministry of Health	Health care associated infection (HCAI) and infection control measures and waste management
32nd Education Policy Guidelines and Instructions, 2018	Policy and Planning Division Ministry of Education	Reference on all education policies, guidelines and circulars that have been issued since the previous publication

Guideline	Prepared by	Description
Environmental codes of practice highways and roads 2000	Department of Roads Ministry of communications	Road construction and maintenance activities
Environmental assessment general guideline – 2012	National Environment Commission	Environmental assessment process
A Guide to Environmental Clearance Application Procedure – 2022	National Environment Commission	EC application process
Environmental assessment guideline for power transmission line projects – 2012	National Environment Commission	Environmental assessment for Power Transmission lines
Bhutan Drinking Water Quality Standard 2016	National Environment Commission	Water quality standards
Environment Standards 2020	National Environment Commission	Standards for physical environment and project emissions (air, noise, emission, sewage)
Protected Area Zonation guidelines 2020	Department of Forest and Park Services	Classification of protected areas into different zones as per the functions of the area with prescriptions on management interventions
Differently-abled-friendly-construction-Guideline	Department of Engineering Services Ministry of Works and Human Settlement	
Disaster Management Planning Guideline 2014	Department of Disaster Management Ministry of Home and Cultural Affairs	Guide for preparing disaster management plans

14.4 Potential Environmental and Social Risk Impacts and Standard Mitigation Measures

14.4.1 Transmission Line Route Options Comparative Analysis

14.4.1.1 Desktop E&S Review Methodology

14.4.1.1.1 Desktop Searches Conducted

For this ESMF, a range of desktop-based searches were conducted to identify potential E&S impacts associated with the proposed transmission line.

research to consider potential impacts on threatened species, protected areas, key biodiversity areas and downstream impacts were carried out using the Integrated Biodiversity Assessment Tool (IBAT, www.ibat-alliance.org). The IBAT draws together information on globally recognised biodiversity information drawn from a number of IUCN's Knowledge Products: IUCN Red List of Threatened Species, Key Biodiversity Areas (priority sites for conservation) and Protected Planet/The World Database on Protected Areas (covering nationally and internationally recognised sites, including IUCN management categories I–VI, Ramsar Wetlands of International Importance and World Heritage sites). Birdlife International data (Important Bird and Biodiversity Areas, bird migration routes, Endemic Bird Areas) is also accessed from the IBAT. Mapping provided within this report presents the approximate placement of the PETL facilities in relation to identified areas on IBAT.

Satellite imagery was assessed to provide an understanding of any potential impacts on settlements, Affected House Holds (AHH), land users, downstream impacts and vegetation (including from construction access) Satellite imagery accessed included Google Earth (imagery dated 11/12/2023, accessed January 2024).

14.4.1.1.2 Limitations of the Desktop Review

This information included remote imaging, to inform assessment of potential impacts. Remote imaging (satellite) is a useful tool to confirm presence impacted by seasonal variability in the identification of vegetation values. Remote imaging can identify potential items (i.e., structures) but is not detailed enough to confirm absence. Remote imaging is based on a specific time when image taken and may not reflect current on ground realities. Therefore, due to these limitations, impacts identified in this review are indicative and this should not be considered as a definitive or exhaustive assessment.

14.4.1.1.3 Transmission Line Route Options E&S Screening

Desktop screening with the IBAT for the two transmission line options, which utilised a 50 km search area, resulted in very similar identification of potential values. This similarity is summarised in the following table and figures.

Table 201: Potential Values Identified within 50km Area

Aspect	Transmission Line 1	Transmission Line 2	E&S Discussion and Comparison
Threatened Species	1468 species listed: Total / Label 17 / CR 41 / EN 62 / VU 75 / NT 1235 / LC 38 / DD	1476 species listed: Total / Label 17 / CR 41 / EN 62 / VU 75 / NT 1241 / LC 39 / DD	Vegetation clearing for PETL could possibly impact threatened species and/or Critical Habitat. Further on the ground biodiversity studies would be required to determine potential impacts on species/habitats. Similar potential impact (possible) between options.
World Heritage areas	No World Heritage Areas within a direct footprint. 1 World Heritage Area within a wider 50 km search area.	No World Heritage Areas within a direct footprint. 1 World Heritage Area within a wider 50 km search area.	The World Heritage Area located approximately 15 km south of TL1 & TL2, no impact expected. Same potential impact (none) between options.
Protected areas	No protected areas within a direct footprint. 8 protected areas within a wider 50 km search area.	No protected areas within a direct footprint. 8 protected areas within a wider 50 km search area.	The closest protected area approximately 5 km northwest of TL1 & TL2, no impact expected. Same potential impact (none) between options
Key Biodiversity Areas	10 KBA identified in PETL project Area	11 KBA identified in PETL project Area	The closest KBA is approximately 5 km northwest of TL1 & TL2, no impact expected. Same potential impact (none) between options
Vegetation	TL1 approximate length 33.5 km. Assuming the RoW is cleared this would result in impact on approximately 395 acres of vegetation. Satellite imagery of approximate route suggests much of the route is heavily vegetated. Vegetation appears continuously	TL2 approximate length 39.5 km. Assuming the RoW is cleared this would result in impact on approximately 470 acres of vegetation. Satellite imagery of approximate route suggests much of the route is heavily vegetated. Vegetation appears continuously with	There is a possibility that vegetation within the PETL project area contains environmentally important values. While more route details are required, TL1 preferred as expected to result in less impact on existing vegetation (estimated 74 acres less).

Aspect	Transmission Line 1	Transmission Line 2	E&S Discussion and Comparison
	with vegetation in the protected areas in wider areas and may hold similar values. This is expected to at least meet the criteria for "Natural Habitat" under ESS6.	vegetation in the protected areas in wider areas and may hold similar values. This is expected to at least meet the criteria for "Natural Habitat" under ESS6.	
Land Use	Routes may intersection with some local roads. Impact on specific land use (i.e. agriculture) could not be determined due to the approximate nature of route.	Routes may intersection with some local roads. Impact on specific land use (i.e. agriculture) could not be determined due to the approximate nature of route.	Requires more route detail.
Settlements	Route may impact settlements, however approximate route not adequate to determine.	Approximate route would impact two settlements (outskirts of Lingmethang and Pangthang).	TL1 is preferred as less likely to impact settlements based on approximate route provided. Settlement observation via remote imagery includes clear limitations (ability to observe and/or date of imagery). On ground survey required more route details.
Access	Route would require additional clearing for access road. Access road is not known.	Route would require additional clearing for access road. Access road is not known.	Both routes appear relatively remote and would likely require extensive clearing in preparation of access road for construction and operation. Requires more route detail.
Rivers	PETL crosses the Manas River.	PETL crosses the Manas River.	Construction activities for the river crossing may impact the river E&S values. Exact river crossing point and potential impact unknown. Requires more route detail.

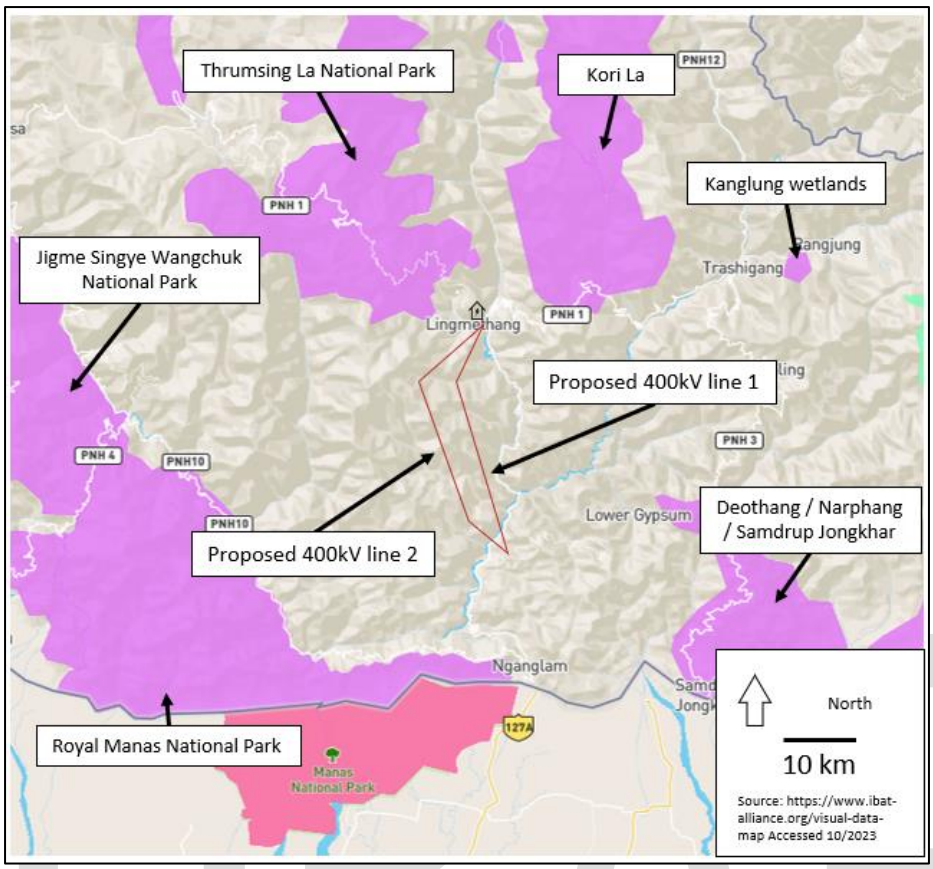


Figure 200: Identified KBA within the PETL 50km Area

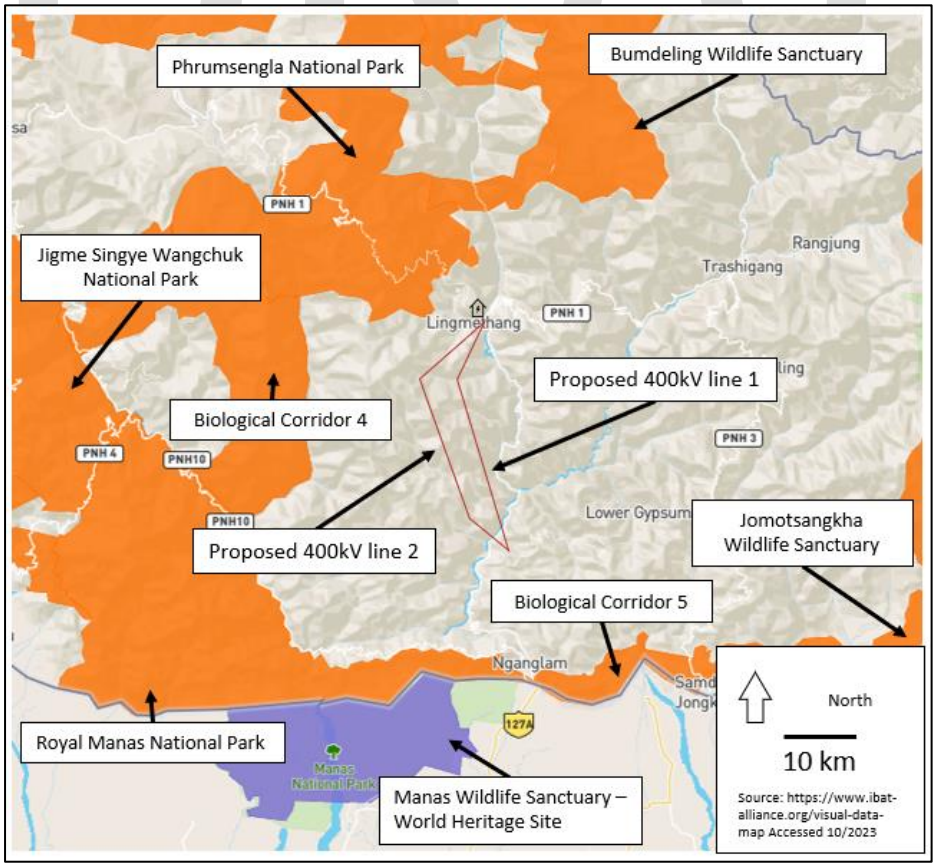


Figure 201: Identified Protected Areas within the PETL 50km Area

14.4.1.1.4 Summary of Route Option Screening

Based on the information provided, the high-level E&S screening identified two key differentiators between the two route options. The first differentiator was related to the vegetation clearing required, as a direct result of the length of the PETL routes. PETL routes appear to be in vegetated areas. TL1 was preferred when considering this aspect, as this route is approximately 6 km shorter, with 74 acres less expected vegetation clearing (assuming clearing width of entire 48 m RoW). The shorter route would also be assumed to require less materials for construction along with shorter access roads and associated clearing, further reducing the impact of this option in comparison.

The second differentiator was related to the potential impact on two settlements by TL2 as the approximate route appears to go through two settlements (outskirts of Lingmethang and Pangthang). TL1 does not appear to go through any settlements based on the approximate route. Therefore, TL1 is preferred from a settlement perspective also.

Due to the very approximate nature of the route options provided, E&S screening for some values could not be carried out adequately for all aspects.

14.4.2 Transmission Line Environmental and Social Risks and Mitigation Measures

14.4.2.1 Summary

The risks and impacts of the PETL are at this stage unclear due to the approximate nature of the routes proposed. Table 202 provides an initial consideration of risks and mitigation measures and should be further developed as the PETL progresses.

Table 202: Transmission Line Environmental and Social Risks and Mitigation Measures

Subcomponent Activity	Risks and Impacts	Mitigation Measures
Construction – impact on threatened species and/or Critical Habitat.	Vegetation clearing for PETL could possibly impact threatened species and/or critical habitat. Further on the ground biodiversity studies would be required to determine potential impacts on these species and/or critical habitat.	Design PETL route in consideration of threatened species. Suggested design measures include: - Design PETL route adjacent to existing infrastructure where possible and avoid undisturbed areas as far as practical. - Carry out environmental and social surveys on detailed routes when available and adjust to minimise impacts where possible. - Carry out a critical habitat assessment in accordance with ESS6 due to the likely presence of CR and/or EN species and habitats (subject to detailed studies).
Construction – vegetation clearing for TL	Satellite imagery of approximate route suggests much of the route is heavily vegetated. Vegetation appears continuously with vegetation in the protected areas in wider areas and may hold similar values. This is expected to at least meet the criteria for "Natural Habitat" under ESS6.	Design PETL route in consideration of threatened species. Suggested design measures include: - Design PETL route adjacent to existing infrastructure where possible and avoid undisturbed areas as far as practical. - Carry out environmental and social surveys on detailed routes when available, and adjust to minimise impacts where possible
Construction – Access Road clearing	As above	Design PETL Route in consideration of access required for construction and operation/maintenance. Suggested design measures include: - Design access roads to be as direct as feasible.

Subcomponent Activity	Risks and Impacts	Mitigation Measures
		- Design access roads to be as and short overall. - Carry out environmental and social surveys on detailed routes when available and adjust to minimise impacts where possible.
Construction – Impact to waterways	PETL crosses the Manas River. Construction activities for the river crossing may impact the river E&S values. Exact river crossing point and potential impact unknown.	Design any waterway crossings (including Manas River crossing) to minimise potential waterway impacts. Suggested design measures include: Use existing crossing infrastructure crossing locations where possible. Design crossing with minimal-no infrastructure in waterway. Design crossing locations away from sensitive receivers where possible.
Construction - Disadvantaged and vulnerable groups – see Section 14.7 for full	Disadvantaged and vulnerable groups may be more likely to be adversely affected by the project impacts and/or more limited than others in their ability to take advantage of a project's benefits. The risks and impacts of the PETL are unclear at this stage due to the approximate nature of the routes proposed, lack of information on staffing requirements, duration of the work, location of the workers camps and potential interaction with local communities.	Prepare standalone Gender, GBV-SEA/SH and Vulnerability Action Plan following framework presented in Section 14.7.
Construction – land and settlement impact	PETL route may impact settlements and land users depending on the land ownership within detailed route.	Design PETL route to avoid impacts on settlements and private landowners where possible. TL1 preferred based on approximate route. A Resettlement Policy Framework has been prepared in this ESMF in Section 14.7.3, and should be followed for the PETL.
Construction – labour influx	Labour required for construction may adversely impact local communities.	Follow labour management mitigation measures presented in Dorjilung HPP ESIA and ESMP. Prepare standalone Labour Management Procedures following framework presented in Section 14.7
Construction – PETL specific E&S and technical considerations	Construction of PETL may face technical installation risks, which could in turn impact E&S values.	In determining the final proposed placement of the PETL the following should be avoided as far as possible when selecting route (reproduced from requirements of the Bhutan Power Corporation): - Marshy areas, low lying lands, riverbeds, earth slip zones etc. involving risk to stability of foundation and the tower. - Areas subjected to floods, gushing nallas during rainy seasons, tanks, ponds, lakes, snow blizzards,

Subcomponent Activity	Risks and Impacts	Mitigation Measures
		hurricanes or similar extreme climatic conditions and natural hazards. - Areas which involve risk to human life, damage to public and private properties, religious places, civil and defence installations, industries, aerodromes and their approach and take off funnels of the aircraft, habitation of important crops, good farming areas, uneven terrain, quarry sites or underground mines, gardens and plantations. - Inaccessible areas where approach roads are not possible. - Areas which will create problems of right of way. - Route involving abrupt changes in levels, too many long spans, river or power line crossings or near parallelism to telecommunication lines. - Reserved forests or areas involving heavy compensation for acquisition of land, tree cutting etc. - Buildings containing explosives, bulk storage oil tanks, oil or gas pipelines, etc. - Aerodromes, helipads etc. - Wildlife sanctuaries, Coal fields, mining areas.

14.4.2.2 Planning and Design Considerations for Avoidance of Environmental and Social Risks and Impacts

Further detailed assessment is required for the PETL. This is suggested in two phases, largely dependent on the timing a resolution of additional technical details on routes. Phase 1 should include detailed screening, based on a refined route estimate. Phase 2 should include field mission to determine on ground realities and clarify potential impacts.

Planning and design during these two suggested phases should focus on avoiding and minimizing potential E&S impacts. It is often possible to avoid or minimize some of the potential environmental and social impacts during project implementation by taking certain environmental and social aspects into account during the design of a project. Examples include considering alternative location of the PETL, selecting different technologies or methodologies, considering proper waste disposal (solid and liquid), preparing for emergencies.

14.5 Procedures and Implementation Arrangements

14.5.1 Environmental and Social Risk Management Procedures

The environmental and social risk management procedures will be implemented through the Project's subproject selection process. Example Project Cycle and E&S Management are shown in Table 203.

Table 203: Example PETL Cycle and E&S Management Procedures

PETL Stage	E&S Stage	E&S Management Procedures
A. Assessment and Analysis: PETL identification	Screening	- For all activities, identify and assess potential environmental and social risks and impacts, and identify the appropriate mitigation measures for the subproject. - Identify the documentation, permits, and clearances required under the government's Environmental Regulation.

PETL Stage	E&S Stage	E&S Management Procedures
		- Screening and PETL identification will include an alternative analysis of the proposed routes and alignment and recommend to the engineering team the option with the least E&S impacts.
B. Formulation and Planning: Planning for PETL activities, including human and budgetary resources and monitoring measures	Planning	- Based on screening results adopt and/or prepare relevant environmental and social procedures and plans. - Depending on the screening ESMP, SEP, LMP and LALRP to be prepared and consulted during planning stage. - Gender, GBV, SH/SEA and Vulnerability Plan to be prepared. - Depending on the bidding process to be implemented: Prepare and submit the ESMP for prior review and no objection by the World Bank prior to initiating bidding processes (for subprojects involving bidding processes) and/or launching activities (for subproject activities not subject to bidding). - Ensure that the contents of the ESMP is shared with relevant stakeholders in an accessible manner and consultations are held with the affected communities in accordance with the SEP. - Complete all documentation, permits, and clearances required under the government's Environmental Regulation. - Train staff responsible for implementation and monitoring of plans. - Incorporate relevant environmental and social procedures and plans into contractor bidding documents; train contractors on relevant procedures and plans.
C. Implementation and Monitoring: Implementation support and continuous monitoring for PETL	Implementation	- Ensure implementation of plans through site visits, regular reporting from the field, and other planned monitoring. - Track grievances/beneficiary feedback. - Continuing awareness raising and/or training for relevant staff, volunteers, contractors, communities
D. Review and Evaluation: Qualitative, quantitative, and/or participatory data collection on a sample basis	Completion	- Assess whether plans have been effectively implemented. - Ensure that physical sites are properly restored.

14.5.1.1 A- PETL Assessment and Analysis – E&S Screening

As a first step, the DGPC will identify and assess relevant environmental and social risks specific to the activities and identify the appropriate mitigation measures.

DGPC will also identify the documentation, permits, and clearances required under the government's Environmental Regulation. This may include a national ESIA, and international level Initial Environmental Examination and/or ESIA.

Screening and PETL identification will include an alternative analysis of the proposed routes and alignment and recommend to the engineering team the option with the least E&S impacts. A critical habitat assessment should be included based on the likely presence of CR and EN species (subject to detailed studies).

14.5.1.2 B - PETL Formulation and Planning – E&S Planning

Based on the process above and the Screening Form, DGPC will adopt the necessary environmental and social management measures or develop relevant site-specific environmental and social management plans.

If site-specific ESMPs are necessary, DGPC will prepare these ESMPs, and other applicable documents as needed. DGPC will provide approval and compile ESMPs and other applicable forms. The contents of the ESMPs will be shared with relevant stakeholders in an accessible manner, and consultations will be held with the affected communities on the environmental and social risks and mitigation measures. If certain subprojects or contracts are being initiated at the same time or within a certain location, an overall ESMP covering multiple subprojects or contracts can be prepared. Some moderate risk subprojects may also benefit from the preparation of a site-specific environmental and social assessment prior to the preparation of an ESMP.

The ESMP will be submitted to the World Bank for review and there is no objection prior to the start of construction activities.

DGPC will also complete the documentation, permits and clearances required under the government's Environmental Regulation before any PETL activities begin.

At this stage, staff who will be working on the various subproject activities should be trained in the environmental and social management plans relevant to the activities they work on. DGPC should provide such training to field staff.

DGPC should also ensure that all selected contractors, subcontractors, and vendors understand and incorporate environmental and social mitigation measures relevant to them as standard operating procedures for civil works. DGPC should provide training to selected contractors to ensure that they understand and incorporate environmental and social mitigation measures; and plan for cascading training to be delivered by contractors to subcontractors and vendors. DGPC should further ensure that the entities or communities responsible for ongoing operation and maintenance of the investment have received training on operations stage environmental and social management measures as applicable.

14.5.1.3 C- Implementation and Monitoring – E&S Implementation

During implementation, DGPC will conduct regular PETL monitoring visits. If there are contractors implementing subproject activities, the contractors will be responsible for implementing the mitigation measures in the E&S risk management documents, with DGPC oversight.

DGPC will ensure that PETL monitoring practices include the environmental and social risks identified in the ESMF and will monitor the implementation of E&S risk management mitigation plans as part of regular project monitoring.

At a minimum, the reporting will include (i) the overall implementation of E&S risk management instruments and measures, (ii) any environmental or social issues arising as a result of project activities and how these issues will be remedied or mitigated, including timelines, (iii) Occupational Health and Safety performance (including incidents and accidents), (iv) community health and safety, (v) stakeholder engagement updates, in line with the SEP, (vi) public notification and communications, (vii) progress on the implementation and completion of project works, and (viii) summary of grievances/beneficiary feedback received, actions taken, and complaints closed out, in line with the SEP. Reports from the local levels will be submitted to the [responsible party in the implementing agency] at the national level, where they will be aggregated and submitted to the World Bank on a quarterly basis.

Throughout the PETL implementation stage, DGPC will continue to provide training and awareness raising to relevant stakeholders, such as staff, selected contractors, and communities, to support the

implementation of the environmental and social risk management mitigation measures. An initial list of training needs is proposed below, in Section 14.5.3.

DGPC will also track grievances/beneficiary feedback (in line with the SEP) during project implementation to use as a monitoring tool for implementation of project activities and environmental and social mitigation measures.

If DGPC becomes aware of a serious incident in connection with the project, which may have significant adverse effects on the environment, the affected communities, the public, or workers, it should notify the World Bank within 48 hours of becoming aware of such incident. A fatality is automatically classified as a serious incident, as are incidents of forced or child labour, abuses of community members by project workers (including gender-based violence / SEA/SH incidents), violent community protests, or kidnappings.

14.5.1.4 D - Review and Evaluation – E&S Completion

Upon completion of PETL activities, DGPC will review and evaluate progress and completion of project activities, and all required environmental and social mitigation measures. Especially for civil works, DGPC will monitor activities regarding site restoration and landscaping in the affected areas to ensure that the activities are done to an appropriate and acceptable standard before closing the contracts, in accordance with measures identified in the ESMPs and other plans. The sites must be restored to at least the same condition and standard that existed prior to commencement of works. Any pending issues must be resolved before a subproject is considered fully completed. DGPC will prepare the completion report describing the final status of compliance with the E&S risk management measures and submit it to the World Bank.

14.5.2 Implementation Arrangements

Implementation arrangements for the PETL are yet to be determined. An example of implementation arrangements is provided in Table 204.

Table 204: Example PETL Implementation Arrangements

Level/ Responsible Party	Roles and Responsibilities
National/regional	- Provide support, oversight, and quality control to field staff working on environmental and social risk management. - Collect, review, and provide quality assurance and approval to Screening Forms and ESMPs as relevant. Keep documentation of all progress. - Oversee overall implementation and monitoring of environmental and social mitigation and management activities, compile progress reports from local levels/subprojects, and report to the World Bank on a quarterly [or biannual] basis. - Train central and field staff and contractors who will be responsible for implementing the ESMF. - If contracting is managed centrally, ensure that all bidding and contract documents include all relevant E&S management provisions per screening forms, and ESMPs.
Regional/local field staff	- Ensure PETL activities do not fall under the Negative List. Fill out Screening Forms for relevant subproject activities and submit forms to the national level. - If relevant, complete site-specific ESMPs for subproject activities and submit forms to the national level. - Oversee daily implementation and monitoring of environmental and social mitigation measures, and report progress and performance to the national level on a monthly basis. - Provide training to local contractors and communities on relevant environmental and social mitigation measures, roles, and responsibilities.

Level/ Responsible Party	Roles and Responsibilities
	- If contracting is managed regionally, ensure that all bidding and contract documents include all relevant E&S management provisions per screening forms, and ESMPs.
Local contractors	- Comply with the PETL environmental and social mitigation and management measures as specified in ESMPs, and contract documents, as well as national and local legislation. - Take all necessary measures to protect the health and safety of workers and community members, and avoid, minimize, or mitigate any environmental harm resulting from project activities.]

14.5.3 Proposed Training and Capacity Building

Training and capacity building required is yet to be determined. For the PETL, consideration of training and capacity building should be read together with other plans prepared for the PETL which include consideration of this topic, including the wider ESIA and ESMP and associated separate plans including ESCP, and E&S Borrower Capacity Assessment. An example of PETL training and capacity building Approach is provided in Table 205.

Table 205: Example PETL training and capacity building Approach

Level	Responsible Party	Audience	Topics/Themes that May Be Covered
National level	National staff	National staff responsible for overall implementation of ESMF	ESMF and approach: - Analysis of E&S Alternatives - Identification and assessment of E&S risks - Selection and application of relevant E&S risk management measures/instruments - E&S monitoring and reporting - Incident and accident reporting - Application of LMP, including Code of Conduct, incident reporting, SEA/SH, COVID-19 mitigation - Application of SEP and the grievance/beneficiary feedback mechanism
Regional level	National staff	Regional staff Contractors	ESMF and approach: - Identification and assessment of E&S risks - Selection and application of relevant E&S risk management measures - E&S monitoring and reporting - Incident and accident reporting - Application of LMP, including Code of Conduct, incident reporting, SEA/SH, COVID-19 mitigation - Application of SEP and the grievance/beneficiary feedback mechanism
Local/site level	Regional staff	Local staff Local contractors	- Application of SEP and the grievance/beneficiary feedback mechanism - Application of LMP, including Code of Conduct, incident reporting, SEA/SH, COVID-19 mitigation - Application of ESMPs as relevant
Community level	Local staff	Community members	- Basic OHS measures and Personal Protective Equipment - Community health and safety issues - Worker Code of Conduct - SEA/SH issues, prevention, measures]

Level	Responsible Party	Audience	Topics/Themes that May Be Covered
		Community Workers, if relevant	- COVID-19 mitigation - Grievance redress - Workers' grievance redress

14.6 Stakeholder Engagement, Disclosure, and Consultations

A separate Stakeholder Engagement Plan (SEP) has been prepared for the HPP Project, based on the World Bank's Environmental and Social Standard 10 on Stakeholder Engagement. Depending on project timing the PETL should be incorporated into this SEP, or a separate SEP prepared following the same format and content requirement.

This ESMF, as well as the SEP and the ESCP (to be amended/prepared for this PETL), will be disclosed for stakeholder consultations.

14.7 Social Policy Framework

14.7.1 Gender, SEA/SH and Vulnerability Policy Framework

14.7.1.1 Introduction

The Gender, SEA/SH and Vulnerability Policy Framework is developed as an important element of compliance with the social and environmental safeguards that are mandatory for the approval of infrastructure development projects under the World Bank's Environmental and Social Framework. Its purpose is to establish terms of agreement between relevant authorities in DGPC and the World Bank regarding principles and procedures to be used in subsequent preparation of Gender, GBV-SEA/SH and Vulnerability Action Plan (GSVAP).

14.7.1.2 Project description

The risks and impacts of the PETL are unclear at this stage due to the approximate nature of the routes proposed, lack of information on staffing requirements, duration of the work, location of the workers camps and potential interaction with local communities. These elements are to be taken into consideration to establish if the project presents a high risk in terms of Gender- Based violence (GBV) and SEA/SH. The mitigation measures in the ESMP will be proportionate to the risks identified.

Investment projects often involve construction of civil works for which the required labour force and associated goods and services cannot be fully supplied locally for several reasons, among them worker unavailability and lack of technical skills and capacity. The influx of workers and followers can lead to adverse social and environmental impacts on local communities, especially if the communities are rural, remote, or small. Pre-existing social issues in the host communities can also easily be exacerbated. Common social risks associated with large infrastructure projects and labour and population influx include among others, increased risk of illicit behaviours and crime, changes in community dynamics, increased risks of communicable disease including Sexually Transmitted Diseases (STDs).

Construction workers are predominantly younger males. Those who are away from home on the construction job are typically separated from their family and act outside their normal sphere of social control. This can lead to inappropriate and criminal behaviours, such as sexual harassment of women and girls, exploitative sexual relations, and illicit sexual relations with minors from the local community. A large influx of male labour may also lead to an increase in exploitative sexual relationships and human trafficking whereby women and girls are forced into sex work.

14.7.1.3 Key principles and definitions

World Bank's Strategy applying to WB financed project aims at closing the gaps between men and women, girls and boys and enhance leadership and voice. Under the ESF, the WB has strengthened its commitment to promoting gender equality and inclusion in Investment Project Financing Operations. The WB ESF sets out actions to achieve results by identifying and implementing operations that narrow opportunity and outcome gaps between males and females. It aims to address constraints to close these gaps such as occupational sex segregation, high prevalence of GBV, lack of clear land and housing ownership and tenure security, women's rights, women's health etc.

The WB ESS aims at addressing gender risks, both (a) in the process and (b) in the methodology for conducting an ESIA, and in risks and impacts to be identified and mitigated.

Disadvantaged or vulnerable refers to those who may be more likely to be adversely affected by the project impacts and/or more limited than others in their ability to take advantage of a project's benefits. Such an individual/group is also more likely to be excluded from/unable to participate fully in the mainstream consultation process and as such may require specific measures and/or assistance to do so. This will consider considerations relating to age, including the elderly and minors, and including circumstances where they may be separated from their family, the community or other individuals upon whom they depend upon (ESFF page 4 footnote 11).

The following Table 206 summarizes the relevant requirements, standard by standard under the ESS, with a highlight on ESS1, 2, 4, 5, 7 and 10, where gender equality and inclusion plays a key role.

Gender mainstreaming and specific measures related to vulnerability are therefore to be reflected in the following ESS related activities/action plans. That is ensure that gender is integrated in other instruments such as Labour Management Plan, Resettlement and livelihood restoration Plans, Stakeholder Engagement Plan, Local Development Plan.

Table 206: Gender and vulnerability aspects in the ESS

ESS1. Assessment and Management of Environmental and Social Risks and Impacts
- Threats to Human Security through the escalation of personal, communal or inter-state conflict, crime or violence (ESS1 para 28 (b) (i)). - Assess risks and impacts that project impacts fall disproportionately on the disadvantaged or vulnerable (which include inequalities between males and females) and any prejudice or - discrimination toward such groups in providing access to development resources and project benefits. (ESS1 para 28 (b) (ii) and (iii)) - Ensure that projects do not inadvertently compromise existing legitimate rights for land and natural resource tenure and use (including collective rights, subsidiary rights and the rights of women) or have other unintended consequences, particularly where the project supports land titling and related issues. (ESS1 footnote 29) - Implement differentiated measures so that adverse impacts do not fall disproportionately on the disadvantaged or vulnerable, and they are not disadvantaged in sharing any development benefits and opportunities resulting from the project. (ESS1 para 29)
ESS2. Labour and Working Conditions
- Apply the principle of equal opportunity and fair treatment in the employment of project workers, so that there will be no discrimination with respect to any aspects of the employment relationship. (ESS2 para 13) - Provide appropriate measures of protection and assistance to address the vulnerabilities of project workers, including specific groups of workers, such as women, people with disabilities, migrant workers and children of working age. (ESS2 para 15)

- Do not employ trafficked people in connection with the project. Women and children are particularly vulnerable to trafficking practices. (ESS2 para 20 and footnote 15)

ESS4. Community Health and Safety

- Evaluate and address the risks and impacts of the project on the health and safety of the affected communities during the project life cycle, including the vulnerable. (ESS4 para 5)
- Avoid or minimize the potential for community exposure to water-borne, water-based, water-related, and vector-borne diseases, and communicable and non-communicable diseases that could result from project activities, taking into consideration differentiated exposure to and higher sensitivity of vulnerable groups. (ESS4 para 15)
- Applying the concept of universal access in environmental design may increase women's safety and security. (ESS4, paras 7 and 9)

ESS5. Land Acquisition, Restrictions on Land Use and Involuntary Resettlement

- Ensure in the consultation process that women's perspectives are obtained, and their interests factored into all aspects of resettlement planning and implementation. Addressing livelihood impacts may require intra-household analysis in cases where women's and men's livelihoods are affected differently. Women's and men's preferences in terms of compensation mechanisms, such as replacement land or alternative access to natural resources rather than in cash, should be explored. (ESS5 para 18)
- Documentation of ownership or occupancy and compensation payments in the names of both spouses or single heads of households as relevant, and other resettlement assistance, such as skills training, access to credit, and job opportunities, should be equally available to women and adapted to their needs. Where national law and tenure systems do not recognize the rights of women to hold or contract in property, measures should be considered to provide women as much protection as possible with the objective to achieve equity with men. (ESS5 footnote 18)
- Establish in the resettlement action plan the entitlements of affected persons and/or communities, paying particular attention to gender aspects and the needs of vulnerable segments of communities, and ensure that these entitlements are provided in a transparent, consistent, and equitable manner. The plan will incorporate arrangements to monitor the effectiveness of livelihood measures during implementation, as well as evaluation once implementation is completed. (ESS5 para 33)

ESS7. Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities

- Proactively engage with the relevant Indigenous Peoples to ensure their ownership and participation in project design, implementation, monitoring and evaluation and consult with them as to the cultural appropriateness of proposed services or facilities and will seek to identify and address any economic or social constraints (including those relating to gender) that may limit opportunities to benefit from, or participate in, the project. (ESS7 para 14)
- Conduct the engagement process which includes stakeholder analysis and engagement planning, disclosure of information, and meaningful consultation, in a culturally appropriate and gender and inter-generationally inclusive manner. (ESS7 para 23)
- Assess and document Indigenous Peoples' resource use without prejudicing any Indigenous Peoples' land claim where the assessment of land and natural resource use will be gender inclusive and specifically consider women's role in the management and use of these resources. (ESS7 para 30 (d))
- Address the gender and intergenerational issues that exist among Indigenous Peoples through technical or financial support. (ESS7 para 35)

ESS10. Stakeholder Engagement and Information Disclosure

- Identify the disadvantaged or vulnerable. (ESS10 para 11)
- Describe in the Stakeholder Engagement Plan (SEP) the measures that will be used to remove obstacles to participation, and how the views of differently affected groups will be captured. Where applicable, the SEP will

include differentiated measures to allow the effective participation of the disadvantaged or vulnerable. (ESS10 para 16)
- Provide stakeholders with access to information on potential risks and impacts that might disproportionately affect the vulnerable and disadvantaged and describe the differentiated measures taken to avoid and minimize these. (ESS10 para 19 (c))
- Disclose information in relevant local languages and in a manner that is accessible and culturally appropriate, considering any specific needs of groups that may be differentially or disproportionately affected by the project or groups of the population with specific information needs (such as disability, literacy, gender, mobility, differences in language or accessibility). (ESS10 para 20)

Source: World Bank Group, Environment & Social Framework for IPF Operations, Good Practices Note, 2019

14.7.1.4 Legal and Regulatory Framework

DGPC agrees to take all actions necessary to ensure full and effective implementation of GSVAP prepared in accordance with the Gender, SEA/SH and Vulnerability Policy Framework, and to otherwise take actions necessary to achieve all relevant provisions of the ESS as described above.

14.7.1.5 Preparing Gender, GBV-SEA/SH and Vulnerability Action Plan

All projects need to develop a Gender and Vulnerability Action Plan. The GBV-SEA/SH Action Plan is required for Moderate, Substantial and High risks projects but the plans will vary in accordance with the risk level/ All projects are recommended to include at least Accountability and Response Framework (GM/incident response) for World Bank approval.

Responsibility for preparation and implementation of the GSVAP rests with DGPC. As necessary, DGPC will exercise its authority to coordinate actions with any other involved agencies, jurisdictions, or project contractors to promote timely and effective planning and implementation.

The preparation of the GSVAP is usually possible once the project design and key features-especially location of work sites and base camps, as well as manpower requirements- have been defined.

GSVAP development requires:

- to have a clear project description,
- to conduct a review of the legal and institutional framework that covers national and institutional framework on gender equality, on SEA/SH and on Vulnerability
- to present good international practice and standards and present key takeaways relevant for design and implementation, i.e WB and IFC good practices, sectoral good practice, an analysis of the gender, SEA/SH and vulnerability issues related to type of project (energy sector and transmission lines).
- to conduct a Gender, SEA/SH and Vulnerability Assessment related to project context:

o present the approach and methodology of the assessment (eg. literature review, collect baseline data, consultations and surveys)
o assess the situation at national level (done for the Dorjilung HPP) and at project level.
o identify key gaps that the project can address or have an influence on (Gender gap analysis).
o identify SEA/SH risks factors.
o conduct a vulnerability analysis.

- to assess the capacity of the Project Owner, institutions and others to manage and address gender, SEA/SH and vulnerability issues.

The GSVAP is then structured in one or two separate plans focusing on (1) closing gender gap and addressing issues of vulnerable groups and (2) GBV-SEA/SH. The plans detail the objectives, the activities, define targets/indicators, assign responsibilities, and precise the timeframe. Each plan has a dedicated budget.

The articulation of the GSVAP with other plans (eg. SEP, Labour Management Plan, LALRP, Local Development Plan) must be indicated as possible.

DGPC will ensure that Gender, inclusion, and GBV-SEA/SH requirements are clearly stated in procurement documents. The proposed approach on how to implement and monitor the Action Plan, including agreed sanctions pursuant to an Accountability and Response Framework, will be provided by the contactor as part of the C-ESMP. Contractors' SEA/SH response proposal will also be evaluated as part of bid evaluation.

For the Dorjilung HPP, the project has plan for a specific process to address GBV-SEA/SH complaints. The key principles of the GBV-SEA/SH GRM (source: World Bank) are to develop a survivor-centred approach and must guarantee confidentiality and informed consent for victims, victim safety, non-discrimination, respect, and must be time-limited and holistic. Effective monitoring and evaluation mechanisms have to be in place and high risks projects have to include independent third-party monitoring.

The HPP Project specific process to address GBV-SEA/SH complaints will need to be amended/extended to cover the PETL.

14.7.2 Labour Policy Framework

14.7.2.1 Introduction

The Labour Management Procedures (LMP) for the PETL will be developed to manage labour arrangements and labour risks during the implementation of the PETL construction for the Project. This LMP shall be in line with national requirements as well as the requirement of the World Bank's Environmental and Social Framework, specifically objectives of Environmental and Social Standard 2: Labour and Working Conditions (ESS2). The final LMP to be implemented by every organisation employing staff and being part of the Project will also need to comply with the ILO standards.

The LMP aims to ensure that all labour-related activities are conducted in accordance with the guidelines set forth by national legislation as well as the requirements of the World Bank. This plan outlines the key measures and strategies that will be implemented to promote fair and safe labour practices, foster a healthy work environment, and enhance the overall well-being of the project's workforce.

The PETL will involve the mobilization and recruitment of many workers. Assuring good labour and working conditions for all people who will be engaged during the implementation of the project is of high priority for DGPC and the World Bank.

Most employees are expected to belong to the contractor(s) or their sub-contractors. The LMP principles related to labour and working conditions will have to be implemented by all parties engaged in the implementation of the PETL.

14.7.2.2 Project description

The labour requirements for the PETL are yet to be confirmed, however it is assumed the PETL Project will mobilize and recruitment of many workers.

14.7.2.3 Key principles and definitions

The objectives of the LMP are as follows:

1. Promote fair employment practices, including non-discrimination, equal opportunities, and respect for workers' rights.
2. To prevent the use of all forms of forced labour and child labour.

3. To protect project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, in accordance with ESS2) and migrant workers, contracted workers, community workers and primary supply workers, as appropriate.
4. To mitigate the risks of sexual exploitation and abuse and sexual harassment (SEA/SH) in the workplace and the project affected community (ESS 4)
5. Ensure compliance with relevant labour laws and regulations of Bhutan.
6. Safeguard the health and safety of all workers and prevent accidents or occupational hazards.
7. To support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law and meet World Bank standards.
8. Encourage capacity building and skill development among the local workforces.
9. Foster effective communication channels between workers, management, and relevant stakeholders.
10. Ensure employees are aware of their rights and entitlements including pay, leave, sick and bereavement leave, and rest breaks.
11. Deliver a fair and equitable environment that includes mechanisms for responding to, and resolving, employees' questions and concerns, while ensuring employee relations issues are managed justly, and in a coordinated and consistent manner, while providing project workers with accessible means to raise workplace concerns (ESS2).
12. Provides guidance to workers on expected behaviours through a Code of Conduct.

14.7.2.4 Legal and Regulatory Framework

14.7.2.4.1 International

The standards that directly apply to this instrument and workers include the following World Bank Environment and Social Standards: (ESS2 and ESS4).

ESS2 Labour and Working Conditions:

This Standard obliges the Developer/Project Proponent (DGPC) to develop and implement written Labour Management Procedures applicable to the Project (this document).

These procedures set out the way in which Project workers will be managed, in accordance with the requirements of national laws. ESS2 applies to project workers including full-time, part-time, temporary, seasonal and migrant workers.

The key objectives of the World Bank's ESS2 are to:

1. Promote safety and health at work.
2. Promote fair treatment, non-discrimination and equal opportunity for project workers.
3. Secure protection of project workers, including vulnerable workers such as women, persons with disabilities, children (of working age, in accordance with this ESS) and migrant workers, contracted workers, community workers and primary supply workers, as appropriate.
4. Prevent the use of all forms of forced labour and child labour.
5. Support the principles of freedom of association and collective bargaining of project workers in a manner consistent with national law; and
6. Provide project workers with accessible means to raise workplace concerns.

Where DGPC staff are working in connection with the project (whether fulltime or part-time), they will remain subject to the terms and conditions of their existing employment agreement or arrangement, unless there has been an effective legal transfer of their employment or engagement to the project.

ESS4 Community Health and Safety

The Standard puts emphasis on community exposure to risks and impacts of project and includes risks associated with the security of personnel as well as addressing water-related, communicable and non-communicable diseases that can result from project activities and have impact on project labour as well as the community.

The objectives of ESS4 as noted in the ESF are:

- To anticipate and avoid adverse impacts on the health and safety of project-affected communities during the project life cycle from both routine and nonroutine circumstances.
- To promote quality and safety, and considerations relating to climate change, in the design and construction of infrastructure, including dams.
- To avoid or minimize community exposure to project-related traffic and road safety risks, diseases and hazardous materials.
- To have in place effective measures to address emergency events.
- To ensure that the safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the project-affected communities.

14.7.2.4.2 National

Labour management is covered under a few national legislation regulations and acts. This includes:

- The Constitution of the Kingdom of Bhutan
- Labour and Employment Act of Bhutan 2007
- Regulation on Working Conditions, 2022
- Regulation on Occupational Health and Safety for Construction Industry, 2022
- Regulation on Occupational Health, Safety and Welfare, 2022
- Regulation on Foreign Workers Management, 2022

Further details on the national labour legislation and its key relevant aspects are provided in the Standalone HPP Project LMP.

14.7.2.5 Preparing Labour Management Procedures

Table 207: LMP Roles and Responsibilities

Key aspects	Direct workers	Contracted workers	Primary supply workers	Community Workers
Hiring and managing individual project workers	DGPC PMU to engage/manage some advisors.	Contractor and Subcontractor to engage their own workforce.	Contractor to require the primary supplier to identify/address child labour/forced labour and serious safety risks. Where there is a significant risk of child labour or forced	N/A as community workers, as defined in ESS2, will not be involved in the project.
OH&S	PMU to use DGPC OH&S procedures outside of construction sites. PMU to use Contractors' OH&S	Contractor to develop and implement Workers OH&S Plan and enforce use with Subcontractors.		

Key aspects	Direct workers	Contracted workers	Primary supply workers	Community Workers
	procedures on construction sites.		labour related to primary supply workers they should be identified and included in the labour management procedures which will set out roles and responsibilities for monitoring primary suppliers. Additionally, where there is a significant risk of serious safety issues related to primary supply workers, Contractor to require the primary supplier to introduce procedures and mitigation measures to address such safety issues. Such procedures and mitigation measures will be reviewed periodically to ascertain their effectiveness. Contractor to monitor and report to PMU.	
Child labour and forced labour	PMU to enforce national regulations on age limit and forced labour for its own workforce.	Contractor to enforce national regulations on age limit and forced labour for its own workforce. Contractor to monitor and report to PMU.		
Training	PMU to facilitate training of its own staff.	Contractor to provide induction to all workers. Contractor to facilitate training as required. Contractor to monitor and report to PMU.		
Code of conduct	PMU to use DGPC Code of Conduct	Contractor to develop and implement Code of Conduct and enforce use with Subcontractors. Contractor to monitor and report to PMU.		
Grievance mechanism	PMU to use DGPC GRM	Contractors to develop and implement WGRM and enforce use with Subcontractors. Contractor to monitor and report to PMU.		
Monitoring and reporting	The PMU supervises and ensures that contractors are complying and enforcing the application of the LMP to the project's contracted and primary supply workers. Lenders E&S advisors monitor and report to Lenders.	Contractor to monitor and report to PMU on all Labour aspects. PMU will provide consolidated report on contracted workers to the World Bank.	Contractor to monitor and report to PMU. Lenders E&S advisors monitor and report to World Bank as required.	

14.7.2.5.1 Roles and responsibilities – DGCP PMU

The Project Management Unit (PMU) will be directly supervised by DGPC and will report to responsible staff within DGPC under the authority of the DGPC MD.

Table 208: Key responsible staff and responsibility

Responsible agencies/ staff	Roles and Responsibilities
MD of the PMU (Dorjilung Hydropower Project)	
Project Director/Engineer Design and supervision Consultant Social Safeguard Expert	Overall responsibility to oversee all aspects of the implementation of the LMP To ensure contractor compliance Incorporate labour-related requirements into procurement of works and suppliers Engagement and management of contractors Conduct health and safety induction to contractors and workers Ensure that the workers' GRM is implemented
Project site office	
PMU Environment and Social Specialists Gender Specialist	Implementing these labour management procedures. Ensuring that contractors comply with LMP. Monitoring to verify that contractors are meeting labour and OH&S obligations toward contracted and subcontracted workers as required by Bhutanese legislation and ESS2. Monitoring contractors and subcontractors. Monitoring compliance with occupational health and safety standards at all workplaces in line with the national occupational health and safety legislation. Monitoring and implement training on LMP and OHS for project workers. Ensuring that the grievance redress mechanism for project workers is established and implemented and that workers are informed of its purpose and how to use it. Have a system for regular monitoring and reporting on labour and occupational safety and health performance. Monitoring implementation of the Worker Code of Conduct. Support training of workers on CoC, Workers GRM, SEA/SH, COVID-19, etc. Tracking and reporting on workers' GRM
Construction Contractors	
Occupational Health and Safety Specialist Gender Specialist	Comply with the requirements of the national legislation and these LMP and reflect all requirements in agreements with sub-contractors and suppliers. Maintain records of recruitment and employment process of contracted workers. Communicate clearly job description and employment conditions to contracted workers. Have a system for regular review and reporting on labour, and occupational safety and health performance. Ensure that all contractors and subcontractor workers understand and sign the Code of Conduct prior to the commencement of work and supervise compliance with the Code. Undertake audits on supply chain workers. Plan and implement contract-specific labour management plans Coordinate toolbox meetings focused on health and safety, SEA/SH, COVID-19, HIV/AIDs, etc Report on OHS performance to PMU monthly Tracking and responding to workers' grievances

The MD of the PMU (Dorjilung Hydropower Project) will oversee and guide all the workers arrangement associated with the Project. The MD of the PMU, daily, will coordinate the project activities including relations with direct employees, contractors and suppliers.

The human resources (HR) representative assigned by DGPC, the PMU's Project Manager and E&S Manager, will be in charge of the following:

- Implementing these labour management procedures.

- Ensuring that contractors comply with LMP.
- Monitoring to verify that contractors are meeting labour and OH&S obligations toward contracted and subcontracted workers as required by Bhutanese legislation and ESS2.
- Monitoring contractors and subcontractors.
- Monitoring compliance with occupational health and safety standards at all workplaces in line with the national occupational health and safety legislation.
- Monitoring and implement training on LMP and OHS for project workers.
- Ensuring that the grievance redress mechanism for project workers is established and implemented and that workers are informed of its purpose and how to use it.
- Have a system for regular monitoring and reporting on labour and occupational safety and health performance.
- Monitoring implementation of the Worker Code of Conduct.

The technical performance of contractors who perform the work will be supervised by the PMU, with support from DGPC head office. DGPC's Project Management Unit Managing Director has the overall responsibility to oversee all aspects of the implementation of the LMP, to ensure contractor compliance.

DGPC will address all LMP aspects as part of procurement for works as well as during contractor induction. The contractor is subsequently responsible for management in accordance with contract specific Labour Management Plans, the implementation of which will be supervised by DGPC's Project Management Unit monthly.

14.7.2.5.2 Roles and responsibilities – Construction Contractor(s)

The Contractors will be responsible for the following:

- Comply with the requirements of the national legislation and these LMP and reflect all requirements in agreements with sub-contractors and suppliers.
- Maintain records of recruitment and employment process of contracted workers.
- Clearly communicate job description and employment conditions to contracted workers.
- Have a system for regular review and reporting on labour, and occupational safety and health performance.
- Ensure that all contractors and subcontractor workers understand and sign the Code of Conduct prior to the commencement of work and supervise compliance with the Code.
- Undertake audits on supply chain workers.
- Contractor to prepare own Labour Management Plan(s) based on these Labour Management Procedures.

14.7.2.6 Workers Grievance Redress Mechanism

A Workers' Grievance Redress Mechanism (WGRM) process will be implemented and maintained throughout the entire PETL duration. It is a separate but complementary process to the Project Grievance Redress Mechanism which is used to record and manage grievances on the Project (e.g., by community members or other stakeholders). The mechanism will be hosted by the contractors.

While each organization (employer) can develop and manage its own WGRM, they must reflect on the principles and process outlined in this section.

DGPC or Lenders' representative can request copies and extract of WGRM at any time and without providing reasons.

The WGRM is closely linked to the Gender, GBV-SEA/SH and Vulnerability Action Plan and sub-plan: Gender Based Violence – Sexual Exploitation and Abuse and Sexual Harassment (GBV-SEA/SH)

Prevention and Response Action Plan, which described the specific GRM process for GBV-SEA/SH complaints. Grievances/cases related to the SEA/SH will be handled by this separate mechanism.

14.7.2.6.1 WORKERS GRM Principles

The WGRM will be based on the following principles:

- The process will be transparent and allow workers to express their concerns and file grievances.
- There will be no discrimination against those who express grievances.
- Grievances will be treated confidentially, except anonymous ones.
- Anonymous grievances will be treated equally as other grievances, whose origin is known.
- Workers will be informed of how their grievances are resolved. Resolution of anonymous grievances will be announced to the wider workforce.
- Management will treat grievances seriously and take timely and appropriate action in response.

A grievance is defined as a complaint by one or more workers, a workers' association, or an employer, relating to any matter concerning working conditions or the working environment arising at work or out of the workplace, as covered by the Labour and Employment Act of Bhutan 2007.

In Bhutan, a grievance procedure shall normally relate to the existing rights of workers under the Act and its Regulations, a written contract of employment, the Internal Service Rules, a collective bargaining agreement between workers and their employer, and rules established by custom and practice.

In any working environment it is essential for both employers and employees to be fully conversant with all aspects of disciplinary processes, the grievance redress procedures and the legal requirements and rights involved.

14.7.2.6.2 WORKERS GRM PROCESS

According to National law an employer of an enterprise with 12 or more employees shall consult with the worker's association at the enterprise or, if there is no such association, the employee(s), prepare and implement a workplace grievance procedure for use at each workplace. The workplace grievance procedure shall:

1. be in writing.
2. give an employee an opportunity to raise his or her grievance and to be heard.
3. enable the prompt and fair resolution of a grievance which arises at the workplace.
4. allow any issue or situation at the workplace relating to the conditions of employment to be grounds for grievance.
5. enable an employee to raise grievance to participate directly in the grievance procedure and to be assisted or represented by the workers' association (if any) or a person of his or her own choosing.
6. ensure that the party or parties raising a grievance is kept informed of the steps being taken under the procedure and of the action taken on the grievance.
7. if the parties to a grievance consider it necessary, provide for minutes of the proceedings to be drawn up in mutual agreement and be made available to the parties; and
8. allow the parties to grievance to draw up an agreement resolving the dispute that is binding on the parties, provided that the agreement does not contravene the provisions of national law.
9. Include a central database for workers' GRM to ensure that tracking and analysis is possible.

The employer should make the grievance procedure known and available to the employees at the workplace.

Please note that grievances/cases related to the SEA/SH will be handled though a separate and dedicated grievance mechanism.

14.7.3 Resettlement Policy Framework

14.7.3.1 Introduction

This section constitutes a simplified template for a Resettlement Policy Framework (RPF) consistent with requirements of the World Bank Environmental and Social Framework. Its fundamental purpose is to establish terms of agreement between relevant authorities in DGPC and the World Bank regarding principles and procedures to be used in subsequent preparation of a Resettlement Plan (RP) or Resettlement Plans (RPs). World Bank approval of an RP (or RPs) is required before project authorities invite bids for any contracts in which work are expected to involve physical or economic displacement because of land acquisition or restrictions on access or use of natural resources.

The RPF is intended to avoid or minimize any adverse impacts associated with physical or economic displacement, and to ensure arrangements are in place to mitigate any adverse impacts that may occur. DGPC hereby agrees to apply the principles, procedures, and standards incorporated in ESS5 of the World Bank ESF if obtaining any sites for project use would cause economic displacement or physical displacement.

This RPF is intended to utilize the existing legal and policy framework of DGPC, incorporating any supplementary measures necessary to achieve consistency with ESS5 principles and standards.

14.7.3.2 Project Description

Any physical displacement and/or land acquisition for PETL is yet to be confirmed. Preparation of a site-specific RP is not technically feasible at the time this RPF is prepared as the specific PETL layout is not known.

14.7.3.3 Key Principles and Definitions

In World Bank-assisted projects, borrowers are expected to take all feasible measures to avoid or minimize adverse impacts from land acquisition and restrictions on land use associated with project development. The fundamental objective of ESS5 is to ensure that, if physical or economic displacement cannot be avoided, displaced people (as defined below) are compensated at the replacement cost for land and other assets, and otherwise assisted as necessary to improve or at least restore their incomes and living standards.

Other ESS5 objectives include:

- To avoid forced eviction.
- To improve living conditions of poor or vulnerable persons who are physically displaced, through provision of adequate housing, access to services and facilities, and security of tenure.
- To conceive and execute resettlement activities as sustainable development programs, providing sufficient investment resources to enable displaced persons to benefit directly from the project, as the nature of the project warrants.
- To ensure that resettlement activities are planned and implemented with appropriate disclosure of information, meaningful consultation, and the informed participation of those affected.

Displaced people (ESS5, Para. 10) are defined as any person subjected to project-related adverse impacts who (a) have formal legal rights to land or assets; (b) have a claim to land or assets that is recognized or recognizable under national law; or (c) who have no recognizable legal right or claim to the land or assets they occupy or use. The term incorporates all potential categories of persons affected by land acquisition and associated impacts; all of those adversely affected are considered "displaced" under this definition regardless of whether any relocation is necessary.

Replacement cost (ESS5, Para. 2, footnote 6) is defined as a method of valuation yielding compensation sufficient to replace assets, plus necessary transaction costs associated with asset replacement. Where functioning markets exist, replacement cost is the market value as established through independent and competent real estate valuation, plus transaction costs. Where functioning markets do not exist, replacement cost may be determined through alternative means, such as calculation of output value for land or productive assets, or the undepreciated value of replacement materials and labour for construction of structures or other fixed assets, plus all transaction costs associated with asset replacement. In all instances where physical displacement results in loss of substandard shelter, replacement cost must at least be sufficient to enable purchase or construction of housing that meets minimum community standards of quality and safety.

ESS5 also establishes key principles to be followed in resettlement planning and implementation. These include:

- All displaced people are entitled to compensation for land and attached assets, or to alternative but equivalent forms of assistance in lieu of compensation; lack of legal rights to the assets lost will not bar displaced persons from entitlement to such compensation or alternative forms of assistance.
- Compensation rates refer to amounts to be paid in full to the eligible owner(s) or user(s) of the lost asset, without depreciation or deduction for fees, taxes, or any other purpose.
- Compensation for land, structures, unharvested crops, and all other fixed assets will be paid prior to the time of impact or dispossession.
- When cultivated land is to be taken for project purposes, the [name of implementing agency] seeks to provide replacement land of equivalent productive value if that is the preference of the displaced persons.
- Community services and facilities will be repaired or restored if affected by the project.
- Displaced people will be consulted during preparation of the RP, so that their preferences are solicited and considered.
- The RP (in draft and final versions) is publicly disclosed in a manner accessible to displaced persons.
- A grievance mechanism by which displaced people can pursue grievances will be established and operated in a responsive manner.
- Negotiated settlement processes are acceptable as an alternative for legal expropriation if appropriately implemented and documented.
- Land donation is acceptable only if conducted in a wholly voluntary manner and appropriately documented.
- The [name of implementing agency] bears official responsibility for meeting all costs associated with obtaining project sites, including compensation and other considerations due to displaced persons. The RP includes an estimated budget for all costs, including contingencies for price inflation and unforeseen costs, as well as organizational arrangements for meeting financial contingencies.
- Monitoring arrangements will be specified in the RP, to assess the status and effectiveness of RP implementation.

14.7.3.4 Legal and Regulatory Framework

DGPC agrees to take all actions necessary to ensure full and effective implementation of RPs prepared in accordance with the RPF, and to otherwise take actions necessary to achieve all relevant provisions of ESS5.

Include preparation of a Gap analysis of Bhutan's land laws compared to ESS5, with specification of the exact standards applicable in the RPF. Special attention needs to be paid to easement issues, since these will be a major issue in the actual LALRP.

14.7.3.5 Preparing a Resettlement Plan

All projects causing physical or economic displacement through land acquisition or project-related restrictions on resource access or use are required to prepare a resettlement plan for World Bank approval. Responsibility for preparation and implementation of the RP (or RPs) rests with DGPC. As necessary, DGPC will exercise its authority to coordinate actions with any other involved agencies, jurisdictions, or project contractors to promote timely and effective planning and implementation.

RP preparation begins once the physical footprint of a proposed investment has been determined, establishing that a particular site (or sites) must be acquired for project use. DGPC initially screens proposed sites to identify current usage and tenurial arrangements and identifies the site (or sites) that will minimize physical and economic displacement. DGPC subsequently carries out, or causes to be carried out, a census survey to identify and enumerate all displaced persons on the selected site (or sites) and to inventory and valuate land and other assets that are to be acquired for project use.

Each RP is based on the principles, planning procedures, and implementation arrangements established in this RPF, and normally includes the following contents:

- Description of the project (with appropriate maps and illustrations), including explanation for the necessity of acquiring sites for project use and efforts undertaken to avoid or minimize the amount of land acquisition or other potential impacts deemed necessary
- Results of a census survey of displaced persons and inventory and valuation of affected land and assets
- Description of any project-related restrictions on resource use or access
- Description of tenure arrangements, including collective, communal, or customary use or ownership claims
- Review of relevant laws and regulations pertaining to acquisition, compensation, and other assistance to displaced people, and identification of gap-filling measures needed to achieve ESS5 requirements
- Description of land and asset valuation procedures and compensation standards for all categories of affected assets
- Eligibility criteria for compensation and all other forms of assistance, including a cutoff date for eligibility
- Organizational arrangements and responsibilities for RP implementation
- Implementation timetable
- Estimated budget and financial contingency arrangements
- Consultation and disclosure arrangements
- Description of grievance mechanism
- Arrangements for monitoring implementation progress.

The RP will be complemented by a separate set of individual compensation files for each displaced household or person. These files are to be handled confidentially by the borrower to avoid any prejudice against displaced people. In fragility, conflict, and violence environments, RPs will also clarify procedures to be applied to ensure the security of displaced persons when they receive compensation payments.

Eligibility criteria for compensation and all other forms of assistance will be clearly summarized in a table that can be used for consultation with displaced people. An example table is provided in Table 209.

Table 209: Suggested Outline for Preparation of RP Entitlements Matrix – Example Only

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
A. Loss of agricultural land - Irrigated land - Rainfed land - Pasture - Groves - Fishpond - Other	Owners Users with legalizable claims Renters/Lessees Other users (squatters, encroachers)	People or communities with formal legal rights to land lost in its entirety or in part. People or communities who lost the land they occupy or use in its entirety or in part who have no formal legal rights to such land, but who have claims to such lands that are recognized or recognizable under national laws. People or communities who lost the land they occupy in its entirety or in part who have neither formal legal rights nor recognized or recognizable claims to such land	Compensation in kind or at replacement cost Compensation in kind or at replacement cost Prorated compensation for the remainder of term; assistance in finding suitable alternative. Compensation for improvements; assistance in lieu of land compensation	(TBD; usually unit of currency per unit of land)
B. Loss of residential land	Owners Users with legalizable claims Renters/Lessees Other users (squatters, encroachers)	People or communities with formal legal rights to land lost in its entirety or in part. People or communities who lost the land they occupy or use in its entirety or in part who have no formal	Compensation in kind or at replacement cost Compensation in kind or at replacement cost Prorated compensation for the remainder of term; assistance in finding suitable alternative.	(TBD; usually unit of currency per unit of land)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
		legal rights to such land, but who have claims to such lands that are recognized or recognizable under national laws. People or communities who lost the land they occupy in its entirety or in part who have neither formal legal rights nor recognized or recognizable claims to such land	Compensation for improvements; assistance in lieu of land compensation	
C. Loss of commercial land	Owners Users with legalizable claims Renters/Lessees Other users (squatters, encroachers, illegal businesses)	Owner of a commercial outlet. Worker in a commercial outlet.	Compensation at replacement cost, commercial real estate value Compensation at replacement cost, commercial real estate value Prorated compensation for the remainder of term; assistance in finding suitable alternative. Compensation for improvements; assistance in lieu of land compensation	(TBD; usually unit of currency per unit of land)
D. Temporary loss of land	Owners, occupants, users	People or communities with formal legal rights to land lost in its entirety or in part.	Compensation for duration of project use; restoration of land to prior condition	(TBD)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
		People or communities who lost the land they occupy or use in its entirety or in part who have no formal legal rights to such land, but who have claims to such lands that are recognized or recognizable under national laws. People or communities who lost the land they occupy in its entirety or in part who have neither formal legal rights nor recognized or recognizable claim such land.		
E. Loss of agricultural production - crops - fruit/nut trees - timber trees - aquaculture - forest produce - livestock forage - livestock	Producers	People with crops at growing or harvesting stage. People growing plants of fruit trees or economic trees on his/her land. A person harvesting fruits and other products from spontaneous fruit and other economic trees for commercial purposes on his/her land.	Opportunity to bring to market, or compensation at market value at maturity (or compensation at net present value for trees and livestock)	(TBD)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
F. Loss of productive fixed assets - irrigation facilities - fencing - wells - troughs - sheds - barns - other	Asset owners/users	A person with productive fixed assets used for commercial purposes on his/her land.	Compensation at replacement cost (non-depreciated value including labour and materials)	TBD)
G. Loss of residential structures (Often categorized by major building material, fixed improvements, or other features)	Owners Occupants with legalizable claims Renters/Lessees Illegal structures	A person or household owning a building that it inhabits as a main residence (covering its dependencies: kitchen, latrine, shower house, chicken house, etc.). A person or household owning a private building dedicated to secondary residence, agriculture storage, etc. People owning a building or renting it. Tenant of a building that will be affected.	Direct house replacement or compensation at replacement cost (non-depreciated value including labour and materials); transitional assistance. Direct house replacement or compensation at replacement cost (non-depreciated value including labour and materials); transitional assistance. Prorated compensation for remainder of term; assistance in finding suitable alternative; transitional assistance. Direct house replacement or compensation at replacement cost (non-depreciated value including labour and materials); transitional assistance	(TBD, usually specified as unit of currency per square meter of structure)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
H. Loss of commercial structures (Often categorized by major building material, function and capacity, fixed improvements, or other features)	Owners Occupants with legalizable claims Renters/Lessees Illegal structures	People or communities with formal legal rights to land lost in its entirety or in part. People or communities who lost the land they occupy or use in its entirety or in part who have no formal legal rights to such land, but who have claims to such lands that are recognized or recognizable under national laws. People or communities who lost the land they occupy in its entirety or in part who have neither formal legal rights nor recognized or recognizable claims to such land	Compensation at replacement cost for structures, fixed equipment and other improvements; transitional assistance Compensation at replacement cost for structures, fixed equipment and other improvements; transitional assistance Prorated compensation for remainder of term; compensation at replacement cost for fixed equipment and other improvements; transitional assistance Compensation at replacement cost for structures, fixed equipment and other improvements; transitional assistance	(TBD)
I. Loss of agricultural livelihood	Affected agricultural producer	TBD requires definition of significant impact caused by severity of loss or imposed changes in livelihood methods.	In addition to compensation for lost land and assets, people whose livelihoods are significantly affected receive alternative employment, skills training, business development assistance, or other additional assistance linked to livelihoods	(TBD)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
			restoration or improvement	
J. Temporary loss of business income	Owner, enterprise	Owner, enterprise who has temporary loss of business income.	Payment of support for period of disruption	(TBD, based on prior reported profits or other forms of estimation)
K. Temporary loss of employment or wages	Employees	Employees of businesses who have temporary loss of business income.	Payment of wages or unemployment support for period of disruption	(TBD, based on payment records or other forms of estimation)
L. Loss of public or community infrastructure, facilities or services	Public or private owners	Community losing public infrastructure established on its territory.	Compensation at replacement cost for damage or destruction of infrastructure and facilities; assistance in restoring functionality and accessibility of services	(TBD)
M. Material assistance to vulnerable or disadvantaged	Displaced illegal residents, users or occupants. Blind or otherwise disabled. Occupants displaced from substandard housing.	Households will be considered vulnerable if: - Registered as poor in the local social services or female-headed households. - Households headed by elderly or disabled without any other primary earner in the household. They have been identified and will be eligible to	In addition to applicable forms of compensation and assistance, provision of defined security of tenure Project design provides features relating to safety and accessibility. Arrangements for obtaining replacement housing meeting minimum legal or community standards.	(TBD)

IMPACT	AFFECTED PERSONS	ELIGIBILITY CRITERIA	ENTITLEMENT IN PRINCIPLE	MITIGATION STANDARDS/MEASURES
		specific assistance.		

Additional planning measures must be incorporated into RPs for projects causing physical displacement, or significant economic displacement, as described below.

For projects causing physical displacement, the RP will include planning measures relating to the following, as relevant for project circumstances:

- Description of relocation arrangements, including options available to displaced people, and including transitional support for moving or other expenses.
- Description of resettlement site selection, site preparation, and measures to mitigate any impacts on host communities or physical environment, including environmental protection and management.
- Measures to improve living standards and otherwise address the needs of relocating poor or vulnerable households, including measures to ensure that replacement housing is at least consistent with minimum community standards and is provided with security of tenure.
- Considerations of resettlement sites and potential strain on public infrastructure, natural resources, labour opportunities, which may cause inter-community strains.
- Description of project design measures to improve living standards, access to or functioning of community services or facilities, or for providing other project-related benefits.
- Any measures necessary to address the impact of resettlement on host communities.

For projects causing significant economic displacement, the RP describes (as relevant):

- The scale and scope of likely livelihoods-related impacts, including agricultural production for consumption or market, all forms of commercial activity, and natural resource use for livelihoods purposes.
- Livelihoods assistance options (for example, employment, training, small business support, assistance in providing replacement land of equivalent productive value, other) available to people losing agricultural land or access to resources.
- Assistance measures available to commercial enterprises (and workers) affected by loss of assets or business opportunities directly related to land acquisition or project construction.
- Project measures to promote improvement of productivity or incomes among displaced people or communities.

14.7.3.6 Consultation and Disclosure Arrangements

The RP summarizes results of measures taken to consult with displaced people regarding the project, its likely impacts, and proposed resettlement measures. It also summarizes the meetings held with displaced people (dates, locations, number of participants), including comments, questions, and concerns expressed by displaced people during these meetings as well as responses provided to them. DGPC discloses a draft RP to the displaced persons (and the public) after Bank review and solicits comments from displaced persons regarding the proposed plan. Disclosure of the final RP occurs following consideration of comments received and following Bank acceptance.

14.7.4 Monitoring and Evaluation

DGPC will plan for monitoring implementation and will provide periodic monitoring reports to the Bank regarding the status of land acquisition and implementation of the RP. For projects with significant impacts, competent resettlement monitoring professionals will monitor implementation progress and provide advice on any necessary corrective actions and will conduct an implementation review when all mitigation measures in the RP are substantially complete. The implementation review evaluates the effectiveness of mitigation measures in achieving RP and ESS5 objectives and recommends corrective measures to meet objectives not yet achieved.

14.7.5 Grievance Mechanism

To ensure that displaced people can raise complaints regarding the land acquisition process, calculation or payment of compensation, provision of assistance, or other relevant matters, the RP provides an accessible and responsive grievance mechanism. The RP describes submission procedures, organizational arrangements, and responsive performance standards for handling grievances, and measures to be taken to inform displaced persons or communities about grievance initiation and response standards. The grievance mechanism does not preclude displaced persons from pursuing other legal remedies available to them.

DGPC will keep a record of all complaints referring to the grievance mechanism, including a description of issues raised and the status or outcome of the review process.

REFERENCES

Bhutan, National Center For Hydrology and Meteorology Royal Gouvement of. n.d. *National Center For Hydrology and Meteorology Royal Gouvement of Bhutan* . https://www.nchm.gov.bt/home/pageMenu/816.

Biggs, B. J., and R. A. Smith. 2002. "Taxonomic richness of stream benthic algae: effects of flood disturbance and nutrients." *Limnology and Oceanography, 47(4)* 1175 - 1186.

FAO. 2011. *Food and Agriculture Organization of the United Nations.* .Bhutan.: AQUASTAT.

Grünthal, Gottfried & Bosse, Christian & Sellami, Souad & D, Mayer-Rosa & D, Giardini. 1999. " Compilation of the GSHAP regional seismic hazard for Europe, Africa and the Middle East. ." *Annals of Geophysics.* 42. 10.4401/ag-3782.

John, D. M., B. A. Whitton, and A. J. Brook. 2002. "The freshwater algal flora of the British Isles: An identification guide to freshwater and terrestrial algae." *Cambridge University Press.*

Ketelsen T., Nguyen V. A, Vinh M. K., Kummu M., Ward P., Meynell P., Rasanen T. 2013. " Assessing the impact of sedimentation on reservoir life, Example from the Yali Reservoir, Viet Nam, MK3 Optimising cascades of hydropower,." *in Hydrology & Flood Contr.*

Muhammad Atiq, ORCID,Kelden Wangchuk and Nitin Muttil. 2021. "A Critical Review of Water Resources and Their Management in Bhutan." *MDPI* Hydrology 2021, 8(1), 31; https://doi.org/10.3390/hydrology8010031.

N. McQuarrie, S.P. Long. 2021. "Documenting basin scale, geometry and provenance through detrital geochemical data: Lessons from the Neoproterozoic to Ordovician Lesser, Greater, and Tethyan Himalayan strata of Bhutan." *Elsevier* Volume 23, Issue 4, May 2013, Pages 1491-1510.

Nadine McQuarrie, S. P. Long, Tobgay Tobgay, J.N. Nesbit. 2012. "Documenting basin scale, geometry and provenance through detrital geochemical data: Lessons from the Neoproterozoic to Ordovician Lesser, Greater, and Tethyan Himalayan strata of Bhutan." *ELSEVIER* Gondwana Research 23 (2013) 1491–1510.

Namgyal, Tshering. 2022. "Forest fire rages in Mongar and Lhuentse." KUENSEL . (https://kuenselonline.com/forest-fire-rages-in-mongar-and-lhuentse/).

Paterson, M. J., K. G. Beaty, D. L. Findlay, W. J. Findlay, S. L. Schiff, V. L. St. Louis, and J. J. Venkiteswaran. 2019. "Long-term changes in nutrient dynamics and plankton communities following the creation of a new reservoir." *Canadian Journal of Fisheries and Aquatic Sciences, 76 (8)* 1459 - 1469.

SAARC. 2010. "lANDSLIDE RISK MANAGEMENT in South Asia ."

Segers, H. 2006. "Rotifera: Biology, Ecology and Systematics." *Kenobi.*

Stevens, V. L. , De Risi, R., Le Roux-Mallouf, R., Drukpa, D., & Hetényi, G. 2020. "Seismic Hazard and Risk in Bhutan." *Natural Hazard* 104, 2339–2367. http://10.1007/s11069-020-04275-3.

Svensson, J. R., M. Lindegarth, and H. Pavia. 2009. "Equal rates of disturbance cause different patterns of diversity." *Ecology, 90 (2)* 496 - 505.

Tshencho Dorji, and Tayba Buddha Tamang,. 2019. *Analysis of Historical Climate Projection for Bhutan.* Thimphu,: National Center for Hydrology and Meteorology. https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Analysis%20of%20Historical%20Climate%20and%20Climate%20Change%20Projection.pdf.

Verma, D. R., T. Ahmad, and S. Bajpai. 2014. "Population dynamics of rotifer fauna in two eutrophic ponds of Bahraich district Uttar Pradesh." *Cibtech J Zool, 3 (2)* 37-42.

WBG. 2021. " Agriculture Interactive Climate Indicator Dashboard. ." WBG Climate Change Knowledge Portal (CCKP, 2021). Bhutan. Agriculture Interactive Climate Indicator Dashboard. URL: https://.

World Bank Group. 2016. "Managing Environmental and Social Impacts of Hydropower in Bhutan." *World Bank Group,.*

worldbank. n.d. *climateknowledgeportal.* https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical.

—. 2023. *climateknowledgeportal.* https://climateknowledgeportal.worldbank. org/country/bhutan/climate-data-projection.

Yoshihiko KARIYA, Jiro KOMORI and Toshiyuki TSUZUKI. 2011. "LANDSLIDE FEATURES IN THE DAMJI AND GASA DISTRICT, GASA DZONGKHAG,." *CORE* oai:tokyo-metro-u.repo.nii.ac.jp:00003127.