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ENVIRONMENTAL FLOW ASSESSMENT FOR THE BUNAKHA HHP, WANGCHHU RIVER, BUTHAN

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JULY 2026

EXECUTIVE SUMMARY

The proposed Bunakha Hydropower Project (HPP) is a 180 MW reservoir-based development located on the Wangchu River in western Bhutan. The project forms part of the Wangchu hydropower cascade and is intended to improve energy security and optimise power generation from the existing downstream Chhukha and Tala hydropower schemes. Given the importance of the Wangchu River in supporting aquatic ecosystems and maintaining ecological processes, an Environmental Flow (e-flow) Assessment was undertaken to determine the flow regime required to sustain ecosystem functioning while accommodating hydropower development (the generic 30% e-flow prescribed will render the project unfeasible).

The assessment focused on the reach between the proposed Bunakha Dam and the Tala Reservoir, representing the only river section within the cascade where e-flow releases can meaningfully influence aquatic habitat conditions. A modified Building Block Methodology (BBM) was applied, integrating hydrological analysis, hydraulic habitat modelling, aquatic ecological surveys, geomorphological assessment and specialist interpretation. The study utilised long-term hydrological records, seasonal aquatic ecology surveys and hydraulic modelling to evaluate flow-habitat relationships and identify ecologically sustainable flow requirements.

The Snow Trout (*Schizothorax richardsonii*) was identified as the primary indicator species due to its ecological importance and sensitivity to flow alteration. Habitat requirements were assessed across critical life-history stages, including migration, spawning, juvenile development, feeding and refuge use. The assessment also considered flow-dependent macroinvertebrate communities, particularly the Heptageniidae (Flathead Mayfly), which represent an important food resource for *S. richardsonii* and a key indicator of aquatic ecosystem health. Results demonstrated that maintenance of suitable water depths, flow velocities, channel connectivity and substrate conditions is essential for sustaining these ecological communities and supporting long-term ecosystem resilience.

At the Client's request, a constant 5 m³/s e-flow scenario (5 % of MAR) was assessed by the team as an alternative to the variable regime originally proposed in this study. The assessment found that a constant 5 m³/s release, combined with anticipated spills at Bunakha and Chukha, would largely preserve the seasonal flow variability needed for Snow Trout spawning and migration during the spring, autumn and monsoon periods, though a residual risk of habitat deterioration remains from November to February and June, when spill volumes are insufficient to restore this variability. Given the low confidence associated with the spill data and its dependence on natural inflow rather than a guaranteed operational commitment, the originally proposed variable e-flow regime of 9% of MAR (Table 1) remains the preferred and recommended approach, providing a robust and reliable means of meeting ecological flow requirements year-round without reliance on incidental spills.

Table 1: Summary of the final e-flows for Wanchu River at e-flow site

Component	Requirement
Reference flows, 1976-2024 (MCM)	3014.5
Total e-flows	9.54%
Base-flows	9.08%
Drought flows	1.82%
Freshets/ floods	0.46%

It must be noted that the assessment identified several limitations that introduce uncertainty into the hydraulic-ecological relationships used to inform the environmental flow recommendations. These include the absence of concurrent hydraulic and aquatic ecological surveys, the lack of hydraulic measurements at the specific locations where fish and macroinvertebrate communities were sampled, limited hydraulic survey resolution and habitat mapping, and the absence of scenario-based ecological evaluations. Consequently, direct relationships between ecological observations and modelled hydraulic conditions could not be established with a high degree of confidence. The recommended environmental flow regime should therefore be regarded as a precautionary yet scientifically defensible approach based on the best available information. Confidence in the findings could be improved through future monitoring, refined hydraulic modelling, detailed habitat assessments and additional ecological investigations.

To support implementation of the recommended flow regime, a series of mitigation and management measures are proposed. These include formal implementation of e-flow releases, sediment management measures, management of alien invasive fish species, monitoring of aquatic ecological indicators and adaptive management through an Environmental Flow Management Plan. In addition, consideration should be given to implementing an ecological offset through the release of environmental flows from the Chukha Dam into the currently dewatered reach between the Chukha and Tala Hydropower Projects (Dewatered Reach 2). Such releases have the potential to restore aquatic habitats and ecological processes within a substantially longer river reach that is presently deprived of ecologically meaningful flows, thereby providing broader catchment-scale ecological benefits. Furthermore, future flow scenario assessments should be undertaken to evaluate the ecological consequences of hydropower operations under changing climatic conditions, including altered rainfall patterns, changing snowmelt contributions and increasing hydrological variability.

Overall, the recommended e-flow regime represents a balanced approach that seeks to maintain ecological integrity and ecosystem functioning within the Wangchu River while supporting the operational objectives of the Bunakha HPP and the wider hydropower cascade. While the proposed e-flow releases will maintain ecological conditions within the isolated 400 m Bunakha–Chukha reach (Dewatered Reach 1), the study recommends implementation of the proposed offset measures within Dewatered Reach 2 to restore aquatic habitat, ecological processes and

connectivity along approximately 10 km of river reach. Although these measures would not fully compensate for habitat losses associated with the Bunakha Dam development, they would provide a meaningful ecological offset and, when combined with the proposed fish conservation and enhancement programme along Reach 2 and in the Bunakha catchment (all rivers draining into Bunakha Reservoir), contribute towards no net loss objectives at the river-system scale while delivering a localised net gain in ecological condition for Dewatered Reach 2. Collectively, the recommended flow regime, offset measures and adaptive management framework provide a robust basis for supporting the long-term sustainability of both the Wangchu River ecosystem and hydropower development within the basin.

LIST OF ACRONYMS

Acronym	Description
ADCP	Acoustic Doppler Current Profiler
BBM	Building Block Methodology
BF	Baseflow
DoFPS	Department of Forests and Park Services
E-flow	Environmental Flow
EFMP	Environmental Flow Management Plan
EFR	Environmental Flow Requirement
EPT	Ephemeroptera, Plecoptera and Trichoptera
FDC	Flow Duration Curve
HABFLO	Habitat Flow Model
HEC-RAS	Hydrologic Engineering Centre – River Analysis System
HHP	Hydropower Project
HPP	Hydropower Plant / Hydropower Project
HEP	Hydroelectric Project
HPCD	Hydropower and Power Systems Coordination Division
IHA	Indicators of Hydrologic Alteration
IUCN	International Union for Conservation of Nature
km	Kilometre
m	Metre
m ²	Square Metre
m ³ /s	Cubic Metres per Second
MCM	Million Cubic Metres
MW	Megawatt
NEC	National Environment Commission
PCS	Punatsangchhu Consultancy Services
RCC	Roller Compacted Concrete
REF	Reference Flow Condition
RoR	Run-of-River
RTK	Real Time Kinematic
<i>S. richardsonii</i>	<i>Schizothorax richardsonii</i> (Snow Trout)
SPATSIM	Spatial and Time Series Information Modelling System
THP	Tala Hydropower Project

Acronym	Description
WQ	Water Quality
WWF	World Wide Fund for Nature

1. INTRODUCTION

This section introduces the study area, the purpose of the study, the approach and assumptions and limitations of the study.

1.1 Background to the Study

The Bunakha Hydropower Project (HPP) is a proposed reservoir-based scheme on the Wangchu River in western Bhutan, designed to generate renewable electricity for domestic use and cross-border trade with India. The Bunakha Dam will be the top-most reservoir of the four HHPs Ps (Figure 1-1). Its operation will influence downstream flows to the existing Chhukha HEP (336 MW), existing Tala HEP (1,020 MW), and the proposed Wangchhu HEP (570 MW) downstream of Tala Dam. The design allows peaking releases, which is absorbed by the daily ponds of the downstream HHPs, effectively not altering their flow releases. The Bunakha Dam with an expected installed capacity of 180 Megawatt (MW) and 136 m³/s flow diversion, a dam height of 197 meters (m), and a gross storage capacity of 329.16 million cubic meters (MCM), the project is part of Bhutan's broader strategy to harness its hydropower potential while contributing to national socio-economic development. The Bunakha project is also expected to play an important role in regional energy cooperation with India, reinforcing Bhutan's position as a clean energy exporter.

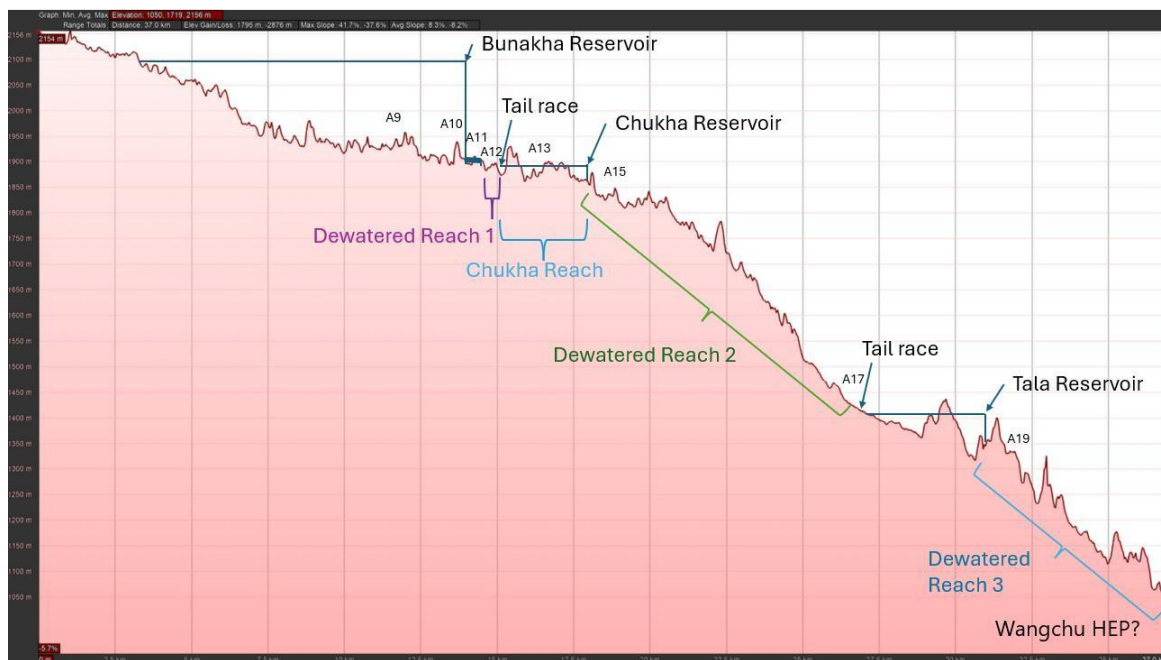


Figure 1-1: Longitudinal profile of the Wangshhu River showing the proposed Bunakha Dam, existing dams and the Dewatered Reaches. Ecological survey sites are numbered from AG to A1G

The Wangchu River, also known as the Raidak River, is one of the river systems of Bhutan, originating from the eastern Himalayas and flowing through the capital city Thimphu before entering India and eventually joining the Brahmaputra River. The river plays a critical role in

supporting hydropower generation, irrigation, domestic water supply, and ecological sustainability in western Bhutan.

The hydrology of the Wangchhu River Basin is strongly influenced by monsoonal precipitation, steep mountainous terrain, and glacial contributions. Seasonal variability is pronounced, with peak flows occurring during the monsoon months (June-September) and significantly reduced flows during winter. Observed discharge data indicate strong seasonal contrasts, with average flows reaching approximately 251 m³/s during peak monsoon months and dropping to as low as 26 m³/s in dry months.

In recent decades, the basin has experienced increasing hydrological variability due to climate change, land use changes, and growing water demand. Studies suggest that river discharge in the basin may increase significantly in the future, potentially by up to 60%, increasing flood risks and altering ecological conditions.

Given these challenges, the assessment of environmental flows (e-flows) is essential to maintain the ecological integrity of the river while ensuring sustainable water resource utilization. Environmental flows help preserve key ecosystem functions such as aquatic habitat maintenance, sediment transport, and seasonal flow variability.

1.2 Purpose of the Study

The purpose of this study is to determine the e-flow requirements of the Wangchhu River between the proposed Bunakha Dam and the existing Chukhha Dam using a holistic e-flow assessment approach. The study seeks to identify a flow regime that maintains the ecological integrity, functioning, and resilience of the river ecosystem while supporting the sustainable development and operation of hydropower infrastructure within the catchment.

Rivers are dynamic systems whose ecological health depends on the magnitude, timing, duration, frequency, and rate of change of flows. Alterations to the natural flow regime can affect aquatic and riparian ecosystems, disrupt ecological processes, and reduce the capacity of the river to support biodiversity and ecosystem services (Poff et al., 1997; Bunn C Arthington, 2022). Environmental flows are therefore required to sustain the ecological processes and functions that underpin river health, while balancing the competing demands of water resource development.

The e-flow requirements identified through this study will contribute to the maintenance of suitable habitats for aquatic biota, including fish and macroinvertebrate communities, and support critical life-history processes such as migration, spawning, recruitment, feeding, and refuge availability. Environmental flows are also necessary for sustaining riparian vegetation communities, preserving ecological connectivity along the river corridor, maintaining water quality, and facilitating sediment transport processes that shape channel morphology and habitat diversity. These processes are fundamental to maintaining ecosystem functioning, biodiversity, and the long-term ecological sustainability of the Wangchu River.

Therefore, to achieve this purpose, the study will:

- Analyse long-term hydrological records to characterise the reference flow regime and hydrological variability of the Wangchu River;

- Assess temporal flow variability, including seasonal and inter-annual patterns that influence ecological processes and ecosystem functioning;
- Determine the flow requirements necessary to sustain fish and macroinvertebrate components; and
- Evaluate the flow regime required to maintain ecological connectivity and ecosystem resilience within the study area.

1.3 Study Approach - Selection of Environmental Flow Method

Environmental flows refer to the quantity, timing, and quality of water required to sustain freshwater ecosystems, maintain riverine processes, and support the livelihoods of communities dependent on river systems. The determination of e-flows is a critical component of sustainable water resource management, particularly for hydropower projects and river basin developments. Appropriate e-flow regimes help preserve aquatic habitats, ensure sediment transport, maintain water quality, and support downstream ecological and socio-economic functions. The selection of suitable methodologies depends on data availability, project scale, ecological sensitivity, and regulatory requirements.

Holistic methods, such as the Building Block Methodology (BBM), provide a comprehensive framework for determining environmental flows by integrating hydrological, ecological, geomorphological, and socio-economic considerations. These methods aim to replicate the natural flow regime necessary for sustaining river ecosystems and human needs. They are particularly suitable for large-scale hydropower projects and cascade river systems.

For the Bunakha Hydropower Project, elements of the BBM approach were used due to limited availability of data for some key components and involves multidisciplinary collaboration and stakeholder engagement to establish a comprehensive environmental flow regime. The procedure includes:

- Assess baseline hydrological, ecological, and socio-economic conditions.
- Identify key ecological and geomorphological processes.
- Define essential flow components, including:
 - **Low flows/ base-flows** for sustaining aquatic habitats and water quality.
 - **High flows** for sediment transport and channel maintenance.
 - **Flood pulses/ freshets** for floodplain connectivity and ecosystem productivity.
- Assign ecological functions such as fish spawning, migration, and nutrient cycling.
- Conduct consultations with multidisciplinary experts and stakeholders.
- Develop a seasonal environmental flow regime reflecting natural variability.
- Establish monitoring, evaluation, and adaptive management mechanisms.

This approach ensures balanced river basin management while addressing ecological, social, and economic objectives. See Section 1.4.5 for the limitations of this approach due to the lack of specific data.

1.4 Assumptions and Limitations

1.4.1 Hydraulic Data

The hydraulic analysis is based on surveyed cross-sectional data collected for dam engineering during the April 2025 field survey. However, the confidence in the results is considered relatively low due to several data limitations and the coarse hydraulic resolution available for modelling.

Firstly, the hydraulic and cross-sectional survey was not undertaken concurrently with any of the three aquatic ecological surveys and assessments. As a result, there is reduced confidence in directly linking the hydraulic conditions represented in the model to the biological observations recorded during the aquatic surveys, as habitat conditions may have differed between survey periods.

Secondly, no discharge measurement was collected at the time of the hydraulic survey. Consequently, flow conditions used to calibrate and interpret the hydraulic data were derived from available reference flow records rather than site-specific measurements. This introduces an additional level of uncertainty regarding the hydraulic conditions represented within the analysis.

In the absence of detailed bathymetry data to develop a 2D hydraulic model, a 1D hydraulic model was developed for a single flow sensitive cross section across a riffle habitat. This assumes that setting e-flows for this flow sensitive habitat will also provide pool habitats along the reach.

Furthermore, the low spatial resolution of the hydraulic dataset constrains the model's ability to accurately represent localised variations in channel morphology, energy gradient, flow hydraulics, and habitat availability. The results should therefore be interpreted as indicative of broad-scale hydraulic conditions and habitat trends rather than precise representations of site-specific conditions.

The lack of cross-sectional data for the dewatered reach between the Chukha and Tala Dams poses a limitation for the possible offset option. It is assumed that the channel dimensions and character for the reach below Bunakha is representative of that for the dewatered reach between the Chukha and Tala Dams.

1.4.2 Assessment of Ecological Processes, Sediment Dynamics and Water Quality

The assessment of relationships between flow, aquatic habitats, ecological processes, sediment transport dynamics, and water quality was constrained by the availability of field data. While the study evaluated these linkages using available hydrological, hydraulic, ecological, and geomorphological information, several key processes could not be directly quantified during the field investigations.

In particular, detailed water quality investigations, including longitudinal and seasonal temperature monitoring, thermal stratification assessments, dissolved oxygen profiling, and other reservoir-related water quality processes, were not undertaken as part of the field surveys. Similarly, longitudinal sediment transport dynamics were assessed qualitatively based on available literature rather than through dedicated sediment transport monitoring or modelling.

As a result, the potential influence of flow alterations on water quality, thermal regimes, sediment processes, and associated ecological responses could only be inferred at a broad scale. The findings should therefore be interpreted as indicative of likely trends and ecosystem responses rather than definitive predictions of these processes.

1.4.3 Habitat Availability Modelling and Ecological Response Assessment

The assessment of habitat availability under varying flow conditions was undertaken using hydraulic modelling and available ecological information; however, the analysis was constrained by several data limitations. Detailed habitat mapping, including the spatial delineation of mesohabitats and microhabitats, was not undertaken during the field surveys. Furthermore, comprehensive riparian vegetation surveys and mapping were not conducted, limiting the ability to assess the influence of riparian habitat features on aquatic habitat availability and ecological functioning.

As a result, habitat suitability assessments for fish and macroinvertebrates were primarily based on hydraulic parameters (depth, velocity, and substrate characteristics where available) rather than a fully integrated habitat classification approach. The absence of detailed habitat and riparian vegetation mapping may have reduced the ability of the model to capture localised habitat heterogeneity and habitat connectivity that can influence species distribution and ecological responses to flow alteration.

Consequently, the model outputs should be interpreted as representing broad-scale trends in habitat availability and ecological response under different flow scenarios. While suitable for informing e-flow recommendations, the results are associated with a moderate degree of uncertainty regarding site-specific habitat conditions and ecological responses.

1.4.4 Macroinvertebrate Habitat Classification and Hydraulic-Ecological Data Uncertainty

Owing to the limited availability and diversity of aquatic habitats and representative field data within the study area, the HABFLO model was unable to adequately represent the full range of macroinvertebrate habitat classes, including combinations of velocity and substrate categories such as slow/fast coarse substrates and slow/fast fine substrates. Consequently, macroinvertebrate habitat preferences could not be assessed independently using the full range of habitat suitability classes. Instead, these habitat requirements were incorporated into the broader depth and velocity habitat classes used for the fish habitat assessment. While this approach allowed macroinvertebrate habitat requirements to be considered within the e-flow assessment, it may not fully capture the habitat-specific responses of all macroinvertebrate taxa to changes in flow conditions.

1.4.5 Environmental Flow Approach and Scenarios

The holistic BBM approach that was followed was limited due to:

No habitat assessments were done for the reach inundated by the Bunakha Reservoir; the Dewatered Reach 1 and Dewatered Reach 2 (see Figure 3-1). These should be included in future assessments to inform the habitats lost, proposed offsets and e-flow requirements to reinstate or maintain habitats.

Limited information for the available cross-sections on geomorphology, bed and bank substrates and riparian vegetation, thus confidence in specified freshets is low and no annual flood was

included. It is assumed that due to the relatively small size of the proposed Bunakha Dam compared to the annual runoff (<10%), the dam will spill often, and annual floods will still occur; and

Due to time constraints and limitations in data availability at the time of reporting, certain aspects of the constant 5 m³/s flow scenario assessment carry a lower level of confidence than others. The depth and velocity conditions associated with the 5 m³/s scenario could be confirmed with reference to the hydraulic habitat relationships already established for this study, providing a reasonable basis for assessing habitat suitability across the relevant life stages of *S. richardsonii*. However, the assessment of spill patterns at Bunakha and Chukha, and their potential to substitute for engineered freshet releases, is presented with lower confidence, as this was based on the data made available within the project timeframe and has not been verified against a comprehensive, multi-year spill record. It is recommended that, should the client wish to proceed further with a constant 5 m³/s e-flow regime, a fuller review of historical spill records be undertaken to confirm the frequency and reliability of incidental spills relative to the critical spawning migration and winter refuge periods, in order to provide a robust and defensible basis for evaluating this scenario relative to the regime proposed in this study.

1.4.6 Stakeholder Engagement and Local Knowledge Integration

The e-flow assessment was believed to have been undertaken without a formal stakeholder consultation process. However, this limitation is considered minor given the largely undeveloped nature of the study area, the relatively low population density, and the limited number of stakeholders directly dependent on the river system for livelihoods, water supply, or other ecosystem services.

The assessment was therefore based primarily on available scientific information, field surveys, and professional judgement. While stakeholder engagement may have provided additional local perspectives and historical observations, it is unlikely that the absence of such input would materially affect the ecological findings or environmental flow recommendations presented in this report.

1.4.7 Structure of the Report

The report presents the regulatory requirements for Buthan, study protocol and methods used, HPPs along the Wangshu River, baseline conditions at the reach between the proposed Bunakha Dam and the Chukha Reservoir, hydraulic model development, environmental flow requirements, the final recommended e-flows, mitigation, offsets, monitoring and project recommendations.

2. ENVIRONMENTAL FLOW FRAMEWORK

2.1 Study Protocol

The environmental flow assessment for the Bunakha Hydropower Project was undertaken through a structured, multi-stage approach integrating hydrological analysis, hydraulic

modelling, and ecological considerations. The objective was to determine an environmental flow regime capable of maintaining downstream aquatic habitats, ecological processes, and water-dependent ecosystem functions within the selected river reach.

The study commenced with the collection and review of available hydrological, hydraulic, ecological, and project design data. Historical river flow records were analysed to characterize the reference flow regime and develop a Flow Duration Curve (FDC) for the Wangchu River at the selected e-flow site.

Following the hydrological assessment, a hydraulic model of the environmental flow reach was developed using HABFLO. A single cross-section at a riffle/rapid habitat was used in the model to simulate flow conditions under a range of discharge scenarios. The modelling assessed variations in water depth, flow velocity and wetted channel area.

To incorporate ecological requirements into the assessment, Snow Trout (*Schizothorax richardsonii*), identified as the key aquatic species of concern, was selected as the indicator species, in addition with its food source comprising EPT taxa, in particular the Heptageniidae (Flathead Mayfly). Habitat suitability criteria were established based on documented depth and velocity preferences for *S. richardsonii*. Hydraulic model outputs were used to determine the minimum ecological requirements for low flows, high flows and drought flows.

The flow requirements included key criteria such as habitat suitability, channel connectivity, maintenance of aquatic refugia and downstream water requirements. The environmental flow regime was developed based on its ability to maintain suitable habitat conditions for *S. richardsonii* while ensuring ecological functionality within the environmental flow reach.

The study also recognized the ecological importance of seasonal flow variability and periodic high-flow events (freshets) for maintaining river processes such as sediment transport and habitat maintenance. While the present assessment focused primarily on determining minimum environmental flow requirements and habitat conditions, the need for further investigation of freshet releases to support fish migration, spawning, sediment transport, and channel maintenance was identified. Recommendations have therefore been made for the development of a comprehensive Environmental Flow Management Plan (EFMP) that incorporates adaptive management, ecological monitoring, and refinement of flow releases based on future ecological studies and the feasibility of the Bunakha HPP.

The overall study protocol followed a building block approach based on available data, combining hydrological analysis, hydraulic modelling, and species-specific habitat assessment to establish an environmentally sustainable and scientifically defensible environmental flow regime for the Bunakha Hydropower Project.

2.2 Study Area and Field Work

The environmental flow assessment was undertaken for the river reach extending from the proposed Bunakha Dam to the upstream end of the Chukha Dam on the Wangchu River in Chukha Dzongkhag, Bhutan. The proposed Bunakha Dam is located approximately 4 km upstream of the Chukha Dam, while the Bunakha powerhouse is situated 800 m downstream of the dam. Under normal operating conditions, only a short river section of approximately 400 m between the end of the Bunakha Dam stilling basin and the powerhouse would experience substantially reduced flows before water is returned to the river through the powerhouse tailrace.

During the inception stage of the study, the environmental flow assessment initially considered a broader study area extending downstream of both the Chukha and Tala Hydropower Projects, including the reach below the Chukha Dam and the Tala Dam located approximately 15 km further downstream. However, subsequent field investigations confirmed that neither the Chukha nor the Tala projects currently have dedicated environmental flow release mechanisms. As a result, the downstream river reaches have been subject to long-term flow diversions associated with hydropower operations. Field observations indicated that aquatic habitats in these reaches are already heavily influenced by regulated flows (no or very low base-flows) that do not

sustain biophysical processes.

Furthermore, under the latest project configuration, the Bunakha powerhouse tailrace discharges directly into the Chukha Dam. Consequently, the river reach between the proposed Bunakha Dam and the Chukha Dam represents the only section (400m) where environmental flow releases can meaningfully influence aquatic habitat conditions and ecological processes. Based on these findings, the environmental flow study area was refined and limited to the 400 m reach between the proposed Bunakha Dam stilling basin and the Chukha Dam. Although we use this to define e-flows as we have data here, we propose as off-set that the e-flows are rather released from Chukha Dam to Tala Dam.

Field surveys were focussed on biological aspects of the pre-monsoon, monsoon and post monsoon season from upstream of the proposed Bunakha Dam to downstream of Tala Dam.

2.4 Specialist Workshop to Determine E-Flows

A specialist e-flow workshop was held on 22 June 2026 to review and evaluate the hydrological, hydraulic, and ecological information available for the study area. The workshop brought together relevant specialists to assess the reference flow regime, existing baseflow conditions, and the proposed e-flow requirements necessary to maintain ecosystem integrity, ecological functionality, and long-term sustainability.

Workshop discussions focused on the relationships between discharge, velocity, depth, and habitat availability, with particular emphasis on the habitat preferences of the two selected ecological indicator taxa, namely *S. richardsonii* and Heptageniidae. For *S. richardsonii*, habitat requirements were assessed across key life-history stages, including spawning, migration, juvenile development, adult feeding, and juvenile refuge habitat requirements. The suitability of different depth and velocity classes under varying flow conditions was evaluated to determine the flows necessary to support the completion of critical life-cycle processes and the long-term persistence of populations within the system. Similarly, habitat requirements for Heptageniidae were evaluated in relation to flow-dependent habitat availability and hydraulic conditions, given their importance as indicators of ecological health and flow-sensitive aquatic habitats.

The outcomes of the workshop were used to refine and inform the e-flow recommendations, ensuring that sufficient flows are retained within the river system to maintain ecological health, habitat diversity, connectivity, ecosystem functioning, and geomorphic processes. The recommended e-flow regime was developed with the objective of achieving a no-net-loss outcome for the aquatic ecology of the system, while supporting the persistence of key fish and macroinvertebrate communities and the ecological processes upon which they depend. Particular consideration was given to maintaining flow conditions that sustain critical habitats and ecological functions throughout the annual hydrological cycle.

3. OPTIMIZING THE WANGCHU CASCADE

3.1 The Strategic Role of Bunakha, Chukha, and Tala HPPs

The Wangchu River basin serves as the powerhouse of Bhutan, hosting a sophisticated cascade of hydroelectric projects that drive the national economy. At the heart of this system is the proposed Bunakha Hydroelectric Project (BHEP), a strategic reservoir-based scheme designed to transform the operational efficiency of the downstream Run-of-River (RoR) plants: Chukha (CHP) and Tala (THP).

3.2 Proposed Dam Area, Downstream and Upstream

The proposed Bunakha Dam is located within a narrow and steep gorge of the Wangchu River, where reservoir impoundment will substantially modify the existing flow regime and riverine characteristics (Figure 1-1). The Wangchu River flows generally from north to south and is bordered by mixed forest communities, including *Alnus nepalensis* along the right bank and spruce-dominated vegetation on the left bank. Evidence of historical slope instability and localized soil erosion is present within the project area.

From an environmental flow perspective, the river reach between the proposed Bunakha Dam and the existing Chukha Dam, located approximately 3.5 km downstream, requires careful consideration. Although this reach represents the only remaining free-flowing section between the two projects, its ecological and hydraulic characteristics are already influenced by the Chukha Dam backwater. Consequently, the reach does not exhibit a fully natural riverine environment but rather a transitional, reservoir-influenced condition with reduced flow

velocities, lake-like characteristics and significant daily level fluctuations typical of a cascade hydropower system. Nevertheless, this section continues to provide aquatic and riparian habitat functions and represents the only wetted river corridor within the immediate cascade during normal operations.

A critical consideration is that the existing Chukha Dam does not include a dedicated environmental flow release mechanism. As a result, the river channel downstream of Chukha Dam remains largely dewatered during low-flow periods, with only occasional spill or operational releases contributing to downstream flow. This existing condition highlights the importance of maintaining ecological connectivity and adequate environmental flows within the Bunakha–Chukha–Tala reach, as it effectively represents the last continuously wetted aquatic habitat within this segment of the Wangchu cascade.

Field observations indicate the presence of riparian vegetation, instream macroinvertebrates, potential fish habitat, and signs of wildlife utilization along this reach. These ecological features depend not only on the maintenance of minimum flow conditions but also on seasonal flow variability, water quality, and habitat connectivity. The construction and operation of Bunakha Dam therefore have the potential to alter habitat availability and ecological processes unless an appropriate environmental flow regime is incorporated into project design and operation.

Community dependence on the river within this reach is limited based on the information available.

3.3 Chukha Hydropower Project

The Chukha Hydropower Project, a concrete gravity dam located in Bhutan's Chukha District, was initially commissioned in 1988 with an installed capacity of 336 MW, later upgraded to 360 MW. It features a 40-meter-high dam and an underground powerhouse supplied by a 6.5 km headrace tunnel.

3.4 Tala Hydropower Project

The Tala Hydropower Project is located near Wangkha village, approximately 6 km downstream of the Chukha Hydropower Project. It features a 92-meter-high concrete gravity dam with a 22 km long headrace tunnel that conveys water to an underground powerhouse in Tala village, equipped with six 170 MW generators. All generated power is exported to India via three 440 kV transmission lines.

The riverbed downstream of the dam is dry, with only minor contributions from natural springs from the incremental catchment. These are insufficient to sustain ecological processes. No aquatic species or aquatic habitats were observed, and the riparian zone showed degradation, including sparse vegetation and erosion along riverbanks.

3.5 The "Mother Reservoir": Bunakha HEP (180 MW)

Located approximately 3.5 km upstream of the Chukha Dam, Bunakha HPP will be uniquely characterized by its 197 meter high Roller Compacted Concrete (RCC) gravity dam. Unlike its downstream counterparts, Bunakha features a massive reservoir with a gross storage capacity

of 329.16 MCM. With direct generation of 180 MW (3 units of 60 MW Francis turbines), producing ~719 GWh annually. By impounding water during the monsoon, Bunakha creates a 17.25 km long lake that serves as a multi-year buffer against seasonal water scarcity.

The Bunakha HPP envisages the inter-seasonal utilization of its reservoir capacity, which is rather small in size compared to the annual runoff inflows from Wangchu River, to guarantee firm energy generation in the power plant, while in addition enhance the operations of the existing schemes downstream Chukha Project (CHP, 336 MW) and Tala Hydro Electric Project (THP, 1020 MW).

The proposed operations can release a maximum 46 m³/s per turbine (3 turbines, 138 m³/s total). A turbine can function on 9.2 m³/s (20% of rated discharge). The hydropeaking could thus vary from 0 m³/s (complete shutdown) to 138 m³/s or 9.2 m³/s (20% of one turbine) to 138 m³/s. The daily operation is defined as 18 hours off peak, with 6 hours peak release during the dry and wet season. The 6 hours could be split in two to allow two three-hour peaking sessions (morning and evening). The daily ponds of the downstream reservoirs have the ability to absorb these releases from Bunakha, thus no spills will occur from the downstream HPPs (Chapter 8 of document S1385Doc-984625413-7350).

3.6 Summary of Annual Inflow: Chukha and Tala Hydropower Project (THP)

The provided data from Client (titled “1. Context: Downstream Cascade Operations) highlights the operational interdependencies among hydropower projects within the Wangchu River cascade in Bhutan. These include the Chukha Hydropower Plant and the Tala Hydropower Plant as key downstream facilities that rely on sustained water releases to maintain their minimum operational requirements. Specifically, the minimum flow requirements are indicated as 4.7 m³/s for the Chukha Hydropower Plant and 4.7 m³/s for the Tala Hydropower Plant, emphasizing the necessity of maintaining adequate discharge levels to ensure uninterrupted power generation. These values underscore the hydrological sensitivity of downstream energy infrastructure and highlight the importance of coordinated water management within the cascade system. Furthermore, the operational flow regimes of these plants will be influenced by future releases from the proposed Bunakha Hydropower Project. This establishes Bunakha’s strategic role as an upstream regulating reservoir capable of enhancing dry season flows, optimizing peaking power generation, and improving overall cascade efficiency. Consequently, the information reflects the critical need for integrated river basin planning, environmental flow compliance, and adaptive reservoir operation to balance energy production, ecological sustainability, and downstream water security.

3.7 Downstream Benefits: Regulating the Cascade

The primary value of Bunakha lies in its ability to regulate river flows for the Chukha (336 MW) and Tala (1,020 MW) projects. During the lean winter months (December–March), when river levels naturally plummet, the RoR plants often operate at a fraction of their capacity.

Energy Augmentation: Bunakha’s controlled releases are expected to contribute an additional 745 GWh of energy annually to the downstream projects.

Financial Gain: Historically, this regulation was projected to generate an additional Nu 972 million for Tala and Nu 575 million for Chukha annually by shifting generation from low-value spill periods to high-value winter peaking periods.

3.8 Environmental Flows and Ecosystem Health of the Wangchu Cascade

Under the Water Act of Bhutan (2011) and the Environmental Flow Guidelines of Bhutan (NEC, 2016) the cascade must balance power generation with ecological integrity.

- The 30% Rule: National guidelines typically require a minimum e-flow of 30% of the mean lean season flow; and
- Mitigating "Dewatered" Reaches: One of Bunakha's critical environmental roles is ensuring that the stretches of river between the diversion dams and the tailrace outfalls (which can be several kilometers long) do not run dry. By providing a regulated minimum to the river's discharge, Bunakha should ensure aquatic habitats remain viable year-round.

The proposed Bunakha HPP may alter the hydrological regime and aquatic ecology of the Wangchu River within the approximately 3.5 km reach extending from the proposed Bunakha Dam to the downstream extent of the Chukha Dam. Only 400 m of this reach will remain river habitat, the rest will be inundated by the Bunakha Dam stilling basin and the backwater effect of the Chukha Dam. This reach represents the only continuously wetted section between the two projects (the reach between the Chukha and Tala Dams is dewatered) and is therefore of particular ecological importance within the Wangchu hydropower cascade. Unfortunately this short reach between the Bunakha and Chukha Dam will be isolated from the rest of the Wangchu River by the dam barriers, limiting its biophysical function.

Unlike a natural free-flowing river, the Bunakha–Chukha reach is already influenced by the backwater effects of the Chukha Dam. Consequently, hydraulic conditions are characterized by relatively reduced flow velocities and impounded conditions, creating a transition zone between riverine and reservoir environments. Nevertheless, the reach continues to support aquatic and riparian habitats and provides ecological connectivity for aquatic organisms adapted to cold-water Himalayan river systems.

Aquatic ecological surveys indicate that the dominant fish fauna within the project influence area comprise cold-water species, particularly the *S. richardsonii*), which are adapted to the clear, well-oxygenated waters of the Wangchu River. These species rely on adequate flow depth, habitat connectivity, water quality, and suitable substrate conditions for feeding, movement, and reproduction. The maintenance of environmental flows is therefore essential to sustain these ecological functions and prevent habitat degradation within the dewatered reach.

The ecological significance of this reach is further amplified by the absence of a dedicated environmental flow release facility at the existing Chukha Dam for the Dewatered Reach 2 (Figure 1-1).

The proposed Bunakha HPP is expected to operate as a peaking plant, with approximately six hours of peak generation during the dry season. Such operations may introduce short-term fluctuations in discharge and water levels. It is expected that these hydropeaking releases could influence the hydraulic habitat of the 400 m Dewatered Reach 1 in an upstream direction,

reducing the biophysical processes further along Reach 1. However, the ecological effects are expected to be moderated by the reservoir-influenced nature of the downstream reach and its relatively short length. Nevertheless, sudden flow variations could affect habitat availability for *S.richardsonii* and flow dependent aquatic macroinvertebrates if appropriate operational controls are not implemented.

3.9 Environmental Flow Regime

The e-flow regime defines the quantity, timing, and variability of water flows that must be maintained downstream of the Bunakha Hydropower Project to sustain riverine ecosystems, aquatic habitat, river morphology, water quality, and downstream water uses.

4. APPROACHES TO SURVEYS AND MODELLING

4.1 E-flow Site Selection and Evaluation

The e-flow assessment was based on the Dewatered Reach 1 (Figure 1-1) between the proposed Bunakha Dam and Chukha Dam (Figure 4-1). A flow sensitive riffle/rapid (Figure 4-1) was selected from the available cross-sections (Kheychock Geo Infosys, 2025).

Table 4-1: Reach and selected EFR site information for the e-flow assessment

Affected reach	Hydrological change	Affected reach length	E-flow Site Code	Latitude	Longitude
Dewatered 1	Dewatered, lateral inflow only	0.4 km	Wangshu_EWR1	27.130107°	89.540877°



Figure 4-1: Location of the Wangchu EWR1 cross-section. Flow is from the top of the image to the bottom of the image.

4.2 Baseline Data Collection and Modelling

4.2.1 Hydraulic Data and Modelling

The hydraulic data used for the modelling was based on the field survey done by Kheychock Geo Infosys on 4 April 2025. Cross-sections (31 in total) were surveyed at 20 – 60 m intervals in the area of the dam axis. The cross-sections covered the section from the dam axis to the tail end of the Chukha Dam (bridge over the river). A Stream Pro ADCP with Trimaran float was used with WinRiver 2 Section by Section software to extract river depth at 1 m intervals. The bank topography data were surveyed with a Trimble R12I RTK or Trimble M3 total stations (Kheychock Geo Infosys, 2025). The bathymetry data were integrated with the topographic data based on the water level during the survey. Flood lines were included in the survey. The energy slope of the river was based on the observed water level between the cross-section upstream and downstream of the e-flow cross-section for low flow (over a distance of 118 m) and over 5 cross-sections (over a distance of 229 m) for the high flow energy slope. Discharge data for the survey day was not available, thus an average for April was used (Figure 4-2). For the flood flow the 1:2 discharge was used as specified in the draft final Hydrology Report (2026).

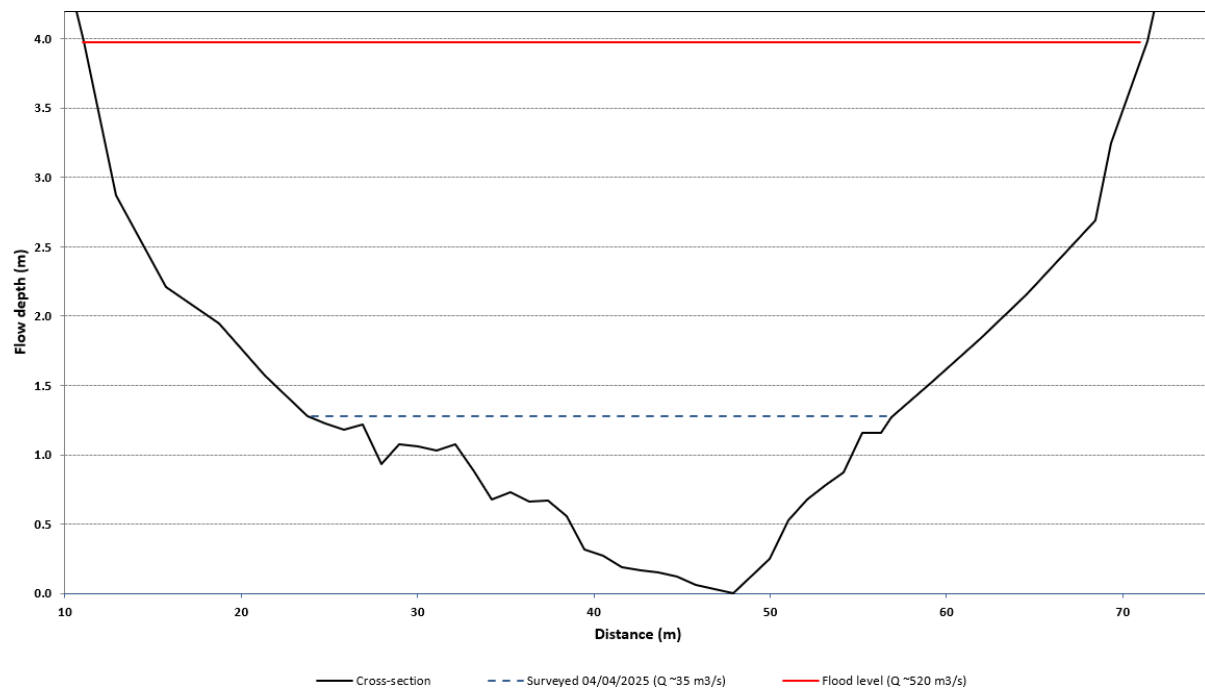


Figure 4-2: Cross-section of the Wangchu River site (Wangchu_EWR1)

Modelling was carried out using the data measured from the site visit, as well as two modelled points to develop a stage discharge curve. The following data were required for the modelling:

- y – maximum flow depth;
- n – resistance coefficient;
- S – slope;
- Q – discharge;
- A – area; and
- WP – wetted perimeter.

The measured and modelled data are shown in (Figure 4-2) below.

Table 4-2: Hydraulic data used to extend observed rating data at the sites

E-flow site	Discharge, Q (m^3/s)	Maximum flow depth (m)	Manning's resistance, n	Surface Slope, S m/m	Ave. Velocity, V (m/s)
Wangchu EWR1	0.001	0.001	0.09	0.0246	0.001
Wangchu EWR1	35	1.28*	0.0679	0.0246*	1.683
Wangchu EWR1	520	3.98*	0.0645	0.0145	3.748

*Measured

The depth-discharge relationship (Hirschowitz et al. 2007) was determined using the following equation:

$$y = aQ^b + c \quad (1)$$

where:

- y is the maximum depth;
- Q is the discharge (m^3/s); and
- a , b and c are coefficients.

The coefficients used in equation (1) are shown Table 4-3 below.

Table 4-3: Regression coefficients in equation (1)

E-flow site	Regression coefficients		
	<i>a</i>	<i>b</i>	<i>c</i>
Wangchu EFR1	0.2870	0.4204	0.0

The stage-discharge relationship for the site is shown in **Appendix 1**.

In addition to the above, the hydraulic habitats were modelled using the HABFLO (HABitat FLOW) program (Hirschowitz *et al*, 2007). The numerical model is used to predict statistical distributions of hydraulic habitat for fish and macroinvertebrates based on inputs such as the cross-sectional survey, observed depths and rating curve developed. The integrated hydraulic habitat predictions for fish and macroinvertebrates were used in this study and were based on accepted combinations of different flow-depth and velocity classes (Table 4-4). Refer to (Figure 5-7) for the hydraulic habitat velocity and depth classes for fish (James and King, 2010).

Table 4-4: Integrated fish and macroinvertebrate habitat classes (adapted James and King, 2010)

Habitat Class	Description	Velocity (m/s)	Depth (m)
SVS	Slow Very Shallow	≤ 0.3	< 0.1
SS	Slow Shallow	≤ 0.3	$0.1 - < 0.5$
SD	Slow Deep	≤ 0.3	≥ 0.5
FVS	Fast Very Shallow	> 0.3	< 0.1
FS	Fast Shallow	> 0.3	$0.1 - < 0.2$
FI	Fast Intermediate	> 0.3	$0.2 - < 0.3$
FD	Fast Deep	> 0.3	≥ 0.3

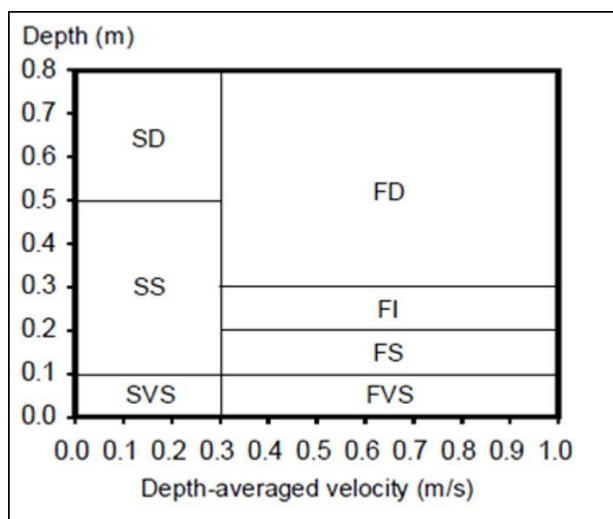


Figure 4-3: The hydraulic habitat velocity and depth classes (James and King, 2010)

4.2.2 Seasonal Aquatic Ecology Surveys and Contribution to E-flow Determination

Three (3) aquatic ecology surveys were undertaken over the seasonal periods to capture temporal variability in aquatic communities and habitat conditions within the Wangchu River system and the proposed Bunakha Hydropower Project area of influence (PCS, 2025a, b, c). The surveys formed part of the ESIA baseline studies and were designed to characterise the present aquatic biodiversity, habitat condition, water quality and flow-dependent ecological components relevant to environmental flow determination. Refer Table 4-5 summarising the three surveys, timing and primary focus (PCS, 2025a, b, c).

Table 4-5: A q u a t i c seasonal survey information

Survey Season	Timing	Number of Sampling Sites	Primary Focus
Season 1 – Pre-Monsoon	March 2024	17 sites (including E-flow sites)	Dry season baseline conditions and low-flow habitat availability
Season 2 – Monsoon	August–September 2024	24 sites	High-flow conditions, peak aquatic biodiversity and habitat connectivity
Season 3 – Post-Monsoon	November–December 2025	24 sites	Flow recession conditions and post-flood ecological recovery

The primary objective of the surveys and assessment was not merely to document biodiversity, but to identify the ecological attributes, species and habitats most sensitive to changes in flow regime and therefore most suitable for informing e-flow recommendations. Particular emphasis was placed on rheophilic aquatic organisms and habitats whose ecological functioning is directly linked to hydraulic conditions such as flow velocity, depth, wetted perimeter and habitat connectivity (PCS, 2025a, b, c).

Based on the findings of the three seasonal surveys, the assessment focused on primarily two principal ecological components:

- Fish communities, with emphasis on flow-dependent native species; and

- Benthic macroinvertebrate communities, particularly rheophilic Ephemoptera, Plecoptera and Trichoptera (EPT) taxa.

These components collectively provide a direct linkage between hydrology, habitat availability, food-web processes and ecosystem integrity.

4.2.3 Survey Design and Site Selection

In accordance with PCS (2025a, b, c), sampling sites were distributed longitudinally throughout the Wangchu River system to encompass the full range of habitats potentially affected by the proposed hydropower development. Sites included upstream reference reaches, the proposed inundation area, bypass and regulated reaches, tributary confluences, downstream river sections and e-flow reaches.

Sampling locations were selected using the Biodiversity Monitoring Grid framework adopted by the Department of Forest and Park Services and were designed to represent the diversity of hydraulic and geomorphic habitats occurring within the river. At each site, representative habitat units including riffles, runs, pools, glides, channel margins and backwater habitats were assessed.

The three-season approach ensured that ecological responses could be assessed under differing hydrological conditions, including low-flow conditions during the dry season, elevated flows during the monsoon period and transitional conditions during the post-monsoon recession period.

4.2.4 Fish Community Assessment

Fish surveys were undertaken to characterise fish community composition, habitat utilisation and flow-dependent aquatic habitats within the study area. Sampling was designed to encompass the full range of aquatic habitat types present within the river system, including riffles, runs, pools, cascades and channel margin habitats. Sampling sites were established within representative river reaches, with each assessment reach extending approximately 400 m and comprising 200 m upstream and 200 m downstream of the sampling point.

A combination of electrofishing, cast netting and spinner-hook angling was employed to maximise sampling effectiveness across differing habitat types and hydraulic conditions. Electrofishing was undertaken using a backpack electrofishing unit operated by a trained field team comprising an electrofisher operator and supporting netters. Sampling was conducted by wading upstream through representative habitats while stunned fish were captured using hand nets. Electrofishing was particularly effective in shallow riffle and run habitats where visibility and access were favourable. Cast netting was undertaken using a standardised cast net and sampling effort, with multiple casts distributed throughout each sampling reach to target a range of habitat types and provide a basis for calculating catch-per-unit-effort (CPUE). Spinner-hook angling was used as a supplementary sampling technique in deeper pools and habitats where electrofishing and cast netting were less effective. Although no gill nets were utilised during the surveys due to the predominantly riverine nature of the system and the focus on active sampling methods, the combination of electrofishing, cast netting and angling allowed for the assessment of both shallow, fast-flowing habitats and deeper pool environments.

During fish sampling, habitat characteristics associated with capture locations were recorded, including water depth, flow velocity, substrate composition and habitat type. Captured fish were identified to species level, measured and weighed, and released where possible following processing. Where field identification was uncertain, specimens were photographed and preserved for subsequent laboratory verification using standard taxonomic references and regional ichthyological identification guides. The approach provided information on species composition, relative abundance, habitat associations and the hydraulic conditions supporting fish communities within the study area (PCS, 2025a, b, c).

4.2.5 Macroinvertebrate Communities Assessment

Macroinvertebrate surveys were undertaken to characterise benthic community structure and assess the availability of flow-dependent aquatic habitats. Sampling focused on representative riffle and run habitats where benthic communities are most strongly influenced by hydraulic conditions and substrate composition.

A standardised kick-net methodology was employed, whereby a net was positioned downstream of the sampling area while the substrate upstream was disturbed manually to dislodge organisms into the net. Larger cobbles and boulders were individually examined and scrubbed to remove attached organisms. Sampling was undertaken across a range of substrate types and hydraulic habitats to ensure representative coverage of the available benthic habitat. Collected material was transferred to sorting trays, where specimens were sorted, counted and identified to the lowest practical taxonomic level, typically family level. Where field identification was not possible, specimens were preserved in ethanol and transported to the laboratory for further identification. Data collected during the surveys were used to characterise macroinvertebrate community composition, diversity and habitat associations, with particular attention given to taxa associated with flowing-water environments (PCS, 2025a, b, c).

4.2.6 Water Quality Assessment

Water quality assessments were undertaken concurrently with the aquatic biodiversity surveys to characterise the physicochemical conditions supporting aquatic ecosystem functioning and to provide baseline information for environmental flow assessments. Water quality sampling was conducted at the established aquatic sampling sites during each survey season to ensure consistency between biological and environmental datasets. A combination of *in situ* field measurements and laboratory analyses was undertaken. Field measurements included water temperature, pH, dissolved oxygen (DO), electrical conductivity, total dissolved solids (TDS), salinity, turbidity and ammonia concentrations. These parameters were measured directly within the river channel using calibrated portable water quality meters and multiparameter sondes.

Water samples were also collected for laboratory analysis of additional physicochemical variables, including total suspended solids (TSS), chloride, iron, phosphorus, calcium, magnesium, total hardness and biochemical oxygen demand (BOD). Samples were collected using standard grab-sampling techniques and preserved in accordance with recognised laboratory protocols to ensure sample integrity. Preserved samples were transported under controlled conditions to an accredited laboratory where analyses were undertaken within the prescribed holding periods.

The water quality programme was designed to evaluate the suitability of aquatic habitats for fish, macroinvertebrates and other aquatic biota, while also providing an indication of potential anthropogenic influences and seasonal variability within the river system (PCS, 2025a, b, c).

4.2.7 Hydraulic Habitat Characterisation

Given the objective of supporting e-flow determination, habitat information was collected concurrently with biological sampling during the three aquatic surveys. Across the study area, habitats were generally characterised by coarse riverbed material associated with high-gradient mountain river environments, including bedrock outcrops, boulders, cobbles and gravel. These habitat features are considered important for maintaining suitable conditions for native rheophilic species, including *S. richardsonii*, as well as macroinvertebrate communities associated with well-oxygenated, flowing-water habitats (PCS, 2025a, b, c).

4.2.8 Geomorphology and sediment

The geomorphology of the system is described based on available field observations from reports and the use of satellite imagery and terrain morphology in Google Earth. The sediment dynamics are based on previous work in the system.

5. BASELINE DATA

5.1 Hydrological Data

Daily, monthly and annual discharge data of the Wangchu River at Bunakha were analysed to evaluate the hydrological characteristics and e-flow requirements of the river system. The available discharge records (1976 to 2024) indicated a mean annual flow (MAF) of 92.5 m³/s, representing the long-term average flow condition of the basin (Figure 5-1). The river exhibited pronounced seasonal variability, with peak discharges occurring during the monsoon season (June to September) and substantially lower flows during the winter months (Figure 5-2). The minimum flow conditions were generally observed during February, reflecting the dry-season hydrological regime of the basin (Figure 5-2).

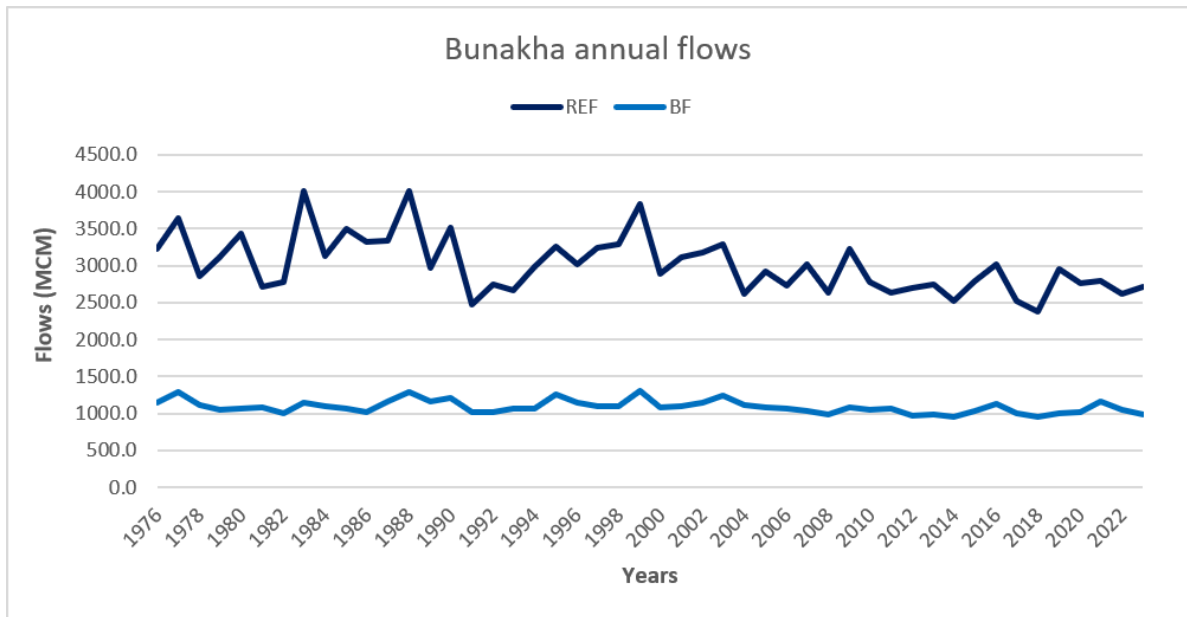


Figure 5-1: Annual flows (MCM) for reference and base-flows at Bunaka

This data was used as the base hydrology for the Desktop Reserve Model (DRM) within SPATSIM to determine the e-flows. Baseflow (BF) separation was undertaken using the method as developed by Smaktin in 2001. The base-flows give an indication of the flows in the river without the influence of floods and freshets and provides a guide for the determination of the low flow requirements of the e-flows. The monthly hydrograph for the Wangchu River at the selected e-flow site downstream of the proposed Bunakha Dam is presented in (Figure 5-2).

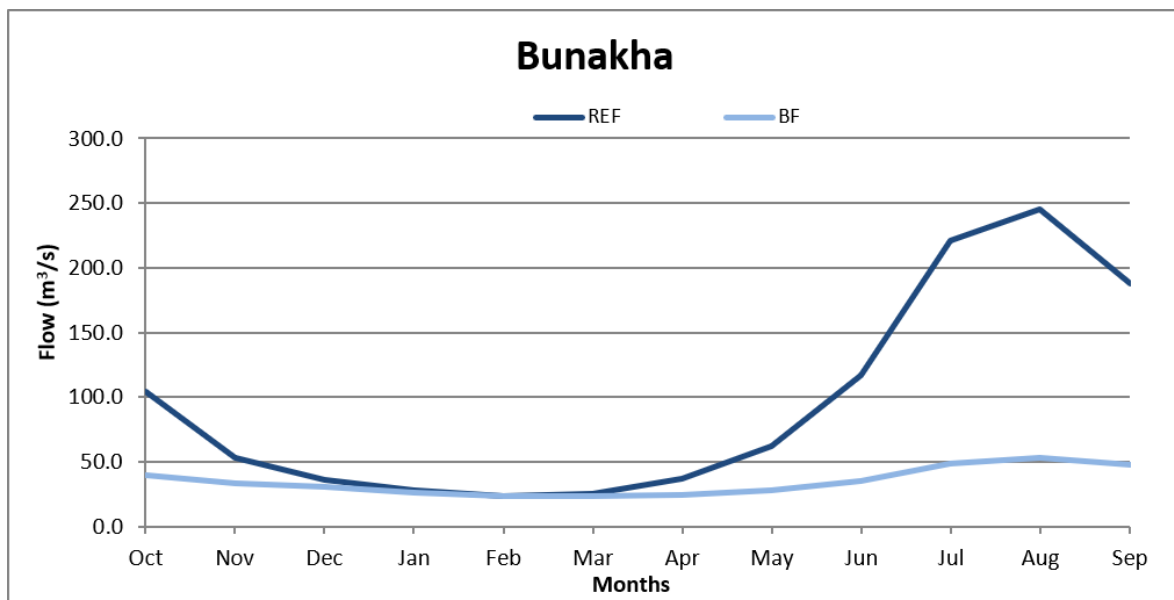


Figure 5-2: Reference Flows, 1G76-2024; BF– Base-flows)

5.1.1 Monthly Hydrograph for Wangchu River at E-Flow Site

The analysis of the e-flow site indicated an average Mean Annual Flow (MAF) of 92.4 m³/s. The Mean Annual Low Flow (MALF) values were estimated as 26.33 m³/s for January, 22.97 m³/s for

February, 24.45 m³/s for March, and 35.42 m³/s for December, highlighting February as the critical low-flow month within the basin. The median annual flow for the study period was calculated as 90.85 m³/s (Figure 5-1).

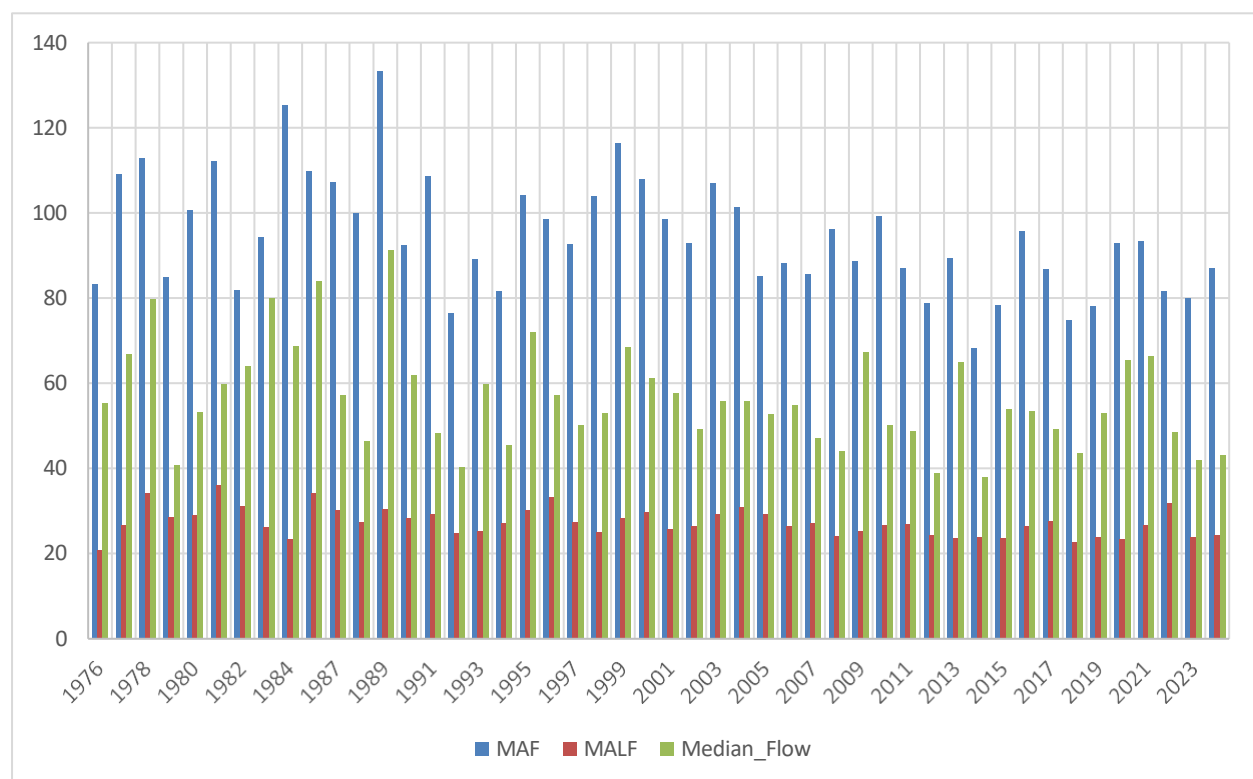


Figure 5-3: Summary graph of flow data

The hydrological statistics for the e-flow site of the Wangchu River were calculated from the monthly and annual discharge dataset (1976–2024).

Table 5-1: Summary of Hydrological data

Parameter	Value (m ³ /s)
Mean Annual Flow (MAF)	92.4
Mean Annual Low Flow (January)	26.33
Mean Annual Low Flow (February)	22.97
Mean Annual Low Flow (March)	24.45
Mean Annual Low Flow (December)	35.42
Median Annual Flow	92.85

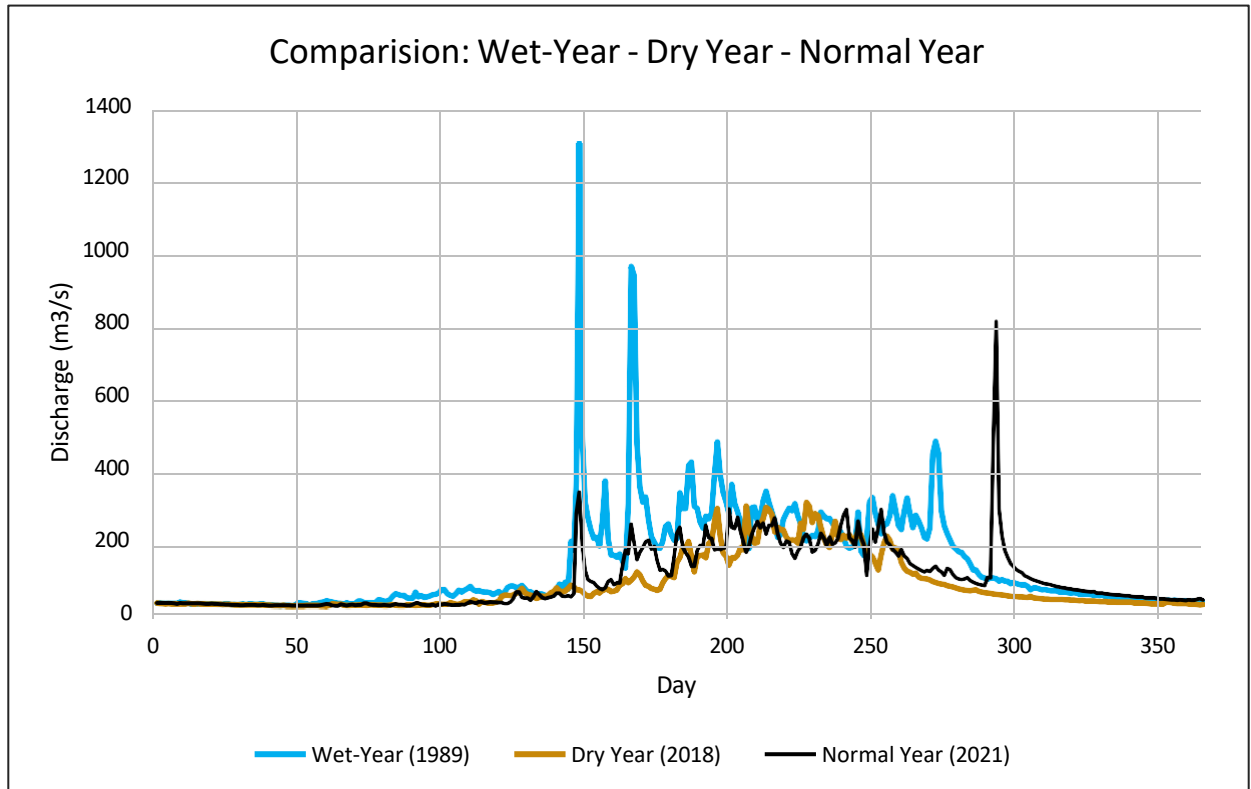


Figure 5-4: Comparison of discharges recorded during wet, dry and normal years

The Flow Duration Curve (FDC) developed for the Wangchu River at Bunakha Hydrological Station is presented in (Figure 5-5). The FDC illustrates the relationship between stream discharge and the percentage of time that a particular flow is equalled or exceeded during the historical observation period. It provides a comprehensive representation of flow variability within the basin and is widely used for assessing hydrological behaviour, water availability, and environmental flow requirements under both low-flow and high-flow conditions.

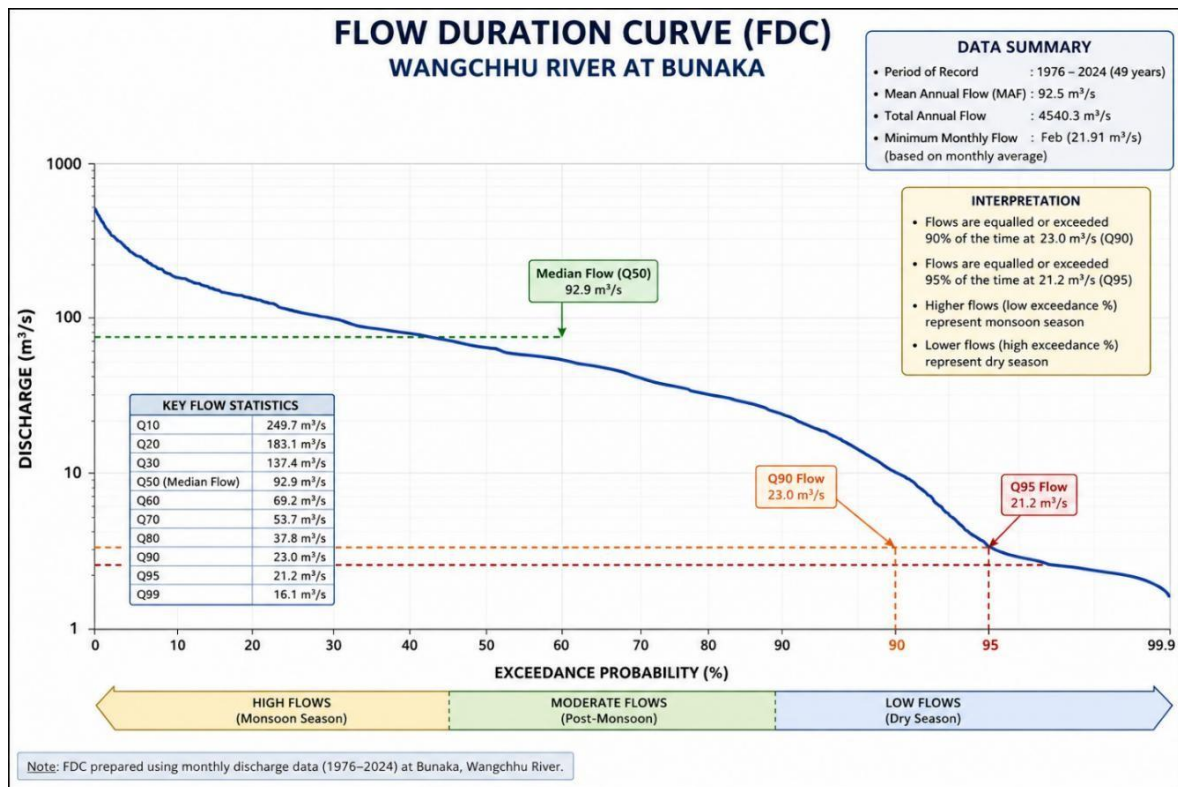


Figure 5-5: Flow Duration Curve (FDC) developed for the Wangchu River at Bunakha Hydrological Station

5.2 Hydraulic Results

The stage discharge relationship is presented in. Modelled predictions of the velocities at the cross-section appear to provide a reasonable output for the steep rocky reach, despite no observed velocity depth data for calibration (Figure 5-6). Uncertainty in the results increase for very low and higher flows as there were no observed data available for calibration (Figure 5-2).

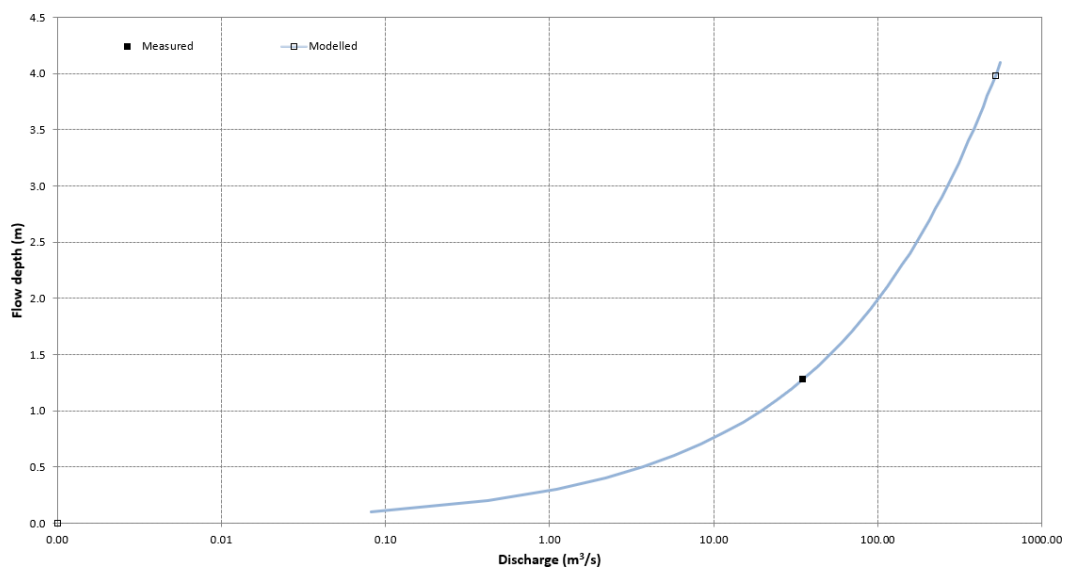


Figure 5-6: Flow depth vs discharge relationship for EFR site Wangchu_EWR1

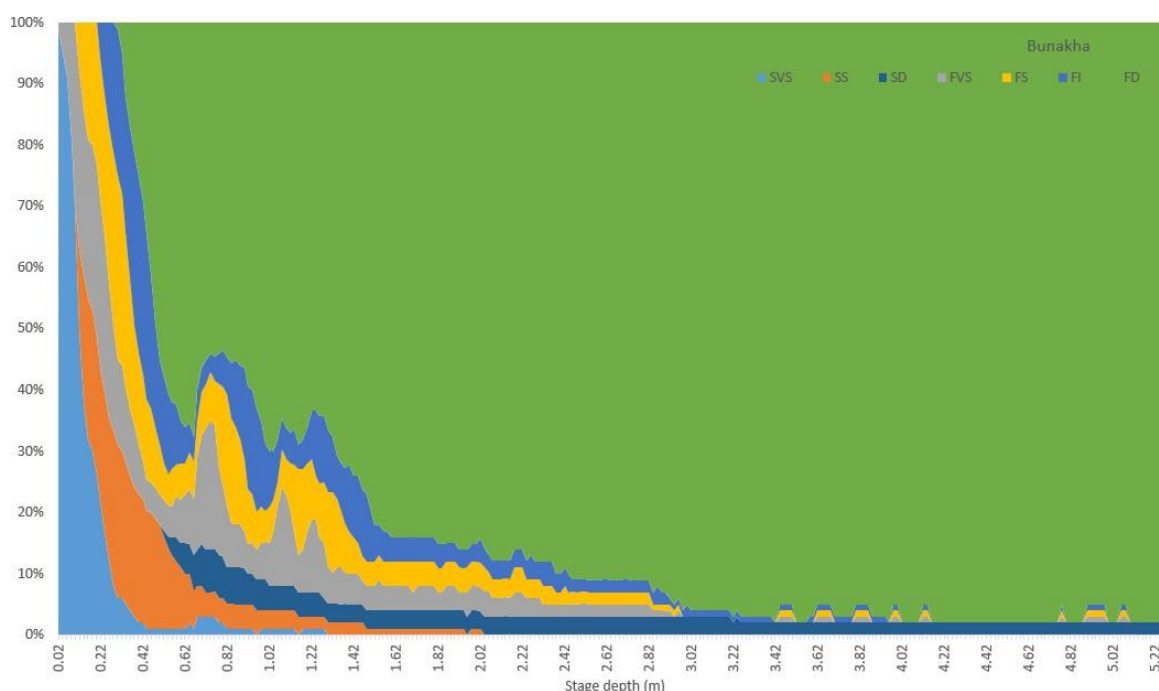


Figure 5-7: Velocity-depth distribution for incremental river levels for the Wangchhu River (EWR1)

Table 5-2: Confidence in the hydraulic modelled results (confidence rating 0=none to 5=high)

E-flow site	Limits of measured discharge range (m ³ /s)	Confidence rating for discharge range		Comments
	Q average for month	Q < Q _{measured}	Q > Q _{measured}	
Wangchu_EWR1	~35	2	2	Only one set of observed water level data was collected. Observed discharge data for the day was not available.

5.3 Water Quality

Results from PCS (2025a, b, c), indicated that the Wangchhu River generally maintains good water quality and remains capable of supporting diverse aquatic communities throughout the study area. Water quality conditions were characteristic of a high-energy mountain river system, with consistently high dissolved oxygen concentrations, relatively low nutrient enrichment and generally low levels of pollution-related stressors.

Dissolved oxygen concentrations remained suitable for supporting sensitive aquatic organisms, including rheophilic fish species such as *S. richardsonii* and flow-dependent macroinvertebrate communities. Water temperatures were generally consistent with those expected in cold-water Himalayan river systems and were suitable for native aquatic fauna. pH values remained within ranges considered acceptable for freshwater ecosystem functioning, while conductivity and

total dissolved solids were generally low, reflecting the relatively unimpacted nature of much of the catchment.

Seasonal differences were observed, particularly during the monsoon and post-monsoon periods when increased runoff and sediment mobilisation resulted in localised increases in turbidity and suspended solids. These changes were largely associated with natural hydrological processes and flood-related sediment transport rather than persistent water quality degradation. Despite these seasonal fluctuations, the overall water quality remained within ranges suitable for sustaining aquatic biodiversity and ecological functioning.

Collectively, the results indicate that water quality is not currently a significant limiting factor for aquatic ecosystem health within the study area. Instead, ecological condition appears to be more strongly influenced by habitat availability, substrate composition, hydraulic conditions and river connectivity. The generally favourable water quality conditions recorded during all three surveys provide an important foundation for supporting rheophilic fish populations, diverse macroinvertebrate assemblages and functioning riverine ecosystems within the Wangchu River system.

5.4 Aquatic Ecology, Biota and Environmental Flow Indicators

5.4.1 Aquatic Ecology of the Wangchu River

The Wangchu River within the Bunakha Project area supports a cold-water aquatic ecosystem characteristic of Himalayan mountain rivers. The river is characterised by clear, well-oxygenated water, steep channel gradients, coarse bed substrates consisting of boulders, cobbles and gravels, and seasonal discharge patterns driven by snowmelt and monsoonal rainfall (PCS, 2025a; b, c).

The reach between the proposed Bunakha Dam and the Chukha Dam extends approximately 3.5 km downstream and supports important aquatic habitat and connectivity functions. Although hydraulic conditions are already influenced by the Chukha Dam backwater effect, resulting in lower flow velocities and partially impounded conditions, the reach remains ecologically functional and continues to support fish populations and diverse aquatic communities.

Aquatic ecology surveys indicate that water quality within the study area is generally good to excellent, supporting diverse biotic assemblages (PCS, 2025a; b, c). Consequently, this reach represents one of the few continuously wetted habitats within the Wangchu hydropower cascade and is therefore of disproportionately high ecological importance.

5.4.2 Snow Trout (*Schizothorax richardsonii*): Fish Indicators Species

Schizothorax richardsonii was selected as the primary fish indicator species for e-flow determination in the Wangchu River due to its conservation significance, dependence on flowing-water habitats, and consistent occurrence throughout the Bunakha aquatic biodiversity surveys (PCS, 2025a, b, c). The species is currently classified as Vulnerable (VU) on the IUCN Red List (Vishwanath, 2010) and is widely recognised as one of the most important native cold-water fish species in Himalayan river systems (Figure 5-8). *Schizothorax richardsonii* is considered a flagship species for river conservation because of its strong dependence on natural flow regimes, habitat connectivity, high-quality lotic habitats and ecological integrity (Bhatt C Manish, 2023).



Figure 5-8: *Schizothorax richardsonii* recorded at site A-14E, E-flow E: downstream peaking flow extent (PCS, 2025a)

Population declines throughout its native range have been attributed to habitat degradation, flow modification, river fragmentation, sedimentation, pollution, overexploitation, climate change, and competition from invasive fish species (Vishwanath, 2010; Bhatt C Manish, 2023). Consequently, the species provides a highly suitable ecological endpoint for assessing environmental flow requirements within regulated Himalayan rivers.

This fish population inhabits cold, well-oxygenated mountain rivers characterised by moderate to high flow velocities and coarse gravel, cobble and boulder substrates (Hayes et al., 2025). Habitat suitability is strongly influenced by hydraulic conditions, particularly water depth, flow velocity, substrate composition and habitat connectivity (Hayes et al., 2025). Throughout its life cycle, *S. richardsonii* utilise riffles and runs for feeding, deeper pools as dry-season refugia, and shallow gravel-cobble habitats and connected tributaries for spawning and recruitment.

The species undertakes seasonal migrations between feeding, spawning and refuge habitats. Adult fish migrate upstream during spring to access spawning areas and move downstream during autumn to utilise deeper overwintering pools. Maintenance of hydraulic connectivity and adequate flow depth is therefore critical to facilitate these migrations. Reduced flows may restrict access to spawning habitats, while altered sediment transport processes can increase fine sediment deposition within spawning gravels, reducing interstitial flow, oxygen availability and egg survival (Kaasa C Rivinoja, 2023).

Early life stages are particularly sensitive to hydraulic alteration, as larvae and fry depend on shallow, low-velocity marginal habitats that provide refuge from high flows and predation. Consequently, environmental flow requirements were developed to maintain habitat availability across all critical life stages, including spawning, breeding, migration, juvenile development and adult feeding.

5.4.3 Alien Invasive Fish Species

Aquatic surveys recorded the presence of Brown Trout (*Salmo trutta*) upstream of the proposed Bunakha Dam (PCS, 2025a, b, c). Brown Trout is an introduced, non-native species in Bhutan and is recognised as a potentially invasive predator and competitor within Himalayan river systems (Bhatt C Manish, 2023).

The presence of Brown Trout represents an additional ecological pressure on the Vulnerable *S. richardsonii* population. Habitat requirements of the two species overlap considerably, resulting

in competition for feeding areas, refuge habitat and spawning grounds. More importantly, Brown Trout are known opportunistic predators that may prey upon *S. richardsonii* eggs, larvae, fry and juveniles, potentially reducing recruitment success and limiting the recovery of native populations (Bhatt C Manish, 2023). Predation pressure is often greatest during spawning and early development stages when eggs and juvenile fish are concentrated within shallow gravel habitats.

The ecological risks associated with Brown Trout may be exacerbated where habitat availability becomes constrained by flow regulation, habitat degradation or reduced connectivity, increasing interactions between native and non-native species. Consequently, maintaining adequate environmental flows, habitat diversity, spawning habitats and ecological connectivity is important not only for supporting *S. richardsonii* populations directly but also for enhancing their resilience to pressures associated with invasive species (Poff et al., 1997; Hayes et al., 2025).

5.4.4 Ecological Linkages with Macroinvertebrates

An important ecological dependency identified during the Bunakha surveys is the strong trophic relationship between *S. richardsonii* and rheophilic macroinvertebrate communities (PCS, 2025a; b, c). Diverse Ephemeroptera, Plecoptera and Trichoptera (EPT) assemblages were recorded at various monitoring sites, reflecting generally good water quality, different hydraulic diversities and ecological condition. These taxa form an important component of the aquatic food web and constitute a significant food source for Snow Trout.

Among the EPT taxa, the family Heptageniidae was selected as the primary macroinvertebrate indicator because of its strong association with fast-flowing riffle habitats and coarse cobble-boulder substrates (Thirion, 2016). Heptageniidae are highly sensitive to reductions in flow velocity, sedimentation and habitat degradation and therefore provide an effective indicator of hydraulic habitat quality.

The ecological relationship underpinning the environmental flow assessment can be summarised as follows:

Environmental Flow → *Riffle Habitat Availability* → *Heptageniidae Production* → *Snow Trout Feeding Success* → *Population Sustainability*

Both *S. richardsonii* and Heptageniidae depend upon similar hydraulic conditions, including moderate to high flow velocities, coarse substrates and high dissolved oxygen concentrations. Consequently, reductions in flow that decrease riffle habitat availability or increase sediment deposition are likely to negatively affect both macroinvertebrate production and fish populations. Conversely, maintaining suitable hydraulic habitats supports food-web processes, recruitment and ecological resilience.

5.4.5 Environmental Flow Objectives

As mentioned above, *S. richardsonii* represents an ideal e-flow indicator species because its ecological requirements integrate multiple riverine processes, including maintenance low flows, drought refugia, seasonal freshets, migration pathways, spawning habitat availability and sediment transport dynamics (Hayes et al., 2025).

The e-flow assessment identified the need to maintain hydraulic habitats that support all critical life stages of this fish species and the macroinvertebrate family upon which they depend. Accordingly, the ecological objective of the Bunakha e-flow assessment is:

To maintain suitable riffle, run, spawning, migration and refuge habitats that support sustainable Snow Trout populations and Heptageniidae-dominated macroinvertebrate communities throughout the Wangchu River system.

This objective provides a scientifically defensible basis for e-flow determination and hydraulic habitat modelling. The habitat preferences used to inform the assessment are summarised in Table 5-3 for *S. richardsonii* and Table 5-4 for Heptageniidae.

Table 5-3 : Indicative Hydraulic Habitat Preferences for Snow Trout (*S. richardsonii*)

Life Stage / Ecological Function	Preferred Velocity (m/s)	Preferred Depth (m)	Preferred Substrate	Ecological Importance	Critical Period
Adult Feeding Habitat	0.40 – 1.20	0.50 – 1.50	Cobble, boulder, coarse gravel	Provides feeding and foraging habitat throughout the year	Year-round
Juvenile Habitat	0.20 – 0.60	0.15 – 0.60	Gravel and cobble	Supports juvenile growth, refuge and recruitment	Year-round
Breeding Habitat	0.20 – 0.70	0.20 – 0.80	Clean gravel and coarse sand	Supports reproductive activities and courtship	March to May (primarily) Occasionally in autumn (September to October)
Spawning Habitat	0.20 – 0.70	0.20 – 0.80	Clean gravel and coarse sand	Provides suitable habitat for egg deposition and incubation	Move downstream: September to October Move upstream: March to April
Migration Pathways	> 0.30	> 0.30	Connected channel habitats	Maintains upstream and downstream movement between habitats	Migrate upstream during spring: March to April (temperatures increase following the monsoon and post summer) Migrate downstream in autumn: October to December (during winter into deeper pools).
Refuge Habitat	< 0.30	> 0.80	Deep pools with cobble and boulder cover	Provides protection during low-flow periods and extreme conditions	Dry season and low-flow periods

Adapted from Hayes et al. (2025), Bhatt and Manish (2023), Kaasa and Rivinoja (2023), and PCS (2025a; 2025b; 2025c).

Table 5-4: Habitat Preferences of the Indicator Macroinvertebrate Family (Heptageniidae)

Indicator Taxon	Ecological Role	Preferred Habitat	Preferred Velocity (m/s)	Preferred Substrate	Flow Sensitivity
Heptageniidae (Flat-headed Mayflies)	Primary prey resource for <i>S. richardsonii</i> and indicator of riffle habitat quality	Riffles, rapid runs and shallow flowing habitats	0.40 – 1.20	Coarse gravel, cobble and boulder	Very High
Heptageniidae (Flat-headed Mayflies)	Indicator of ecological integrity and water quality	Well-oxygenated, hydraulically diverse habitats with stable coarse substrates	Moderate to high velocities	Coarse gravel, cobble and boulder	Highly sensitive to sedimentation, habitat degradation and flow reduction

Adapted from Thirion (201c) and PCS (2025a, b, c)

5.4.6 Geomorphology and Sediment Dynamics

The catchment is very steep, located at high elevation, and prone to rock falls, landslides and soil erosion. The reach between the proposed Bunakha Dam and the Chukha Dam is characterized by a confined mountain valley with steep side slopes, a steep fast flowing river reach with very limited sediment storage along the valley floor (Figure 5-9). The river is largely straight and follows geological lineaments. The reach channel morphology consists of riffle/rapid sections, pools and runs.

The channel is largely composed of large immobile boulders with cobble and gravel between the boulders. Bedload transport is largely gravel and sand as can be seen from the sediment dredging of the Chuka Reservoir (Figure 5-10).

Observed turbidity ranged from 3 to 20 NTU (~90 mg/L) indicating relatively low suspended sediment concentrations during the field observations. Suspended sediment concentrations can be much higher for higher flows, reaching levels of ~1000 to 16 000 mg/L (Figure 5-11).

Monthly and annual suspended sediment load data at the Damchu Site were analyzed for the period 2009–2023 to evaluate the temporal variability of sediment transport within the basin. The results revealed substantial seasonal fluctuations in sediment yield, with significantly higher sediment loads occurring during the monsoon months (June to September) due to intense rainfall, enhanced surface runoff, and increased erosion processes. The average annual sediment load at the Damchu site was estimated at approximately 836,313 tons, indicating considerable sediment transport within the catchment. Exceptionally high sediment loads were observed during 2009, with an annual total of about 8.12 million tons, representing an extreme sediment transport year likely associated with intense hydrometeorological events.



Figure 5-G: Steep sided valley with large boulders, cobble and gravel substrates (PCS 2025, a,b,c)



Figure 5-10: Sediment dredging at the Chucka Reservoir

In contrast, relatively low sediment yields were recorded during dry years such as 2019, where the annual sediment load was approximately 83,858 tons. The analysis further demonstrated that the majority of sediment transport occurs during peak monsoon flows, particularly in July and August, emphasizing the strong influence of seasonal hydrology on sediment dynamics within the river system.

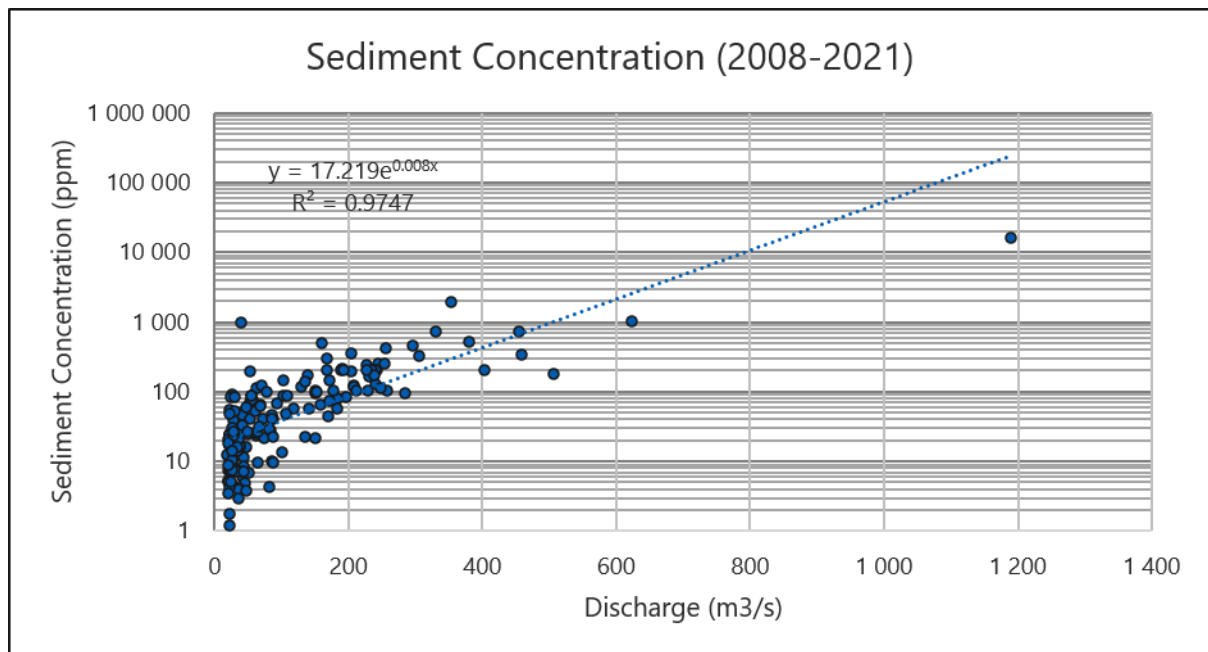


Figure 5-11: Relationship between monthly sediment concentration with monthly discharge (Fichtner, 2026)

Sediment dredging from the Chukka Reservoir shows largely sand and gravel as bedload transport (Figure 5-10). Hydraulic reservoir modelling shows that the Bunakha Reservoir will trap all of the bedload as a delta at the top of the Bunakha Reservoir. This is due to the large volume of the Bunakha Reservoir and the expansion of cross-sectional area and reduction in stream power where the river enters the reservoir. This leads to a large reduction of mobile sediment supply to the reach below the Bunakha Dam and the Chukha Dam. Over time this river reach will become armoured, consisting of immobile boulders and cobbles. Local lateral sediment supply could alleviate this to some extent, but the impact of lateral supply will be localized. The Chukka Reservoir is likely to accumulate the localised bedload inputs, but at a much lower rate than before the Bunakha Reservoir.

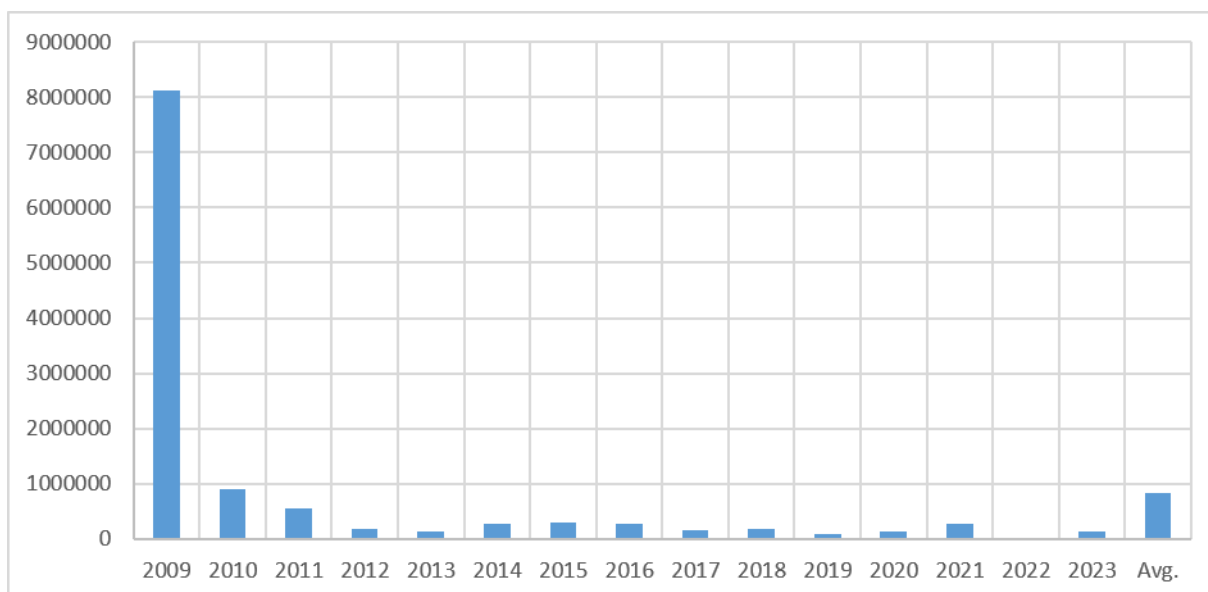


Figure 5-12: Total annual sediment load at Damchu (Wangchu)

5.4.7 Critical Habitat Assessment: Summary, Habitat and Species Screening Considerations

A Critical Habitat Screening (CHS) was undertaken for the Bunakha HPP in accordance with the criteria and thresholds set out in the Asian Development Bank's Safeguard Policy Statement (SPS) (ADB, 2009), supplemented by the International Finance Corporation (IFC) Guidance Notes on Performance Standard 6, to establish a preliminary basis for discussion with the Client and ADB ahead of a full Critical Habitat Assessment (CHA). The screening identified twenty-five candidate species and one internationally recognised biodiversity area (the Kamji Key Biodiversity Area/Important Bird Area) as likely to qualify Ecologically Appropriate Areas of Assessment as Critical Habitat, including the Golden Mahseer (*Tor putitora*), an Endangered, migratory species screened in on the basis of its national population share and its recognised ecological and cultural significance in Bhutan. The screening to date, however, is predominantly based on the terrestrial and riparian distribution of qualifying species and designated biodiversity areas; it does not include a dedicated instream or hydraulic assessment of the river channel itself, and no natural, modified or critical habitat classification has yet been assigned to the specific dewatered reaches affected by the Project. Notably, the Snow Trout (*S. richardsonii*) does not appear among the screened-in species in the CHS to date, despite its Vulnerable status, its dependence on longitudinal habitat connectivity for seasonal spawning migration, and its identification as a key cold-water indicator species requiring targeted conservation management in the Project's Biodiversity Action Plan (BAP, 2023). The rationale for the species not being carried forward as a Critical Habitat trigger has not yet been made available, as the relevant screened-out species schedules are held in annexes external to the CHS progress report. Confirmation of this outcome, and its underlying basis, remains outstanding and should be sought from the CHA specialist team. As the CHA does not form part of the scope of this e-flow study, this assessment has relied solely on the information made available at the time of reporting. In the absence of a finalised instream habitat classification, this e-flow study has adopted a precautionary surrogate approach, independently characterising

the affected reach as Moderately Modified through assessment of relevant hydrological, connectivity and habitat-condition attributes, summarised as the Overall Ecological State of the Wangchu River (Section 5.4.8). This approach ensures that the habitat and connectivity requirements of Vulnerable and migratory species such as *S. richardsonii*, whether or not formally confirmed as a Critical Habitat trigger, are addressed in a manner consistent with the precautionary principle underpinning ADB SPS (2009).

5.4.8 Overall Ecological State

Although the aquatic baseline surveys undertaken by PCS (2025a, b, c) did not formally assign a Present Ecological State (PES), the collective findings indicate that the Wangchu River within the Bunakha Project area currently exhibits a high degree of ecological integrity and supports a largely intact riverine ecosystem.

Overall, based on the available evidence, the Wangchu River within the study area is considered to be in a Moderately Modified condition. Although the river continues to retain many of its natural habitat characteristics, ecological functions, and native biodiversity, the system is influenced by a high degree of longitudinal disconnection associated with existing dams, hydropower infrastructure, and flow regulation throughout the catchment. These modifications have altered natural flow patterns and connectivity, which are important drivers of ecological condition. Thus, a precautionary approach has therefore been adopted in assigning the PES, with the moderately modified classification representing a conservative, worst-case assessment to ensure that e-flow recommendations remain adequately protective of ecological requirements. This assessment is supported by findings from the three seasonal aquatic surveys and provides a robust and defensible baseline for environmental flow determination and the assessment of potential project-related impacts.

6. ENVIRONMENTAL FLOW ASSESSMENT RESULTS

6.1 Quantification of Environmental flows

The Desktop Reserve Model (DRM) within the SPATSIM framework (Hughes, 1999) was used to calculate the e-flows for the Wangchu River. The input requirements of the model are the following:

- Reference flows, in this case the flows at Bunakha Dam for the period 1976 to 2024;
- Table of monthly flow distribution values that contains the default values for the monthly distribution parameters to determine the e-flows and include information per month on high and low flow distribution factors, high and low flow assurance rules and shape factors. These values were used as the starting point for the determination and adjusted where necessary with the information provided by the ecologist by interpreting the hydraulics results;
- Ecological information from the ecologist per month for specific flow components, namely dry periods (99th percentile) and base-flows (50th percentile). See table xx below for the monthly requirements. Drought flows are the minimum flow required to ensure the survival of the aquatic ecosystem in a particular condition/state and over short, infrequent periods of time, especially during periods of drought. Base-flows are those flows required to meet the requirements of the aquatic ecosystem to maintain the resource base in a particular condition/state during “normal”/ average climatic years; and
- The e-flows were converted to hydraulic conditions at the site (i.e. depths and flow velocities at discharges measured in m³/s) using the hydraulic model. The discharge at the site during the surveying of the cross-section in April 2025 was not available, but was estimated as between 35 m³/s and 37 m³/s.

Refer to Table 6-1 for the Specific e-flow requirements per month for 50th and 99th percentiles.

Table 6-1: Specific e-flow requirements per month for 50th and 99th percentiles

	Months											
Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
50	3.3	10.3	11.8	12.6	12.6	3.3	3.3	3.3	13.5	13.5	13.5	3.3
99	1.9	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.4	1.6	1.2	1.9

6.1.1 Drought and Baseflows

The information and data as described above were used for the initial run of the DRM for the river and the modelled drought and baseflow requirements were adjusted until a close fit was obtained with the ecological indicator requirements as provided by the ecologist (Figure 6-1). The above was undertaken for both the baseflow as well as drought flow requirements for all the months.

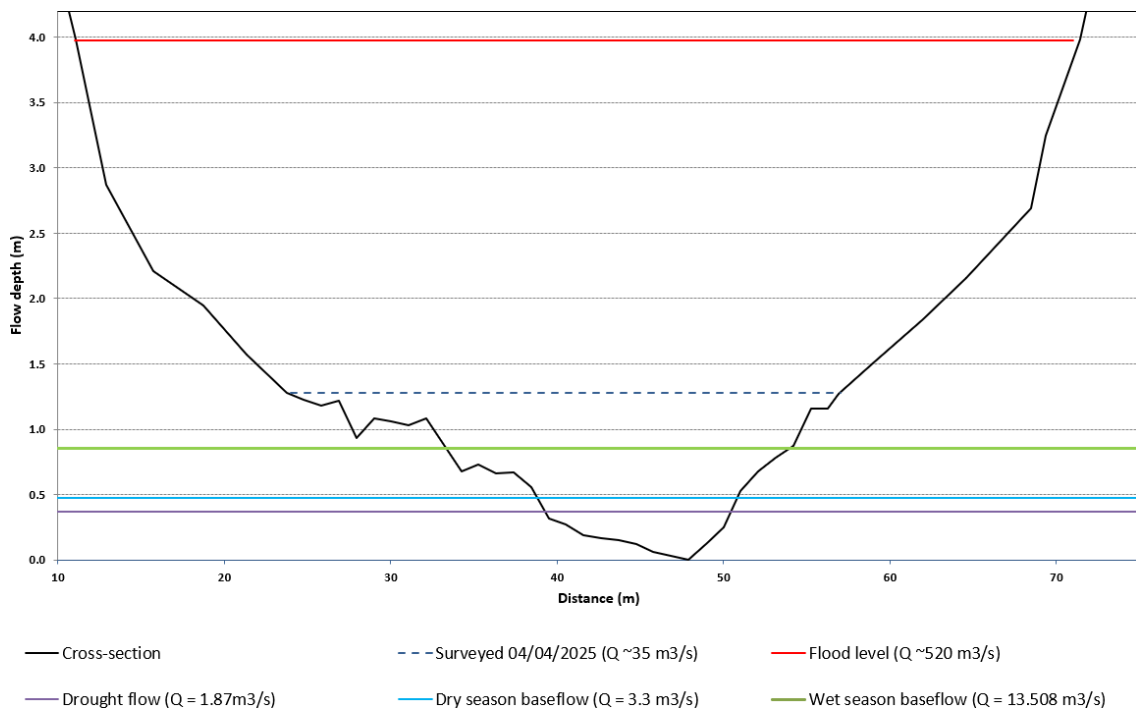


Figure 6-1: River cross-section showing the main eflow components for base-flows

The final step was to specify the freshets and annual flood requirements to provide the necessary ecological functioning of the river. As limited information was available, only smaller freshets for the movement of gravel and small cobbles were specified and to ensure fish movement through the reach. No annual flood was specified as it is assumed that the proposed Bunakha Dam will spill during high flows. 18 m³/s with a duration of 3 days were included for the months of March, April, October, November and December. If the dam is spilling during these months, only the difference between the freshet requirement and the spill needs to be released.

The final e-flows as a percentage of the reference flows (9.54% of reference MAR) for the Wangchu River at the e-flow site are summarised, along with the percentile requirements in (Table 6-2) and (Table 6-3). These percentile requirements per month specify the frequency of occurrence relationships of the defined baseflow and drought flow requirements for each month of the year. The tables thus specify the percentage of time that defined flows should equal or exceed the flow regime required to satisfy the e-flows.

Table 6-2: S u m m a r y of the final e-flows for Wangchhu River at e-flow site

Component	Requirement
Reference flows, 1976-2024 (MCM)	3014.5
Total e-flows	9.54%
Base-flows	9.08%
Drought flows	1.82%

Component	Requirement
Freshets/ floods	0.46%

Table 6-3: E-flows including drought, base-flows and freshets (m³/s) for implementation

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.1	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
1	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
5	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
10	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
15	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
20	5.9	15.6	17.2	17.1	16.9	5.9	5.9	4.6	19.5	19.5	19.5	4.6
30	5.8	15.4	16.9	16.8	16.7	5.8	5.9	4.6	19.3	19.3	19.3	4.6
40	5.7	15.1	16.1	16.3	16.1	5.7	5.7	4.5	19.0	18.9	18.9	4.5
50	5.5	14.6	15.4	15.3	15.3	5.6	5.6	4.4	18.4	18.6	18.4	4.4
60	5.2	13.4	13.7	13.6	13.5	5.3	5.3	4.2	17.6	17.6	17.6	4.2
70	4.7	11.4	10.9	10.8	10.7	4.7	4.7	3.8	15.9	15.9	15.8	3.8
80	3.6	8.0	6.8	6.8	6.5	3.6	3.7	3.1	12.4	12.5	11.8	3.1
85	3.2	6.4	5.3	5.1	5.1	3.2	3.3	2.8	10.1	10.2	10.0	2.8
90	2.7	4.2	3.6	3.5	3.4	2.7	2.7	2.4	6.6	7.2	6.9	2.4
95	2.2	2.8	2.5	2.7	2.5	2.2	2.3	2.1	4.1	3.9	4.2	2.1
99	2.1	2.2	2.2	2.1	2.1	2.1	2.1	1.9	2.1	1.9	2.3	1.9
99.9	2.0	2.0	2.1	2.0	2.0	2.0	2.0	1.9	1.6	1.7	1.4	1.9

The seasonal distribution graph for reference (REF), base-flows (BF) and the e-flows is presented in (Figure 6-2).

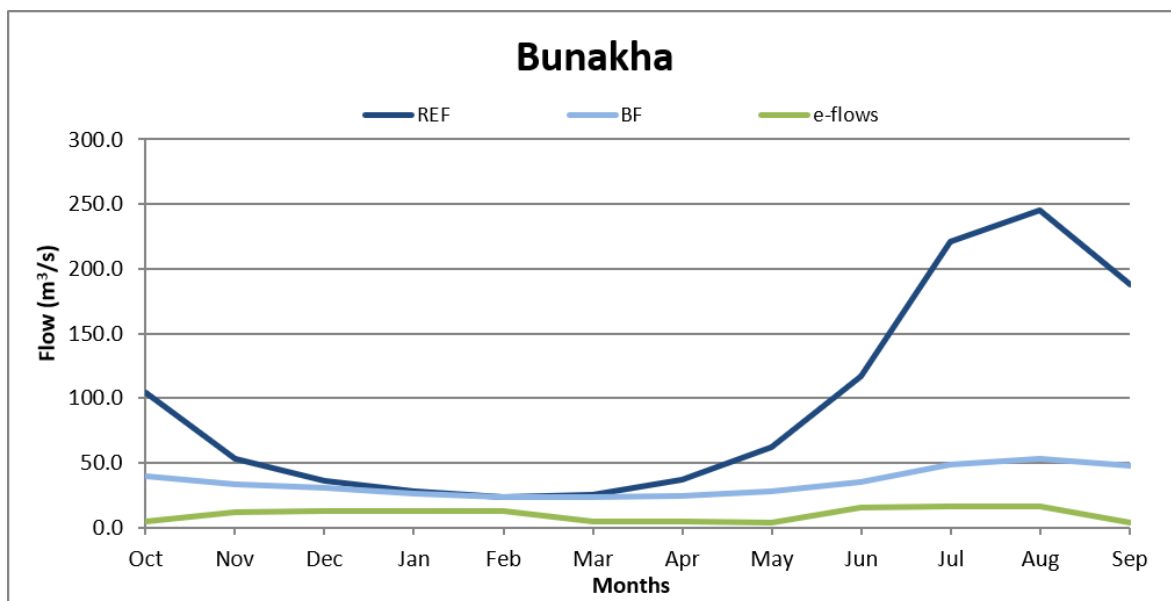


Figure 6-2: Seasonal distribution graph for reference (REF), base-flows (BF) and e-flows at e-flow site

6.2 Ecological Interpretation of Environmental Flow Requirements

To reiterate, the e-flow regime was developed using two key ecological indicators representative of the riverine ecosystem namely the *S. richardsonii* and the Family Heptageniidae. These taxa were selected because they represent both higher trophic-level habitat requirements and lower trophic-level food web processes. The *S. richardsonii* is a rheophilic, cold-water fish species that is highly dependent on flow velocity, depth diversity, habitat connectivity and seasonal flow variability, while Heptageniidae are flow-sensitive benthic macroinvertebrates that require stable, well-oxygenated riffle habitats and constitute an important food resource for juvenile and adult snow trout.

The fish species habitat preferences demonstrate that habitat suitability varies considerably among spawning, juvenile and adult life stages and that maintenance of seasonal flow variability is essential for sustaining viable populations (Hayes et al., 2025). Furthermore, their populations are known to be adversely affected by altered flow regimes, habitat fragmentation and reductions in flow variability associated with river regulation and abstraction (Bhatt and Manish, 2023; Wanjari et al., 2026).

The habitat preferences presented in (Table 5-3) (*S. richardsonii*) and (Table 5-4) (Heptageniidae) were used to assess the HabFlow outputs presented in Appendix 1. The following sections provide the ecological interpretation of the resulting depths and velocities and their suitability for supporting these indicator species, their life stages and associated ecosystem functions.

6.2.1 Spawning and Breeding Flow Requirements (March–May and Occasionally in autumn (September to October downstream))

The prescribed spawning flow of 3.313 m³/s, producing maximum depths of approximately 0.5 m and average velocities of approximately 0.83 m/s, is considered suitable for supporting *S. richardsonii* breeding and spawning activities (Appendix 1). At this discharge, the hydraulic

habitat is dominated by the Fast Deep (FD) flow-depth-velocity class, with additional contributions from Fast Shallow (FS) and Fast Very Shallow (FVS) habitats (Figure 5-7). Collectively, these habitat classes provide well-oxygenated flowing-water environments with moderate depths and sufficient hydraulic energy to maintain clean gravel and cobble substrates preferred for spawning and egg incubation.

The average velocity of 0.83 m/s falls within the range associated with rheophilic mountain-river fish species and is sufficient to prevent excessive fine sediment accumulation within spawning habitats while maintaining suitable oxygen exchange through the substrate. The maximum depth of approximately 0.5 m provides adequate water cover for adult migration and spawning while ensuring connectivity between suitable breeding habitats (Appendix 1).

The timing of this flow release is equally important. The natural flow paradigm recognises that the magnitude, timing and duration of seasonal flows regulate critical ecological processes such as fish migration, spawning cues, recruitment and habitat maintenance (Poff et al., 1997). Consequently, maintaining elevated spring flows during the March to May breeding season provides both the hydraulic habitat conditions and ecological cues required to support successful *S. richardsonii* reproduction.

6.2.2 Drought and Low-Flow Habitat Requirements (Juveniles and Food Resources)

The drought-period e-flow of $\sim 1.872 \text{ m}^3/\text{s}$, producing maximum depths of approximately 0.4 m and average velocities between 0.6 and 0.7 m/s, represents the minimum ecological threshold required to sustain juvenile *S. richardsonii* and their primary benthic food resources (Appendix 1). At this discharge, the channel remains dominated by FD habitat, while retaining areas of Fast Shallow (FS), FVS and some Slow Deep (SD) habitat. This hydraulic diversity maintains habitat heterogeneity and ensures that a range of ecological niches remain available within the river reach.

Juvenile *S. richardsonii* generally occupy shallow, low-velocity habitats along channel margins, where energetic demands are reduced and the risk of downstream displacement is minimised. These sheltered marginal areas, often associated with shallow edge habitats, velocity shadows behind substrate particles, and low-velocity microhabitats adjacent to the main channel, provide important nursery and rearing habitat. While the deeper and faster-flowing FD habitats within the centre of the channel are primarily utilised by larger fish, the retention of shallow marginal habitats at the prescribed drought flow allows juvenile fish to avoid excessive velocities while maintaining access to food resources and refuge from predators. The maintenance of these low-velocity edge habitats is therefore critical for juvenile survival, recruitment and population persistence during low-flow periods.

The prescribed velocity range of 0.6–0.7 m/s is sufficient to maintain flowing-water conditions and support Heptageniidae and other flow-dependent benthic macroinvertebrates that form an important component of the *S. richardsonii* food web. Heptageniidae are specialised riffle-dwelling mayflies associated with well-oxygenated habitats and coarse gravel-cobble substrates, and are known to decline under reduced flow velocities and increasing sedimentation (Thirion, 2016). Consequently, the proposed drought flow maintains suitable habitat conditions for these key macroinvertebrate communities while preventing habitat contraction and ecological degradation during low-flow periods.

The proposed drought flow therefore serves a dual ecological function:

1. Maintaining sufficient hydraulic habitat for juvenile *S. richardsonii* survival and growth; and
2. Preserving Heptageniidae populations and other flow-dependent benthic macroinvertebrates (EPT taxa) that constitute an important component of the snow trout food web.

As a result, the prescribed drought flow can be regarded as the temporary **absolute minimum** ecological flow required to sustain both the target fish population and its supporting trophic resources during droughts.

6.2.3 Wet-Season Baseflow Requirements (January, February, June, July, August, November and December)

The prescribed wet-season baseflow of 13.5 m³/s, generating maximum depths of approximately 0.9 m and average velocities of 1.3 m/s, provides extensive habitat for *S. richardsonii* and benthic macroinvertebrates (Appendix 1). At this discharge, the channel is dominated by FD habitat, with smaller areas of FS and limited FVS habitat (Figure 5-7). These conditions maintain well-oxygenated, connected flowing-water habitats, support adult feeding and migration, and sustain productive riffle habitats for flow-dependent macroinvertebrates such as Heptageniidae.

These hydraulic conditions reflect the naturally dynamic character of mountain river systems and support:

- Adult feeding and growth habitats;
- Migration and longitudinal connectivity;
- Maintenance of riffle-run-pool habitat diversity;
- Transport of organic matter and nutrients.
- Prevention of excessive sediment accumulation.
- Sustained production of aquatic macroinvertebrates.

The relatively high velocities generated under this flow regime are particularly important for maintaining the clean, oxygen-rich habitats preferred by Heptageniidae and other rheophilic invertebrate taxa. These conditions promote high secondary productivity and provide a stable food base for snow trout populations.

From an ecosystem perspective, these flows are consistent with the principles of the natural flow regime concept, whereby seasonal variation in discharge maintains ecological processes, habitat heterogeneity and biological diversity (Poff et al., 1997). The maintenance of higher wet-season base-flows therefore contributes not only to snow trout habitat availability but also to the long-term resilience and ecological functioning of the river ecosystem.

6.2.4 Freshets (Habitat Maintenance and Spawning Cue Flows)

In addition to the prescribed seasonal base-flows, periodic freshets of approximately 18.0 m³/s, generating maximum depths of approximately 1.0 m and average velocities of approximately 1.27

m/s, are recommended as an essential component of the e-flow regime. These short-duration (3 days) flow pulses fulfil several important ecological and geomorphological functions that cannot be achieved through base-flows alone.

From a biological perspective, freshets provide critical hydraulic and environmental cues that stimulate upstream movement and spawning migrations of *S. richardsonii*. As a rheophilic and potamodromous species, snow trout has evolved under naturally variable flow conditions where seasonal increases in discharge act as behavioural triggers for migration, habitat selection and reproductive activities (Bhatt C Manish, 2023). The maintenance of these flow pulses therefore contributes to preserving the natural life-cycle processes of the species and supports successful recruitment. Similar principles underpin the Natural Flow Regime concept, which recognises that not only flow magnitude, but also the timing, frequency, duration and rate of change of flows are critical for sustaining ecological integrity and riverine biodiversity (Poff et al., 1997).

The proposed freshet discharge also performs a vital geomorphological function by mobilising silt, sand, gravels and small cobbles within the active channel (shear stress of $\sim 190 \text{ N/m}^2$). Periodic fine sediment mobilisation is necessary to maintain the dynamic habitat mosaic characteristic of healthy mountain river systems. The redistribution of these substrate classes replenishes and maintains spawning habitats, which are typically associated with clean non-embedded gravel-cobble substrates, while simultaneously sustaining shallow, coarse-substrate habitats utilised by juvenile snow trout.

Furthermore, the increased hydraulic energy associated with the freshet flow assists in preventing substrate embeddedness and excessive sediment consolidation. The mobilisation and downstream transport of accumulated fine sediments and silts help maintain interstitial spaces within gravel and cobble beds, thereby improving oxygen exchange and reducing the risk of egg suffocation within spawning habitats. This process also benefits benthic macroinvertebrate communities, particularly flow-sensitive taxa such as Heptageniidae, which require clean, well-oxygenated substrates and are adversely affected by excessive fine sediment deposition.

The average velocity of approximately 1.27 m/s and shear stress of $\sim 190 \text{ N/m}^2$ (sufficient to mobilise sediment up to small cobble size) generated during freshet events is sufficient to flush fine sediments from riffle and run habitats while maintaining channel complexity and habitat diversity. These periodic channel maintenance flows therefore contribute directly to sustaining the ecological processes that support both snow trout populations and their macroinvertebrate food resources.

Consequently, the recommended freshets should not be viewed solely as hydraulic maintenance flows but rather as ecologically important events that:

- Provide migration and spawning cues for snow trout;
- Enhance longitudinal connectivity and fish movement opportunities;
- Mobilise and redistribute gravels and small cobbles required for spawning and juvenile habitats;
- Flush accumulated fine sediments and silts from the channel bed;
- Improve substrate quality and oxygenation within spawning areas;

- Maintain suitable habitat conditions for flow-dependent macroinvertebrates, including Heptageniidae; and
- Preserve the natural geomorphic and ecological processes upon which the river ecosystem depends.

The inclusion of periodic freshets therefore represents a critical component of the environmental flow regime and complements the prescribed spawning, drought and wet-season base-flows by maintaining both habitat quality and ecosystem functionality over the long term.

6.3 Comparison of 30% rule with proposed e-flow

Additionally the 30% rule was also applied to the reference flows to provide the requirements inline with the National compliance. The average monthly e-flows for both the 30% rule and the 9% as determined through this assessment are presented in (Table 6-4) and (Figure 4-3)

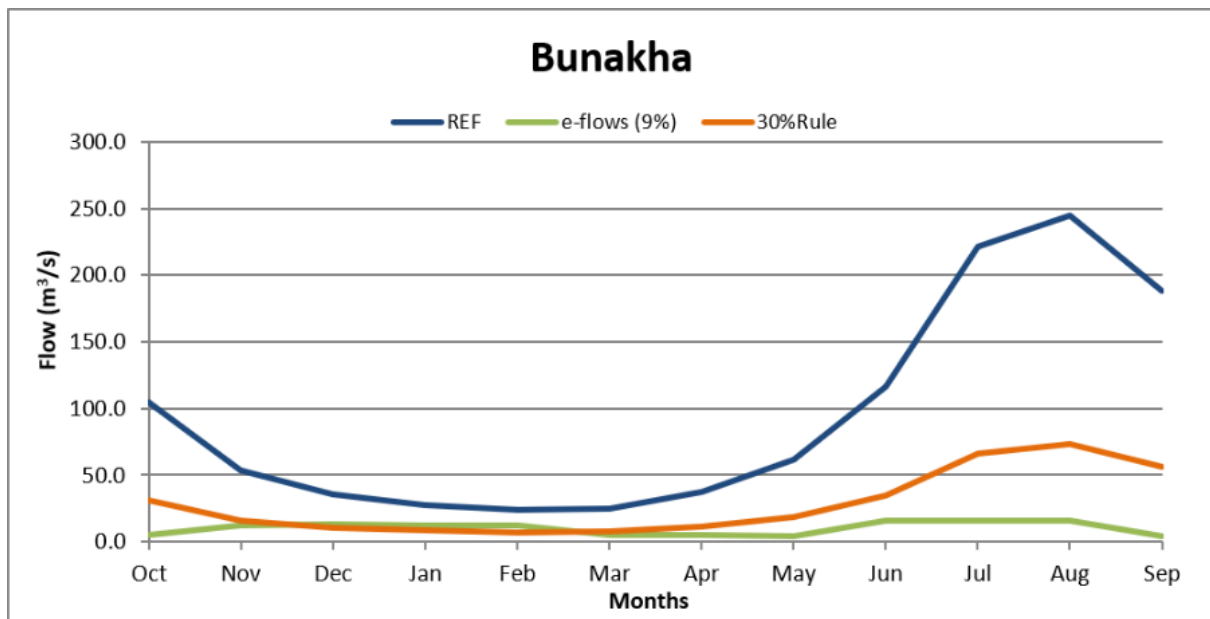


Figure 6-3.

Table 6-4: Average monthly e-flows for the 30% rule and G% as determined based on reference flows

m³/s	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
REF	104.60	53.34	35.91	27.57	23.87	25.07	37.30	61.61	116.69	221.27	244.98	188.14
Total (9%)	4.86	12.13	12.70	12.62	12.46	4.88	4.92	3.94	15.78	15.87	15.83	3.93
Baseflows (9%)	4.38	13.36	14.35	15.27	15.34	4.41	4.37	4.40	18.38	18.58	18.42	4.42
30%Rule	31.38	16.00	10.77	8.27	7.16	7.52	11.19	18.48	35.01	66.38	73.49	56.44
Total difference %	15	76	118	153	174	65	44	21	45	24	22	7

Baseflows													
%													
difference	14	84	133	185	214	59	39	24	53	28	25	8	

From the above table it can be seen that the e-flows for the 30% rule are consistently higher than the 9% as determined through this assessment, except for December, January and February. This is due to the higher baseflows that were specified to provide adequate habitats for the indicator species and the inclusion of a small freshet in December.

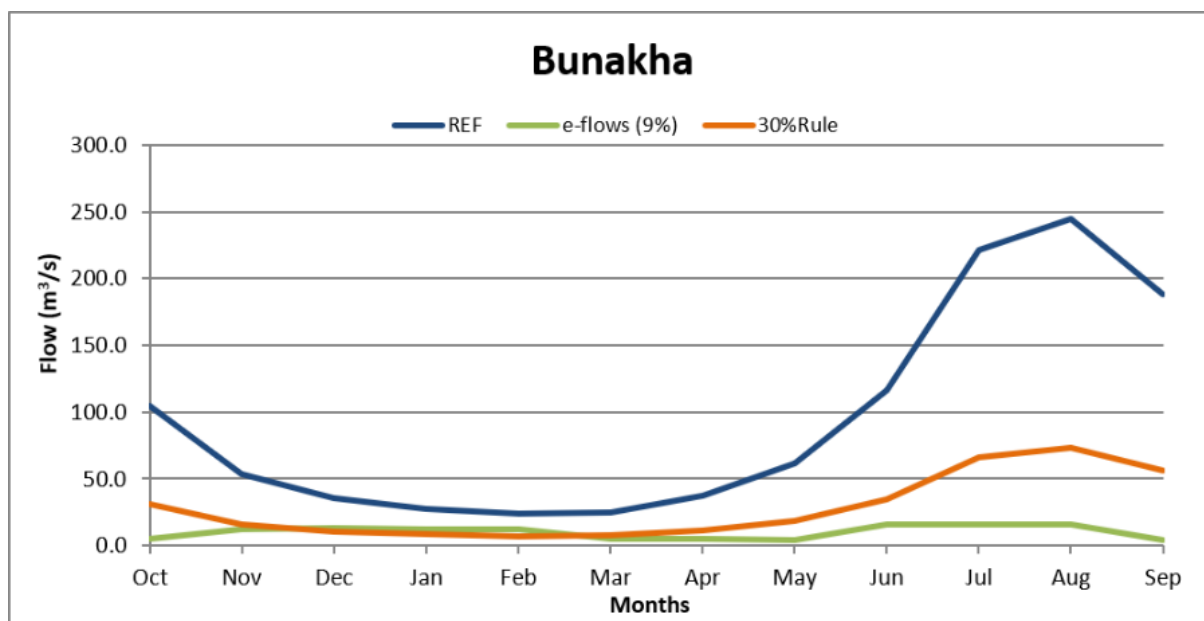


Figure 6-3: Seasonal hydrograph of average monthly e-flows for 30% rule and G% requirements

6.4 Scenario evaluation using a constant e-flow of 5 m³/s

In addition to the above scenario considerations for the e-flows, it was pertinent to understand the effect of the constant 5 m³/s flow as an e-flow (Figure 6-4). This flow is proposed by the developer from the Bunakha Dam to the Tala Dam (Dewatered Reach 1 and 2 respectively).

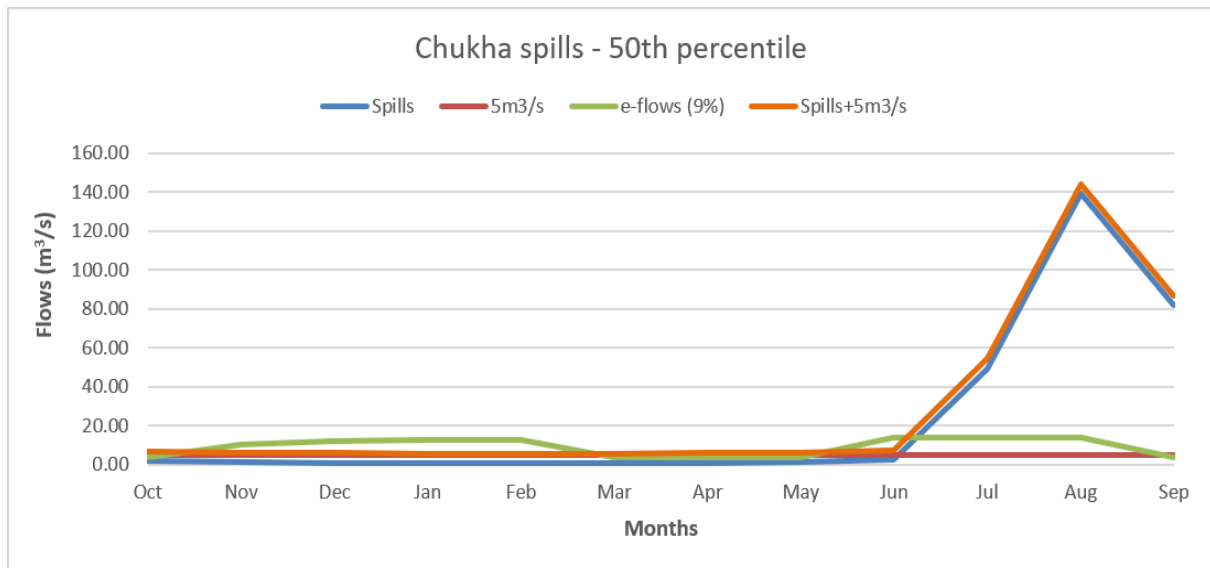


Figure 6-4: Chuka spills and constant 5m³/s e-flow compared to the prescribed G% MAR e-flow initially recommended at the 50th percentile

This constant 5 m³/s flow exceeds the prescribed baseflow requirement during the driest months (Oct, Mar, Apr, May, Sep: 3.313 m³/s), but falls below the average variable e-flow baseflow of approximately 8.7 m³/s calculated across the year, and substantially below the wet-season baseflow requirements of 10.3–13.5 m³/s (Nov–Feb, Jun–Aug). It also lacks the higher pulsed flows provided by freshets, which are needed to stimulate and facilitate spawning migration cues and to reset the relevant substrate by moving finer sediments downstream. The negative impacts that will incur should the constant 5m³/s e-flows be implemented without spills:

- Constant habitat diversity and availability along Dewatered Reach 1 and 2;
- No seasonal flow variability that the initial e-flow regime was specifically designed around in order to maintain habitats by flushing and renewing gravel habitats unless the reservoir spills. This is likely to degrade the gravel and cobble habitat quality and embeddedness, with consequences for fish and macroinvertebrate recruitment and sustainability;
- Macroinvertebrate and food-web decline would occur, as Heptageniidae decline under reduced, non-fluctuating flow, weakening the prey base that supports Snow Trout condition and growth;
- Lack of flow related queues for fish migration and spawning;
- Reduced habitat heterogeneity resulting from a static flow regime that homogenises channel hydraulic conditions;
- Loss of juvenile refuge and marginal nursery habitats on which juvenile fish depend. A constant elevated flow regime will not create the low-velocity refuge conditions required by juveniles during genuine low-flow periods, thereby reducing the availability of suitable nursery and refuge habitat; and
- Lack of wetting new instream habitats and riparian vegetation to support biological lifecycles during the wet season.

The positive aspects of the 5 m³/s are that the reach from Bunakha to Tala will be permanently wetted compared to the very low flows that it currently experiences. There will be spills along these e-flow reaches during the monsoon season, providing some level of seasonal variability.

Recorded spill data for Chukha, interpreted with caution given the relatively low confidence in the dataset, indicate that when combined with a constant 5 m³/s release, the resulting flow (Spills + 5 m³/s) meets or exceeds the previously specified e-flow requirement (9% of MAR) during October, March, April and May, coinciding with the spring and autumn spawning migration periods, as well as during July, August and September, which correspond to the monsoon high-flow period. However, during November, December, January, February and June, the combined Spills + 5 m³/s flow falls short of the 9% requirement, indicating a potential deficit within the system during these months (Table 6-5) and (Figure 6-4). Where spills of this magnitude do occur as indicated by the hydrology data, they would reintroduce a meaningful degree of natural flow variability and fluctuation into the system, thereby alleviating most of the previously identified impacts associated with a constant, unvarying 5 m³/s release; the residual risk is therefore concentrated in the months noted above, where the constant flow alone would not adequately replicate the natural variability, the biota rely on.

Table 6-5: Chukha spills per percentile per month

Percentiles	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
0.1	530.22	126.63	1.61	0.94	0.80	1.10	15.81	197.40	647.62	463.99	521.82	588.25
1	251.19	16.54	1.35	0.89	0.70	0.99	1.93	47.69	155.18	355.41	407.65	365.93
5	103.09	1.68	1.04	0.74	0.60	0.78	1.35	14.23	49.03	264.30	309.55	236.30
10	65.10	1.46	0.97	0.68	0.57	0.67	1.17	1.79	47.56	218.00	258.45	193.06
15	49.87	1.36	0.88	0.64	0.55	0.61	1.04	1.56	46.86	194.65	230.72	162.88
20	37.50	1.27	0.83	0.61	0.53	0.58	0.97	1.44	46.49	173.56	212.86	144.89
30	17.82	1.17	0.78	0.57	0.50	0.53	0.87	1.28	42.08	137.34	181.67	120.41
40	6.02	1.10	0.74	0.55	0.49	0.50	0.79	1.17	20.59	97.59	159.22	98.76
Spills	1.89	1.04	0.71	0.53	0.47	0.48	0.72	1.07	2.17	49.26	139.11	81.95
60	1.74	0.98	0.67	0.51	0.45	0.46	0.67	0.99	1.70	47.82	124.73	66.56
70	1.59	0.92	0.64	0.50	0.44	0.44	0.61	0.92	1.46	46.87	106.79	52.64
80	1.44	0.86	0.61	0.48	0.42	0.42	0.56	0.84	1.25	46.22	86.43	38.00
85	1.36	0.83	0.59	0.47	0.41	0.41	0.53	0.79	1.12	42.76	74.04	30.59
90	1.28	0.79	0.57	0.45	0.40	0.40	0.50	0.74	0.99	30.21	57.91	20.10
95	1.18	0.74	0.53	0.38	0.38	0.34	0.46	0.67	0.84	11.18	46.84	10.74
99	1.03	0.67	0.00	0.00	0.00	0.00	0.34	0.58	0.69	1.54	32.31	1.74
99.9	0.91	0.63	0.00	0.00	0.00	0.00	0.00	0.53	0.64	1.29	23.36	1.20
5m ³ /s	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
e-flows (9%)	3.31	10.29	11.79	12.62	12.62	3.31	3.31	3.31	13.51	13.51	13.51	3.31
Spills+5m ³ /s	6.89	6.04	5.71	5.53	5.47	5.48	5.72	6.07	7.17	54.26	144.11	86.95

Therefore overall, a constant 5 m³/s flow, falling below the average variable baseflow requirement and lacking freshet pulses, would, in the absence of spills, result in a general deterioration in aquatic habitat quality and a loss of seasonal variability, with consequent effects on aquatic life and biodiversity extending beyond Snow Trout to macroinvertebrate communities and the broader food web. However, where spills occur as indicated by the hydrology data, the resulting flow variability is retained during the ecologically critical spring (March–April) and

autumn (September–October) spawning migration periods, as well as through the monsoon months, meaning the seasonal cues required for spawning are largely preserved rather than lost outright. The residual risk is instead concentrated in November to February and June, when spills are insufficient to restore this variability; persistent impacts during these months could still have knock-on consequences for downstream ecological processes, ecosystem services, and the communities and land uses that depend on a functioning river system.

6.5 Effect of the Hydropeaking on the Instream Habitat

The proposed Bunakha HPP is designed to operate as a storage-based peaking power plant, enabling the generation of electricity during periods of peak demand. During the low-flow season, when river inflows are limited, the project is expected to operate under a daily peaking regime of approximately six hours. Water will be stored in the reservoir during non-generation periods and released through the turbines during designated peak demand hours to maximize energy production and grid stability.

Under this operational regime, river flows downstream of the dam will be modified from their natural pattern. During the six-hour generation period, turbine releases will result in increased downstream discharges, while flows during non-generation periods will be substantially reduced and maintained through dedicated environmental flow releases. Consequently, the downstream river reach will experience daily fluctuations in discharge and water level, commonly referred to as hydropeaking.

The extent of these fluctuations is expected to extend from the Bunakha Dam tail race and along the Chukha Dam. It is possible that water from the tail race can push back up the Dewatered Reach during peak releases, flooding riffle/rapid habitats. The extent of this back flooding is not known at this stage. Furthermore, much of this reach is already influenced by the backwater effect of the Chukha Dam, resulting in hydraulic conditions that are more reservoir-like than free-flowing riverine environments. Nevertheless, variations in flow and water level may affect aquatic habitat availability, fish movement, macroinvertebrate communities, and riparian ecosystems.

7. FUTURE IMPACTS TO CONSIDER: CLIMATE CHANGE CONSIDERATIONS FOR SNOW TROUT CONSERVATION

Schizothorax richardsonii is recognised as one of the most climate-sensitive fish species within Himalayan river systems due to its dependence on cold-water environments and natural hydrological processes (Bharti et al., 2023). The species is particularly vulnerable to changes in water temperature, flow regime, and habitat connectivity, all of which are expected to be affected by climate change.

Rising water temperatures can influence key biological processes, including growth, reproduction, migration, and overall physiological performance. Climate-driven warming is also expected to reduce the extent of suitable habitat, with populations increasingly restricted to higher-elevation reaches where cooler thermal conditions persist. Modelling studies indicate

that significant habitat contraction and population declines may occur across parts of the species' range under future climate scenarios (Bharti et al., 2023).

In addition to thermal stress, climate change is expected to alter the magnitude, timing, and variability of river flows through changes in precipitation patterns, snowmelt dynamics, and the frequency of extreme hydrological events. Such changes may disrupt migration cues, reduce habitat availability during critical life-history periods, and affect recruitment success.

The impacts of climate change may be further compounded by river regulation and hydropower development, which can fragment habitats, restrict movement, and modify natural flow patterns. Reduced connectivity may limit the ability of this species to access thermal refugia and suitable spawning areas, thereby decreasing population resilience.

Given its sensitivity to warming temperatures, altered flow regimes, and habitat fragmentation, snow trout should be regarded as a key indicator species for climate resilience in Himalayan rivers. Maintaining environmental flows that preserve connectivity, seasonal flow variability, and thermal refugia will be critical for supporting the long-term persistence of the species (Bharti et al., 2023).

8. PROPOSED MITIGATION, OFFSETS, MONITORING AND CONCLUSION

Based on the recommended e-flow regime for the proposed Bunakha Hydropower Project, the following mitigation and monitoring measures are proposed to maintain the long-term health, integrity and resilience of the Wangchu River aquatic ecosystem. The objective of these measures is to ensure the continued provision of suitable habitat, ecological connectivity and ecosystem processes required to support sustainable aquatic biodiversity, while achieving no net loss of ecological function within the affected river reach.

8.1 Mitigation Measures

8.1.1 Sacrificial Reach

The mitigation measures are limited due to the short ~400 m Dewatered Reach (Reach 1, see (Figure 1-1) between the end of the Bunakha Dam infrastructure and the beginning of the hydropeaking release at the Bunakha tail race into Chukha Dam. It is proposed that no specific e-flows are released for this short isolated reach and rather improve the flow conditions downstream of Chukha Dam as partial offset (Dewatered Reach 2, (Figure 1-1), see more details in Section 8.1.5) where the proposed e-flows will maintain the hydraulic habitats and provide adequate flows for the aquatic biota. Thus, this short, dewatered reach will be dependent on lateral seepage (if any), contribution of the small tributary and when the proposed Bunakha Dam spills during wet periods. Refer for more information in terms of this proposed off-set measure in Section 8.1.5.

8.1.2 Sediment Management

Sediment management should be undertaken through annual reservoir flushing operations using the bottom outlet during the monsoon period, either at the beginning or end of the season,

depending on operational constraints and sediment load conditions. The sediment releases should be timed with extended flood flows to enable sediment transport (sediment deposited in the Wangchhu River from lateral sources) down the river system after the main release from the Bunakha Reservoir. This will offset the sediment starvation and riverbed armouring expected for most of the Dewatered Reach.

It is further necessary to release freshet flows as part of the e-flows to transport fine sediment contributions from lateral sources (tributaries, slopes and landslides) to clean out spawning habitats before and during the breeding season.

8.1.3 Fish Management, Conservation and Enhancement Measures

Alien Invasive Fish Management Upstream of Bunakha

As per Section 5.4.3 Brown trout (*Salmo trutta*) have become established in the upper reaches of the Wangchu River upstream of the Bunakha Reservoir, where they may exert predation pressure on indigenous fish species, including *S. richardsonii*, and potentially compete for habitat and food resources. To support the conservation and recovery of native fish communities, a targeted brown trout management programme should be considered for all tributaries to the Bunakha Reservoir. This may include the controlled removal of brown trout from priority reaches, prevention of further stocking or translocation, and ongoing monitoring of population trends.

In parallel to the above suggested mitigation is a *S. richardsonii* conservation and enhancement programme which could be implemented to strengthen indigenous fish populations. Potential measures may include the establishment of a captive breeding and stocking programme, protection of key spawning habitats, and maintenance of e-flows that support critical life stages. Together, these measures would contribute to reducing pressures on native fish communities and improving the long-term persistence and resilience of indigenous fish populations within the river system.

Conservation of the Snow Trout

It is recommended that a dedicated *S. richardsonii* fingerling introduction programme be implemented, focused primarily on Dewatered Reach 2 and the reach upstream of the proposed Bunakha Dam. Given that Dewatered Reach 1 will be predominantly dry, dependent on lateral seepage, tributary inflow and periodic wet-season spills (Section 8.1.1), it is not considered a suitable receiving environment for fingerling introduction and has therefore been excluded from this recommendation.

The presence of the Bunakha Dam, together with the downstream Chukha and Tala infrastructure, introduces an unnatural barrier to longitudinal connectivity within the Wangchu River, disrupting the upstream–downstream migratory movements that *S. richardsonii* relies on to access spawning, feeding and refuge habitats across its life cycle (Section 5.4.2). Where hydraulic barriers restrict natural recruitment and re-colonisation between reaches, targeted fingerling stocking can serve as a complementary measure to sustain and strengthen local population structure. Within Dewatered Reach 2, this is particularly relevant given that *S. richardsonii* was recorded during the aquatic biodiversity surveys undertaken there (PCS, 2025a, b, c), confirming the reach's continued capacity to support the species where suitable flow and habitat conditions are maintained.

Upstream of the proposed Bunakha Dam, aquatic surveys recorded the presence of Brown Trout, a competitor of *S. richardsonii*, with no *S. richardsonii* reported at these survey locations (Section 5.4.3; PCS, 2025a, b, c). A fingerling introduction programme targeting this reach, implemented alongside the brown trout management measures proposed in Section 8.1.3, would support the re-establishment of a native *S. richardsonii* population within a reach currently dominated by an invasive predator, representing a positive contribution to indigenous fish community recovery within the upper Wangchu catchment.

Fingerlings should be sourced from a captive breeding and rearing programme using broodstock collected from the Wangchu River system or immediately adjacent catchments, to preserve local genetic integrity and avoid the introduction of non-native genetic material (Joshi, 2011). Artificial propagation and hatchery-rearing of *S. richardsonii* from egg to fingerling stage has been demonstrated under controlled farm conditions elsewhere in the Himalayan region, with reported survival rates of approximately 80–85% from fertilised egg to fry and 35–45% from fry to fingerling stage (Joshi, 2004), indicating the technical feasibility of establishing a similar programme for the Bunakha catchment. Stocking should be staged and adaptively managed, timed to coincide with the maintenance of suitable base flows and habitat conditions in the receiving reaches, and supported by post-release monitoring to evaluate survival, growth and integration with existing wild populations, including monitoring for evidence of brown trout predation pressure on introduced fingerlings in the upstream reach.

It is emphasised that fingerling introduction should be regarded as a supplementary measure that reinforces, rather than substitutes for, the maintenance of e-flows, habitat connectivity and spawning habitat protection, which remain the primary mechanisms for sustaining a self-recruiting, viable *S. richardsonii* population within the Wangchu River system (Joshi, 2011).

8.1.4 Flow Regulation

Given Bunakha HEP's position as the most upstream project in the Wangchu River cascade, flow release operations will be coordinated with:

- Chukha HEP (336 MW) – 3.5 km downstream
- Tala HEP (1,020 MW) – 15 km downstream
- Proposed Wangchu HEP (570 MW) – further downstream

This ensures that cumulative effects of flow regulation and hydropeaking do not adversely impact river ecology or community water uses and that environmental flow objectives are achieved across the cascade system. It is important that most of the peaking releases from Bunakha Dam are absorbed by the Chukha reservoir and does not propagate along the Dewatered Reach 2 (Figure 1-1).

8.1.5 Proposed Offsets to Achieve No Net Loss Objectives and Localised Net Gain

To further support biodiversity conservation objectives, it is recommended that the e-flows specified in this report be implemented within Dewatered Reach 2, located between the Chukha Dam and Tala Dam (Figure 1-1). The proposed e-flow regime incorporates base flows, drought flows and periodic freshets designed to reinstate key ecological and geomorphic processes, including habitat maintenance, sediment mobilisation, connectivity and fish movement cues. Implementation of these flows is expected to improve ecological conditions along approximately

10 km of river reach that exhibits habitat characteristics comparable to those that will be lost through inundation associated with the Bunakha Dam development.

While the enhancement of Dewatered Reach 2 would not fully compensate for the approximately 17 km of river habitat converted to reservoir conditions, it would provide a meaningful ecological offset through the restoration and maintenance of riverine habitat and ecological processes within an existing regulated reach. When combined with the proposed fish conservation and enhancement programme as per Section 8.1.3, these measures would contribute towards achieving no net loss objectives for key aquatic ecosystem functions and native fish populations at the river-system scale, while improving the ecological condition and resilience of a reach that is currently flow-limited. The implementation of e-flows within Dewatered Reach 2 is also expected to deliver a net gain in ecological condition within this reach through the enhancement of habitat quality, restoration of ecological processes, and improved support for indigenous fish populations. Collectively, these measures would represent a significant compensatory biodiversity enhancement within the wider river system, contributing towards no net loss of aquatic ecological function while achieving a localised net gain in ecological condition within the Reach 2, thereby helping to offset a portion of the residual impacts associated with the Bunakha Hydropower Project.

8.1.6 Environmental Flow Scenario Assessment under Future Climate Conditions

It is suggested to undertake a comprehensive environmental flow scenario analysis to evaluate the ecological consequences of altered flow regimes on *S. richardsonii* and the broader aquatic ecosystem. The assessment should consider a range of future hydrological scenarios, including project-related flow modifications (such as hydropeaking intensity, ramp rates and timing) as well as climate change-induced changes in water temperature and river hydrology, such as altered precipitation patterns, shifts in snowmelt timing and magnitude, increased hydrological variability, and prolonged low-flow periods. The scenario analysis should assess the potential implications for habitat availability, migration connectivity, spawning success, thermal refugia, and overall ecosystem resilience. The outcomes should be used to refine the environmental flow recommendations and identify adaptive management measures required to maintain ecological integrity under both current and future climate conditions.

8.2 Proposed Monitoring Plan

The purpose of the monitoring plan is to ensure that the e-flows defined in the EFMP are implemented, maintained, and effective in achieving ecological, social, and regulatory objectives. Monitoring provides feedback for adaptive management, ensuring that flow releases continue to support:

- Downstream aquatic ecosystems and biodiversity;
- River morphology and sediment transport;
- Water quality and riparian vegetation;
- Downstream water uses by communities, agriculture, and livestock; and

- Compliance with the Water Act of Bhutan (2011), the Environmental Flow Guidelines of Bhutan (NEC, 2016), and ADB Safeguard Policy Statement (2009).

The Environmental Flow Monitoring Plan includes the following proposed components:

8.2.1 Time Lapse Photography

High-resolution fixed-point photos (land based) and aerial images (drone based) should be conducted twice a year during the low flows (pre and post monsoon). These images will allow for the detection of changes to the vegetation, substrates and river morphology.

8.2.2 Flow Discharge Monitoring

Continuous measurement of river discharge should be carried out at the Bunakha inflow, and downstream of the Chukha Dam. These measurements will ensure that the prescribed e-flows including base-flows, seasonal variations, and high-flow releases are consistently met. By maintaining this continuous monitoring, the dam operations will be able to verify compliance with the Environmental Flow Management Plan, promptly identify any deviations, and make necessary adjustments to protect aquatic habitats, riparian vegetation, and downstream communities, thereby supporting the long-term ecological health of the river system.

8.2.3 Water Quality Monitoring

Water quality monitoring should focus on parameters most likely to be affected by hydropower operations, including water temperature, DO, turbidity, TSS, and sediment deposition. Monitoring should be undertaken upstream and downstream of the dam, diversion reach and tailrace on a monthly or quarterly basis. Particular attention should be given to changes in temperature, oxygen levels and sediment dynamics, as these may affect *S. richardsonii*, macroinvertebrate communities, spawning habitats and overall aquatic ecosystem health. Results should be used to inform adaptive management and ensure environmental flow objectives are achieved.

8.2.4 Aquatic Ecology Monitoring

Aquatic ecosystem monitoring will include assessments of fish diversity, abundance, and spawning habitats, as well as surveys of macroinvertebrate communities and abundances. In addition, key aspects of aquatic habitat, such as water depth, flow velocity, and substrate composition, will be regularly evaluated. These surveys and assessments should be undertaken during the dry season (pre-monsoon and post-monsoon) to capture seasonal variations, providing critical information on the ecological health of the river and the effectiveness of the determined e-flows and environmental flow management in supporting biodiversity and maintaining functional aquatic habitats.

8.2.5 River Morphology and Sediment Monitoring

River Morphology and Sediment Monitoring will involve detailed river cross-sectional surveys that note bed material along the cross-section, and systematic observations of bank erosion. These activities will be conducted annually to track sediment transport, assess channel stability, bank erosion, sediment deposition and identify any changes in river morphology over time. This monitoring will provide essential information to ensure that environmental flows and dam operations are supporting natural sediment dynamics and maintaining the physical integrity of the river system.

8.2.6 Riparian Vegetation Monitoring

A riparian monitoring programme should be implemented to establish baseline conditions and assess changes over time. Monitoring should evaluate riparian vegetation cover, species composition, recruitment, and riverbank stability along the downstream reach on an annual basis. The programme should also assess potential erosion, habitat degradation, and vegetation response to the e-flow regime. Results should be used to determine whether flow releases adequately supporting riparian ecosystem health and to inform adaptive management where necessary.

8.2.7 Downstream Water Use Monitoring

Downstream Water Use Monitoring will focus on understanding how water released from the dam meets the needs of local communities for domestic use, irrigation, and livestock. This will include annual community surveys and consultations to identify any flow-related issues or shortages, ensuring that environmental flow management aligns with the social and livelihood requirements of downstream populations.

8.2.8 Monitoring Locations

Monitoring should be conducted at multiple strategically selected locations, including:

- In Dewatered Reach 2: for compliance with minimum environmental flows (sites as per PCS (2025a), sites A15 and A17);
- Downstream near communities: to assess water availability for domestic and livelihood uses; and
- Additional locations in coordination with Chukha and Tala HEPs: to evaluate cumulative impacts along the Wangchu cascade.

8.2.9 Frequency of Monitoring

Hydrology Report (DPR) presents the proposed e-flow monitoring plan, including the key proposed components, monitoring parameters, and recommended monitoring frequencies for assessing the effectiveness of the environmental flow regime and detecting changes in ecosystem condition.

Table 8-1: Summary of the monitoring plan

Component	Parameter / Focus	Frequency
Flow Discharge	m ³ /s at inlet to Bunakha and Dewatered Reach 2	Daily / Continuous
Water Quality	DO, pH, Temp, Turbidity, TSS	Monthly / Quarterly
Aquatic Ecology	Fish C Macroinvertebrates, habitats and populations/communities and abundances	Bi-annual
River Morphology / Sediment	Cross-sections, sediment sampling	Annual
Riparian Vegetation	Vegetation cover, riverbank stability	Annual

Component	Parameter / Focus	Frequency
Downstream Water Use	Community water access C survey	Annual

8.2.10 Data Management and Reporting

All monitoring data should be compiled, analyzed, and stored in a central database maintained by the Project's environmental team. A publicly available digital dashboard should show the real time/near real time flow data for the hydrological stations.

Reports should be prepared at regular intervals:

- Annual Environmental Flow Compliance Report: flow releases vs required E-Flow;
- Annual Environmental Monitoring Report: summary of all monitoring components;
- Annual Environmental Flow Review: evaluation of ecological and social outcomes, and recommendations for adaptive management; and
- Reports should be submitted to DGPC, the Royal Government of Bhutan, and ADB for safeguard compliance.

8.2.11 Adaptive Management

Monitoring results will guide adjustments to the environmental flow regime where required, ensuring that any deviations or observed ecological or social impacts are addressed promptly. Adaptive management includes:

- Modifying flow releases to respond to ecological stress or community water shortages;
- Coordinating flow releases with downstream cascade HEPs to mitigate cumulative impacts; and
- Updating monitoring protocols based on lessons learned during operation.

This monitoring framework ensures that environmental flows are measurable, verifiable, and responsive, safeguarding river ecosystems and downstream water uses throughout the operational life of the Bunakha Hydropower Project.

8.3 Conclusion

The e-flow assessment undertaken for the Bunakha HPP demonstrated that a carefully designed and managed e-flow regime can maintain the ecological functionality, health and integrity of the Wangchu River while supporting the operational objectives of the proposed hydropower scheme. The e-flow assessment included hydrological analyses, hydraulic modelling, aquatic ecology surveys undertaken across three seasons, geomorphological assessments, and specialist reviews to determine the flow requirements necessary to sustain key biophysical processes and aquatic biodiversity. Particular emphasis was placed on the habitat and life-stage requirements of the indicator species *S. richardsonii* and flow-sensitive macroinvertebrate families.

Based on the ecological requirements of the selected aquatic biota, and to ensure the maintenance of suitable habitat conditions, ecological connectivity, migration pathways,

spawning opportunities, refuge habitats, and associated ecosystem processes downstream of the proposed development, a proposed e-flow regime was developed for the Wangchu River. The recommended e-flow components and associated flow releases are presented in Table 8-2 below and it should be noted this volume is significantly lower than the generic 30% rule and higher than the constant 5 m³/s (5% of MAR).

Under a constant 5 m³/s e-flow regime, most of the identified negative impacts on aquatic habitat and biodiversity would be substantially mitigated where the anticipated spills at Bunakha and Chukha occur, as indicated by the hydrology data. When combined with the constant baseline flow, these spills restore flow variability during the ecologically critical spring (March–April) and autumn (September–October) spawning migration periods, as well as through the monsoon months (July–September), meaning the seasonal flow cues required to support Snow Trout spawning and migration are largely preserved rather than lost outright. A residual risk remains during November to February and June, when spill volumes are insufficient to restore the required variability and the system would be more reliant on the constant 5 m³/s flow alone; if sustained, this could result in localised deterioration in habitat quality and knock-on effects on macroinvertebrate communities, the broader food web, and downstream ecological processes and ecosystem services during these months.

Notwithstanding the above, and given the relatively low confidence associated with the spill data and its reliance on natural inflow variability rather than a guaranteed operational commitment, the originally proposed e-flow regime of 9% of MAR, incorporating engineered base-flows, drought flows and freshets, remains the preferred and recommended approach (Table 8-2). This variable regime provides a robust, defensible and operationally reliable means of meeting the river's ecological flow requirements throughout the year, without dependence on incidental spill occurrence. A constant 5 m³/s release, while shown to be broadly workable where spills materialise as anticipated, should be regarded as a lower-confidence alternative rather than a like-for-like substitute for the recommended e-flow regime.

Table 8-2: Summary of the final e-flows for Wangchu River at e-flow site

Component	Requirement
Reference flows, 1976-2024 (MCM)	3014.5
Total e-flows	9.54%
Base-flows	9.08%
Drought flows	1.82%
Freshets/ floods	0.46%

It should be noted that confidence in some of the hydraulic and ecological relationships underpinning the assessment was constrained by limitations in the available data, including the reliance on a single representative cross-section, limited hydraulic calibration data, the absence

of detailed habitat mapping, and the lack of long-term water quality and sediment transport information. Consequently, the recommended e-flow regime should be viewed as a precautionary and scientifically defensible approach that is based on the best available information and specialist judgement.

The above recommended e-flow regime comprised a combination of seasonal base-flows, drought protection flows, and periodic freshet releases designed to mimic key elements of the natural flow regime. The regime aims to:

- Maintain year-round aquatic habitat and ecological connectivity;
- Provide suitable hydraulic conditions for *S. richardsonii* migration, spawning, juvenile development, feeding, and refuge requirements;
- Sustain macroinvertebrate communities and overall aquatic ecosystem health;
- Support sediment mobilisation, channel maintenance, and habitat renewal processes; and
- Preserve water quality and ecosystem resilience throughout the annual hydrological cycle.

The layout of the Bunakha infrastructure in relation to the Chukha Dam backwater effects results in only 400 m of the Bunakha-Chukha reach remaining river habitat, the rest will be inundated by the Bunakha Reservoir, Bunakha Dam stilling basin and the backwater effect of the Chukha Dam. This short river reach between the Bunakha and Chukha Dam will be isolated from the rest of the Whanchu River by the dam barriers, limiting its biophysical function. This Dewatering Reach 1 is proposed to become a sacrificial reach with no e-flow. The study recommends that the proposed e-flow regime be implemented within Dewatered Reach 2, between the Chukha and Tala dams, as a partial offset to restore key ecological processes and improve aquatic habitat conditions along approximately 10 km of river reach. Although this would not fully compensate for the loss of river habitat associated with the Bunakha Dam development, it would provide a meaningful ecological offset. When combined with the proposed fish conservation and enhancement programme, these measures would contribute towards no net loss objectives for aquatic ecosystem function and indigenous fish populations at the river-system scale, while delivering a localised net gain in ecological condition within the Dewatered Reach 2.

To reduce uncertainty and improve confidence in future e-flow management, implementation of the recommended flow regime should be supported by an updated eflow study to improve on the current gaps (such as hydraulics, scenario analysis, habitat mapping, stakeholder input). The updated e-flows study should inform a comprehensive Environmental Flow Management Plan, together with long-term ecological, hydraulic, and water quality monitoring. An adaptive management framework should be adopted to evaluate ecosystem responses and refine environmental flow releases as additional ecological and operational data become available. This approach will assist in maintaining the long-term ecological integrity and resilience of the Wangchu River while optimising the benefits of the Bunakha Hydropower Project within the broader Wangchu cascade system.

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10 APPENDICES

APPENDIX 1: Hydraulic Lookup Tables

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
0.02	0.01	0.001	0.9	0.9	0.07	0.23	99	0	0	1	0	0	0
0.04	0.02	0.004	1.8	1.8	0.11	0.36	95	0	0	5	0	0	0
0.06	0.03	0.012	2.6	2.6	0.15	0.47	91	0	0	9	0	0	0
0.08	0.04	0.026	3.1	3.2	0.19	0.6	81	0	0	19	0	0	0
0.1	0.06	0.047	3.7	3.7	0.23	0.71	70	1	0	29	0	0	0
0.12	0.07	0.075	4.2	4.2	0.26	0.8	50	13	0	29	8	0	0
0.14	0.07	0.106	5.1	5.1	0.28	0.85	38	21	0	27	14	0	0
0.16	0.08	0.145	6.1	6.1	0.3	0.9	32	23	0	26	19	0	0
0.18	0.08	0.194	7.3	7.3	0.31	0.94	30	23	0	27	20	0	0
0.2	0.1	0.264	8.1	8.1	0.34	1.01	26	22	0	28	23	0	0
0.22	0.11	0.354	8.6	8.6	0.38	1.1	22	22	0	28	23	6	0
0.24	0.12	0.458	9	9	0.41	1.2	17	23	0	26	23	12	0
0.26	0.14	0.577	9.4	9.4	0.44	1.3	12	23	0	22	25	17	0
0.28	0.15	0.708	9.8	9.8	0.47	1.37	8	25	0	17	28	21	0
0.3	0.16	0.85	10.3	10.3	0.5	1.44	6	25	0	14	30	24	1
0.32	0.18	1.007	10.8	10.8	0.53	1.5	6	24	0	14	28	23	5
0.34	0.19	1.199	10.9	11	0.57	1.6	5	23	0	12	25	22	12
0.36	0.21	1.408	11.1	11.1	0.6	1.69	4	22	0	11	21	25	17
0.38	0.23	1.632	11.3	11.3	0.64	1.79	3	21	0	10	16	28	21
0.4	0.24	1.872	11.4	11.5	0.67	1.88	2	21	0	8	15	29	25
0.42	0.26	2.127	11.6	11.6	0.7	1.96	2	20	0	6	14	28	29
0.44	0.28	2.399	11.7	11.8	0.74	2.04	1	19	0	5	13	27	34
0.46	0.29	2.687	11.9	12	0.77	2.11	1	19	0	5	12	22	41
0.48	0.31	2.992	12.1	12.1	0.8	2.18	1	18	0	5	10	17	49
0.5	0.33	3.313	12.2	12.3	0.83	2.25	1	17	0	5	8	14	55
0.52	0.34	3.651	12.4	12.5	0.87	2.32	1	15	1	5	6	14	58

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
0.54	0.36	3.999	12.6	12.7	0.89	2.38	1	13	2	5	5	13	60
0.56	0.37	4.359	12.8	12.9	0.92	2.45	1	12	3	5	6	11	62
0.58	0.38	4.714	13.1	13.2	0.95	2.51	1	11	4	7	5	10	63
0.6	0.39	5.088	13.5	13.6	0.97	2.56	1	10	4	7	6	7	65
0.62	0.4	5.481	13.8	13.9	0.99	2.59	1	9	5	8	5	6	66
0.64	0.41	5.894	14.1	14.2	1.02	2.66	2	8	5	9	6	5	66
0.66	0.42	6.328	14.5	14.6	1.04	2.69	1	6	6	9	6	4	67
0.68	0.4	6.458	16	16.2	1.01	2.63	3	5	6	15	6	5	60
0.7	0.39	6.782	17.1	17.2	1.01	2.63	3	5	7	18	7	4	57
0.72	0.39	7.146	18.1	18.2	1.01	2.6	3	4	7	20	7	4	55
0.74	0.4	7.643	18.8	18.9	1.03	2.65	3	4	7	21	8	3	54
0.76	0.41	8.263	19.1	19.2	1.06	2.7	3	4	7	20	7	4	54
0.78	0.42	8.912	19.4	19.5	1.08	2.76	2	4	7	14	14	5	54
0.8	0.44	9.584	19.8	19.9	1.11	2.83	2	4	7	12	16	6	54
0.82	0.45	10.287	20.1	20.2	1.14	2.9	1	4	6	10	18	6	54
0.84	0.46	11.02	20.4	20.6	1.17	2.91	1	4	6	7	17	9	55
0.86	0.47	11.786	20.8	20.9	1.2	3	1	4	6	7	16	11	55
0.88	0.49	12.615	21	21.2	1.23	3.07	1	4	6	7	14	12	56
0.9	0.5	13.508	21.2	21.4	1.27	3.09	1	4	6	6	12	15	57
0.92	0.52	14.436	21.4	21.5	1.3	3.07	1	4	5	5	9	17	60
0.94	0.53	15.35	21.7	21.8	1.33	3.12	1	4	5	5	8	17	60
0.96	0.54	16.249	22.1	22.2	1.36	3.1	0	4	5	5	6	17	63
0.98	0.55	17.186	22.5	22.6	1.39	3.17	1	3	5	6	6	14	65
1	0.56	18.16	22.8	23	1.41	3.18	1	3	5	6	5	11	68
1.02	0.57	19.174	23.2	23.4	1.44	3.2	1	3	4	7	6	9	70
1.04	0.57	19.923	24.2	24.4	1.44	3.19	1	3	4	9	5	8	70
1.06	0.56	20.45	25.7	25.9	1.43	3.19	1	3	4	13	4	7	68
1.08	0.54	20.899	27.6	27.8	1.41	3.22	1	3	4	16	6	5	64

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
1.1	0.56	22.296	27.7	27.9	1.45	3.21	1	3	4	15	6	5	67
1.12	0.57	23.743	27.8	28.1	1.49	3.24	1	3	4	12	8	5	67
1.14	0.59	25.243	28	28.2	1.53	3.27	1	3	4	9	11	6	67
1.16	0.61	26.795	28.1	28.4	1.57	3.3	0	3	4	6	14	4	69
1.18	0.6	27.76	29.4	29.6	1.57	3.31	1	2	4	7	13	5	68
1.2	0.6	28.84	30.5	30.7	1.58	3.36	1	2	4	10	11	6	66
1.22	0.6	29.997	31.6	31.9	1.59	3.4	1	2	4	12	10	8	64
1.24	0.61	31.601	32.1	32.4	1.62	3.43	1	2	4	12	7	11	64
1.26	0.62	33.268	32.7	32.9	1.65	3.42	1	2	4	9	9	11	65
1.28	0.63	34.982	33.2	33.5	1.68	3.47	1	2	3	9	10	11	64
1.3	0.64	36.355	33.6	33.8	1.69	3.5	0	2	3	6	12	10	66
1.32	0.65	37.7	33.9	34.2	1.7	3.51	0	2	3	5	13	9	67
1.34	0.67	39.073	34.2	34.5	1.71	3.52	0	2	3	6	11	7	70
1.36	0.68	40.474	34.6	34.9	1.72	3.55	0	2	3	6	9	8	72
1.38	0.69	41.904	34.9	35.2	1.73	3.58	0	2	3	5	8	9	72
1.4	0.71	43.363	35.3	35.5	1.74	3.57	0	2	3	5	7	11	73
1.42	0.72	44.851	35.6	35.9	1.75	3.58	0	2	3	5	6	10	74
1.44	0.73	46.369	35.9	36.2	1.76	3.61	0	2	3	5	5	11	74
1.46	0.75	47.915	36.3	36.6	1.77	3.57	0	2	3	4	4	11	77
1.48	0.76	49.491	36.6	36.9	1.78	3.6	0	1	3	4	4	11	77
1.5	0.77	51.097	37	37.2	1.79	3.61	0	1	3	4	4	9	80
1.52	0.78	52.732	37.3	37.6	1.8	3.64	0	1	3	4	4	6	83
1.54	0.8	54.398	37.6	37.9	1.81	3.7	0	1	3	5	4	5	82
1.56	0.81	56.093	38	38.3	1.82	3.7	0	1	3	4	4	5	83
1.58	0.82	57.819	38.3	38.6	1.83	3.71	0	1	3	4	4	5	84
1.6	0.84	59.575	38.6	38.9	1.84	3.69	0	1	3	4	4	4	84
1.62	0.85	61.362	39	39.3	1.86	3.77	0	1	3	4	4	4	84
1.64	0.86	63.179	39.3	39.6	1.87	3.79	0	1	3	4	4	4	84

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
1.66	0.87	65.027	39.6	39.9	1.88	3.82	0	1	3	4	4	4	84
1.68	0.89	66.907	39.9	40.2	1.89	3.84	0	1	3	4	4	4	84
1.7	0.9	68.817	40.2	40.5	1.9	3.86	0	1	3	3	5	4	84
1.72	0.91	70.758	40.6	40.9	1.91	3.91	0	1	3	4	4	4	84
1.74	0.93	72.731	40.9	41.2	1.92	3.93	0	1	3	4	4	4	84
1.76	0.94	74.735	41.2	41.5	1.93	3.94	0	1	3	4	4	4	85
1.78	0.95	76.771	41.5	41.8	1.94	3.97	0	1	3	4	4	4	85
1.8	0.96	78.839	41.8	42.2	1.95	3.97	0	1	3	4	4	4	85
1.82	0.98	80.939	42.2	42.5	1.97	3.95	0	1	3	3	4	4	86
1.84	0.99	83.071	42.5	42.8	1.98	3.95	0	1	3	3	4	4	86
1.86	1	85.235	42.8	43.1	1.99	4.03	0	1	3	4	4	3	85
1.88	1.02	87.431	43.1	43.4	2	4.06	0	1	3	4	4	3	85
1.9	1.03	89.659	43.4	43.7	2.01	4.09	0	1	3	4	4	3	85
1.92	1.04	91.921	43.7	44	2.02	4.11	0	1	3	3	4	3	86
1.94	1.05	94.215	44	44.3	2.03	4.15	0	1	3	3	4	3	87
1.96	1.06	96.542	44.4	44.7	2.04	4.21	0	0	3	4	4	3	86
1.98	1.08	98.901	44.8	45.1	2.05	4.23	0	1	3	4	4	3	86
2	1.09	101.294	45.2	45.5	2.07	4.24	0	1	3	4	4	3	86
2.02	1.1	103.72	45.5	45.9	2.08	4.24	0	1	3	4	4	4	86
2.04	1.11	106.18	45.9	46.3	2.09	4.26	0	0	3	4	4	3	85
2.06	1.12	108.673	46.3	46.7	2.1	4.24	0	0	3	4	3	3	86
2.08	1.13	111.199	46.7	47.1	2.11	4.23	0	0	3	3	3	3	87
2.1	1.14	113.759	47.1	47.5	2.12	4.26	0	0	3	3	3	3	87
2.12	1.15	116.354	47.5	47.9	2.13	4.3	0	0	3	3	3	3	87
2.14	1.16	118.982	47.9	48.3	2.14	4.34	0	0	3	3	3	3	86
2.16	1.17	121.644	48.3	48.6	2.15	4.35	0	0	3	3	3	3	87
2.18	1.18	124.34	48.7	49	2.16	4.42	0	0	3	4	4	3	86
2.2	1.19	127.071	49	49.4	2.17	4.44	0	0	3	4	4	3	86

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
2.22	1.21	129.836	49.3	49.7	2.18	4.47	0	0	3	4	4	3	86
2.24	1.22	132.635	49.5	49.9	2.2	4.45	0	0	3	3	3	3	87
2.26	1.23	135.47	49.8	50.2	2.21	4.5	0	0	3	3	3	4	86
2.28	1.25	138.339	50	50.4	2.22	4.46	0	0	3	3	3	3	88
2.3	1.26	141.243	50.2	50.6	2.23	4.49	0	0	3	3	3	3	88
2.32	1.28	144.182	50.5	50.9	2.24	4.52	0	0	3	2	3	4	88
2.34	1.29	147.156	50.7	51.1	2.25	4.51	0	0	3	2	3	4	89
2.36	1.3	150.165	50.9	51.3	2.26	4.58	0	0	3	2	3	4	88
2.38	1.32	153.21	51.2	51.6	2.27	4.56	0	0	3	2	2	3	90
2.4	1.33	156.29	51.4	51.8	2.28	4.59	0	0	3	2	2	3	90
2.42	1.35	159.406	51.6	52	2.29	4.67	0	0	3	2	3	3	89
2.44	1.36	162.558	51.9	52.3	2.3	4.67	0	0	3	2	2	3	90
2.46	1.37	165.745	52.1	52.5	2.31	4.73	0	0	3	2	2	2	90
2.48	1.39	168.968	52.3	52.8	2.33	4.73	0	0	3	2	2	2	91
2.5	1.4	172.228	52.6	53	2.34	4.78	0	0	3	2	2	2	90
2.52	1.42	175.523	52.8	53.2	2.35	4.79	0	0	3	2	2	2	90
2.54	1.43	178.855	53	53.5	2.36	4.78	0	0	3	2	2	2	92
2.56	1.44	182.223	53.3	53.7	2.37	4.86	0	0	3	2	2	2	91
2.58	1.46	185.628	53.5	53.9	2.38	4.82	0	0	3	2	2	2	92
2.6	1.47	189.069	53.7	54.2	2.39	4.85	0	0	3	2	2	2	91
2.62	1.48	192.547	54	54.4	2.4	4.87	0	0	3	2	2	2	91
2.64	1.5	196.062	54.2	54.6	2.42	4.85	0	0	3	2	2	2	92
2.66	1.51	199.613	54.4	54.9	2.43	4.93	0	0	3	2	2	2	91
2.68	1.52	203.202	54.7	55.1	2.44	4.91	0	0	3	2	2	2	92
2.7	1.54	206.827	54.9	55.3	2.45	4.97	0	0	3	2	2	2	91
2.72	1.56	210.49	55	55.4	2.46	4.99	0	0	3	2	2	2	91
2.74	1.57	214.19	55.1	55.6	2.47	5.03	0	0	3	2	2	2	92
2.76	1.59	217.928	55.2	55.7	2.48	5.06	0	0	3	2	2	2	92

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
2.78	1.61	221.703	55.3	55.8	2.5	5.06	0	0	3	2	2	2	92
2.8	1.62	225.516	55.5	55.9	2.51	5.07	0	0	3	2	2	2	92
2.82	1.64	229.367	55.6	56.1	2.52	5.1	0	0	3	2	2	2	93
2.84	1.66	233.255	55.7	56.2	2.53	5.08	0	0	3	1	1	2	94
2.86	1.67	237.181	55.8	56.3	2.54	5.12	0	0	3	1	1	3	93
2.88	1.69	241.146	55.9	56.4	2.55	5.16	0	0	3	1	1	2	93
2.9	1.71	245.148	56	56.5	2.57	5.14	0	0	3	1	1	2	95
2.92	1.73	249.189	56	56.6	2.58	5.23	0	0	3	1	1	1	94
2.94	1.74	253.268	56.1	56.7	2.59	5.22	0	0	3	0	1	1	95
2.96	1.76	257.385	56.2	56.7	2.6	5.3	0	0	3	1	1	1	94
2.98	1.78	261.542	56.2	56.8	2.61	5.29	0	0	3	0	0	1	95
3	1.8	265.736	56.3	56.9	2.63	5.32	0	0	3	0	0	2	95
3.02	1.81	269.97	56.4	57	2.64	5.4	0	0	3	0	0	1	95
3.04	1.83	274.242	56.4	57	2.65	5.35	0	0	3	0	0	1	96
3.06	1.85	278.553	56.5	57.1	2.66	5.43	0	0	3	0	0	1	95
3.08	1.87	282.903	56.5	57.2	2.68	5.41	0	0	3	0	0	1	96
3.1	1.89	287.292	56.6	57.3	2.69	5.43	0	0	3	0	0	1	96
3.12	1.9	291.721	56.7	57.3	2.7	5.52	0	0	3	0	0	1	95
3.14	1.92	296.189	56.7	57.4	2.72	5.45	0	0	3	0	0	1	97
3.16	1.94	300.696	56.8	57.5	2.73	5.55	0	0	3	0	0	1	96
3.18	1.96	305.243	56.9	57.6	2.74	5.52	0	0	3	0	0	1	97
3.2	1.98	309.829	56.9	57.6	2.75	5.54	0	0	3	0	0	1	97
3.22	1.99	314.455	57	57.7	2.77	5.63	0	0	2	0	0	1	96
3.24	2.01	319.121	57.1	57.8	2.78	5.59	0	0	3	0	0	1	97
3.26	2.03	323.827	57.1	57.9	2.79	5.67	0	0	2	0	0	1	96
3.28	2.04	328.572	57.2	58	2.81	5.7	0	0	2	0	0	1	96
3.3	2.06	333.358	57.3	58.1	2.82	5.67	0	0	2	0	0	1	97
3.32	2.08	338.184	57.4	58.2	2.83	5.75	0	0	2	0	0	1	96

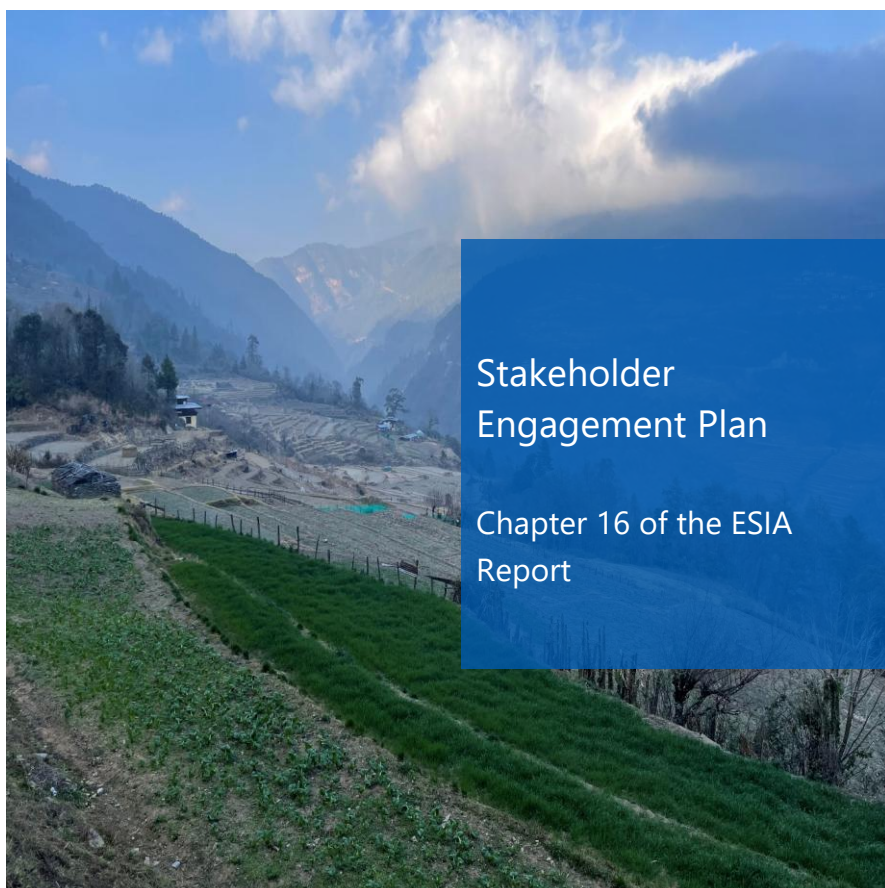
Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
3.34	2.1	343.05	57.5	58.3	2.85	5.73	0	0	2	0	0	1	97
3.36	2.11	347.956	57.6	58.4	2.86	5.77	0	0	2	0	0	1	97
3.38	2.13	352.903	57.7	58.5	2.87	5.8	0	0	2	0	0	1	97
3.4	2.15	357.891	57.8	58.6	2.89	5.82	0	0	2	0	0	1	97
3.42	2.16	362.919	57.9	58.7	2.9	5.82	0	0	2	0	0	0	96
3.44	2.18	367.988	57.9	58.8	2.91	5.92	0	0	2	1	1	1	95
3.46	2.2	373.097	58	58.9	2.93	5.95	0	0	2	1	1	1	95
3.48	2.21	378.247	58.1	59	2.94	5.99	0	0	2	1	1	1	95
3.5	2.23	383.439	58.2	59.1	2.96	6.03	0	0	2	1	1	1	95
3.52	2.25	388.671	58.3	59.2	2.97	6	0	0	2	0	0	0	96
3.54	2.26	393.945	58.4	59.3	2.98	6.03	0	0	2	0	0	0	96
3.56	2.28	399.26	58.5	59.4	3	6.05	0	0	2	0	0	0	96
3.58	2.3	404.616	58.6	59.4	3.01	6.1	0	0	2	0	0	1	96
3.6	2.31	410.013	58.6	59.5	3.02	6.13	0	0	2	0	0	1	96
3.62	2.33	415.452	58.7	59.6	3.04	6.19	0	0	2	1	1	1	95
3.64	2.34	420.933	58.8	59.7	3.05	6.21	0	0	2	1	1	1	95
3.66	2.36	426.455	58.9	59.8	3.07	6.25	0	0	2	1	1	1	95
3.68	2.38	432.02	59	59.9	3.08	6.27	0	0	2	1	1	1	95
3.7	2.39	437.625	59.1	60	3.09	6.2	0	0	2	0	0	1	96
3.72	2.41	443.273	59.2	60.1	3.11	6.23	0	0	2	0	0	1	96
3.74	2.43	448.963	59.3	60.2	3.12	6.27	0	0	2	0	0	1	96
3.76	2.44	454.695	59.3	60.3	3.14	6.31	0	0	2	0	0	1	96
3.78	2.46	460.469	59.4	60.4	3.15	6.33	0	0	2	0	0	1	96
3.8	2.48	466.286	59.5	60.5	3.16	6.44	0	0	2	1	1	1	95
3.82	2.49	472.145	59.6	60.6	3.18	6.46	0	0	2	1	1	1	95
3.84	2.51	478.046	59.7	60.7	3.19	6.5	0	0	2	1	1	1	95
3.86	2.53	483.99	59.8	60.8	3.21	6.52	0	0	2	1	1	1	96
3.88	2.54	489.976	59.9	60.9	3.22	6.49	0	0	2	0	0	1	96

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
3.9	2.56	496.005	60	61	3.23	6.52	0	0	2	0	0	1	97
3.92	2.57	502.077	60.1	61.1	3.25	6.54	0	0	2	0	0	1	97
3.94	2.59	508.192	60.1	61.2	3.26	6.57	0	0	2	0	0	1	97
3.96	2.61	514.349	60.2	61.3	3.28	6.59	0	0	2	0	0	0	97
3.98	2.62	520.55	60.3	61.4	3.29	6.69	0	0	2	1	1	1	96
4	2.64	526.794	60.4	61.5	3.31	6.67	0	0	2	1	1	1	96
4.02	2.66	533.081	60.5	61.6	3.32	6.65	0	0	2	0	0	0	97
4.04	2.67	539.411	60.5	61.6	3.33	6.7	0	0	2	0	0	0	97
4.06	2.69	545.785	60.6	61.7	3.35	6.73	0	0	2	0	0	0	97
4.08	2.71	552.202	60.7	61.8	3.36	6.77	0	0	2	0	0	0	97
4.1	2.72	558.663	60.8	61.9	3.38	6.81	0	0	2	0	0	0	97
4.12	2.74	565.167	60.8	62	3.39	6.92	0	0	2	1	1	1	96
4.14	2.76	571.715	60.9	62.1	3.41	6.96	0	0	2	1	1	1	96
4.16	2.77	578.306	61	62.2	3.42	6.96	0	0	2	0	0	0	97
4.18	2.79	584.942	61.1	62.2	3.43	6.99	0	0	2	0	0	0	97
4.2	2.81	591.621	61.1	62.3	3.45	7.03	0	0	2	0	0	0	97
4.22	2.82	598.344	61.2	62.4	3.46	6.99	0	0	2	0	0	0	98
4.24	2.84	605.112	61.3	62.5	3.48	7.02	0	0	2	0	0	0	98
4.26	2.86	611.923	61.4	62.6	3.49	7.04	0	0	2	0	0	0	98
4.28	2.87	618.779	61.4	62.7	3.51	7.13	0	0	2	0	0	0	97
4.3	2.89	625.679	61.5	62.7	3.52	7.12	0	0	2	0	0	0	97
4.32	2.91	632.624	61.6	62.8	3.54	7.09	0	0	2	0	0	0	98
4.34	2.92	639.613	61.7	62.9	3.55	7.22	0	0	2	0	0	0	97
4.36	2.94	646.646	61.7	63	3.57	7.25	0	0	2	0	0	0	97
4.38	2.95	653.724	61.8	63.1	3.58	7.29	0	0	2	0	0	0	97
4.4	2.97	660.847	61.9	63.2	3.59	7.25	0	0	2	0	0	0	98
4.42	2.99	668.015	61.9	63.2	3.61	7.29	0	0	2	0	0	0	98
4.44	3	675.227	62	63.3	3.62	7.31	0	0	2	0	0	0	98

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
4.46	3.02	682.485	62.1	63.4	3.64	7.34	0	0	2	0	0	0	98
4.48	3.04	689.787	62.2	63.5	3.65	7.36	0	0	2	0	0	0	98
4.5	3.05	697.135	62.2	63.6	3.67	7.46	0	0	2	0	0	0	97
4.52	3.07	704.527	62.3	63.7	3.68	7.5	0	0	2	0	0	0	97
4.54	3.09	711.965	62.4	63.8	3.7	7.53	0	0	2	0	0	0	97
4.56	3.1	719.448	62.5	63.8	3.71	7.57	0	0	2	0	0	0	97
4.58	3.12	726.977	62.5	63.9	3.73	7.6	0	0	2	0	0	0	97
4.6	3.13	734.551	62.6	64	3.74	7.55	0	0	2	0	0	0	98
4.62	3.15	742.171	62.7	64.1	3.76	7.53	0	0	2	0	0	0	98
4.64	3.17	749.836	62.8	64.2	3.77	7.64	0	0	2	0	0	0	97
4.66	3.18	757.547	62.8	64.3	3.79	7.61	0	0	2	0	0	0	98
4.68	3.2	765.303	62.9	64.3	3.8	7.72	0	0	2	0	0	0	97
4.7	3.22	773.106	63	64.4	3.82	7.68	0	0	2	0	0	0	98
4.72	3.23	780.954	63.1	64.5	3.83	7.71	0	0	2	0	0	0	98
4.74	3.25	788.849	63.1	64.6	3.85	7.82	0	0	2	0	0	0	97
4.76	3.26	796.789	63.2	64.7	3.86	7.85	0	0	2	0	0	0	97
4.78	3.28	804.776	63.3	64.8	3.88	7.89	0	0	2	1	1	1	96
4.8	3.3	812.808	63.4	64.8	3.89	7.86	0	0	2	0	0	0	97
4.82	3.31	820.887	63.4	64.9	3.91	7.89	0	0	2	0	0	0	97
4.84	3.33	829.013	63.5	65	3.92	7.92	0	0	2	0	0	0	97
4.86	3.35	837.185	63.6	65.1	3.94	7.96	0	0	2	0	0	0	97
4.88	3.36	845.403	63.6	65.2	3.95	8	0	0	2	0	0	0	97
4.9	3.38	853.668	63.7	65.3	3.97	8.09	0	0	2	1	1	1	96
4.92	3.39	861.979	63.8	65.4	3.98	8.11	0	0	2	1	1	1	96
4.94	3.41	870.338	63.9	65.4	4	8.13	0	0	2	1	1	1	96
4.96	3.43	878.743	63.9	65.5	4.01	8.12	0	0	2	1	1	1	96
4.98	3.44	887.195	64	65.6	4.03	8.16	0	0	2	1	1	1	96
5	3.46	895.693	64.1	65.7	4.04	8.12	0	0	2	0	0	0	97

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
5.02	3.47	904.239	64.2	65.8	4.06	8.17	0	0	2	0	0	0	97
5.04	3.49	912.832	64.2	65.9	4.07	8.2	0	0	2	0	0	0	97
5.06	3.51	921.472	64.3	65.9	4.09	8.34	0	0	2	1	1	1	96
5.08	3.52	930.159	64.4	66	4.1	8.38	0	0	2	1	1	1	96
5.1	3.54	938.894	64.4	66.1	4.12	8.32	0	0	2	0	0	0	98
5.12	3.56	947.676	64.5	66.1	4.13	8.43	0	0	2	0	0	0	97
5.14	3.57	956.505	64.5	66.2	4.15	8.38	0	0	2	0	0	0	98
5.16	3.59	965.382	64.6	66.3	4.16	8.41	0	0	2	0	0	0	98
5.18	3.61	974.306	64.7	66.4	4.18	8.45	0	0	2	0	0	0	98
5.2	3.62	983.278	64.7	66.4	4.19	8.57	0	0	2	0	0	0	97
5.22	3.64	992.298	64.8	66.5	4.21	8.6	0	0	2	0	0	0	97
5.24	3.66	1001.365	64.8	66.6	4.22	8.54	0	0	2	0	0	0	98
5.26	3.67	1010.48	64.9	66.6	4.24	8.63	0	0	2	0	0	0	97
5.28	3.69	1019.644	65	66.7	4.25	8.57	0	0	2	0	0	0	98
5.3	3.71	1028.855	65	66.8	4.27	8.53	0	0	2	0	0	0	98
5.32	3.72	1038.114	65.1	66.9	4.28	8.57	0	0	2	0	0	0	98
5.34	3.74	1047.421	65.1	66.9	4.3	8.7	0	0	2	0	0	0	97
5.36	3.76	1056.777	65.2	67	4.32	8.75	0	0	2	0	0	0	97
5.38	3.77	1066.181	65.2	67.1	4.33	8.7	0	0	2	0	0	0	98
5.4	3.79	1075.633	65.3	67.1	4.35	8.83	0	0	2	0	0	0	97
5.42	3.81	1085.133	65.4	67.2	4.36	8.79	0	0	2	0	0	0	97
5.44	3.82	1094.682	65.4	67.3	4.38	8.83	0	0	2	0	0	0	97
5.46	3.84	1104.28	65.5	67.4	4.39	8.87	0	0	2	0	0	0	97
5.48	3.86	1113.926	65.5	67.4	4.41	8.97	0	0	2	0	0	0	97
5.5	3.87	1123.62	65.6	67.5	4.42	8.99	0	0	2	0	0	0	97
5.52	3.89	1133.364	65.7	67.6	4.44	8.93	0	0	2	0	0	0	97
5.54	3.91	1143.156	65.7	67.6	4.45	9.05	0	0	2	0	0	0	96
5.56	3.92	1152.997	65.8	67.7	4.47	9	0	0	2	0	0	0	97

Maxdepth	Avdepth	Discharge	Width	Perim	AvVel	Vel98%	Dist_FishHT's(%)						
(m)	(m)	(m3/s)	(m)	(m)	(m/s)	(m/s)	SVS	SS	SD	FVS	FS	FI	FD
5.58	3.94	1162.887	65.8	67.8	4.48	9.02	0	0	2	0	0	0	97
5.6	3.96	1172.826	65.9	67.9	4.5	9.04	0	0	2	0	0	0	97
5.62	3.97	1182.814	65.9	67.9	4.52	9.14	0	0	2	0	0	0	96
5.64	3.99	1192.851	66	68	4.53	9.17	0	0	2	0	0	0	96
5.66	4.01	1202.938	66.1	68.1	4.55	9.1	0	0	2	0	0	0	97
5.68	4.02	1213.073	66.1	68.1	4.56	9.21	0	0	2	1	1	1	95
5.7	4.04	1223.258	66.2	68.2	4.58	9.17	0	0	2	0	0	0	96
5.72	4.05	1233.493	66.2	68.3	4.59	9.21	0	0	2	0	0	0	96
5.74	4.07	1243.776	66.3	68.3	4.61	9.25	0	0	2	0	0	0	96
5.76	4.09	1254.11	66.3	68.4	4.62	9.39	0	0	2	0	0	0	95
5.78	4.1	1264.493	66.4	68.5	4.64	9.42	0	0	2	0	0	0	95
5.8	4.12	1274.925	66.5	68.6	4.66	9.38	0	0	2	0	0	0	96
5.82	4.14	1285.407	66.5	68.6	4.67	9.49	0	0	2	0	0	0	95
5.84	4.15	1295.94	66.6	68.7	4.69	9.44	0	0	2	0	0	0	96
5.86	4.17	1306.521	66.6	68.8	4.7	9.48	0	0	2	0	0	0	96
5.88	4.19	1317.153	66.7	68.8	4.72	9.52	0	0	2	0	0	0	96
5.9	4.2	1327.835	66.8	68.9	4.73	9.65	0	0	1	0	0	0	95
5.92	4.22	1338.567	66.8	69	4.75	9.68	0	0	1	0	0	0	95
5.94	4.23	1349.349	66.9	69.1	4.76	9.62	0	0	1	0	0	0	96
5.96	4.25	1360.181	66.9	69.1	4.78	9.75	0	0	1	0	0	0	95
5.98	4.27	1371.063	67	69.2	4.8	9.69	0	0	1	0	0	0	95
6	4.28	1381.996	67	69.3	4.81	9.79	0	0	1	0	0	0	95



Stakeholder Engagement Plan

Chapter 16 of the ESIA
Report

Consultancy Services for Review and Update of DPR and ESIA of
Bunakha Hydropower Project

Druk Green Power Corporation Ltd.

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List of Abbreviations

ADB	Asian Development Bank
AM	Accountability Mechanism
BHRM	ADB Bhutan Resident Mission
CBO	Community-Based Organization
CDA	Chhukha District (Dzongkhag) Administration
CLO	Community Liaison Officer
CRO	Complaint Receiving Officer
CRP	Compliance Review Panel
DECC	Department of Environment and Climate Change
DGPC	Druk Green Power Corporation
DoFPS	Department of Forests and Park Services
DoW	Department of Water
EBRD	European Bank for Reconstruction and Development
EIB	European Investment Bank
EHS	Environment, Health and Safety
EO	Environment Officer
ESIA	Environmental and Social Impact Assessment
ESMU	Environment and Social Management Unit
ESHS	Environment, Social, Health and Safety
FGD	Focus Group Discussion
GAO	Gewog Administrative Officer
GBV	Gender-Based Violence
GRM	Grievance Redress Mechanism
GVA&AP	Gender and Vulnerability Assessment & Action Plan
HPP	Hydropower Project
IAP	Interested and Affected Party
IP	Interested Party
IUCN	International Union for Conservation of Nature
KII	Key Informant Interview
MoENR	Ministry of Energy and Natural Resources
NEC	National Environment Commission
NGO	Non-Governmental Organization
OSPF	Office of the Special Project Facilitator
PAP	Project Affected Person
PIC	Project Implementation Consultant
PIU	Project Implementation Unit
PMU	Project Management Unit
PCS	(Project Consulting Services — referenced but not spelled out)
RGoB	Royal Government of Bhutan
RP	Resettlement Plan
SEA	Sexual Exploitation and Abuse
SEP	Stakeholder Engagement Plan
SH	Sexual Harassment
SO	Social Officer
SPS	Safeguard Policy Statement
WB ESS	World Bank Environmental and Social Standard

1 Stakeholder Engagement

Stakeholder engagement, which in technical terms goes beyond “consultation” and includes “disclosure of information” as well, is a requirement of the ADB for every sponsored project that may create significant environmental and social impacts. Therefore, as part of the ESIA, a Stakeholder Engagement Plan is developed and, together with the Client, some of its activities have already been implemented.

1.1 Basic Concepts

Stakeholder engagement is an inclusive process conducted throughout a project’s life cycle designed and implemented in order to support the development of strong, constructive and responsive relationships that are important for successful management of a project’s environmental and social risks (WB ESS 10¹).

Stakeholder should be understood as every governmental or administrative body, every community, non-governmental organization, groups or individual persons who might get affected (directly or indirectly, positively or negatively) by the proposed project (commonly referred to as “project-affected people”, “project-affected communities” or “project-affected parties”), as well as those who might have an interest in, or may influence, the project (the “interested parties”) (EIB, 2022; EBRD, 2019; WB ESS 10). In a broad way, stakeholders can be referred to as **IAPs - interested and affected parties**

Disclosure is a formal-sounding term for making information accessible to IAPs. Information is critical to the effective participation of affected citizens near the project under assessment. ADB’s SPS (2009) require that relevant information (whether positive or negative) about social and environmental safeguard issues is made available in a timely manner, in an accessible place, and in a form and language(s) understandable to affected people and to other stakeholders, including the general public, so they can provide meaningful inputs into project design and implementation.

ADB will post the following safeguard documents on its website:

- for environment category A projects, draft environmental impact assessment reports at least 120 days before Board consideration;
- draft environmental assessment and review framework, draft resettlement frameworks and/or plans, and draft Indigenous Peoples planning frameworks and/or plans before project appraisal;
- final or updated environmental impact assessments and/or initial environmental examinations, resettlement plans, and Indigenous Peoples plans upon receipt;
- environmental, involuntary resettlement, and Indigenous Peoples monitoring reports submitted by borrowers/clients during project implementation upon receipt.

Consultation is a process of deliberation, discussion and dialogue. It is more than just disclosing information, although clear, transparent and timely information is the basis for any consultation process. The objective of the consultation is also to seek feedback, advice and opinion of the stakeholders in order to shape the project, to the extent possible, to their needs and concerns. In this sense, the vulnerable

¹ World Bank E&S Standard 10, Stakeholder Engagement and Information Disclosure:
<https://thedocs.worldbank.org/en/doc/837721522762050108-0290022018/original/ESFFramework.pdf#page=111&zoom=80>

groups shall be given a particular chance of having their voice heard. According to ADB's SPS (2009), meaningful consultation is a process that:

- begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle;
- provides timely disclosure of relevant and adequate information that is understandable and readily accessible to affected people;
- is undertaken in an atmosphere free of intimidation or coercion;
- is gender inclusive and responsive, and tailored to the needs of disadvantaged and vulnerable groups; and
- enables the incorporation of all relevant views of affected people and other stakeholders into decision making, such as project design, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.

1.2 Applicable Requirements

1.2.1 National legal requirements

The Environmental Assessment Act, 2000 of Bhutan establishes procedures for assessing environmental impacts of projects, plans, and programs. It requires developers to obtain environmental clearance and follow an assessment process that includes public consultation.

The Act itself sets the framework, while the detailed requirement for stakeholder or public consultation is elaborated in the Regulation for the Environmental Clearance of Projects (2016), Chapter VI, which explicitly states that public consultation is a required step in the environmental assessment process.

1.2.2 International safeguard requirements

ADB SPS (2009) requires continuous meaningful consultation, information disclosure based on clear, transparent, and inclusive communication, and availability of an accessible grievance redress mechanism throughout the project cycle. It emphasizes early disclosure, culturally appropriate engagement, and ongoing consultation to ensure that stakeholders—especially vulnerable groups—are informed and can participate in decisions affecting them. Specifically:

- Safeguard Requirements 1 requires borrower/clients to carry out meaningful consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation in project development, mitigation measures, the sharing of development benefits and opportunities, and implementation issues.
- Safeguard Requirements 2 (involuntary resettlement) requires the borrower/clients to provide relevant resettlement information, including information on resettlement plans in a timely manner, in an accessible place and in a form and language(s) understandable to affected persons and other stakeholders. For illiterate people, suitable other communication methods shall be used.

ADB's Access to Information Policy (2018) outlines the need to disclose impact assessment results and allow stakeholders to provide comments during a disclosure period. The Policy supports the right of people to seek, receive, and impart information and ideas about ADB-assisted activities.

1.3 Framework and Instruments for Stakeholder Engagement

The nature and extent of stakeholder engagement will reflect the nature and complexity of the project and its stakeholders, the project risks and the potential adverse impacts on individuals, communities and other stakeholders, the sector, and the country context.

Stakeholder engagement is most effective when initiated at an early stage of the project development process and project decisions and the assessment, management and monitoring of the project's environmental and social risks and impacts. A typical process of stakeholder engagement and their key elements are presented in Figure 1.

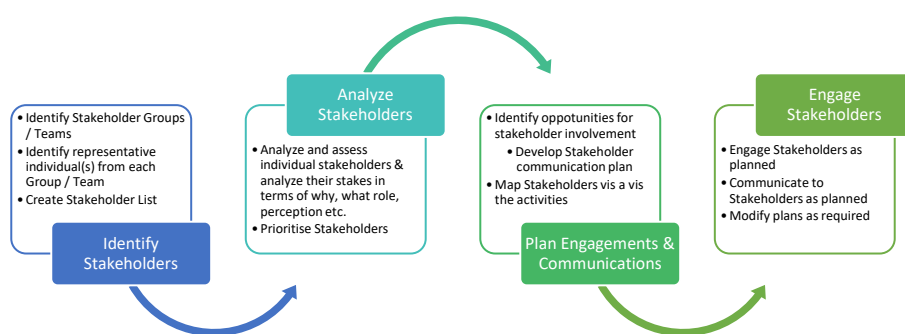


Figure 1: A typical stakeholder engagement process

To support stakeholder engagement planning for the Bunakha HPP, a **Stakeholder Mapping** is prepared (Chapter 1.4) that provides an overview and analysis of the potentially Project-affected communities and interested parties and identifies the interests and potential concerns of each stakeholder group.

Based on the Stakeholder Mapping, a **Stakeholder Engagement Plan (SEP)** is prepared (Chapter 1.5) describing the engagement activities undertaken during the inception and ESIA stages of the Assignment. The stakeholder engagement activities for the Project were performed under consideration of the requirements of the ADB SPS, Access to Information Policy, and the Bhutanese law.

Complementary to the SEP, **Grievance Mechanisms (GMs)** are proposed (1.8) with the objective to provide an effective and systematic procedure in responding to queries, feedbacks and complaints from interested and affected parties (IAPs), including Project workers. The GMs provide clarity and predictability on how complaints will be received, assessed, resolved, and monitored.

1.4 Stakeholder Mapping

The Project stakeholders are identified in terms of their i) impact, ii) influence, iii) partnership, and iv) interest, and are classified using a stakeholder's influence - interest matrix, based on Mendelow (1991) (Figure 2). The matrix is built considering the following:

Q1: the stakeholders that appear in the top right quadrant need to be managed closely. They require continuous, proactive, two-way engagement in form of information, consultation and co-creation of

solutions. These are the stakeholders that are most interested in the Project and have the potential to impact its outcome, i.e., they influence approvals, timelines, budgets, or public acceptance, and ultimately the ability of the Project to go ahead.

Q2: stakeholders in the “high influence, low interest” quadrant (top left) require been kept satisfied. These stakeholders have the power to shape or disrupt the Project, even if they're not deeply invested in its day-to-day details, as they can mobilize public opinion, trigger political pressure, or escalate concerns. Keeping Q2 stakeholders satisfied means proactively ensuring they feel respected, informed, and confident that the Project is being managed responsibly.

Q3: the stakeholders in this quadrant (bottom right) care about the Project because it affects their livelihoods, access to resources, or daily routines. Q3 stakeholders/PAPs are distinct from the Q1 PAPs, who experience direct, primary impacts. They do not possess significant collective power to influence project decisions on their own. Q3 stakeholders do not need high-level political engagement, but they do need consistent, accessible, and meaningful communication.

Q4: the stakeholders in the bottom left quadrant do not require intensive engagement but shall be informed of key Project aspects. While no intensive or targeted consultation is required, the Project shall ensure that basic information remains publicly available and that any emerging concerns or shifts in stakeholder interest are identified early (“monitor”) and addressed appropriately.

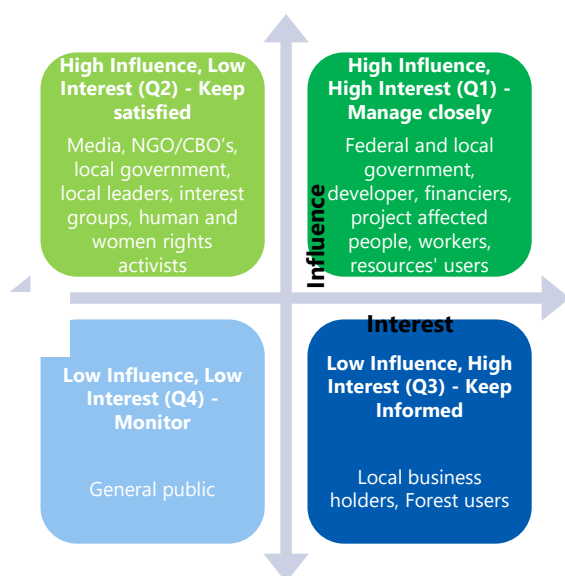


Figure 2: Stakeholder's influence - interest matrix for Bunakha HPP

The stakeholder mapping for the Bunakha HPP is shown in Table 1. The color codes applied correspond to the influence-interest quadrant defined in Figure 2.

Commented [MC1]: How are forest users different from “resources’ users”? Not clear

Commented [P2R1]: Generally it is named as Forest user group.

Table 1: Stakeholder mapping for the Bunakha HPP

Stakeholder	Description	Key Contact	Telephone	Location	Email address
DGPC	Proponent, electricity generation company mostly in HPP	Environment Officer	+97577330839	DGPC, Thimphu	k.dolma3853@drukgreen.bt
NEC	National Environmental Permitting Authority				
ADB	Financer				
PAPs	Project Affected Persons	N.A.	N.A.	Bunakha, Chanachen, Tsamdrak, Shemagangkha	N.A.
Vulnerable Persons	Women and girls, elderly individuals, and single-member households, all of whom may be adversely affected by Project activities such as involuntary resettlement and restricted access to resources due to their social and demographic circumstances. The site surveys recorded two (2) single-member households—one male and one female, both elderly. Nine (9) female residents aged over 70 years and six (6) male residents within the same age bracket.	N.A.	N.A.	Bunakha, Chanachen	N.A.
Project workforce	Includes all individuals employed or contracted to work on the Project during construction, operation, and/or decommissioning phases. This group may consist of skilled and unskilled laborers, technical specialists, supervisors, contractors, and subcontractor personnel. The workforce may be locally hired or brought in from other regions, and will reside either in nearby communities or in dedicated worker accommodation facilities to be built at the site.	Contractors	N.A.	Bunakha, Chanachen	N.A.
Community-Based Organizations (CBOs)	Will be added once formed because for now CBOs are absent in the location				

Commented [MC3]: No one below the poverty line?
No vulnerable ethnic minorities in the project impact area?

Commented [P4R3]: Correct.,

Stakeholder	Description	Key Contact	Telephone	Location	Email address
Non-Governmental Organizations (NGOs)	<i>Will be added once formed because for now CBOs are absent in the location</i>				
Activists (not in the formal structure of NGOs)	<i>Will be added once formed because for now CBOs are absent in the location</i>				
Elected Representatives (local government authorities)	Gups, Mangmis, and Tshogpas are the three key elected local leaders in Bhutan's rural governance system. They form the Gewog Tshogde (Gewog Council), which manages local development, resolves community issues, and represents villagers in decision-making.	Gup/Mangmi, Tshogpas	+97577652638 17791004 17576858	Chapcha, Geling Gewogs	rigdentshoki@gmail.com Geling Gewog phubsithup13@gmail.com Chapcha Gewog
District government officials	They operate within the Dzongkhag Administration, the executive arm of the district government. Their responsibilities are defined by the Local Government Act of 2009 and the structure of the Dzongkhag Tshogdu (District Council). The Dzongkhag Tshogdu is the highest decision-making body at the district level. District officials are responsible for implementing these decisions.	Dzongkhag Surveyor Land Records Officer	17959324 17935544		rigdentshoki@gmail.com Dzongkhag Land record officer gyelmokunzang244@gmail.com Chhukha Dzongkha Land records officer
Local leaders (Communities leaders)		Gup/GAO/Tshogpa	As indicated above		
Forest Officers	Forest officers operate under the Department of Forests and Park Services (DoFPS), which is part of the MoENR. They are responsible for enforcing forest laws, managing forest resources, supporting community forestry, conserving biodiversity, issuing forest-use permits, and monitoring environmental compliance in forests.	Forest Range Office, Gedu	17290405	Gedu	
Media	<i>Will be those that will emerge during the time of project execution</i>				
Forest User Groups (CFs)	Community forests management	Tshogpas	17791004 17576858	Bunakha, Chanachen, Tsamdrak, Shemagangkha	

Stakeholder	Description	Key Contact	Telephone	Location	Email address
Fishery Groups	<i>Will be added</i>				
General Public	Individuals and households who are not directly affected by the Project and do not have a specific functional, economic, or regulatory relationship to it. They include residents of the wider Project region, citizens who may have a general interest in environmental quality or public services, and members of society who may follow project developments through media or public communication channels.	N.A.	N.A.	Bunakha and Chanachen under Chukha Dzongkhag and the general public	N.A.

1.5 Stakeholder Engagement Plan

The Stakeholder Engagement Plan (SEP) describes the timing and methods of engagement with stakeholders of the Project, distinguishing between project-affected persons (PAPs) and other interested parties (IPs). The SEP sets out how communication with stakeholders is and will be handled throughout Project preparation and implementation.

The objective of the SEP is:

- To establish a systematic approach to stakeholder engagement that will help DGPC to build and maintain a constructive relationship with stakeholders.
- To assess the level of stakeholder interest and support for the Project and to enable stakeholders' views to be considered in Project design, improving thereof the environmental and social sustainability of the Project.
- To provide means for effective and inclusive engagement with Project-affected parties and other interested 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 DGPC to respond to and manage such grievances

The Project made and will make disclosure materials available to stakeholders via different communication channels: publishing of documents in DGPC's website, direct disclosure of printed Project brochures in villages, and meetings and hearings in the affected area (details on the selected strategies can be consulted in the SEP table below). Other effective communication networks in the local communities identified throughout the Project lifecycle have been/will be utilized whenever relevant.

Table 2: Stakeholder Engagement Plan for the Bunakha HPP

#	Target Stakeholders	Engagement Activities	Methods of consultation	Location, Timing and Frequency
1	Project Affected People (PAPs), Project Affected Communities and their local government representatives	- Disclosure of project documents such as DPR, ESIA, RP, SEP, GVA&AP and technical reports related to disclosure - Disclosure of the mitigation and compensation measures - Assistance in gathering official documents for authorized land uses - Interactions for identification of land parcels affected, determine and provide compensation - Disclosure of the grievance mechanisms - Consultation meetings - Grievance settlement procedure - During the development of livelihood restoration plan and its implementation - Compensation distribution	- Public meetings / hearings - Face-to-face meetings, FGDs and KIs - Mass/social media communication (as needed and available) - Disclosure of written information in brochures, posters, flyers, and on DGPC's website - Information boards or desks in local, regional and central offices in Thimpu - Individual and group consultation - For illiterate PAPs, provisioning for dictation of disclosures - Focus group discussion - Operation of the grievance mechanism and complaint settlement	Location – places of living of PAPs / village Frequency: - Milestone specific engagements: during inception (January 2025: see Chapter 1.6.1); during baseline surveys (April 2025 - see Chapter 1.6.2) and for presenting ESIA and RP (July 2025 - see Chapter 1.6.3 and December 2025 - see Chapter 1.6.4) - Regular engagements – Quarterly consultation with PAPs representatives is recommended during project construction and initial 2 years of operation to actively obtain their feedback and provide information.
2	Vulnerable PAPs	All of the above (#1) Additionally, these groups require separate dedicated consultation to cater for their limitations and needs	All of the above (#1) - Individual and group meetings. Properly capture opinion of vulnerable PAPs - Open-end interviews, if need is identified	All of the above (#1) Additionally, as needed
3	Community forestry/fishery related groups	All of the above (#1) Additionally, these groups require separate dedicated consultation to cater for their limitations and needs	All of the above (#1) FGDs	All of the above (#1) Location - at the groups centre or residence of groups representatives Frequency: as issues arise
4	Local organizations, NGOs CBOs, and activists - environmental issues	All of the above (#1) Disclosure of Project milestones 'achievement Disclosure of ESMP implementation status	All of the above (#1) Open ended interviews FGDs	All of the above (#1) - Location – in the Project's site office - Upon achievement of significant Project milestones - As and when information dissemination is required

Commented [MC9]: What about during the activities mentioned in the above comment and also during delivery of compensation and other entitlements?

Also, how will functioning of GRM be ensured given the frequency recommended here?

Commented [P10R9]: Added, timing and frequency is indication, engagement will be done as per the requirement and as and when required basis.

Commented [MC5]: What about during the needs assessment to develop the livelihood restoration program, and during the replacement cost study to establish compensation rates that meet SPS requirement of replacement cost?

Commented [P6R5]: Added.

Commented [MC7]: Consultation method for this is not clear

Commented [P8R7]: Individual and group discussion

Commented [MC11]: At minimum

Commented [P12R11]: Noted. As and when required.

#	Target Stakeholders	Engagement Activities	Methods of consultation	Location, Timing and Frequency
5	Local organizations, NGOs CBOs, and activists - social issues	All of the above (#1) Disclosure of Project milestones 'achievement Disclosure RP implementation status	All of the above (#1) In depth qualitative consultation consisting of: Open ended interviews FGDs	All of the above (#1) - Location – affected villages, organization/ NGO/CBO/activists' office or Project office - To start before construction and before any resettlement impacts are delivered - Upon achievement of significant Project milestones - Upon occurrence of grievances or an issue requiring information disclosure - Semi-annually until RP completion audit report is finalized
6	All the executing agencies / Govt. agencies/district agencies	- Disclosure of legal compliance-related documents (ex.: audit reports, monitoring results, etc.) - Involvement in the land procurement process - Disclosure of grievance mechanism process - Disclosure of the Project's E&S documentation	- Face-to-face meetings - Coordination activities - Invitations to public /community meetings - Submission of legal compliance-related documents	All of the above (#1) - Legal compliance-related documents to be disclosed as required - Upon occurrence of ESHS issues that require information and/or consultation of these parties
7	Media	- Disclosure of Project milestones 'achievement - Disclosure of ESMP and RP implementation status to assure transparency	Media briefing or press releases Invitation to Project events Invitation to cover Project activities	- Location – in affected villages, the Project's site office, or DGPC's office in Thimpu - Upon achievement of significant Project milestones - As and when information dissemination is required
8	Project workforce: staff employed by the contractors and sub-contractors, including those locally and externally recruited, temporary and permanent employees	- Disclosure of worker's Code of Conduct - Disclosure of actions derived from the ESIA's Labour Management Plan - Disclosure of workers Grievance Mechanism and remedial measures available - Disclosure of workers' rights	- Toolbox talks - Transparent contractual procedures (either for formal or for informal/daily jobs) - One to one discussion	Project work site Labour camp Frequency: - Upon hiring new staff (formal or informal hires) - As needed

1.5.1 Monitoring and reporting

The following indicators shall be used to monitor and assess the efficiency of the stakeholder's engagement activities:

- Number of meetings of various kinds (public hearings, meetings, consultation, meetings/open-ended interviews etc.) held with each category of stakeholders and number of participants disaggregated by sex
- Number of affected households and persons, disaggregated by gender, vulnerability and disadvantaged groups participation, at X% out of total PAPs
- Number of stakeholders included in the stakeholder log derived from the stakeholder mapping of the ESIA
- Number of suggestions and recommendations received using the Grievance Redress Mechanism
- Number of publications covering the Project in the local, regional and national media.

Commented [MC13]: Disaggregated by gender

Commented [P14R13]: added

All stakeholder engagement activities shall be adequately documented both in substance and process. The reporting shall include:

- Statistics of the indicators listed above
- Minutes of consultation meetings
- Overview of grievances received, resolutions agreed to, and respective answers provided
- Consequences for the Project planning and implementation activities resulting from all the above.

Commented [MC15]: Supporting documentation of resolution has to be obtained

Commented [P16R15]: Noted. Will be included

It is recommended that the ESMU-ESHS performs quarterly reporting during construction and annual reporting during operation.

1.5.2 Resource planning and budget

It is assumed that the SEP will be implemented during the whole construction period of 6 years and the first 2 years of operation. Afterwards, engagement tasks will become minor and can potentially be managed within DGPC without involving exclusively dedicated staff.

Commented [MC17]: E&S officers should be designated at both PMU and PIU levels

Commented [P18R17]: Noted. Will be added accordingly.

DGPC, through the SPV ESHS Team, will be responsible for the overall implementation, coordination, and oversight of stakeholder engagement, grievance management, regulatory compliance, and reporting. The Communication Officer will lead day-to-day stakeholder engagement activities, including consultations, information disclosure, grievance management, and coordination with local communities and authorities.

The Project Supervision Consultant (PSC) will independently supervise and verify SEP implementation through the Community Liaison/Stakeholder Officer, who will monitor consultations, grievance resolution, public disclosure, and compliance with stakeholder engagement commitments. The PSC will report stakeholder engagement performance to the Resident Engineer and the SPV-ESHS and support continual improvement throughout project implementation.

It is recommended to establish a ESHS as the central coordinating body for the Project, sitting at the DGPC headquarters. The ESHS shall be responsible for overall Project governance and oversight, strategic planning and decision-making, budget approval and financial control, monitoring and evaluation, reporting to funders (ADB) and government agencies (DECC, MoENR, etc.), and ensuring compliance with safeguards, procurement rules, and national regulations.

Commented [ro19]: Removed to make consistent with DGPC SPV i.e., BHPL

The ESHS shall not be expected to have a direct overview of the SEP implementation activities. In this sense, the on-the-ground oversight shall be performed by a **Project Implementation Unit (PIU)**, recommended to be established at the Project site under DGPC. The PIU shall establish an **Environment and Social Management Unit (ESMU)** to manage the implementation of the E&S activities, including public engagement. Within the ESMU, it is recommended to establish a dedicated desk (Public Information Center).

The ESMU may procure an external **Project Implementation Consultant (PIC)** to provide technical support, ensure adherence to the SEP, and strengthen the Project's capacity for implementing the E&S activities.

The Project shall allocate adequate human and financial resources to implement the SEP. At a minimum, the ESMU (or PIC) shall be supported by a **Community Liaison Officer (CLO)**, a **Social Officer (SO)** and an **Environment Officer (EO)** fully dedicated to SEP related activities.

An estimated budget for implementing the SEP for the Bunakha HPP is estimated at **1,056,000** ~~15,312,000~~ Nu (ca. ~~183,000~~ USD) presented in Table 3. The budget assumes national expert rates and full-time positions for the implementation period of 8 years.

Table 3: Budget estimated for implementation of the SEP for the Bunakha HPP

Items	Monthly Cost (Nu.) ²	Annual Cost (Nu.)	8-Year Total (Nu.)
Personnel Costs			
Community Liaison Officer	45,000	540,000	4,320,000
Social Officer	45,000	540,000	4,320,000
Environment officer	45,000	540,000	4,320,000
Sub-total personnel tasks			12,960,000
	Unit cost (Nu.)	Annual cost (Nu.)	8-Year Total (Nu.)
Operational Costs			
Engagement events - venue, refreshments, translations, materials, local facilitation	30,000	Assuming 4 events per year: 120,000	960,000
Sub-total operational costs			960,000
		Total	13,920,000
		Contingency (10%)	96,000 10%
		Grand total	1,056,000 15,312,000

1.6 Engagement Activities Already Conducted

During the time of preparation of the ESIA and update of the DPR, community engagement activities have been undertaken. The meetings were focused on obtaining information from stakeholders related to the Project and its potential foreseen impacts, and also on disseminating the Project's information available at the time. Several focus group meetings with specific groups were undertaken, as well as consultations with communities, key institutional personnel, project affected people, government officials, local government representatives and community leaders and ward representatives.

² Based on average salaries in Bhutan for junior-mid level officers retrieved from <https://remotepople.com/countries/bhutan/average-salary/>

Commented [NH20]: PMU will be at project site? Or its field office. Clarify

Commented [P21R20]: PMU is expected be based on project construction site.

Commented [SG22R20]: We additionally explain that a PIC may be hired.

Commented [MC23R20]: It seems from the above that PIU is the one at the project site level

Commented [P24R20]: Correct.

Commented [NH25]: confirm if this is discussed with DGPC and will be established. What will be the structure and staff resources? Specify.

Commented [P26R25]: It is recommended to establish a dedicated unit. In an informal discussion DGPC expressed positive. For resource planning please see Table 3

Commented [SG27R25]: At this stage, we are providing recommendations. Upon checking of the Draft Report, DGPC may provide their inputs.

Commented [NH28]: specify are these PIC staff or PMU staff

Commented [P29R28]: These resources are expected to be housed into PIC

Commented [SG30R28]: Or ESMU, if no PIC is hired (unlikely)

Commented [SG31R28]: The names of the staff have been changed for clarity

Commented [NH32]: Avoid "some" - Provide numbers and details, #, locations, dates, summary of key issues raised by APs and communities and responses from DGPC

Commented [P33R32]: Kindly see the annexure .

Commented [SG34R32]: Agreed. Further information is provided below and details are in the annexes. The objective is not to overburden the main text, but still give key information.

An overview of the engagement activities already conducted is provided in *Table 4* and in the following chapters; details such as invitations, memoranda of the meetings, lists of participants and pictures of the meetings are attached to this ESIA report (Annex 1: Public Engagement Documentation).

Table 4: Summary of the stakeholder engagement activities undertaken for the Bunakha HPP during the ESIA and DPR update phases

Date	Location	Participants	Objectives	Remarks
22 January 2025	Chhukha District (Dzongkhag) Administration (CDA)	Representatives of DGPC, Jade, FICHTNER, PCS, and of the offices visited	Introducing the ESIA study, providing basic Project information, naming contact persons.	During the inception stage of the Assignment
22 January 2025	Gedu Divisional Forest Office		Showing the Client's and the ESIA Team's availability to hear the stakeholders' concerns and suggestions throughout the entire ESIA process.	Details in the Inception Report
24 January 2025	Department of Water (DoW)			
24 January 2025	Department of Environment and Climate Change (DECC)			
23 to 29 April 2025	Public consultation in the Bunakha village, Chapcha Gewog	22 participants (11 males and 11 females)	Introduce the project and initiate impact assessment	During the site surveys Annex 1.2.1: pictures Annex 1.5.1: minutes
	Public consultation in the Chanachen Village, Geling Gewog	PCS, DGPC	Hear suggestions, concerns, and opinions	During the site surveys Annex 1.2.2: pictures, list of presences Annex 1.5.2: minutes
22 July 2025	Bunakha, Chapcha Gewog	50 Participants (31 males and 19 females) PCS, DGPC	Disseminate preliminary assessment information	Annex 1.2.3: pictures, list of presences Annex 1.2.5: presented information Annex 1.5.3: minutes
23 July 2025	Chanachen Village, Geling Gewog	25 Participants (14 males and 11 females) PCS, DGPC	Hear suggestions, concerns, and opinions	Annex 1.2.4: pictures, list of presences Annex 1.2.5: presented information Annex 1.5.4: minutes

Date	Location	Participants	Objectives	Remarks
9 December 2025	Geling Gewog office, Chhukha	33 Participants (22 males and 11 females) PCS, DGPC, ADB	Disclose the expected impacts identified and mitigation measures proposed	Annex 1.2.6: pictures, list of presences Annex 1.2.8: presented information Annex 1.5.6: minutes
10 December 2025	Bunagu village, Chhukha	50 Participants (30 males and 20 females) PCS, DGPC, ADB	Obtain feedback on the mitigation actions proposed	Annex 1.2.7: pictures, list of presences Annex 1.2.8: presented information Annex 1.5.7: minutes

1.6.1 Inception stage stakeholder engagement - January 2025

The national and international ESIA Team supported DGPC in early stakeholder engagement (during the Inception Stage) by visiting the following regional and national authorities:

- Chhukha District (Dzongkhag) Administration (CDA) on 22.01.2025
- Gedu Divisional Forest Office on 22.01.2025
- Department of Water (DoW) on 24.01.2025
- Department of Environment and Climate Change (DECC) on 24.01.2025

The visits served the purpose of introducing the ESIA study, providing Project information (objective, installed capacity and location), naming contact persons and showing the Client's and the ESIA Team's availability to hear the stakeholder's concerns and suggestions throughout the entire ESIA process.

District and sub-district authorities in the CDA show that they welcome the Project. They added that compensation issues (such as fair compensation above the current government rates, option for certain units of electricity in place of land compensation, land replacement in other Gewogs/Dzongkhags), from past projects shall not be repeated in Bunakha. They stressed the need to assure that compensation is paid before construction works begin (ca. 11 months later, in consultations undertaken in December 2025, the issue was raised by the PAPs, who received from DGPC the assurance that payment for compensation will be done before construction begins—see Chapter 1.6.4 of ESIA report).

The authorities were informed that the ESIA will include a Resettlement Plan to establish compensation requirements in respect for the national legislation and the ADB SPS.

The Gedu Divisional Forest Office highlighted their availability to share data on species ranges for informing the ESIA study. They also informed of a known range of the Bengal tiger (endangered species as per the IUCN Red List; EN) in a distance of ca. 11 km to the Project area (Toktogom, Bongo Gewog), as well as of sightings of the Rufous-necked Hornbill (vulnerable species as per the IUCN Red List; VU) in the

Commented [NH35]: spell what is this

Commented [P36R35]: District authority

Commented [SG37R35]: CDA is spelled in the beginning of this sub-chapter.

Commented [NH38]: What was the issue? Pls provide details **ADDED**

Commented [SG39R38]: Please note that the meeting at the CDA was done in a highly formal environment (see Inception Report) and we were not provided with details. However, for the sake of independency of our reporting, we mentioned that such issues existed. This was subject of the Inception Report. To provide assurance that the issue was not forgotten during the ESIA process, we add now a reference to the public consultation done in Dec. 2025, where the PAPs explicitly mentioned they were afraid of this happening again, and where DGPC guaranteed that the project won't advance without payment of compensation. The report is now transparent regarding concerns vs assurances.

Commented [EP40]: to confirm, was there Consultations with PAPs during RP study specifically? Or were part of ESIA?

Commented [SG41R40]: the public consultations were mixed, ESIA and RP were always mentioned; then there were FGDs for RP

Project area. They recommended the ESIA Team to apply for a permit for site surveys one month before they are planned to occur. They added that the ESIA Team shall provide the methodology of the surveys, as well as the survey area during the submission of the application for the permit.

The DoW also showed openness to share information and data with the ESIA Team and showed interest in being informed of the results of the E-flow assessment. They informed the team that the Government of Bhutan is interested in managing existing and future hydropower plants as multi-purpose projects and suggested the ESIA team to study the possibility of water-related sports businesses in the future Bunakha reservoir.

At DECC, the ESIA Team received important highlights on the national ESIA approval process.

1.6.2 Public engagement during baseline surveys - April 2025

During the consultations and key informant interviews performed in tandem with the baseline site surveys in April 2025, the ESIA Team explained various features of the Project including design, environmental considerations, land use requirement and mitigation measures. The People from project affected area were consulted about, and informed of, the Project's social impacts, and grievance redress procedures through the villages-level consultations.

Similarly, Project communications were made accessible to women, differently abled, illiterate, and other vulnerable groups considering literacy, language and culture of beneficiary communities and existing local practices of warning.

Consultations performed in April 2025 in Bunakha and Chanachen showed that the communities are aware of the upcoming Bunakha Hydropower Project and expect benefits such as rural electrification, improved infrastructure, job opportunities, and economic growth. They also wish for better access to markets, health, and education, along with flood control and tourism potential.

Concerns expressed by the consulted persons include economic and physical displacement, environmental degradation, health risks, and inadequate compensation. Bunakha relies on the Wangchhu River for fishing and income, while Chanachen uses it mainly for commuting. Social and economic risks identified as possible by the consulted persons include loss of land, livelihoods, inequality, short-term jobs, and rising living costs. Existing issues like unemployment and domestic violence are perceived as under worsening risk by the people consulted.

To mitigate impacts, communities recommend inclusive resettlement planning, fair compensation, livelihood restoration, and capacity building through technical and vocational training, farming skills, and support for women. They see opportunities for local employment and small enterprises if the project prioritizes local hiring and infrastructure improvements. Stakeholder engagement through meetings, resettlement planning, and community involvement is considered essential. Communities are willing to sell or lease their land to the Project and request a respectful handling of cultural practices.

1.6.3 Stakeholder consultations in July 2025

On 2 July 2025, the national ESIA Team requested DGPC to conduct public consultations at Chapcha Gewog and Geling Gewog, following the receipt of project features and technical information from the technical team. The Team also requested DGPC to send a formal letter to the Chhukha Dzongkhag

- Commented [NH42]: specify who were target ...
- Commented [MC43R42]: Pls address the comment ...
- Commented [P44R42]: Revised.
- Commented [NH45]: see comment above on land ...
- Commented [P46R45]: Removed. Voluntary Land ...
- Commented [MC47]: Not previously mentioned that ...
- Commented [P48R47]: Noted. Will revise in ESIA ...
- Commented [NH49]: add details on key issues and ...
- Commented [P50R49]: See annexure
- Commented [SG51R49]: Please see chapters 16.6.2. ...
- Commented [MC52R49]: Where is 16.6.2.1 and ...
- Commented [R53R49]: Summary of each consultatio ...
- Commented [MC54]: Not clear what is meant by ...
- Commented [NH55]: add dates and locations
- Commented [P56R55]: Refer annex
- Commented [SG57R55]: Added
- Commented [NH58]: these are two villages? add to ...
- Commented [P59R58]: added.
- Commented [NH60]: Is this include din the project ...
- Commented [P61R60]: Corrected.
- Commented [SG62R60]: While rural electrification is ...
- Commented [MC63R60]: This is another reason why ...
- Commented [P64R60]: Summary of consultation ...
- Commented [NH65]: elaborate how these will be ...
- Commented [SG66R65]: This chapter discusses abo ...
- Commented [MC67R65]: Pls see above comment of ...
- Commented [P68R65]: Summary of consultation ...
- Commented [NH69]: specify on loss of scared sites ...
- Commented [P70R69]: Corrected.
- Commented [SG71R69]: References to sacred sites a ...
- Commented [MC72R69]: Important to confirm what ...
- Commented [P73R69]: Corrected.
- Commented [MC74]: I did not see any measures to ...
- Commented [P75R74]: Direct income from fishing is ...
- Commented [MC76]: Impacts of the dam on ...
- Commented [NH77]: ?? which sort inequality the ...
- Commented [SG78R77]: Please note that this ...
- Commented [MC79R77]: Project-induced inequality ...
- Commented [P80R77]: The section describes the ...
- Commented [NH81]: Explain what these means and ...
- Commented [SG82R81]: This has been expressed by ...
- Commented [MC83R81]: Pls update the relevant ...
- Commented [NH84]: Review the report thoroughly, ...
- Commented [P85R84]: Reviewed and corrected.
- Commented [SG86R84]: Please note that this ...
- Commented [NH87]: final drawings of what? specify ...
- Commented [P88R87]: Corrected.

Administration seeking approval to hold these consultations and focus group discussions, and to inform the Project Affected People (PAP) in the respective gewogs. Additionally, the team indicated that the ADB should be informed of the consultation dates, as ADB had expressed interest in attending.

On 8 July 2025, DGPC submitted a request to the Chhukha Dzongkhag Administration, stating that DGPC is in the process of updating the ESIA for the Bunakha HPP and that, as part of this process, consultation meetings and focus group discussions with local communities, including PAPs from Chapcha and Geling Gewogs, were required. These consultations were scheduled for 22 July at Chapcha Gewog and 23 July at Geling Gewog, with a 15-day advance notice provided. DGPC also informed ADB of the dates and invited their representatives. A copy of the request letter to Chhukha Dzongkhag can be read in Annex 17.1.1.

The public consultations were conducted at Chapcha Gewog and Geling Gewog on 22 and 23 July 2025, respectively, following announcements made by the Dzongkhag Administration. Officials from Chhukha Dzongkhag Administration, Chapcha Gewog and Geling Gewog Administrations, and PAPs from both gewogs participated in the consultations. Representatives from DGPC and the National ESIA Team organized and attended the sessions.

Public consultation in Bunakha, Chapcha Gewog - 22 July 2025

A stakeholder consultation meeting was conducted on 22 July 2025 at 10:00 AM in the Green Valley Hotel, Bunakha (Chapcha Gewog). The meeting was attended by a total of 50 participants, comprising 31 males and 19 females, representing local communities and stakeholders.

During the consultation, technical features of the Project including key project components, physical and economic impact/relocation, impact due to blasting and access road construction, community supports such as water supply, school refurbishment, potential impact due to water storage, loss of agricultural production, replacement and compensation and the grievance redress mechanism were discussed.

Public consultation in the Chanachen Village, Geling Gewog - 23 July 2025

Another stakeholder consultation meeting was held on 23 July 2025 at 10:00 AM in the Geling Gewog Meeting Hall, Chanachen Village (Geling Gewog). The meeting was attended by 25 participants in total, including 14 males and 11 females, ensuring representation from different sections of the local community. Major topics discussed were:

- Land replacement
- Dam issues
- Road maintenance
- Request for primary school, recognition and protection of Geling Gonpa
- Potential impact of water storage on agricultural production
- Land replacement cost
- Blasting Impacts
- Land replacement flexibility.

Commented [NH89]: attach copy of advance notice on consultation

Commented [P90R89]: Kindly refer the annex. RT

Commented [SG91R89]: PCS / Jade to please add

Commented [NH92]: which villages and locations in these gewogs-specify

Commented [P93R92]: Both of the villages

Commented [NH94]: see comments above. elaborate for each issue in bullet points what was the concerns of people and affected persons and what was DGPC responses

Commented [P95R94]: Kindly see the annex

Commented [MC96R94]: Pls specify annex number for ease of review

Commented [R97R94]: Annex 1.4.4

1.6.4 Stakeholder consultations in December 2025

Stakeholder consultations were undertaken in the Gewogs of Geling and Bunagu in December 2025 with the participation of DGPC and ADB.

Public consultation in the Geling Gewog - 9 December 2025

The 9 December 2025 consultation at Geling Gewog focused on presenting updated Project component locations and responding to long-standing community concerns. While participants expressed consultation fatigue, they emphasized the need for a clearer and simpler grievance redress mechanism and reassurance that compensation, land replacement, and issuance of ownership certificates would occur before construction, as required by ADB. Concerns were also raised about road widening, potential impacts on private land, and the future of Chanachen as an organic village, with DGPC confirming that any affected assets would be compensated.

Environmental and social impacts were a major theme. The community sought clarity on dust, blasting, worker influx, and biodiversity risks. DGPC and the Consultant explained that blasting will be monitored, structures will be documented beforehand, and dust suppression will be implemented. Risks related to worker influx—including community tensions and GBV/SEA/SH—will be addressed through contractor training and ongoing monitoring. Environmental baseline findings were shared, including potential water shortages.

Participants also expressed uncertainty about farming and construction decisions due to unclear timelines. The Consultant noted that DGPC will announce a formal cut-off date for compensation eligibility to reduce this uncertainty.

Public consultation in the Bunagu Gewog - 9 December 2025

During the consultation at Bunagu village on 10 December 2025, DGPC explained the national energy rationale for the Bunakha HPP, emphasizing the need to reduce winter electricity imports and expand domestic generation. Community members raised questions about the benefits the Project could provide, including support for religious and cultural activities, opportunities for local hiring, and preferential access to project-related work. DGPC clarified that while national tendering rules must be followed, project-affected communities will be prioritized where skills align. Concerns about worker influx, theft of crops, and recent blasting-related crop damage were also raised, with DGPC committing to investigate the incident and highlighting that mitigation measures will be included in the Labour Management Plan and broader ESIA instruments.

PAPs sought clarity on compensation, particularly regarding wetland loss, sustenance allowances during the transition to replacement land, and administrative costs associated with land transfer. DGPC confirmed that sustenance support will be provided where livelihoods depend on affected land, and that administrative and regulatory fees for land replacement will be borne by the Project.

PAPs also expressed concern about the availability and suitability of replacement land, requesting flexibility in location and support for land development. DGPC reiterated that replacement land will be sought as close as possible—within the same village, chiwog, gewog, or Dzongkhag—and that land development (e.g., flattening) may be supported. Opportunities for leasing land to contractors were also discussed, particularly for plots not directly acquired by the Project.

1.7 General Public Grievance Redress Mechanism

One of the core requirements under ADB's SPS (2009) is that a project-level Grievance Redress Mechanism (GRM) is established and maintained to receive and address concerns from affected people regarding environmental and social safeguards, as well as consultation and information disclosure.

DGPC shall establish a GRM to voice and resolve social and environmental concerns linked to the Project and ensure greater accountability towards all affected persons. This mechanism is not intended to bypass the RGoB's own legal process but is intended to provide a time-bound and transparent mechanism that is readily accessible to all segments of the affected people.

The aggrieved party shall be free to approach national legal system at any time. All costs involved in resolving the complaints (meetings, consultations, communication and reporting/information dissemination) shall be borne by the Project. Typically, the complaints and problems that typically arise during and before the implementation of a project of the nature of the Bunakha HPP are, but not limited to:

- Project affected persons that are not listed in the compensation list
- Losses that are not identified correctly
- Compensation/assistance inadequate or not as per the entitlement matrix
- Dispute about ownership
- Delay in disbursement of compensation/assistance and
- Improper distribution of compensation/assistance in case of joint ownership
- Livelihood loss
- Impact due to blasting
- Air and noise pollution
- Traffic increase in public roads
- Social conflicts with workers
- Lack of employment opportunities in the Project

Through public consultations (see Annex 1: Public Engagement Documentation), the PAPs were informed that they have a right to file complaints through local representatives (Gup, Tshogpa, Mangmi or any other representative), or other means as accessible to submit the complaint. For example, they are eligible to call upon support of the [ESMU-ESHS](#) in DGPC (see Chapter 1.5.2 of ESIA) to assist them in submitting or presenting their grievances or queries to the GRM. In addition, DGPC's environmental focus person may be directly contacted:

Kinzang Dolma, Assistant Environment Officer

Email: k.dolma3853@drukgreen.bt

Mobile: +975 77330839

Post Box 1351, Thori Lam, Thimphu 11001

+975 2 336414

A three-tier Project-level GRM will be in place for addressing any grievances put forth by the public.

Level 1 will comprise of field staff including the contractor's [QEHS Officer](#), [the Project Implementation Consultant \(if engaged\)](#) and/or, [ESHS communication officer](#) [the ESMU \(within the PIU\)](#).

In case the grievance is not resolved at this level within 7 working days, then it will be referred to **Level 2**. This level will comprise of PIU representatives (where an ESMU shall be formed as recommended in Section Resource Planning and Budget), representatives from the local government (Dzongkhag/Dungkhag), and, if engaged, the environmental and social officers of the Project Implementation Consultant.

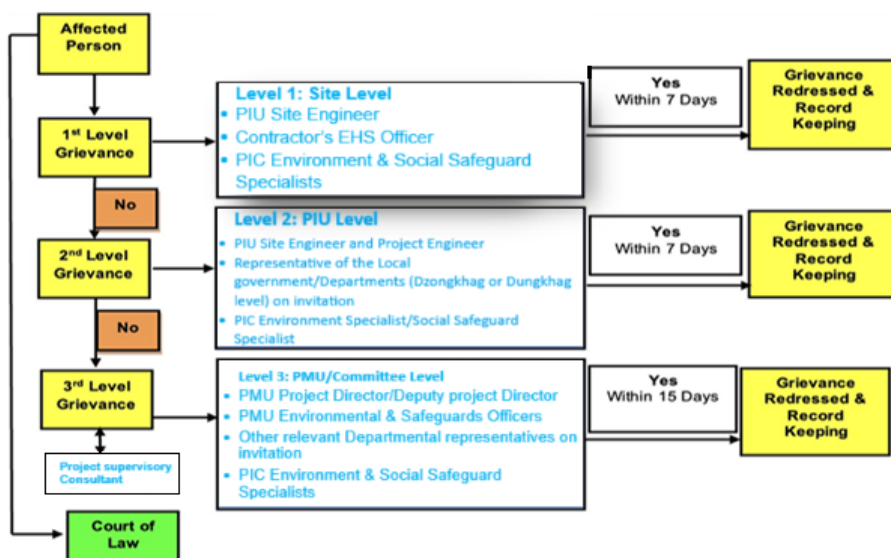
Level 2 will comprise representatives from the BHPL ESHS Team, including the Communication Officer, Social Safeguard Officer, Environmental Safeguard Officer, and other relevant officers depending on the nature of the grievance. The committee will also include the PSC Community Liaison/Stakeholder Officer, Social and Resettlement Specialist, representatives of the Contractor, and representatives from the relevant Dzongkhag and/or Dungkhag Administration, as appropriate.

If the case is not resolved at level 2 within 7 working days, then it will be further escalated to **Level 3**.

Level 3 will comprise the Project Grievance Redress Committee (GRC) established by the BHPL. The committee will be chaired by the Chief Executive Officer (CEO) or an authorized senior representative of the BHPL and will include the Chief Operating Officer, relevant members of the BHPL ESHS Team, the PSC Team Leader/Resident Engineer, representatives from the relevant government agencies, and other technical specialists, as required depending on the nature of the grievance.

Level 3 will comprise of a Grievance Redressal Committee at the Project Management Unit (PMU) level and will include the Project Director/Deputy Director, other relevant Department representatives (based on the nature of the case) and Project Implementation Consultant, where hired. 15 working days shall be foreseen for a resolution at level 3.

Any issues not resolved at the three levels will be forwarded to the court of law. All actions/decisions taken with regard to the grievances shall be kept for record in the Grievances Log.



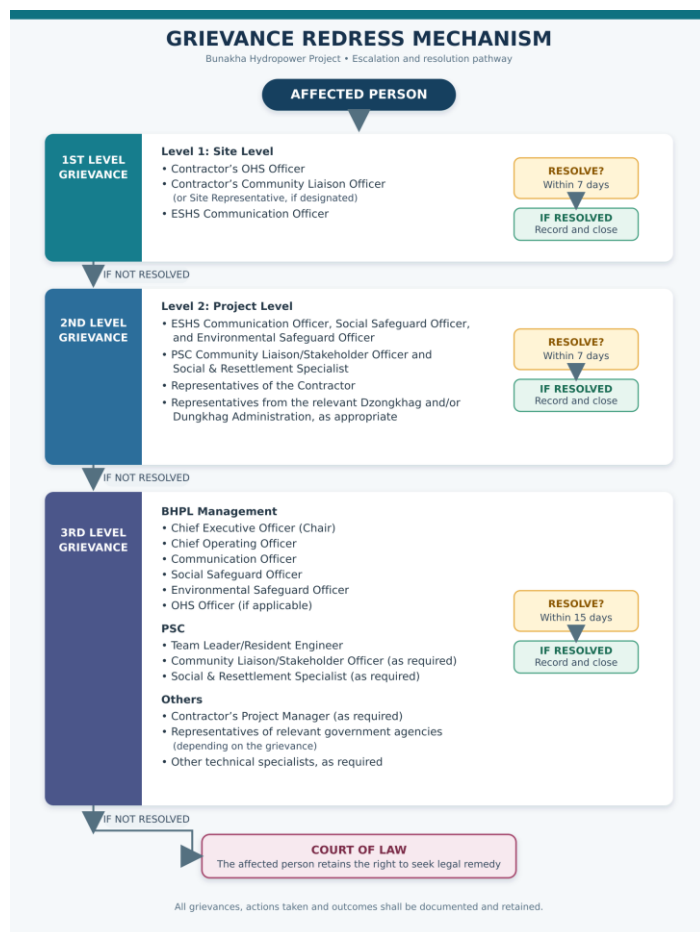


Figure 3: General public Grievance Redress Mechanism for the Bunakha HPP

1.8 Workers Grievance Redress Mechanism

Workers Grievance Redress Mechanisms are formal procedures within an organization that allow employees to raise and resolve workplace issues or complaints. These mechanisms provide a structured way for employees to voice concerns, seek remedies, and for the organization to address those concerns fairly and transparently.

Effective grievance mechanisms contribute to a positive work environment by fostering trust, improving employee morale, and reducing the risk of legal issues or reputational damage. They also help organizations comply with labour laws and regulations, as well as internal policies and ethical standards. Workers GMs are a crucial component of responsible and ethical business practices, promoting a fair and respectful workplace for all employees. The responsibility for its implementation and management lies with the preconstruction, construction, operation and decommissioning Contractors.

Purpose and Scope

The purpose of the workers' GRM is to ensure that all employees have a safe, confidential, and accessible way to raise concerns and seek resolution. It aims to:

- Promote fairness and transparency in the workplace
- Provide timely and effective resolution of grievances
- Prevent escalation of workplace conflicts
- Support compliance with legal and ethical standards

This mechanism applies to all employees and covers a wide range of workplace issues, including:

- Workplace harassment and sexual harassment
- Discrimination and unfair treatment
- Pay and benefit disputes
- Health and safety concerns
- Any other employment-related grievances

Process

The workers' GM should follow a formal process. While it may begin with informal attempts at resolution, it should allow for escalation into more structured steps, such as:

- Submitting a written complaint
- Meeting with Human Resources staff or a supervisor
- Investigation
- Mediation or arbitration
- Documenting in a grievances log

It is important that the workers' GRM is both confidential and fair. All employees must feel safe to raise concerns without fear of retaliation. They must also have easy access to the mechanism and understand how to initiate it.

To ensure timely handling of complaints:

- Acknowledgment of the written complaint should be made within 3 working days
- A resolution should be made within 10 working days

If there are any delays, they must be clearly communicated to everyone involved.

Instruments

All workers shall have the opportunity to submit their grievances in writing through designated grievance boxes that shall be strategically placed at appropriate locations within the workplace. These boxes are intended to provide a confidential and accessible channel for employees to voice their concerns.

The grievances deposited shall be collected on a regular basis by the designated representative of the contractor. Subsequently, the matters raised will be addressed through the formal grievance resolution mechanism established by the organization.

1.9 ADB's Accountability Mechanism

In addition to the Projects' GRM, stakeholders can register their complaints to ADB Bhutan Resident Mission (BHRM):

2nd Floor, Royal Textile Academy Building, Norzin Lam, Chhubachhu, Thimphu – 11001, Bhutan
+975 339150, +975 339151

ADBbhutan@adb.org

Further information and on-line contact forms:

https://www.adb.org/where-we-work/bhutan/knowledge?utm_source

Recourse to ADB's Accountability Mechanism (AM), framed by ADB's Accountability Mechanism Policy (2012), is also possible. The complaints are filed with ADB's Complaint Receiving Officer (CRO), who forwards them to either:

the Office of the Special Project Facilitator (OSPF) for problem-solving,
the Compliance Review Panel (CRP) for policy compliance checks.

The complainant must indicate at the time of filing whether they want problem-solving (handled by the OSPF), a compliance review (handled by the CRP), or both in sequence (starting with the OSPF)³.

The OSPF focuses on dialogue and finding practical solutions; the CRP checks whether ADB has followed its own policies and procedures. Both functions operate independently and aim to ensure fairness, transparency, and remedy for those affected.

Complainants must show they made "good faith efforts" to resolve the issue with ADB's operations department before filing a complaint. This means they must have attempted to raise concerns, seek clarification, or request action from ADB project staff or the executing agency. If they cannot demonstrate this, the complaint can be ruled ineligible.

If good faith efforts have been undertaken, then complainants are eligible to the AM if they are:

- any group of two or more people in a borrowing country where the ADB-assisted project is located, or in an adjacent member of ADB;
- people who are directly, materially, and adversely affected; this means people who are harmed or might be harmed by ADB projects;
- a duly authorized local representative of the affected people;
- a duly authorized nonlocal representative in exceptional cases where local representation cannot be found and the OSPF or CRP agrees; or
- for the CRP, one or more ADB Board members.

³ A Guide to the ADB Accountability Mechanism (ADB- AM): https://aconsole-static.s3.amazonaws.com/media/public/Asian_Development_Bank_-_Complaint_Pathfinder_I_Accountability_Toolkit.pdf?utm_source=copilot.com

Commented [NH98]: Add also about sending complaint to ADB BHRM

Commented [P99R98]: added

Commented [NH100]: add how it will be decided to forward to whihc - check ADB AM policy

Commented [SG101R100]: Added

Commented [NH102]: Pls check the eligibility requirement for the complainants good faith efforts made to resolve the project with the ADB project operational departments

Commented [SG103R102]: Checked and added

The complainants have several submission options:

- **ADB's AM webpage:** ADB provides an online complaint form⁴ where complainants can choose a quick form or a full form for detailed submissions.
- **Email:** Complaints can be sent directly to: amcro@adb.org (Complaint Receiving Officer)
- **Postal Address:** Complaints can be sent directly to: Complaint Receiving Officer, Accountability Mechanism, Asian Development Bank, 6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines

If not using the on-line form, a sample complaint letter and a sample complaint form can be retrieved from ADB's AM webpage ⁵.

⁴ ADB's AM: Online complaint form: <https://www.adb.org/who-we-are/accountability-mechanism/complaint>

⁵ ADB's AM - How to file a complaint: <https://www.adb.org/who-we-are/accountability-mechanism/how-file-complaint>

Annex 1: Public Engagement Documentation

Annex 1.1: List of invited and consulted People in the Project Affected Area, their Opinions, Records of Public Involvement (e.g., Meeting, Workshop, Consultation)

Annex 1.1.1: Letter to Chhukha Dzongkhag administration requesting for public consultation - April 2025



DrukGreen
(a DB company)

DGPC/PCD/DGC/12/2025/ ~~383~~

Dasho Dzongdag
Dzongkhag Administration
Chhukha

April 21, 2025

Subject: Request for assistance and facilitation during socio-economic survey for the Updation of Environment and Social Assessment Report (ESIA) of Bunakha Hydropower Project

Dasho,

Druk Green Power Corporation Limited is in the process of updating the Environment and Social Impact Assessment (ESIA) for Bunakha Hydropower Project through the consultancy services of Fichtner GmbH & Co. KG, Germany and Jade Consult Pvt Ltd., Nepal and their local partner, Phuensum Consultancy Services (PCS) and NexGen Hydro Consult.

As part of this mandate, DGPC is planning to conduct a socio-economic survey of Project Affected Persons (PAP) to refresh the socio-economic baseline to reflect current conditions. The socio-economic survey will be conducted using a structured questionnaire. Additionally, DGPC and the consultant will also visit Geling and Chapchaa Gewog Office at the convenience of the local government officials. The team will also meet some of the Dzongkhag Officials such as Kidu officer, Land record Officer, Planning Officer and Survey in-charge.

In this regard, DGPC would like to request the Dzongkhag Administration, concerned officials and Gewog's Support to the Consultant during socio-economic surveys which will be held on the following dates:

Date	Day	Program
24 April 2025	Day 1	Socio-economic survey at Bunagu Chiwog
25 April 2025	Day 2	Socio-economic survey at Chanachen Chiwog
26 April 2025	Day 3	KII interviews/ socio-economic of Bunagu Chiwog
27 April 2025	Day 4	KII interviews/ socio-economic survey of Chanachen Chiwog
28 April 2025	Day 5	Household survey/Consultation with the Geling Local Govt. Officials
29 April 2025	Day 6	Consultation with Dzongkhag Kidu officer, Land record and Survey and Planning officers
30 April 2025	Day 7	KII at Bomeyna village
1 May 2025	Day 8	KII at Geling Goenpa
2 May 2025	Day 9	KII at Damchu & Watsa
3 May 2025	Day 10	Socio-economic survey /consultation with the Chapchaa Local Govt. Officials

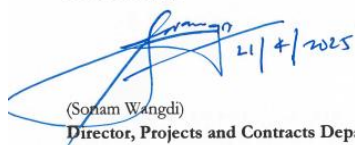
We remain grateful for the continued support and cooperation.

Druk Green Power Corporation Limited

CORPORATE OFFICE: Post Box 1351, Thori Lam, Thimphu 11001, Bhutan PABX +975 2 336413/4 www.drukgreen.bt



Yours sincerely,


(Sonam Wangdi)

Director, Projects and Contracts Department

Copy to:

1. Managing Director, DGPC for kind information
2. Project Lead, DGC, Projects and Contracts Department for coordination
3. Dorji Rinchen, Local Consultant focal for follow-up and necessary action

Annex 1.1.2: Letter to Chhukha Dzongkhag administration requesting for public consultation - July 2025



Annexure I List of PAP who are impacted by submergence and ancillary facilities

SL No.	PlotID	Owner	CID	Thram	Total Area	Area Affected	% of total	Land Type	Owner Type	PlotName	Gewog	Remarks
1	GEN-1407	Chungden	10207000677	165	1.852	1.852	100	Kamzhing	F. Ownership	Pema Aring	Geling	Submergence
2	CHP-2366	Gyem Bidha	10204000190	20	0.951	0.951	100	Chhuzhing	F. Ownership	Doesar	Chapchha	Submergence
3	GEN-503	Phub Lhamo	10207000342	432	0.521	0.506	97.12	Kamzhing	F. Ownership	Pema Aring	Geling	Submergence
4	GEN-1462	Gangchumo	10207001462	209	0.234	0.234	100	R. Land	F. Ownership	Chag Nag Chey Pagshing Kha	Geling	Submergence
5	CHP-52	Gembo Tashi	10204001089	395	1.487	1.005	67.59	Kamzhing	I. Ownership	Garilam Wok	Chapchha	Submergence
6	CHP-61	Pasang	10204000761	1496	1.171	1.171	100	Kamzhing	I. Ownership	Damchhu Lamwok	Chapchha	Submergence
7	CHP-1070	Choeing Denma	10204000824	863	1	1	100	Kamzhing	F. Ownership	Chhutoe Gaykhar	Chapchha	Submergence
8	CHP-5241	Dendup Tshering	11607002741	1507	0.944	0.688	72.88	Kamzhing	I. Ownership	Tsigyelning	Chapchha	Submergence
9	CHP-2287	Gyem Bidha	10204000190	20	0.897	0.128	14.27	Kamzhing	F. Ownership	Karshok	Chapchha	Submergence
10	CHP-47	Karma Gyeltsen	10204001884	1231	0.42	0.346	82.38	Kamzhing	I. Ownership	Tsigyelning	Chapchha	Submergence
11	CHP-2368	Lhadon	10204000034	21	1.44	0.943	65.49	Kamzhing	F. Ownership	Zarwok Lumpa	Chapchha	Submergence
12	CHP-51	Kuchumo	10204001210	899	0.7	0.57	81.43	Kamzhing	I. Ownership	Damchhu Gangtog	Chapchha	Submergence
13	CHP-3634	Kuchumo	10204001210	899	1.338	1.323	98.88	Kamzhing	I. Ownership	Damchhugangto	Chapchha	Submergence
14	CHP-2704	Karma Eden	10204001204	99	1.655	1.465	88.52	Kamzhing	I. Ownership	Damchhugangto	Chapchha	Submergence
15	CHP-2341	Choki	10204000077	1073	1.031	1.031	100	Chhuzhing	F. Ownership	Dongchen Gyedkhar	Chapchha	Submergence
16	CHP-2342	Choki	10204000077	1073	0.668	0.668	100	Kamzhing	F. Ownership	Langdor	Chapchha	Submergence
17	CHP-2363	Yeshey	10204000178	1452	0.858	0.858	100	Chhuzhing	I. Ownership	Zarwok Lumpa	Chapchha	Submergence
18	CHP-2358	Kezang	10204000088	37	0.869	0.869	100	Chhuzhing	F. Ownership	Bangma	Chapchha	Submergence
19	CHP-2343	Tandin Pem	10204000074	30	1.52	1.52	100	Kamzhing	F. Ownership	Langdor	Chapchha	Submergence
20	CHP-2288	Choden	10204000056	384	1.5	1.241	82.73	Kamzhing	F. Ownership	Karshog	Chapchha	Submergence
21	CHP-2347	Kencho Bida	10204000002	25	0.422	0.422	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Labour Camp 4
22	CHP-2337	Kinzang Jamtsho	10204000113	32	0.693	0.056	8.08	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Client Temp. Camp 2
23	CHP-2349	Markum	10204000012	29	0.661	0.661	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Client Temp. Camp 2
24	CHP-2333	Nyinda	10204000120	31	2.328	0.085	3.65	Kamzhing	F. Ownership	Tongphu Gaykha	Chapchha	Labour Camp 1
25	CHP-3442	Rinzin	10204000177	28	0.392	0.392	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Client Temp. Camp 2

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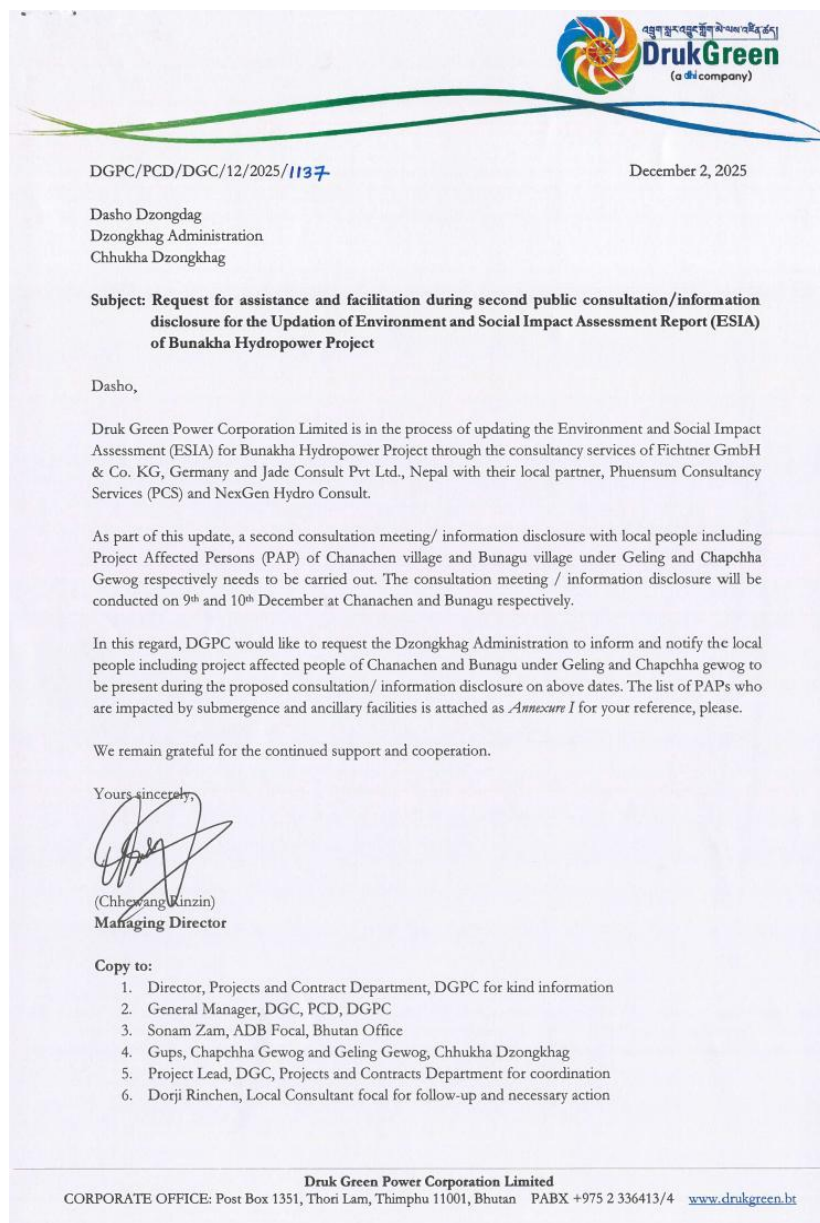
Commented [MC104]: This shows 33 AHs, but previously sections of this ESIA mentioned 30 AHs affected by LAR, pls clarify

26	CHP-2361	Sangay Om	10204000042	1076	0.17	0.17	100	Kamzhing	F. Ownership	Zarwok Lumpa	Chapchha	Labour Camp 4
27	CHP-2339	Tshewang	10204000184	1069	0.586	0.586	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Labour Camp 4
28	CHP-2352	Tshewang Rinzin	10204000081	27	0.806	0.806	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Labour Camp 4
29	CHP-2348	Ugyen Pem	10204000149	24	0.343	0.343	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Labour Camp 4
30	CHP-2351	Ugyen Pemo	10204000018	1089	0.27	0.27	100	Chhuzhing	F. Ownership	Zarwok Lumpa	Chapchha	Client Temp. Camp 2
31	CHP-2258	Buthi	10204000013	1078	0.048	0.011	22.05	Kamzhing	F. Ownership	Barchhed Lumpa	Chapchha	Labour Camp 2
32	CHP-2247	Deki Seldon	10204000094	1098	0.231	0.186	80.36	Kamzhing	F. Ownership	Pangmo	Chapchha	Client's proposed office
33	CHP-2285	Thinlay Zangmo	10204000209	22	1.137	0.927	81.566	Kamzhing	F. Ownership	Karzhing	Chapchha	Labour Camp 1

Commented [R105R104]: SL No12 &13, 15&16, and 29 & 30 are repeated AHs, so only 30 numbers of AHs

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Annex 1.2: Letter to Chhukha Dzongkhag administration requesting for public consultation - December 2025



Annexure I: Project affected people who are impacted by project components and submergence in Chapchha Gewog and Geling Gewog:

Table 1: 1 Affected Household in Chapchha Gewog

Sl. No.	Name of owner	CID No.	Plot ID	Thram No.	Total Area	Affected Area (acres)	Type of Land	Chiwog (Gewog)	Project Component
1	Gyem Bidha	10204000190	CHP-2367, CHP-2287, CHP-2366, CHP-2350	20	0.469	0.469	Kamzhing	Chapchha	Submergence
					0.897	0.049	Kamzhing		
					0.612	0.612	Chhuzhing		
2	Gembo Tashi	10204001089	CHP-52	395	1.487	0.771	Kamzhing	Chapchha	Submergence
3	Pasang	10204000761	CHP-61	1496	1.171	1.132	Kamzhing		Submergence
4	Sangay Om	10204000042	CHP-2361, CHP-2362	1076	0.17	0.17	Kamzhing		Submergence
					0.575	0.575	Chhuzhing		Submergence
5	Kencho Bida	10204000002	CHP-2346, CHP-2345, CHP-2347,	25	0.05	0.05	Chhuzhing		Submergence
					0.73	0.73	Kamzhing		Submergence
6	Choeing Denma	10204000824	CHP-1070	863	1	1	Kamzhing		Submergence
7	Dendup Tshering	11607002741	CHP-5241, CHP-47	1507, 1231	0.944	0.018	Kamzhing	Dhendup Tshering purchased Karma Gyeltshen's land	Submergence
	Karma Gyeltshen	10204001884			0.42	.001	Kamzhing		
8	Kinzang Jamtsho	10204000113	CHP-2337	32	0.693	0.011	Chhuzhing	Chapchha	Submergence
9	Nyinda	10204000120	CHP-2333	31	2.328	0.017	Kamzhing		Submergence
10	Tandin Pem	10204000074	CHP-2343	30	1.52	1.52	Kamzhing		Submergence
11	Kuchumo	10204001210	CHP-51, CHP-3634	899	0.7	0.491	Kamzhing		Submergence
					1.338	1.148	Kamzhing		Submergence
12	Karma Eden	10204001204	CHP-2704	99	1.655	1.3	Kamzhing		Submergence

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Sl. No.	Name of owner	CID No.	Plot ID	Thram No.	Total Area	Affected Area (acres)	Type of Land	Chiwog (Gewog)	Project Component
13	Choki	10204000077	CHP-2341, CHP-2342	1073	1.031	1.031	Chhuzhing		Submergence
					0.668	0.668	Kamzhing		Submergence
14	Ugyen Pem	10204000149	CHP-2356	24	0.164	0.164	Chhuzhing		Submergence
15	Rinzin	10204000177	CHP-3442	28	0.392	0.392	Chhuzhing		Submergence
16	Choden	10204000056	CHP-2288, CHP-2364, CHP-2338, CHP-2340	384	0.469	0.47	Chhuzhing	Bunakha Chapchha Party impacted	Submergence
					1.5	1.139	Kamzhing		
					0.629	0.629	Kamzhing		
17	Markum	10204000012	CHP-2349	29	0.661	0.661	Chhuzhing		Submergence
18	Tshewang	10204000184	CHP-2339	1069	0.586	0.586	Chhuzhing		Submergence
19	Tshewang Rinzin	10204000081	CHP-2352, CHP-2353	27	0.806	0.806	Chhuzhing		Submergence
					0.18	0.18	Chhuzhing		
20	Kezang	10204000088	CHP-2358, CHP-2359	37	0.69	0.571	Kamzhing		Submergence
					0.869	0.869	Chhuzhing		
21	Tshering Penjor	10204000055	CHP-2344	1135	0.69	0.571	Kamzhing		Submergence
					0.51	0.51	Kamzhing		
22	Yangka Penjor	10204000110	CHP-3810	1167	0.400	0.400	Kamzhing		EM Store
			CHP-5238		0.150	0.150			
Total					19.86 acre				

Table 1:2 Affected People in Geling Gewog

Sl. No.	Name of Owner	CID No.	Plot ID	Thram No.	Total Area	Affected Area (acres)	Type of Land	Chiwog (Gewog)	Project Component
1	Chungden	10207000677	GEN-1407, GEN-1463	165	1.852	1.852	Kamzhing	Geling	Submergence
					0.151	0.151	Residential Land		
2	Phub Lhamo	10207000342	GEN-503	432	0.521	0.42	Kamzhing		Submergence
3	Gangchumo	10207001462	GEN-1462, GEN-459	209	0.234	0.234	Residential Land		Submergence
					4.885	4.679	Kamzhing		
Total area						7.336 acre			

Annex 1.2.1: Public consultation in Bunakha, Chapcha Gewog - April 2025, during socio-economic survey

Photographs of the field visit (23 April 2025 to 29 April 2025)



Annex 1.2.2: Public consultation in the Chanachen Village, Geling Gewog - April 2025, during socio-economic survey

Participants were reluctant to sign the attendance sheet. A list of presences is shown below.

SN	Date:25/04/2025	Gender	Dzongkhag: Chhukha	Gewog Geling, Chanachen Chiwog
	Name		CID	Phone Number
1	Dawa zangmo	F	10207002748	17634982
2	Dechen	F	10207000530	17804087
3	Tobgay	M	10207000473	77681358
4	Deki wangmo	F	10207000931	17511598
5	Phekimo	F	10207000894	17986580
6	Yangden	F	10207000529	16903451
7	Chimi wangmo	F	10207000688	77419905
8	Thinley bidha	F	10207000531	77286329
9	Dawa lham	F	10207000521	17377036
10	Kinley wangmo	F	10207000540	17309171
11	Changlo	M	10801000206	17610035
12	Ugyen	M	10207000735	77479047
13	Tandin Wangchhuk	M	11410000215	17635102
14	Phuntsho	M	10207000152	77407775
15	Passang dorji	M	10207000514	77711663
16	Sangay thinley	M	10207000929	77613847
17	Tandin Wangchhuk	M	10207000663	77726737
18	Sonam Tshering lapcha	M	11205001298	17353829
19	Chencho dorji	M	10207000863	77289459
20	kinley om	F	10207000767	77728717
21	Sonam wangmo	F	10706003425	17295063
22	Dada	M	10207000006	17717305



Title: Dzongkhag/Gewog/Village: Chhukha, Geling, Chanachen
 Version: 1.0

SN	Name	MF	Age	Designation	Email Address/Contact Number	Signature
1	Chencho Dorji	M	31	Manager	77989457	
2	Sonam Wangmo	F		GAO	17353829	
3	Deki Gyeltshen	F		Gangyen Tolong	17745621	
4	Sam Tshering	M	29	CSE	17353829	



Annex 1.2.3: Public consultation in Bunakha, Chapcha Gewog - July 2025



Figure 4: Inauguration address by the Gup, Chapcha Gewog



Figure 5: Welcome the participants by DGPC



Figure 6: Presentation by PCS team



Figure 7: Social Presentation by PCS team



Figure 8: Biodiversity presentation by PCS team

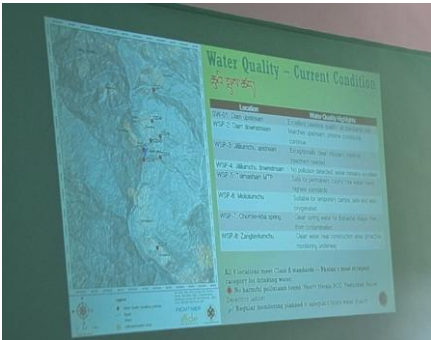


Figure 9: Environment presentation by PCS team

Title (Dzongkhag/Gewog/Village) Dzongkhag

Date: 22/07/2025

Venue: Damchoe Hotel

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
1	Lobzang	m	35	Bhagpa	17791004	
2	Phinley	m	42	Bun Lam	37377480	
3	Renzin Pem	F		Inservice.	17709127	
4	Damchoe	m		Businessman	17170714	
5	Dan Tshering	m	65	Businessman	17163034	
6	Tshering Dorji	m		Farmer	77447525	
7	Jigme Norbu	m		Farmer	77833421	
8	Nga Wang	m		Inservice.	17969061	
9	Phinley Wangdi	m		Farmer	17493777	

Title (Dzongkhag/Gewog/Village) Dunag

Date: 22/07/2023

Venue: Damchoe Hotel

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
1	Senam Tobgay	M	45	Business	77100771	
2	Gyem Tshering	M	60	Farmer	77658997	
3	Ugyen Dorji	M	42	Business	77293027	
4	Gyemba Tashi	M	60	"	17619073	
5	Passang	M	72	"	17600588	
6	Tshering	M	60	Farmer	77262404	
7	Tandin	M	60	Farmer	17683433	
8	Kencho Rinchen	M	54	"	17630505	
9	Gyembo	M	54	"	17654273	

Title (Dzongkhag/Gewog/Village) Bumthla

Date: 22/1/25

Venue Green valley hotel

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
10.	Pema Wangmo	F		Farmer	77884203	
11.	Kassang Phewang	m		-/-	17290013	
12.	Wangmo Pem	F		-/-	17676520	
13.	Pem	F		-/-	7789164	
14.	Rinzin Pem	F		-/-	17589143	
15.	Sonam Wangchok	m		-/-	17695421	
16.	Rinzin Pem	m	49	Businessman	17743347	
17.	Wangmo Pem	F		Farmer	77793666	

Title (Dzongkhag/Gewog/Village) Bumthla

Date: 22/1/25

Venue Green valley hotel

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
18.	Tangki Om	F	58	Farmer	77643850	
19.	Buthi	F	65	Farmer	17821241	
20.	Nima Gyeltshen	m	71	EX INSPECTOR	17693159	
21.	Wangmo Pem	F	52	Farmer	17676520	
22.	Phewang Pem	m	65	Farmer	17418932	
23.	Uham	F	55	Farmer	17986341	
24.	Wangmo	m	62	Farmer	17666409	
25.	Tandin Pem	F	72	Farmer	17514428	
27.	Chakhy	m		Businessman	77110894	

Title (Dzongkhag/Gewog/Village) Akhayakha
 Venue Hotel valley

Date: 22/07/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
28.	Phub sidhab	m		Gup.	77406144	
29.	Nyanda Jamkhom			Geog Engineer.	17705726	
30.	Uram Wangdi	m		Geog. CC.	17679946	
31.	Rindea N. Oser	m		GAD	17470388	
32.	Kinley Gyem	F		Business	17764054	
33.	Dorji Om	F.		Business		DOC.
34.	Thujis	BF	66	Farmer.	1378645	
35.	Choden	F.	60	Business	77110894	
36.	Chimi Om	F	47	Farmer.	13909508	

Title (Dzongkhag/Gewog/Village) Chutha Bura
 Venue Hotel valley

Date: 22/07/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
37.	Lemo	F		Manager	17252670	

Title (Dzongkhag/Gewog/Village).....Chhukha.....(Bumthang)
 Venue.....Khem Valley Hotel.....

Date: 22/07/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
①	Phurba Khing	M		Offg. US	phurba@chhukha.gov.bt	P. Khing
②	Karna Phurong	M		Environment Officer	karnaphurong@gmail.com	K. Phurong
③	Kuenang Gyamo	F		Land Registrar	kgyamo@chhukha.gov.bt kgyamo@gmail.com	K. Gyamo
④	Dakha Thondup	M		Guarantor	dakha@guar.com	D. Thondup
⑤	Dorji Wangmo	F		Tshogpa	77652638	D. Wangmo
⑥	Dawa Gyen	F		Tshogpa	77202829	D. Gyen
7.	Soren Wangmo	F	-	PCS Support	sorenwangmo719@gmail.com 171404107	S. Wangmo

Title (Dzongkhag/Gewog/Village).....Chapelha.....
 Venue.....Green Valley Restaurant, Bumthang.....

Date: 22/07/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
1	Dhewjit Singen	M	37	General Manager, DGC	d.singen2147@dnm.gov.bt 17617553	D. Singen
2.	Kinzang Dolma	F	23	AO, DGC	k.dolma3853adnubpaen.bt	K. Dolma
3.	Pema Dorji	M	38	Head (GESU)	p.dorji1869@dnm.gov.bt	P. Dorji
4.	Kezang Jian	M	58	Res. Support	kjgan55@gmail.com	K. Jian
5	Karna Wangchuk	M	25	- II	karna.wangchuk@dnm.gov.bt	K. Wangchuk
6	Dorji Rinchen	M	-	Consultant-PCS	khenzing@gmail.com	D. Rinchen
7	Magayla-jos	M	22	"	mgy4p@dnm.gov.bt	M. Jos
8	Karna Chogyel	M		"	karabkutan@gmail.com	K. Chogyel
9,	Singye Wangchuk	M	44	"	singye1@gmail.com	S. Wangchuk

Annex 1.2.4: Public consultation in the Chanachen Village, Geling Gewog - July 2025



Figure 10: The Gup of Geling Gewog welcoming the Team



Figure 11: Presentation by PCS team



Figure 12: The participants



Figure 13: DGPC representative clearing doubts



Figure 14: Presentation on biodiversity by PCS team



Figure 15: Presentation on environment by PCS team

Title (Dzongkhag/Gewog/Village) CHANGCHAN
 Venue GENOG CENTRE AT CHANGCHAN VILLAGE

Date: 23/4/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
1	Ugyen Dorji	M	53	Farmer	77479027	
2	Tobgyal	M	42	"	77681358	
3	Dem	M	56	"	77910273	
4	Nima Dorji	M	20	"	12555482	
5	Pentsho	M	45	"	17996251	
6	Khandi	M	54	"	73630094	
7	Tand Wangyel	M	63	"	77726937	
8	Tskindapan	F	26	"	77213946	
9	Tshandapan	F	48	"	77292405	

Title (Dzongkhag/Gewog/Village) Sikling Gewog
 Venue Sikling Gewog Center

Date: 23/07/25

Sl/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
10	Sam Tshering	M	28	CC	tshering.sam1997@gmail.com	
11	Soram Wangmo	F	-	GAID	swangmo1991@gmail.com	
12	Pema Lham	F	-	Stet I	lham103@gmail.com	
13	Soram Wangmo	F	-	PCA Support	soramwangmo714@gmail.com	
14	Kezang Tshering	M	-	"	kezangtshering1995@gmail.com	

Title (Dzongkhag/Gewog/Village) CHANACHAN Date: 23/4/25

Venue GEWOG CENTRE AT CHANACHAN VILLAGE

SI/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
19	Lhap Tshering	M	30	Doctor farmer	77609777	
20	Yangden	F	49	"	16903451	
21	Thihlay	F	52	"		
22	pasam	F	58	"		
23	Kinley Wangmo	F	30	"	7229217	
24	Passang Wangmo	F	51	"	72204040	
25	Chimi Wangmo	F	48	"	77419905	
26						
27						

Title (Dzongkhag/Gewog/Village) Geling Gewog Date: 23/04/25

Venue Geling Gewog Center

SI/No	Name	M/F	Age	Designation	Email Address/Contact Number	Signature
1	Dharjit Senger	M	37	General Manager, DGEC	dsenger2107@dnk.gov.bt 1767553	
2	Kinzang Dolma	F	23	AEO, DaPC	k.dolma5583@dnk.gov.bt 77330839	
3	Kinzang Dorji	M	39	Group, GELIG	ngdentshokig@gmail 17339124	
4	Chencho Dorji	M	31	mangmi	chenchosquare94@gmail.com	
5	Dawa Gyeltshen	M	46	Tshopa		
6	Pema Dorji	M	38	Head (GESU)	p.dorji1889@dnk.gov.bt	
7	Dorji Rinchen	M	-	Deputy ES, GPO Coordination Information Specialist, CMC	k.dorji1889@gmail.com	
8	Megay Penjore	M	-	PCS	megay4.penjore@gmail.com	
9	Karna Chogyel	M	-	PCS	chogyelk@yachos.com	

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ශ්‍රී ලංකා වන සම්පත් සංරක්ෂණ පනත, 1980

99 The trees, either grown naturally or planted, in a registered shall belong to the landowner.

Right to trees on registered land (Land Act 2007)

99 The trees, either grown naturally or planted, in a registered shall belong to the landowner.

ශ්‍රී ලංකා වන සම්පත් සංරක්ෂණ පනත, 1980

104 The Government may acquire a registered land for public interests.

Mode of compensation for land acquired

147 The landowner shall have the discretion to opt for substitute land or cash compensation offered by the Government in case of the land acquired from rural areas.

ශ්‍රී ලංකා වන සම්පත් සංරක්ෂණ පනත, 1980

104 The Government may acquire a registered land for public interests.

Acquisition of registered land (Land Act 2007)

142 The Government may acquire a registered land for public interests.

104 The Government may acquire a registered land for public interests.

143 The Government may provide substitute land or cash payment, or both, as compensation.

9. Allotment of a land substitute shall not enclose any patch of State land inside its boundary.

10. In the event the land substitute process is being delayed, to facilitate project implementation, the project may consider taking over the proposed land on lease by executing an agreement between parties until the land substitute is registered. However, this clause is limited to the National strategic projects only.

(LACRR)

ශ්‍රී ලංකා වන සම්පත් සංරක්ෂණ පනත, 1980

104 The Government may acquire a registered land for public interests.

Right to trees on Kudu, rehabilitation and substitute land (Land Act 2007)

105 Any trees on Kudu, rehabilitation and substitute land at the time of allotment shall belong to the Government unless otherwise specified in the Kasho or allotment order. Such trees shall be disposed by the Ministry if in the Government Reserved Forests land and the Municipal authority in the Government land, and hand over the land free of encumbrances within 60 days after registration of the land in the Thram of the person to whom the land is allotted.

104 The Government may acquire a registered land for public interests.

149 Compensation shall be provided for the immovable property on the acquired land.

140 The Government may acquire a registered land for public interests.

150 Upon acquisition, if the remaining land parcel is less than 10 decimals such land both in Thromde and rural areas shall also be acquired. However substitute amendment states that "The acquisition of land less than 10 decimals prevalent before the enactment of the Act shall be eligible for a proportionate land substitute".

104 The Government may acquire a registered land for public interests.

144 Acquisition of land shall entail a fair compensation.

104 The Government may acquire a registered land for public interests.

145 Acquisition shall be in accordance to the procedure on acquisition of registered land.

104 The Government may acquire a registered land for public interests.

146 Acquisition of the land occupied by religious monuments shall be avoided.

ශ්‍රී ලංකා වන සම්පත් සංරක්ෂණ පනත, 1980

147 The landowner shall have the discretion to opt for substitute land or cash compensation offered by the Government in case of the land acquired from rural areas.

Valuation of land and property

151 The rates issued by the Property Assessment and Valuation Agency established under the Ministry of Finance shall be basis to value and fix the value of land and any other collateral property that may be acquired. The valuation of the land and property shall consider the total registered area, registered land category, its current use, location in relation to accessibility to vehicular road, immovable property, local market value, and other elements such as scenic beauty, cultural and historical factors, where applicable.

འོས་ལྷན་གྱི་ས་ཚབ་གནང་དགོས

746 སའི་ཚེ་ལག་ལུ་ གཞུང་གིས་བཞེས་པའི་ ས་དང་མཉམ་པའི་འོས་ལྷན་གྱི་ས་ཚབ་ གནང་དགོ།

No choice for substitute land

156 The landowner shall have no choice over the location of substitute land provided by the Government.

གཞུང་གི་ས་ཆ་ ཡང་ན་གཞུང་དང་ནགས་ཚལ་གྱི་ས་ཆ་ཚུན་ནི་མེད་པ།

747 ས་ཚབ་སྒྲུབ་པའི་ས་ཆ་དེའི་ས་མཚན་མཉམ་གྱི་ཚུན་འགྲུབ་ལུ་ གཞུང་གི་ས་ཆ་ ཡང་ན་ གཞུང་དང་ནགས་ཚལ་གྱི་ས་ཆ་སྒྲུབ་པའི་མེད་པ་ལོང་དགོ།

Non-enclosure of Government land or Government Reserved Forests land

157 A land allotted as substitute shall not enclose any patch of Government land or Government Reserved Forests land inside its boundary.

Land Compensation Rates, 2023

a) Compensation rate of Developed pasture = Nu. 30,680.00 per acre

b) Land Development Cost of Chhuzhing = Nu. 2,392.60 per decimal.

Guideline on Compensation Rate for Buildings/Structures on the Land

The compensation for building/structures shall be based on its current construction cost, which is the cost of constructing a similar structure at the current prices. This should amount to the replacement cost with no depreciations being applied, as done earlier.

Rural Land Compensation Rates 2023 in the Chhiwogs of Chhukha Dzongkhag

Sl. No.	Designation	Category	Compensation	Chhuzhing	Chhiwog
37	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
38	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
39	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
40	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
41	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
42	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
43	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
44	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
45	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
46	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
47	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
48	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
49	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
50	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
51	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
52	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
53	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
54	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
55	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
56	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
57	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
58	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
59	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
60	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
61	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
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67	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
68	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
69	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
70	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
71	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
72	Chhukha	Musavara	Chhukha	Chhukha	Chhukha

Compensation rate of fruit trees 2023

Sl. No.	Designation	Category	Compensation	Chhuzhing	Chhiwog
1	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
2	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
3	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
4	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
5	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
6	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
7	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
8	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
9	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
10	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
11	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
12	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
13	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
14	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
15	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
16	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
17	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
18	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
19	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
20	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
21	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
22	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
23	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
24	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
25	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
26	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
27	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
28	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
29	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
30	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
31	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
32	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
33	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
34	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
35	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
36	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
37	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
38	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
39	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
40	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
41	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
42	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
43	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
44	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
45	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
46	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
47	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
48	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
49	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
50	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
51	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
52	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
53	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
54	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
55	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
56	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
57	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
58	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
59	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
60	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
61	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
62	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
63	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
64	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
65	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
66	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
67	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
68	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
69	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
70	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
71	Chhukha	Musavara	Chhukha	Chhukha	Chhukha
72	Chhukha	Musavara	Chhukha	Chhukha	Chhukha

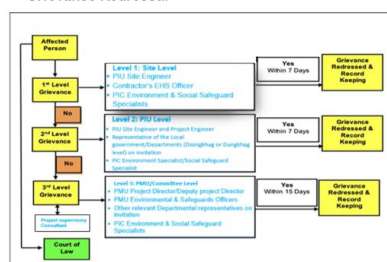
LIST OF HERITAGE SITES WITHIN CHAPCHA & GELING DZONG

Sl. No.	Name of Heritage Sites	Category
1	Pagar Gompas	
2	Lombari Rukhang	
3	Rimekha Rukhang	
4	Gangkha Rukhang	
5	Phandrak Gompas	
6	Shulma Gompas Nye Rukhang	
7	Kudung Chorten Rukhang	
8	Phelgen Nigmas Rukhang	
9	Bunakha Rukhang	
10	Dokkachu Gompas/ Dorgens Dargay Choling	Chapcha
11	Tshandrak Gompas	
12	Tshandrak Gompas nyekhang	
13	Gurgen Rukhang	
14	Lo Nyekha Rukhang	
15	Lobnyekha Gompas Rukhang	
16	Chapcha Dong	
17	Kony gompas/ Lung'ng gompas	
18	Karsel Rukhang	
Other important "Nyes" within Chapcha gewog		
1	Zhandruvng thri (Buddha)	
2	Patsheiling Trolku home	Chapcha
3	Dorj pham nyey	
4	Nye go	
Name of Heritage Sites		
1	Kamp Korng Chholing Rukhang	Geling
2	Geling Sanga Choling Rukhang	
3	Dapa Mangi Rukhang Rukhang	

Livelihood Restoration Program.

- Incase Livelihood of HHs/Families is jeopardized because of the project, what sort of remedies are to be taken up;
 - ✓ Trainings for men?
 - ✓ Trainings for women?
 - ✓ Skills development programs?
 - ✓ Agriculture/livestock training?
 - ✓ Skill enhancement & vocational trainings?

Grievance Redressal



Next step

- Finalisation of project components (which is fairly established)
 - Followed by Census survey of the project affected HHs,
 - Inventory of loss, (crops, trees, structures, houses etc.)
 - Compensation distribution process
 - Drawing up land lease agreements
 - Land replacement process
 - Finally acquiring land Ownership Certificates

Photographs of the field visit (23 April 2025 to 29 April 2025)



THANK YOU

Megaw Penjore
Social Capital
PSS
Bumkhu IPP
FNU DGP

Question answer and discussions

Annex 1.2.6: Public consultation in the Geling Gewog office, Chhukha - 9 December 2025





Bunakha HPP Public Consultation

Place: GELING GONGG, CHANACHEN

Date: 9/12/25

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
1	TILGICHEN	FORMER	CHANACHEN	57	M	17804087	
2	UGYEN	"	"	53	M	77479047	
3	TANDIN KANGCHU	"	"	63	M	77786737	
4	SANGAY THINLEY	"	"	49	M	77613847	
5	CHANGA	"	"	51	M	17610085	
6	SANGAY CHU	"	"	63	F	17255442	
7	SANAM YANGEL	STUDENT	"	18	F	17739253	
8	DEKI KANGMO	FARMER	"	39	F	17511598	
9	PEN LHAM	"	"	58	F	77710237	
10	SANAM KANGCHU	"	"	32	M	77801858	

Date: 9/12/25

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
11	TASHI TSHERING	Farmer	Chawachen	24	M	17318746	
12	LHAS DORJI	"	"	36	M	17816693	
13	CHOKI LAMGAYE	"	"	66	M	77808893	
14	DADA RAM	"	"	30	F	17634982	
15	DADA	"	"	38	M	17717305	
16	NAMA	"	"	30	M	17982869	
17	TORGAY	"	"	42	M	74681358	
18	TIMILEY RIDHA	"	"	52	F	17344394	
19	YANGDEN	"	"	57	F	16903151	
20	DZASANG DORJI	"	"	48	M	77711663	

Date 9/12/25

[illegible]

Public Consultation:

Place: GIELING GENWOG OFFICE HALLDate: 9/12/2025

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
1	Kinzang Dolma	AEO	DGPC		F	79330889	<i>[Signature]</i>
2	Dorji Tangden	Env. officer	DGPC		F	16935100	<i>[Signature]</i>
3	Karma Chogyal	Comm specialist	PCS		M	17765487	<i>[Signature]</i>
4	Mogang Pongso	Soc. cal	PCS		M	17618624	<i>[Signature]</i>
5	Tshering		Non-hon. Support		M	7710161	<i>[Signature]</i>
6	GOSHA TSHALSTEN	Env.	Jade		M	-	<i>[Signature]</i>
7	Dorji Rinchen	Deputy Village Coordinator	PCS		M	17110716	<i>[Signature]</i>
8	ARRGIS HADIMOR	Safeguard Specialist	ADB		F	-	<i>[Signature]</i>
9	Dr. Klabar Singh Mukherjee	Biodiversity Expert	Jade		M	-	<i>[Signature]</i>
10	Dr. B. K. D. Raja	Environment Expert	Jade		M	+91 9393333430	<i>[Signature]</i>

Public Consultation:

Place: GIELING GENWOG OFFICE HALLDate: 9/12/2025

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
11	Sangam Zang	Sanitation Project Officer	ABD, B.H.H.1		F	17607235	<i>[Signature]</i>
12							
13							

Annex 1.2.7: Public consultation in the Bunagu village, Chhukha - 10
December 2025



Public Consultation:

Place: GREEN VALLEY HOTEL BUNAGUDate: 10/12/2025

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
1	Kenzang Dolma	AEO	DAPC		F	97330839	
2	Dorji Yangdon	Env Officer	DAPC		F	16933700	
3	Megay Penjor	Social	PCS		M	17618624	
4	Karma Choqyel	Env. Spl	PCS		M	17765489	
5	Tshering	Nation Spl	Nation		M	7710061	
6	ROJOSHA TAMALDINA	Env.	Joke		M	-	
7	Dorji Rachen	Deputy Env Coordinator/ Sustainability Spl	PCS		M	17110716	
8	MARJIS MATIMON	ADB Secretary	Specialist		F	-	
9	Dr. Laksh Singh Mehta	Biodiversity Expert	"		M	-	
10	Dr. B. K. D. Raja	Environment Expert	Jade		M	491939333430	

Public Consultation:

Place: BunakhaDate: 10/12/2025

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
1	Phub Sathup	Sup	Gezagkha	31	M	97406144	
2	Rachen Nikey	GAO	Chiwog Center/hamtong	-	M	9717470395	
3	འཕྲུལ་པ་	འཕྲུལ་པ་	འཕྲུལ་པ་	24	M	97666664	
4	འཕྲུལ་པ་	འཕྲུལ་པ་	-	24	M	97666664	

Public Consultation:

Place: GREEN VALLEY HOTEL - BUNAKHADate: 10/12/25

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
1/	Lobsang	Tshogpa	Bunakha		M	17791004	
2/	Ugyen Pem	Farmas	-11-		F	77643852	
3/	Jusmay	-11-	-11-		M	17550158	
4/	Pema Wangmo	-11-	-11-	49	F	77884203	
5/	Ugyen Jamtsho	-11-	-11-		M	77208635	
6/	Thinley	Bunakha	-11-		M	77397480	
7/	Tshering Dorjup	Farmas	-11-		M	77447575	
8/	Nidup Parla	Business	-11-		M	17224884	
9/	Nangdi	Farmas	-11-		M	17636449	
10/	Tandin Pem	-11-	-11-		F	17514428	

Public Consultation:

Place: GREEN VALLEY HOTEL - BUNAKHADate: 10/12/25

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
11/	Tshering Pema	Farmas	Bunakha		F	17537074	
12/	Qinchen	Business	Bunakha		M	17743747	
13/	Krelbhas Doji	Service	Bunakha		M	17610840	
14/	Nim Tshering	Student	Bunakha		M	17913908	
15/	Jigme Nidup	Farmas	Bunakha		M	77833471	
16/	Par Tshering	Business	Bunakha		M	17163034	
17/	Thuji	Farmas	-11-		F	17778645	
18/	Pem	-11-	-11-		F	77789164	
19/	Phuspa Uam	-11-	-11-		F	16905142	
20/	Tshenlang Uam	-11-	-11-		F	17837235	

Public Consultation:

Place: GREEN VALLEY HOTEL - BUNAKHADate: 10/12/25

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
21	Lham	Farmer	Bunakha		F	17986341	
22	Choden	Business	Bunakha		F	77110894	
23	Chatty	Business	-/-		M	77110894	
24	Namgyal Dorji	Lam	-/-		M		
25	Kasma Langpa	Farmer	-/-		F		
26	Choeing Denna	Service	Chapka		F	17602528	
27	Linley	Farmer	Bunakha		F	17309484	
28	Nagaling	Service	-/-		M	17169061	
29	Yonten Gyeltshen	Farmer	-/-		M	17743169	
30	Wangden Pem	Farmer	-/-		F	17850783	

Public Consultation:

Place: _____

Date: _____

#	Name	Designation	Village/Chiwog	Age	M/F	Contact No.	Signature
31	Gyem Bidha	Service	Bunakha		F	17648773	
32	Linley Gyem	Business	Bunakha		F	17764054	
33	Nim Dorji	Farmer	-/-		M	17264219	
34	Namgyal Dorji						
35	Yonten Gyeltshen						
36							
37	Pishenlang Rinzin	Farmer	-/-		M	17418952	
38	Samgyal Om	Business	-/-		F	77833328	
39	Nima Gyeltshen	Service	-/-		M	17697159	
40							

Project Introduction ལས་འགུལ་ངོ་སྤྱོད།

Project Background ལས་འགུལ་རྒྱུ་ཁུངས།

- The Bunakha Hydropower Project (HPP) is a proposed 180 MW storage-type project located on the Wangchhu River in the Chapcha and Geling Gewogs under Chhukha Dzongkhag of western Bhutan.

Historical Development and Previous Studies གོང་འཕེལ་གྱི་ལོ་རྒྱུས་དང་སྤྱི་མཐོན་ཞིབ་འཇུག།

- First DPR was prepared by WAPCOS in 1995.
- Pre-feasibility level study done by Tehri Hydro Development Corporation Limited (THDC) in 2009.
- Comprehensive DPR was completed by THDC India Ltd. in October 2013.
- Environmental Impact Assessment (EIA) conducted in 2014

Project Introduction ལས་འགུལ་ངོ་སྤྱོད།

Current Impetus ད་ལྟོའི་ལྷན་ཁྲུག་ལྟེན་འགྲུབ།

- The current phase of study is being financed by the Asian Development Bank (ADB) through a Project Readiness Financing (PRF) facility titled "BHU: Green Power Project Readiness Enhancement."

Current Consultancy and Baseline Survey ད་ལྟོའི་གྲོས་སྤྱོད་དང་གཞི་རྒྱུ་ཞིབ་འཇུག་གི་བྱེད་སྒོ།

- **Druk Green Power Corporation Ltd.** appointed the **Joint Venture (JV) of Fichtner GmbH & Co. KG and JADE Consult** to perform the "Consultancy Services for **Review and Update of DPR and ESIA of Bunakha Hydropower Project**."
- The joint venture is backed by national experts, notably the teams from **Next Gen** and **Phuensum Consultancy Services (PCS)**, who are leading the environmental and social baseline assessments.

Technical Details རྒྱལ་འཇུག་ཁ་གསལ།

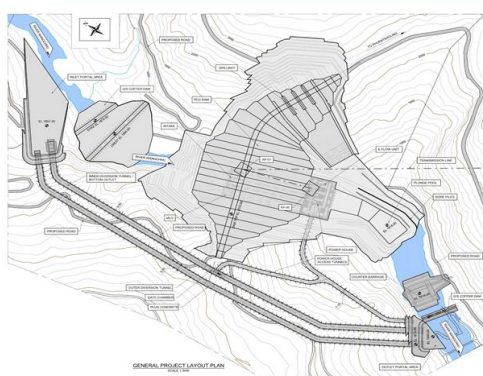
Hydrological study

- The river's average flow of **95 m³/s** ensures reliable power generation.
- Updated flood estimates (PMF 9,224 m³/s, routed outflow 9,164 m³/s) confirm **safe dam performance**.
- Low sediment deposition (122 Mm³ in 100 years) supports a **long reservoir lifespan**.
- Climate-change and GLOF risks are **low**, with continued monitoring recommended.

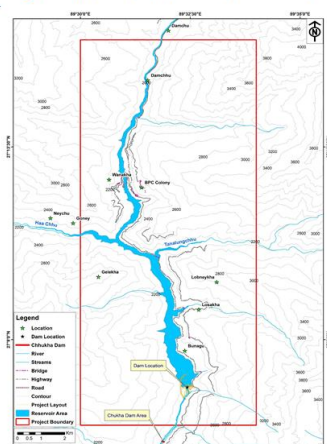
Parameters	Unit	Bunakha Dam Site
Catchment area	km ²	3,541
Average flow	m ³ /s	95.0
Average of annual maximum flow	m ³ /s	536
Average of annual minimum flow	m ³ /s	20.4
Average annual volume	Mm ³	2,996
25-year flood	m ³ /s	1,822
100-year flood	m ³ /s	3,606
1000-year flood	m ³ /s	2,326
PMP	m ³ /s	393
PMF	m ³ /s	9224
Annual average sediment load	Mm ³	1.22

(GLOF = Glacier lake outburst flood)

Project Layout and Optimization ལས་འགུལ་གཞི་བོད་དང་ལེགས་བཅོས།



General Project Layout



Reservoir Area

Project Design ལས་འགུལ་གནི་བོད་།

Reservoir

- FRL : EL 2006 m, MWL: EL 2008 m,
- MDDL :EL 1950 m,
- Gross Storage: 240.53 M cum,
- Live Storage:-157.90 M cum,
- Area: 4.23 km², Length: 17.25 km

Coffer Dam

■ Upstream Coffer Dam

- 40.00 m high Rockfill dam with central clay core and grouted cut-off

■ Downstream Coffer Dam

- 15.00 m high vibrated grout-enriched CSGR

Diversion Tunnel

- 2 Nos, Circular, 9.5 m dia,
- Inner: 860.70 m; Outer 904.30 m

Dam

- 197 m high RCC Dam (EL 1813–2010 m)
- top width -499 m long, bottom width -262.37 m
- Dam Includes
 - Gated spillway for flood management
 - Mid-level outlets and bottom outlet for reservoir control
 - Energy dissipation structures to safely release high flows

Powerhouse

- Surface Enclosed -at Dam Toe,
- Design Discharge 46 cumecs,
- Rated Head 143 m (net) Vertical Francis Turbines,
- 3 units × 60 MW each

Transmission Line

- 2 Single-Circuit Alignment, Bunakha HEP–Malbase line
- 2 km loop-in/out with Chukha-Simtokha

- The final design integrates all structural and electromechanical components required for safe and efficient operation.
- The powerhouse layout and waterways are designed to meet Bhutanese and international safety standards, including resistance to major floods and earthquakes.

Schedule ལས་རིམ།

- RCC dam technology helps reduce construction time and cost.
- Main construction is planned for 60 months (5 years); before there is 1 year for preparatory works = **6 years total construction time**
- Preparatory works include:
 - Land acquisition
 - Construction of roads and bridge
 - Construction of office and camps
 - Etc.
- Begin of construction is foreseen for **January 2027** – tentative date
- End of construction is foreseen for **April 2032** – tentative date

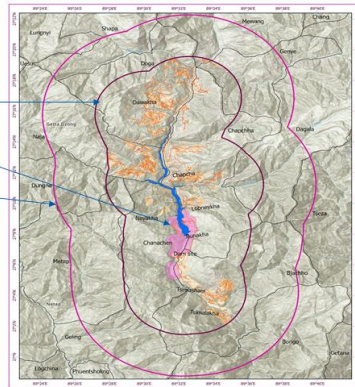
Environmental & Social Impact Assessment

མཐའ་འཁོར་དང་མི་སྡེ་ཕན་གཞི་དྲུག་བརྟག་ཞིབ།

Geographical Scope – Project Area of Influence (Aol)

The Aol is composed of a direct Aol and an indirect Aol, each delineated into smaller zones

- **Direct Aol** for the Bunakha HPP: 5-kilometer buffer around the Project's main components. Includes:
 - **Direct Impact Zone (DIZ):** 500-meter buffer
- **Indirect Aol:** 10-kilometer buffer
- The Aol includes:
 - Communities affected by land acquisition, resettlement, livelihood changes, and cultural impacts.
 - Areas affected by noise, air pollution, traffic increase, deforestation, etc.
 - Upstream and downstream river systems.



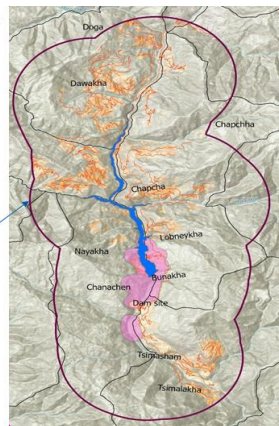
Environmental & Social Impact Assessment

མཐའ་འཁོར་དང་མི་སྡེ་ཕན་གཞི་དྲུག་བརྟག་ཞིབ།

Communities within the Direct Aol (direct Area of Influence)

- **Gewogs:** Chapcha, Bongo, and Geling in the south, and extends north to include parts of Doga and Shapa
- **Upstream communities:** The 5 km buffer extends far upstream to include settlements such as Chapcha and Dawakha
- **Downstream communities:** Settlements of Tsimasham and Tsimalakha

Direct Aol
5-km buffer

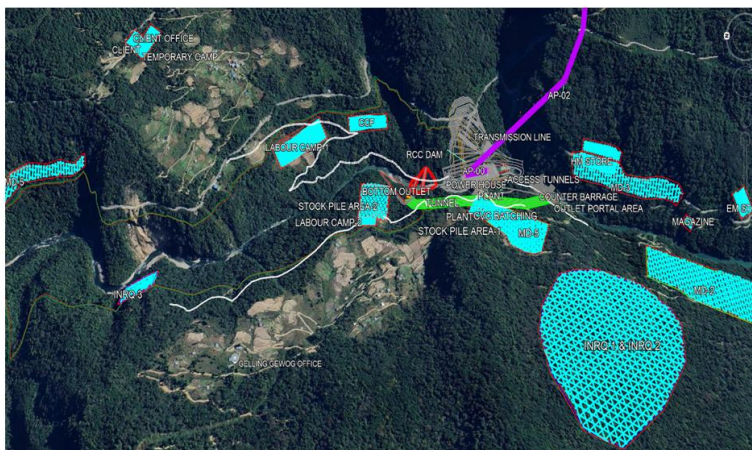


Pre-Project Scenario

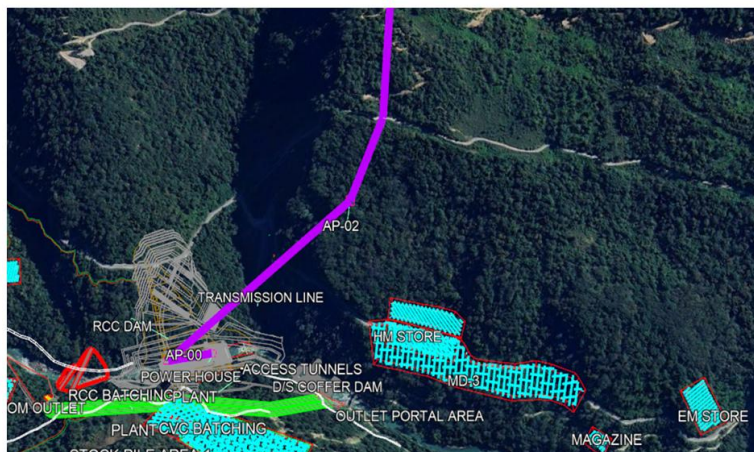


Pre-Project Scenario

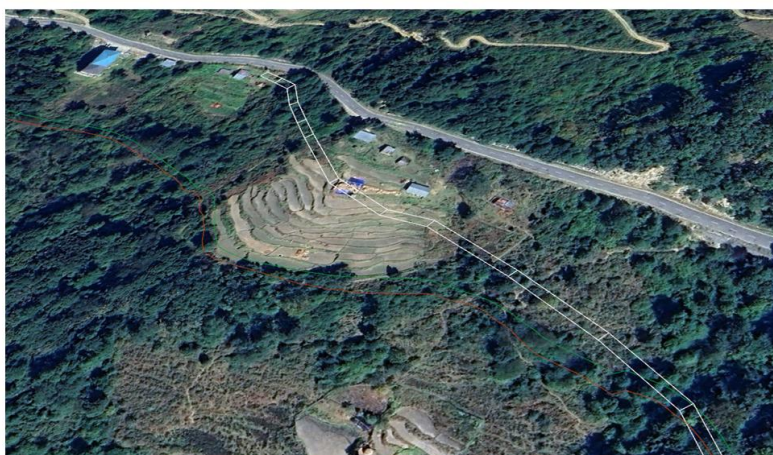




Bunakha



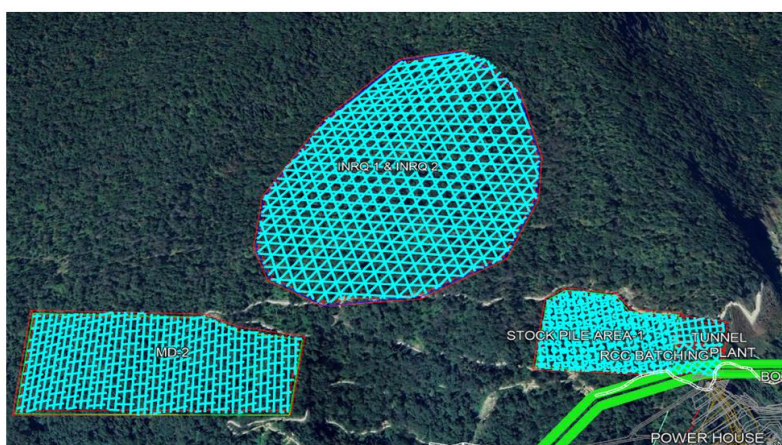
Bunakha



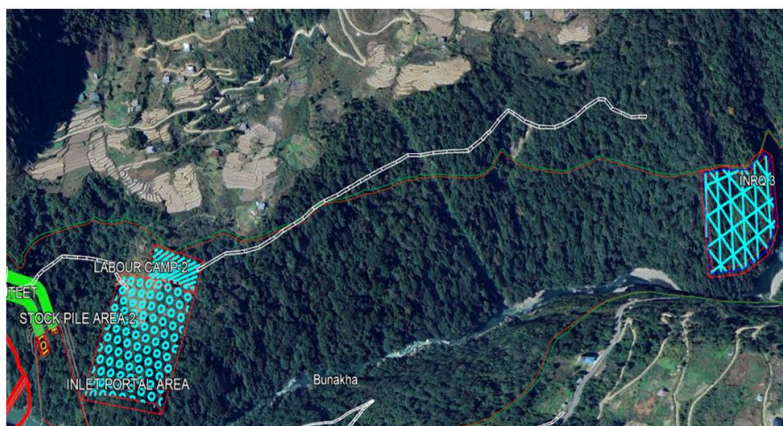
Bunakha



Chanachen Chiwog



Chanachen Chiwog



Tsamdrak and Shemgangkha



Damchu, Tsamdrak 1



Damchu, Tsamdrak 2



Shemgangkha 1



Shemgangkha 2



Social Environment - Resettlement Action Survey

མི་སྡེའི་གནས་སྤངས་ - གཞི་ཆགས་དང་ལེན་བརྟག་ཞིབ།

Survey: August 21 to 24 2025 བརྟག་ཞིབ་: ཟ࿳་ལོ་ ༢༠༢༥ ཟ࿳་ ༨ སེའི་ཟ࿳་ཚེས་ ༢༡ ལས་ ༢༤ ཟུན།

Comprehensive socioeconomic data on households affected by the project

Affected Asset Inventory གཞི་ཆགས་ལོ་ལྔ་དང་ལེན་བརྟག་ཞིབ་

The resettlement team with the support of the engineering design team, local community and PAPs prepared the list of affected assets and their owners that are located within the project footprint.

Project Components	Affected Households	Private Area (ha)	Remarks
Submergence Area	24	26.646	
EM Store	1	0.55	Partially
Total	25	27.196	

List of Affected Fruit trees/Vegetation-Private

FRUIT TYPE	Mrs. Nyind	Mrs. Mindum	Mrs. Gyem Bidha	Mrs. Tshewang Rinzin	Mr. Tshewang	Mrs. Rinzin	Mrs. Ugyen Pem	Mrs. Chungden	Mr. Pasang
Nos. (status/age)									
Agarwood	1 (10 yrs)	-	2 (3 yrs)	-	-	-	-	-	
Apple	-	-	-	-	-	-	-	1 (5 Yrs)	
Bamboo	-	-	-	100 (2" size)	-	-	-	-	
Banana	-	-	100	-	-	-	-	30	
Buddhi-shing	3 (1 yr)	1 (1 yr)	-	-	-	-	-	-	
Cashewnut (Kaju)	-	-	-	-	-	-	-	30 (1 yr)	
Fodder tree	2 (matured)	4 (matured)	10 (matured)	-	1 (matured)	1 (matured)	5 (matured)	-	
Humpa Scent-shing	-	-	10	2 (matured)	-	-	-	-	
Oak	7 (7 yrs)	-	-	-	-	-	-	-	
Walnut	5 (5 yrs)	-	2 (fruiting)	-	-	-	-	3 (fruiting)	4 (1 yr)
Peach	-	-	-	-	-	-	-	-	2 (1 Yr)
Pear	-	-	-	-	-	-	-	-	6 (1 Yr)
Wild pepper	-	-	-	-	-	-	-	2	

SUMMARY OF AFFECTED STRUCTURES								
BUNAKHA HYDROPOWER PROJECT (2025)								
Sl. No.	Owner	Permanent House	Semi-permnt. House	Store/ Shack	Shed	Fence	Greenhouse	Wall
1	Mrs. Chungden, Geling Gewog	Yes	-	-	Yes	Yes	Yes	Yes
2	Mrs. Gyem Bidha, Chapcha Gewog	-	Yes	-	-	Yes	-	-
3	Mrs. Rinzin, Chapcha Gewog	-	-	-	Yes	Yes	-	-
4	Mrs. Yeshey, Chapcha Gewog	-	-	-	-	Yes	-	-
5	Mr. Tshewang Rinzin, Chapcha Geog	-	-	-	Yes	Yes	-	-
6	Mr. Tshewang, Chapcha Gewog	-	-	-	-	Yes	-	-
7	Mrs. Sangay Wangmo, Chapcha Geog	-	-	-	-	Yes	-	-
8	Mr. Kezang, Chapcha Gewog	-	-	-	-	Yes	-	-
9	Mrs. Ugyen Pem, Chapcha Geog	-	-	-	-	Yes	-	-
10	Mrs. Ugyen Pemo, Chapcha Geog	-	-	-	-	Yes	-	-
11	Mrs. Markum, Chapcha Geog	-	-	-	-	Yes	-	-
12	Mr. Passang, Damchu, Chapcha Geog	-	-	Yes	-	-	-	-

Summary of Land Requirement for the Project

ལས་འགུལ་གྱི་དོན་ལུ་ ས་ཆ་དགོས་མཁའི་བརྩམས་ཐོག་

Total land required: - 1,410.6 acres; reservoir submergence: -1,108 acres.

སའི་དགོས་མཁའི་ཡོངས་བསྟོམས།: ཞེ་ཀར་ ༡༤༡༠.༦ | རྩམ་ཇོད་གྱི་སྤྱིང།: ཞེ་ཀར་ ༡༡༠༨ |

SN	Designation	Location	Area (acres)	Total Area (acres)
A.	Construction Facilities (Independent)			8.71
1	Batching Plant – CVC	Near MD-1 (Right bank)	1.75	
2	Batching Plant – RCC	Near MD-1 (Right bank)	2.03	
3	H&M Store	Near MD-3	2.36	
4	E&M Store	Chainachen farm road junction with highway	2.20	
5	Explosive Magazine	–	0.37	
B.	Client's Facilities			3.50
1	Temporary Camp	Near Bunaga Village	2.50	
2	Site Office	–	1.00	
C.	Dumping Yard			129.85
1	MD-1	Right bank of Wangchhu	15.00	
2	MD-2	–	40.20	
3	MD-3	Left bank of Wangchhu	12.50	
4	MD-4	–	53.20	
5	MD-5	–	8.95	
D.	Access Road (New Road)			8.71
1	Dam top right bank up to DT inlet	–	5.48	
2	Dam foundation & powerhouse (Left bank)	–	3.23	
E.	Improving Existing Farm Road			17.65
1	Chainachen farm road from junction till INRQ3	–	17.65	
F.	Project Component & Other Area			1242.154
1	Dam & powerhouse complex	–	80.00	
2	Reservoir area	–	1108.00	
3	Construction power	–	54.154	
4	Quarries	–	38.16	
	Total Area			1410.57

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Summary of Land Requirement for the Project

ལས་འགུལ་གྱི་དོན་ལུ་ ས་ཆ་དགོས་མཁའི་བརྩམས་ཐོག་

SN	Description	Road length (km)	Remarks
A	New Roads		
1	Dam top right bank up to DT inlet	2.20	Temporary road From Chainachen Village farm road (2nd Zig from Bailey Bridge
2	Dam foundation & powerhouse (Left Bank) up to u/s coffer dam	1.00	Temporary road plan to construct auxiliary access roads to various levels of the dam foundation and abutments
3	Dam area to various construction facilities on left bank	1.70	Temporary road From Primary National Highway near Bunagu village
4	Stockpile area to INRQ-3	1.25	Temporary Road for access to Quarry side.
	Total:	6.15	
B	Road Tunnel		
1	Access tunnel to PH	0.36	Permanent
2	Access tunnel to bottom outlet	0.23	Permanent
	Total	0.59	
B	New Bridges	Span (m)/Type/Capacity	Remarks
1	Bridge - 1	60/Bailey bridge/ 40R	Replacement of Chainachen farm road bridge
C	Improvement of Existing Road		
1	Chainachen village farm road	5.5 km	From highway till quarry site (INRQ3)
2	Re-alignment of highway	0.15km	

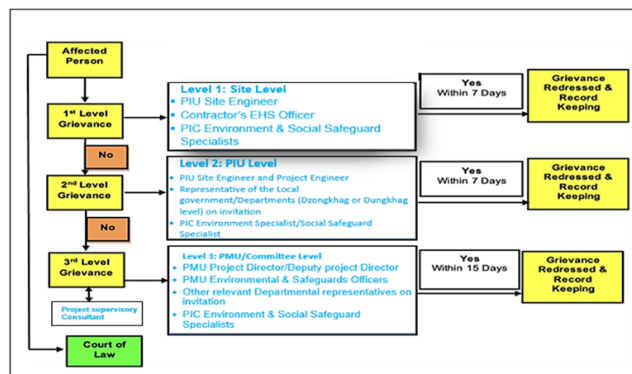
Grievance Redress Mechanism (GRM)

ཉེན་བཞོན་བསལ་ནིའི་ཐབས་ལམ། (རི་ཁར་ཨེམ)

DGPC will establish a GRM to address social and environmental concerns and ensure project accountability.

Affected persons (PAPs) will be informed about grievance procedures during public consultations and provided with relevant contact information at local and project levels.

PAPs can seek assistance from DGPC's social mobilizer to help submit or present grievances or queries to the Grievance Redress Committee (GRC).



Grievance Redress Mechanism (GRM-Committee)

ཉེན་བཞོན་བསལ་ནིའི་ཐབས་ལམ། (རི་ཁར་ཨེམ་ཚོགས་ཚུངས་)

Level 1: Site Level

- Contractor

Level 2: Project Implementation Unit (PIU) Level

- Site engineer
- Dzongkhag/Dungkha/Gewog/Mangmi/Tshogpa
- Project Implementation Consultant (PIC) - Social and Environment

Level 3: Project Management Unit (PMU) Level

- DGPC Project Director
- DGPC Environment and Safeguards Officer
- Project Implementation Consultant (PIC) - Social and Environment

DGPC Focal Person

Kinzang Dolma, Assistant Environment Officer

Email: k.dolma3853@drukgreen.bt Mobile: +975 77330839

Post Box 1351, Thori Lam, Thimphu 11001 +975 2 336414

Social Environment – Relocation and Income Restoration

མི་སྤོང་གནས་སྤོང་སྒྲིག་འཛུགས་ཀྱི་གཞི་གསལ་དང་འོང་འབབ་སྒྲིག་འཛུགས་

Compensation for acquired assets (རྒྱ་དངོས་ལེན་ཡོད་མི་ལུ་རྒྱ་དངོས་སྤོང་འཛུགས་): Covers costs of resettlement, land acquisition, housing, crops, trees, temporary/permanent assets, and replacement of common property.

Relocation costs (གཞི་གསལ་གྱི་རིན་ཐོང་ཚད་): Expenses for physically moving people/businesses, acquiring and preparing resettlement land, and replacing lost private/community assets including infrastructure and agricultural support.

Compensation for loss of income (འོང་འབབ་འབྱུང་མེད་པའི་དོན་ལུ་རྒྱ་དངོས་སྤོང་འཛུགས་): Provides temporary stipends or case-by-case payments until income is restored; collective compensation may be used for natural resource-based losses.

Income and livelihood restoration costs (འོང་འབབ་དང་འཚོ་བ་བསྐྱར་གསོ་གི་ཐོང་ཚད་): Costs for training, skill development, and providing credit to restore or improve livelihoods.

Administrative/implementation service costs (བདག་སྐྱོང་ལག་ལེན་ཞབས་ཏྲུག་གི་རིན་ཐོང་): Covers staff, consultants, NGOs, office space, equipment, transport, resettlement plan preparation, studies, and capacity building.

Costs for monitoring and evaluation (ལྟ་རྟོག་དང་དཔྱད་ཞིབ་ཀྱི་ཐོང་ཚད་): Expenses for periodic monitoring, external verification, and evaluation of resettlement plan implementation.

Social Environment – Livelihood Restoration Plan

མི་སྤོང་གནས་སྤོང་སྒྲིག་འཛུགས་ - འཚོ་ཐབས་སྐྱར་གསོའི་འཆར་གཞི།

Skill Training for Affected Persons (APs) (གནོད་པ་འབྱུང་ཡོད་མི་ཚུ་གི་དོན་ལུ་རིག་ཅུལ་སྦྱང་བཟུང་། (ཞེ་མི།)

- One member per affected household (AH) considered for vocational or skill training.
- Priority for temporary project employment based on skills and qualifications.
- Training areas flexible, responding to AP demand.

Employment and Contractor Consultation (ལཱ་གཞི་གཏམ་དང་འཕགས་པ་གི་ཐོས་བསྟུན།)

- Project consults with contractors and communities for fair employment conditions.
- Contracts will be encouraged for hiring APs and vulnerable groups first, then local community members based on capability.

Income Restoration Strategies (འོང་འབབ་བསྐྱར་གསོའི་ཐབས་ལམ།)

- Two types:
 - Land-based: Replacement land, farm/agro-business support, improving productivity.
 - Non-land-based: Skill training, temporary employment, small business support, credit, job facilitation.

Non-land-based support more effective due to out-migration reducing land use.

Social Environment - Roles & Responsibilities for implementation

མི་སྡེའི་གནས་སྡངས་ - བསྟར་སྦྱོར་གྱི་དོན་ལུ་ལཱ་འགན་དང་འགན་ཁུར།

1. Executing Agency & Project Management

DGPC serves as the Executing Agency.

Project Management Office (PMO) led by Project Coordinator oversees all project activities.

2. Environment and Social Management Unit (ESMU)

Formed under PMO to implement ESIA and RP.

Headed by a manager, supported by officers for effective safeguard implementation.

3. Role of Dzongkhag & Gewog Officials

Assist in resettlement and rehabilitation with technical/logistical support.

Dzongkhag team (LRO, DAO, DE, Survey Officer) helps with Cadastral surveys and Identification & allocation of replacement land

4. Support from Project Construction & Supervision Consultant (PSC)

Social/Resettlement Specialist works with ESMU on daily RP implementation.

Leads capacity building and training/orientation for Dzongkhag/Gewog officials.

5. Coordination & Monitoring

DGPC collaborates with local officials for daily coordination.

Jointly monitor progress, facilitate communication with Grievance Redress Committee and APs.

6. Budget & Inclusion Measures

DGPC ensures funds for land replacement, acquisition, and compensation.

All APs should be included in resettlement.

Social Environment - Gender & Vulnerability Assessment and Action Plan (GVA&AP)

མི་སྡེའི་གནས་སྡངས་- མོ་མོའི་དབྱེ་བ་དང་ཉེན་ཅན་གྱི་དབྱེ་ཞིབ་དང་ དང་ལེན་འཆར་གཞི། (ཇི་དང་མི་ཨ་ཨ་མི་)

The primary objective of the Gender & Vulnerability Assessment and Action Plan (G&VAAP) is to ensure equivalent participation of women and vulnerable people in the project lifecycle and decision-making processes.

Data collected at the site shows that:

- The female population is higher than male population
- The female illiteracy rate is about 38% whereas only 25% of men are illiterate.
- Females have a higher dropout rate post-secondary education than men
- More than 50% land and other property are owned by women
- Deforestation caused by the project will particularly impact women because mostly fodder collection, animal grazing and cattle rearing are jobs carried out by them.

Gender-tailored public consultation revealed that women are concerned about the different impact from land and other asset acquisition, as well other project activities, that they may feel. They requested the developers to prepare a separate action plan to ensure women participation in project construction and decision-making.

** 15 vulnerable persons (old age) were identified at the project affected area. The GVA&AP is being updated to include these persons too.*

Social Environment – Gender & Vulnerability Assessment and Action Plan (GVA&AP)

མི་སྒེའི་གནས་སྟངས་- ཕོ་མོའི་དབྱེ་བ་དང་ཉེན་ཅན་གྱི་དབྱེ་ཞིབ་དང་ དང་ལེན་འཆར་གཞི། (རི་དང་མེ་ཨ་མེ་པེ)

The Project is categorized as an effective gender mainstreaming opportunity, expecting to create skilled and non-skilled job opportunities for women. Additionally, women's involvement in institutional development and green jobs is one of the main recommendations of the GVA&AP. More specific measures and targets include small and medium enterprise through suggestions on capacity building /skill enhancement.

The GVA&AP suggests actions, targets, timelines and responsibilities for assuring gender mainstreaming in the Project. These include:

- Ensure meaningful consultation and participatory approach in all stages of the resettlement plan
- Emphasize legal entitlements and rights of girls/women.
- Recruit at least two women representative
- Prioritize grievances raised by women
- Engage women social mobilizers from each affected community.
- Prepare inventory of women existing skill levels
- Provide training in informal cottage industries (sewing, arts & crafts, agro-forestry, veterinary services).
- Focus on improving quality of life for women (maternal care), infants, elderly, and poor.
- Collect sex-disaggregated data on workforce
- Ensure segregated toilet facilities for women at work sites.

Social Environment – Inception Stage Stakeholder Engagement

མི་སྒེའི་གནས་སྟངས་ - ཁེ་རྒྱུད་འབྱུང་མི་གྲུལ་གཏོགས་འགོ་བཙུགས་གནས་ཅིམ།

The national and international ESIA Team undertook early stakeholder engagement (during the Inception Stage) by visiting the following regional and national authorities:

- Chhukha District (Dzongkhag) Administration (CDA) on 21.01.2025
- Gedu Divisional Forest Office on 22.01.2025
- Department of Water (DoW) on 24.01.2025
- Department of Environment and Climate Change (DECC) on 24.01.2025



Stakeholder Consultation Meeting: Gedu Divisional Forest Office, 22.01.2025



Stakeholder Consultation Meeting: Chhukha Dzongkhag Administration, 21.01.2025

Social Environment - Public consultation

མི་སྒེའི་གནས་སྟངས་ - མི་དམངས་ཐོལ་བསྐྱུལ།



Bunakha, Chapcha Gewog - April 2025

Public consultation in Bunakha, Chapcha Gewog
Meeting Location: Bunakha Village
Participants: 22 (M 11, F 11)
Date: 25.04.2025

Chanachen Village, Geling Gewog - April 2025

Public consultation in the Chanachen, Geling Gewog
Meeting Location: Gewog Meeting Hall
Participants: 22 (M 11, F 11)
Date: 25.04.2025

Social Environment - Public consultation during Baseline Surveys

མི་སྒེའི་གནས་སྟངས་ - ཞི་རྟེན་བརྟན་ཞིབ་ཀྱི་སྐབས་ལུ་མི་དམངས་ཐོལ་གཏོགས།

Public Consultation	Date	Location	Engagement
Chapcha Gewog	22 July 2025	Green Valley Hotel, Bunakha	Participants: 50 Male: 31 Female: 19
Geling Gewog	23 July 2025	Geling Gewog Meeting Hall, Chanachen Village	Participants: 25 Male: 14 Female: 11



Inauguration address by the Gup, Chapcha Gewog



DGPC representative clearing doubts at Chapcha Gewog

Social Environment - Stakeholder Engagement Plan

མི་སྒེའི་གནས་སྤངས། - ཁོ་རྒྱུད་འབྱུང་མི་གྲུལ་གཏོགས་འཆར་གཞི།

Target Stakeholders	Engagement	Methods
Project Affected People (PAPs)	Project documents (DPR, ESIA, RP, SEP, GAP), compensation, livelihood restoration, employment opportunities.	Public meetings, face-to-face, mass/social media, brochures, posters, dictation for illiterate PAPs.
Vulnerable APs	Entitlements, compensation, GRM, employment, tailored consultations.	PRA techniques, open-ended interviews, culturally appropriate disclosure.
Community Groups (Forestry/Fishery, Local Key Personnel)	RP, DPR, ESIA, ESMP, E&S disclosures.	Face-to-face, group interviews, consultations.
Local Organizations, NGOs, CBOs	E&S disclosures, employment opportunities, GRM.	Open ended interviews Community consultations
Media & Activists	Project milestones, compensation, R&R transparency.	Media briefing or press release Inviting media personnel to cover project activities Open ended interviews Discussions

Social Environment - Stakeholder Engagement Plan

མི་སྒེའི་གནས་སྤངས། - ཁོ་རྒྱུད་འབྱུང་མི་གྲུལ་གཏོགས་འཆར་གཞི།

Target Stakeholders	Engagement	Methods
Local government representative	Environment and social documentations and its disclosure Identification of land plots and uses Grievance Redressal mechanism process	Interactions Joint public / community meeting with PAPs
Project Workforce All Workers employed by contractor and sub-contractor Workers recruited locally	ESIA Code Conduct, labour management procedure disclosure related to workforce Workers Grievance Redressal mechanism Know-how of rights and other remedial measures available	Group orientation Separate interaction with subject stakeholders whenever interaction with concerned community is scheduled Informal interaction, one to one discussions or public meeting as per the need assessed by social officer.
Executing agencies / Govt. agencies/district agencies	Legal compliance issues, Coordination, Land Replacement process, Grievance mechanism process, E&S disclosures	Face-to-face meetings Invitations to public /community meetings Submission of required reports

List of Affected Land Owners-Geling Gewong

Sl. No.	Name of Owner	CID No.	Plot ID	Thram No.	Total Area	Affected Area (acres)	Type of Land	Chiwog (Gewog)	Project Components
1	Chungden	10207000677	GEN-1407, GEN-1463	165	1.852	1.852	Kamzhing	Geling	Submergence
					0.151	0.151	Residential Land		
2	Phub Lhamo	10207000342	GEN-503	432	0.521	0.42	Kamzhing		
3	Gangchumo	10207001462	GEN-1462, GEN-459	209	0.234	0.234	Residential Land		
					4.885	4.679	Kamzhing		
Total area						7.336			

List of Affected Structures-Geling Gewong

Sl. No.	Owner	Permanent House	Semi-permnt. House	Store/Shack	Shed	Fence	Greenhouse	Wall
1	Mrs. Chungdhen, Geling Gewog	Y	-	-	Y	Y	Y	Y

List of Affected Vegetation-Private

FRUIT TYPE	Nos. (status/age)	Mrs. Nyind	Mrs. Mindum	Mrs. Gyem Bidha	Mrs. Tshewang Rinzin	Mr. Tshewang	Mrs. Rinzin	Mrs. Ugyen Pem	Mrs. Chungden	Mr. Paung
Agarwood	1 (10 yrs)	-	-	2 (3 yrs)	-	-	-	-	-	-
Apple	-	-	-	-	-	-	-	-	1 (5 Yrs)	-
Bamboo	-	-	-	-	100 (2" size)	-	-	-	-	-
Banana	-	-	-	100	-	-	-	-	30	-
Buddhi-shing	3 (1 yr)	1 (1 yr)	-	-	-	-	-	-	-	-
Cashewnut (Kaju)	-	-	-	-	-	-	-	-	30 (1 yr)	-
Fodder tree	2 (matured)	4 (matured)	10 (matured)	-	1 (matured)	1 (matured)	5 (matured)	-	-	-
Humpa Scent-shing	-	-	10	2 (matured)	-	-	-	-	-	-
Oak	7 (7 yrs)	-	-	-	-	-	-	-	-	-
Walnut	5 (5 yrs)	-	2 (fruiting)	-	-	-	-	-	3 (fruiting)	4 (1 yr)
Peach	-	-	-	-	-	-	-	-	-	2 (1 Yr)
Pear	-	-	-	-	-	-	-	-	-	6 (1 Yr)
Wild pepper	-	-	-	-	-	-	-	-	2	-

Summary of Land Requirement for the Project

ལས་འགུལ་གྱི་དོན་ལུ་ ས་ཆ་དགོས་མཁོའི་བརྩམ་དོན།

Total land required: - 1,410.6 acres; reservoir submergence: -1,108 acres.

སའི་དགོས་མཁོའི་དང་ས་བསྐྱེམས།: ཨ་ཀར་ ༡༤༡༠.༦ | ལུ་མཛོད་གྱི་སྤྱི་དང་: ཨ་ཀར་ ༡༡༠༨ |

SN	Designation	Location	Area (acres)	Total Area (acres)
A.	Construction Facilities (Independent)			8.71
1	Batching Plant – CVC	Near MD-1 (Right bank)	1.75	
2	Batching Plant – RCC	Near MD-1 (Right bank)	2.03	
3	H&M Store	Near MD-3	2.36	
4	E&M Store	Chainachen farm road junction with highway	2.20	
5	Explosive Magazine	–	0.37	
B.	Client's Facilities			3.50
1	Temporary Camp	Near Bunaga Village	2.50	
2	Site Office	–	1.00	
C.	Dumping Yard			129.85
1	MD-1	Right bank of Wangchhu	15.00	
2	MD-2	–	40.20	
3	MD-3	Left bank of Wangchhu	12.50	
4	MD-4	–	53.20	
5	MD-5	–	8.95	
D.	Access Road (New Road)			8.71
1	Dam top right bank up to DT inlet	–	5.48	
2	Dam foundation & powerhouse (Left bank)	–	3.23	
E.	Improving Existing Farm Road			17.65
1	Chainachen farm road from junction till INRQ3	–	17.65	
F.	Project Component & Other Area			1242.154
1	Dam & powerhouse complex	–	80.00	
2	Reservoir area	–	1108.00	
3	Construction power	–	54.154	
4	Quarries	–	38.16	
Total Area				1410.57

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Sl. No.	Plot ID	Owner	CID	Thram No.	Total Area	Affected Area (acres)	Type of Land
1	CHP-2367, CHP-2287, CHP-2386, CHP-2350	Gyem Bidha	10204000190	20	0.469	0.469	Kamzhing
					0.897	0.049	Kamzhing
					0.612	0.612	Chhuzhing
					1.852	1.852	Kamzhing
2	GEN-1407, GEN-1463	Chungden	10207000677	165	0.151	0.151	Residential Land
3	GEN-503	Phub Lhamo	10207000342	432	0.521	0.42	Kamzhing
4	GEN-1462, GEN-459	Gangchumo	10207001462	209	0.234	0.234	Residential Land
					4.885	4.679	Kamzhing
5	CHP-52	Gembo Tashi	10204001089	395	1.487	0.771	Kamzhing
6	CHP-61	Pasang	10204000761	1496	1.171	1.132	Kamzhing
7	CHP-2361, CHP-2362	Sangay Om	10204000042	1076	0.17	0.17	Kamzhing
					0.575	0.575	Chhuzhing
8	CHP-2346, CHP-2345, CHP-2347	Kencho Bida	10204000002	25	0.05	0.05	Chhuzhing
					0.73	0.73	Kamzhing
9	CHP-1070	Choening Denma	10204000824	863	1	1	Kamzhing
10	CHP-5241, CHP-47	Dendup Tshering Karma Gyeltshen	11607002741	1507	0.944	0.018	Kamzhing
					0.42	0	Kamzhing
11	CHP-2337	Kinzang Jamtsho	10204000113	32	0.693	0.011	Chhuzhing
12	CHP-2333	Nyinda	10204000120	31	2.328	0.017	Kamzhing
13	CHP-2343	Tandin Pem	10204000074	30	1.52	1.52	Kamzhing
14	CHP-51, CHP-3634	Kuchumo	10204001210	899	0.7	0.491	Kamzhing
					1.338	1.148	Kamzhing
15	CHP-2704	Karma Eden	10204001204	99	1.655	1.3	Kamzhing
16	CHP-2341, CHP-2342	Choki	10204000077	1073	1.031	1.031	Chhuzhing
					0.668	0.668	Kamzhing
17	CHP-2356	Ugyen Pem	10204000149	24	0.164	0.164	Chhuzhing
18	CHP-3442	Rinzin	10204000177	28	0.392	0.392	Chhuzhing

Sl. No.	Plot ID	Owner	CID	Thram No.	Total Area	Affected Area (acres)	Type of Land
19	CHP-2288, CHP-2364, CHP-2338, CHP-2340	Choden	10204000056	384	0.469	0.47	Chhuzhing
					1.5	1.139	Kamzhing
					0.629	0.629	Kamzhing
					0.661	0.661	Chhuzhing
20	CHP-2349	Markum	10204000012	29	0.661	0.661	Chhuzhing
21	CHP-2339	Tshewang	10204000184	1069	0.586	0.586	Chhuzhing
					0.806	0.806	Chhuzhing
22	CHP-2352, CHP-2353	Tshewang Rinzin	10204000081	27	0.18	0.18	Chhuzhing
					0.69	0.571	Kamzhing
23	CHP-2358, CHP-2359	Kezang	10204000088	37	0.869	0.869	Chhuzhing
					0.69	0.571	Kamzhing
24	CHP-2344	Tshering Penjor	10204000055	1135	0.51	0.51	Kamzhing
					0.51	0.51	Kamzhing
25	CHP-3810 CHP-5238	Yangka Penjor	10204000110	1167	0.400	0.400	Kamzhing
					0.150	0.150	

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལོན་དང་རྒྱུ་འཕུལ་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

༢༤༽ རྫོང་གསེབ་ནང་ས་ལོན་འབད་མི་འཛིན་ཆ་བཟོ་མ་སྒྲིག་ལས་སྒྲོལ་མི་ཆོག།

24. A land substitute for the land acquired from rural areas shall not be provided from urban areas.

༢༥༽ བཅའ་ཁྲིམས་ཀྱི་དོན་ཚན་ ༡༤༧ པ་ལྟར་ གཤམ་གྱི་ཁྲུང་གིས་ལོན་པའི་ས་ཆ་དེ་ རྫོང་གསེབ་ནང་ལོན་པ་ཅིན་ སའི་ཚེ་བདག་
ལུ་ས་ཆ་བ་ ཡང་ན་ དངུལ་རྒྱུ་འཕུལ་ལཱ་ས་ ཡང་ན་ ལོན་ཡོད་པའི་ས་ཆ་འཛིན་གནས་གོང་དང་འབྲེལ་ ཆ་ཤས་ཅིག་ས་ཆ་བ་དང་
ཆ་ཤས་ཅིག་དངུལ་རྒྱུ་འཕུལ་སྒྲིག་གཞི་ཆ་ར་ གནས་ལ་རྒྱབ་ཞིའི་དབང་ཚད་ཡོད།

27. Pursuant to Section 147 of the Act, if the private registered land is acquired from rural areas, the landowner shall have the discretion to opt for land substitute or cash compensation or a combination of both, proportionate to the value of the acquired land.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལོན་དང་རྒྱུ་འཕུལ་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

༢༨༽ རྫོང་གསེབ་ནང་ལུ་ས་ཆ་བ་སྒྲོལ་ནི་ཕྱི་ཐང་ ས་གནས་དེ་གཤམ་འཁོད་སྒྲོལ་ཆོག་གྱི་ཕྱི་ཐང་འཁོད་འབྲེལ་དགོ།
གཤམ་འཁོད་འབྲེལ་སྒྲོལ་ནང་འཁོད་ལས་སྒྲོལ་དགོ།
འོ་ གཤམ་གྱི་དང་ ས་ཆ་བ་དེ་གཤམ་གྱི་ཅིག་ནང་མེད་པ་ཅིན་ རེད་ཐོག་ནང་འཁོད་ལས་སྒྲོལ་དགོ།
གཤམ་གྱི་དང་ ས་ཆ་བ་དེ་གོང་གི་ས་གནས་གཉིས་ཆ་ར་ནང་མེད་པ་ཅིན་ རྫོང་ཁག་གཅིག་ནང་ལས་སྒྲོལ་དགོ། རྫོང་ཁག་ས་ལོན་དང་
ས་ཆ་བ་ཆོག་ས་རྒྱུ་འཕུལ་འདེབས་ལྟར་ ལྷན་ཆོག་ཡིག་ཚང་གིས་བསམ་རྒྱུ་འབད་དེ་བཟུམ་འཛིན་འབད་ཆོག།

28. The land substitute in rural areas shall be in the following order of priority:

- Within the same village;
- If the land substitute is not available in the same village, then it shall be proposed from the same Gewog;
- In the event the land substitute is not available in the above two locations, then it may be proposed from the same Dzongkhag. Based on the recommendation of the DLACC, (Dzongkhag Land Acquisition and Compensation Committee) the Secretariat upon review may consider the proposal.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་ལྷན་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

ཁྲུང་བོ་དང་སྒྱུ་བ་པའི་ས་ཆ་ནང་ཡོད་པའི་ཤིང་གི་ཐོབ་དབང་།

༩༩ ཁྲུང་བོ་དང་སྒྱུ་བ་པའི་ས་ཆ་ནང་ རང་བཞིན་གྱིས་སྐྱེས་མི་དང་ བཅུག་ས་མི་ཤིང་གི་
བདག་དབང་འདི་སའི་ཚོ་བདག་ལུ་ཡོད་པ་ཡིན།

Right to trees on registered land (Land Act 2007)

99 The trees, either grown naturally or planted, in a registered land shall belong to the landowner.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་ལྷན་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

སྤྱད་སྒྱུག་དང་ གནོས་གསར་ ས་ཆ་བཟྱི་ས་ཆ་ཚུ་ནང་གི་ཤིང་གི་ཐོབ་དབང་།

༡༠༥ སྤྱད་སྒྱུག་དང་ གནོས་གསར་ ས་ཆ་བཟྱི་ས་ཆ་ཚུ་ནང་ཡོད་པའི་ཤིང་གི་ཐོབ་དབང་ལ་རུང་
ས་ཆ་སྤྱད་པའི་བཀའ་བྱ་རྒྱུ་ཆེད་དུ་བཀོད་དེ་ཡོད་ན་མ་གཞིགས་ནི་མིན་ གཞུང་གི་
བདག་དབང་ལུ་ཚུད་པ་ཡིན། དེ་ལྟགས་ཀྱི་ཤིང་ཚུ་ གཞུང་དབང་ནགས་ཚལ་འགྲེལ་
ཚུད་མི་ཡིན་པ་ཅིན་ལྷན་ལག་དང་ གཞུང་གི་ས་ཆ་ཚུ་ནང་ཚུད་མི་ཡིན་པ་ཅིན་ཁྲོམ་སྤྱོད་དབང་
འཛིན་གྱིས་ ས་ཆ་ཐོབ་མི་གི་མིང་ཐོག་ལུ་ཁྲུང་བོ་དང་སྒྱུ་བ་པའི་ཤུལ་ལས་ཉིན་གང་ས་༤༠
འི་ནང་འཁོད་སྤྱད་ལེན་འབད་དགོ།

Right to trees on Kidu, rehabilitation and substitute land (Land Act 2007)

105 Any trees on Kidu, rehabilitation and substitute land at the time of allotment shall belong to the Government unless otherwise specified in the Kasho or allotment order. Such trees shall be disposed by the Ministry if in the Government Reserved Forests land and the Municipal authority in the Government land, and hand over the land free of encumbrances within 60 days after registration of the land in the Thram of the person to whom the land is allotted.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་འཕུལ་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

གཞུང་གི་ཐུགས་མཐོང་བཞེས་མི་ས་ཆ་འཕུལ་སྒྲོན་བྱེད་ཐབས།

༡༤༧ གཞུང་གིས་ གོང་གསལ་གྱི་ས་གོ་ནང་ལས་ས་ཆ་གཞུང་གི་ཐུགས་མཐོང་བཞེས་པ་ཅིན་
སའི་ཚེ་བདག་དེ་གིས་ ས་ཆ་བ་ ཡང་ན་དངུལ་རྒྱུ་ཆ་གཞུང་གི་ཐུགས་མཐོང་གིས་གདམས་པ་
རྒྱུ་ཆེ་ཉི་དབང་ཚད་ཡོད།

Mode of compensation for land acquired

147 The landowner shall have the discretion to opt for substitute land or cash compensation offered by the Government in case of the land acquired from rural areas.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་འཕུལ་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

༡༤༩ གཞུང་གི་ཐུགས་མཐོང་བཞེས་མི་ས་ཆ་ནང་ཡོད་པའི་ བསྐྱལ་མེད་རྒྱ་དངོས་ཚུ་ལུ་ རྒྱུ་
འཕུལ་སྒྲོན་དགོ།

149 Compensation shall be provided for the immovable property on the acquired land.

༡༥༠ གཞུང་གི་ཐུགས་མཐོང་བཞེས་པའི་སྐབས་ལུ་ ལྷག་ལུས་གྱི་ཆ་ཤས་ས་ཆ་དེ་དྲི་སེ་སྤུལ་
༡༠ ལས་ཉུང་མ་སྤེལ་པ་ཅིན་ འདི་ཡང་གཞུང་གི་ཐུགས་མཐོང་བཞེས་དགོ།

150 Upon acquisition, if the remaining land parcel is less than 10 decimals, such land both in Thromde and rural areas shall also be acquired. However substitute amendment states that “The acquisition of land less than 10 decimals prevalent before the enactment of the Act shall be eligible for a proportionate land substitute”.

ས་ལེན་དང་རྒྱ་ལུས་ཀྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

༡༤༢ གཞུང་གིས་ མི་དམངས་ཀྱི་མཐའ་དྲོན་ལུ་ཁྲུབ་བཀོད་སྒྲུབ་པའི་ས་ཆ་ཅིག་ གཞུང་གི་
ཐུགས་མཁའ་དང་བཞེས་ཆོག།

142 The Government may acquire a registered land for public interests.

143 The Government may provide substitute land or cash payment, or both, as compensation.

ས་ལེན་དང་རྒྱ་དམུས་ཀྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༣༠༣༣ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

144 Acquisition of land shall entail a fair compensation.

145 Acquisition shall be in accordance to the procedure on acquisition of registered land.

146 Acquisition of the land occupied by religious monuments shall be avoided.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལོན་དང་རྒྱུ་འཕུས་ཀྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། 2022 ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

- ༩༽ ས་ཚབ་སྤྱོད་པའི་ས་ཆ་དེ་ ས་མཚན་སྤྱོད་པའི་ཆུ་ལམ་གྱི་ས་ཆ་ ལྷོ་ལོ་གཏང་ཡང་བཙུགས་མི་ཚོགས།
- ༡༠༽ ས་ཚབ་སྤྱོད་ནི་འདི་ལྟར་འགྲུབ་ལུས་པ་ཅིན་ ལས་འགུལ་གཞི་བཙུགས་ནི་དེ་ལྟར་ཐབས་ལུ་ ལས་འགུལ་འཛིན་སྐྱོང་གིས་ ས་ཆ་བཀོད་བསྐྱབས་ཐུན་ ལྷོ་ལོ་གཏང་གྲུབ་པའི་སྤྱི་ས་ཆ་དེ་ ས་འཛིན་བཀོད་པའི་མཉམ་གཞི་བཙུགས་པའི་སྤྱོད་པའི་ ལོན་དགོ། མིན་རུང་ རྟོན་ཚན་འདི་གིས་ རྒྱལ་ཡོངས་འཆར་གཞི་གི་ལས་འགུལ་ནང་རྒྱུ་འཕུས་ཅིག་འགན་ཁུར།

9. Allotment of a land substitute shall not enclose any patch of State land inside its boundary.
10. In the event the land substitute process is being delayed, to facilitate project implementation, the project may consider taking over the proposed land on lease by executing an agreement between parties until the land substitute is registered. However, this clause is limited to the National strategic projects only.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལོན་དང་རྒྱུ་འཕུས་ཀྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། 2022 ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

ས་ཆ་དང་རྒྱུ་འཕུས་ཀྱི་གནས་ཁོང་བཙོན་ཐངས།

- ༡༥༡ གཞུང་གི་ཐུགས་མཁོར་བཞེས་ནི་ལེན་པའི་ ས་ཆ་དང་ གན་ལེན་གྱི་རྒྱུ་འཕུས་གནན་ གང་རུང་ཅིས་རྒྱབ་ཏེ་ གནས་ཁོང་གཏན་འཁེལ་བཙོན་ནི་དོན་ལུ་ དཔུལ་ཅིས་ལྷན་ཁག་ གི་འོག་ལུ་ རྒྱུ་འཕུས་དབྱེ་ཞིབ་དང་གནས་ཁོང་བཙོན་མི་ལས་སྡེ་ཅིག་གཞི་བཙུགས་ འབད་དགོ། ས་ཆ་དང་རྒྱུ་འཕུས་ཀྱི་གནས་ཁོང་འདི་ ལྷོ་ལོ་གཏང་གྲུབ་པའི་ས་ཆ་ཚུ་ ཡོངས་བསྟོམས་དང་ ས་ཆ་འདི་དབྱེ་བ་ དེ་ལྟར་བཀོད་སྤྱོད་འབད་ཐངས་ འགྲུལ་ལམ་གྱི་ རྒྱུ་འཕུས་དང་འབྲེལ་བའི་ས་གནས་ ས་གནས་ཀྱི་ཚང་འབྲེལ་གྱི་གནས་ཁོང་ དེ་ལས་ གནན་ཡང་འོས་འབབ་དང་བསྟན་ མཐོང་སྤང་གི་མཛེས་ཆ་དང་ ལམ་སྟེན་ རྒྱལ་ རབས་ཀྱི་རྒྱབ་ཁུངས་ལ་སོགས་པ་ཚུ་ལུ་གཞི་བཞག་སྡེ་བཙོན་དགོ།

Valuation of land and property

- 151 The rates issued by the Property Assessment and Valuation Agency established under the Ministry of Finance shall be basis to value and fix the value of land and any other collateral property that may be acquired. The valuation of the land and property shall consider the total registered area, registered land category, its current use, location in relation to accessibility to vehicular road, immovable property, local market value, and other elements such as scenic beauty, cultural and historical factors, where applicable

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་ལྷན་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

འོས་ལྷན་གྱི་ས་ཆ་བཀོད་སྟོན་པ།

༡༥༦ སའི་ཇོ་བདག་ལུ་ གཞུང་གིས་བཞེས་པའི་ ས་དང་མཉམ་པའི་འོས་ལྷན་གྱི་ས་ཆ་བཀོད་སྟོན་པ།

No choice for substitute land

156 The landowner shall have no choice over the location of substitute land provided by the Government.

གཞུང་གིས་ཆ་ ཡང་ན་གཞུང་དབང་ནགས་ཆལ་གྱི་ས་ཆ་རྒྱུད་ནི་མེད་པ།

༡༥༧ ས་ཆ་བསྐྱོད་མི་ས་ཆ་དེའི་ས་མཆོམས་ཀྱི་ནང་འཁོད་ལུ་ གཞུང་གིས་ཆ་ ཡང་ན་ གཞུང་དབང་ནགས་ཆལ་གྱི་ས་ཆ་སྤེལ་བཞག་ནི་མེད་པ་བཟོ་དགོ།

Non-enclosure of Government land or Government Reserved Forests land

157 A land allotted as substitute shall not enclose any patch of Government land or Government Reserved Forests land inside its boundary.

Land Acquisition and Compensation Rules and Regulations 2022 LACRR (Relevant Clauses)

ས་ལེན་དང་རྒྱུ་ལྷན་གྱི་བཅའ་ཡིག་དང་སྒྲིག་གཞི། ༢༠༢༢ ཅན་མ། (འབྲེལ་ཡོད་དོན་ཚན།)

Land Compensation Rates, 2023 ས་གནི་རྒྱུ་ལྷན་གྱི་ཆད་གཞི་ ༢༠༢༣ ་།

a) Compensation rate of Developed pasture = Nu. 30,680.00 per acre

b) Land Development Cost of Chhuzhing = Nu. 2,392.60 per decimal.

Guideline on Compensation Rate for Buildings/Structures on the Land ས་གནི་ཐོག་གི་རྒྱུ་ བྱེད་པའི་རྒྱུ་ལྷན་གྱི་ལམ་སྟོན།

The compensation for building/structures shall be based on its current construction cost, which is the cost of constructing a similar structure at the current prices. This should amount to the replacement cost with no depreciations being applied, as done earlier.

ཀུ་ཁ་ཇོང་ལག་འོག་གི་སྤྱི་འོག་ཚུ་ནང་གི་ཁོང་གསེབ་ལ་ཆའི་རྒྱུ་འབྲས་ཤོང་ཚད་ ༢༠༢༣

Sl no.	Dzongkhag	Gewog	Chiwog	Category	Kamzhing	Chhuzhing	Orchard
37	Chhukha	Metakha	Uekha	Class D	3,112.89	2,801.60	3,405.64
38	Chhukha	Metakha	JOZHINGKHA, MAEDTAB-TOED	Class D	3,112.89	2,801.60	3,405.64
39	Chhukha	Metakha	MAEDTAB-MAED	Class D	3,112.89	2,801.60	3,405.64
40	Chhukha	Metakha	PANGU	Class D	3,112.89	2,801.60	3,405.64
41	Chhukha	Loggchina	DOLEPCHEN, BIAGCHHU	Class D	3,112.89	2,801.60	3,405.64
42	Chhukha	Loggchina	CHAGDOKHA, DAMCHEKHA	Class D	3,112.89	2,801.60	3,405.64
43	Chhukha	Getana	JANAMO, PHOOTSHA	Class D	3,112.89	2,801.60	3,405.64
44	Chhukha	Getana	DARGA, TSEBBI	Class D	3,112.89	2,801.60	3,405.64
45	Chhukha	Getana	CHIYUEL, GETAG	Class D	3,112.89	2,801.60	3,405.64
46	Chhukha	Getana	BACHHU, GETANA	Class D	3,112.89	2,801.60	3,405.64
47	Chhukha	Getana	TASHIGANG	Class D	3,112.89	2,801.60	3,405.64
48	Chhukha	Geling	DAGPA, SORCHEN	Class D	3,112.89	2,801.60	3,405.64
49	Chhukha	Geling	GELINGKHA, GEYGOEN	Class C	5,299.93	4,239.15	5,350.44
50	Chhukha	Doogna	CHHULAKHA, MANGDOKHA	Class D	3,112.89	2,801.60	3,405.64
51	Chhukha	Doogna	BABANA, PAPALING	Class D	3,112.89	2,801.60	3,405.64
52	Chhukha	Doogna	DRUKDINGSA, KHORI	Class D	3,112.89	2,801.60	3,405.64
53	Chhukha	Doogna	DOONGNA, PAGSEL-LHAKHA	Class D	3,112.89	2,801.60	3,405.64
54	Chhukha	Doogna	DAMCHERKHA, UEZHI	Class D	3,112.89	2,801.60	3,405.64
55	Chhukha	Darla	SAMARCHEN, SINCHULA	Class D	3,112.89	2,801.60	3,405.64
56	Chhukha	Darla	TAGP-THANG-BOOG	Class D	3,112.89	2,801.60	3,405.64
57	Chhukha	Darla	NYIMGANG, TABJI	Class D	3,112.89	2,801.60	3,405.64
58	Chhukha	Darla	GENGU, YAGANG	Class D	3,112.89	2,801.60	3,405.64
59	Chhukha	Darla	GAMANANG, KALZANG-RI	Class D	3,112.89	2,801.60	3,405.64
60	Chhukha	Darla	SHARPHUG	Class D	3,112.89	2,801.60	3,405.64
61	Chhukha	Chapchha	PAGGA	Class D	3,112.89	2,801.60	3,405.64
62	Chhukha	Chapchha	GANGKHA, SHEL-YUEL	Class D	3,112.89	2,801.60	3,405.64
63	Chhukha	Chapchha	BUNAKHA	Class D	3,112.89	2,801.60	3,405.64
64	Chhukha	Chapchha	LANG NYELSA	Class D	3,112.89	2,801.60	3,405.64
65	Chhukha	Chapchha	DOKHARCHHU, RIMTEKHA	Class D	3,112.89	2,801.60	3,405.64
66	Chhukha	Chapchha	TSHAMDRAG	Class D	3,112.89	2,801.60	3,405.64
67	Chhukha	Bongo	CHOONGKHA, CHHASILAKHA	Class D	3,112.89	2,801.60	3,405.64
68	Chhukha	Bongo	GEDU, MIITSEMO	Class D	3,112.89	2,801.60	3,405.64
69	Chhukha	Bongo	KETOGKHA	Class D	3,112.89	2,801.60	3,405.64
70	Chhukha	Bongo	TOGTOKHA, TOSTOGONGM	Class D	3,112.89	2,801.60	3,405.64
71	Chhukha	Bongo	BONGO, PHASOOMA	Class D	3,112.89	2,801.60	3,405.64
72	Chhukha	Bongro	BAEYUEL, KUNZANG	Class D	3,112.89	2,801.60	3,405.64

Compensation Rates of Fruit Trees 2023

ཤོང་འབྲས་ཤོང་ཚུ་འབྲས་ཤོང་ཚད་ ༢༠༢༣

SN		YRT*	0	1	2	3	4	5
1	Apple	5	746.73	1,209.58	2,135.28	2,598.13	3,060.98	6,333.33
2	Apricot	5	765.25	1,314.50	1,863.74	2,412.99	2,962.24	4,389.36
3	Areca nut	5	265.37	499.88	672.68	993.58	1,487.29	2,167.68
4	Avocado	5	654.16	1,147.87	1,641.57	2,073.57	2,628.98	3,517.66
5	Banana	2	175.88	268.45	268.45	-	-	-
6	Cardamom	5	49.83	73.42	107.93	139.13	170.58	477.31
7	Guava	5	373.94	888.67	1,203.41	1,518.15	1,832.88	2,298.82
8	Jackfruit	5	999.75	1,690.95	2,382.13	3,073.33	3,764.51	5,569.63
9	Lemon	5	549.25	1,166.38	1,783.52	2,092.08	2,246.37	2,807.96
10	Lime	5	450.51	697.36	944.22	1,191.07	1,252.78	1,643.12
11	Litchi	5	956.56	1,647.74	2,338.94	3,030.12	3,721.32	5,129.92
12	Mango	5	746.73	1,579.86	2,412.99	3,246.12	4,079.25	6,140.47
13	Olive	5	703.53	1,444.09	2,184.65	2,925.21	3,665.77	5,507.91
14	Orange	5	802.27	1,437.92	2,073.57	2,709.22	3,344.86	4,543.64
15	Papaya	4	277.71	347.14	416.56	439.71	586.28	586.28
16	Peach	5	573.94	1,004.39	1,434.83	1,726.43	2,567.27	2,610.48
17	Pear	5	604.79	1,098.50	1,592.21	2,085.91	2,579.62	3,841.65
18	Plum	5	647.99	1,197.24	1,746.49	2,295.73	2,844.98	4,242.79
19	Pomegranate	5	444.33	826.96	1,209.58	1,592.21	1,789.69	2,406.82
20	Pomelo	5	581.65	768.78	1,417.55	2,126.33	2,835.10	3,543.89
21	Tree Tomato	4	167.39	334.80	502.19	669.59	669.59	669.59
22	Bamboo 4"	5	15.38	15.38	15.38	15.38	61.51	124.42
23	Bamboo 2"	5	7.69	7.69	7.69	7.69	24.00	50.00
24	Walnut	5	1,092.32	1,715.63	2,338.94	2,962.24	3,585.54	5,201.06
25	Cocunut	5	1,432.90	1,845.30	2,157.57	2,369.75	2,481.81	3,583.00
26	Persimmon	5	1,464.28	1,816.90	2,079.88	2,253.20	2,336.87	3,351.41
27	Passion fruit	2	679.84	889.03	1,048.91	-	-	-
28	Tamarind	5	826.28	984.65	1,101.19	1,172.92	1,202.80	1,709.32
29	Sapota	5	930.86	1,080.28	1,187.86	1,250.61	1,271.53	1,795.99
30	Grapes	3	307.79	439.29	533.41	1,016.03	-	-
31	Sugarcane	1	17.85	17.85	-	-	-	-
32	Pineapple	1	23.57	23.57	-	-	-	-
33	Watermelon	1	64.04	64.04	-	-	-	-
34	Coffee	4	655.54	768.11	999.86	1,152.16	1,783.42	-
35	Hazelnut	4	329.29	376.97	427.09	430.40	721.98	-
36	Kiwi	4	3,423.37	3,718.03	4,148.43	4,800.66	7,270.52	-
37	Strawberry	2	17.65	17.65	-	-	-	-
38	Exotic Trees	5	1,101.19	1,417.55	1,715.63	2,126.33	2,835.10	3,543.89

Physical Environment – Most affected communities

མཐའ་འཁོར་གནས་སྤངས། གནོད་སྐྱོན་མང་ཤོས་འབྱུང་མི་མི་སྡེ།

Chanachen Village

Most critically sensitive community due to immediate proximity to quarry, crusher, and batching plants.

Exposed to high noise, dust, vibration, and heavy traffic—creating cumulative environmental and social stress.

Baseline noise levels are extremely low, meaning even moderate construction noise will be disruptive.

Nayakha Village

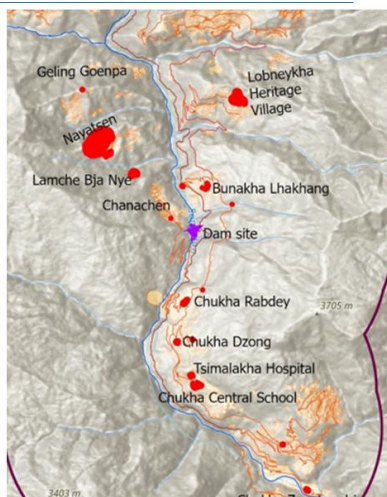
Highly vulnerable to noise intrusion and local accumulation of air pollutants from construction traffic.

Bunakha Village

Major residential and agricultural hub; includes culturally important Bunakha Lhakhang temple. Located along AH48, the main logistics route, and near a proposed project campsite (SSP-4), making it highly sensitive to traffic impacts.

Tsimalakha Village

Tsimalakha Hospital and Chukha Central School—both highly sensitive receptors. Main project traffic will bypass the town, but internal colony-related traffic will still impact local roads.



Physical Environment – Most affected cultural sites

མཐའ་འཁོར་གནས་སྤངས། གནོད་སྐྱོན་མང་ཤོས་འབྱུང་མི་མི་སྡེ་སྤངས།

Bunakha Lhakhang:

A major temple on the eastern riverbank, located beside the main access road and visible from the quarry, making it highly vulnerable to construction noise, vibration, and dust.

Lamche Bja (Elephant Cliff):

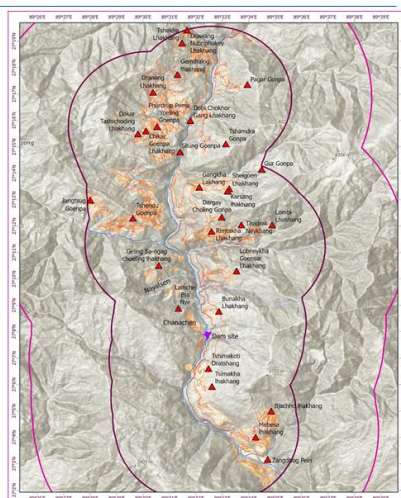
A spiritually important cliff above the proposed quarry. During July 2025 consultations, communities raised strong concerns that blasting could disturb protective deities and jeopardize cliff stability.

Lobnekha Heritage Village:

A heritage settlement 3–4 km north-northeast of the activity zone and directly downwind, making it susceptible to dust and combustion emissions due to prevailing winds.

Nayatsen, Tsho Sacred Sites & Geling Goenpa:

Sacred sites and an active monastery northwest of the Project, located downwind and characterized by poor air dispersion and a quiet soundscape, making them highly sensitive to dust and low-frequency blasting noise.



Physical Environment - Pre-Construction Impacts

མཐའ་འཁོར་གནས་སྤངས། བཟོ་སྐྱོད་ཀྱི་གོང་གི་སྐབས། ཕན་གཞི།

Project Key Activities	Sub-Activities	Potential Environmental and Social Impacts
Pre-Construction Phase (Planning, Design and Procurement)		
Lay out designs གཞི་བཞུག་བཟོ་རྒྱུ།	Siting of project facilities	Avoid: Change project design or location to prevent negative impacts entirely through Site selection, technology choice, rerouting, etc. Reduce: Minimize the scale or likelihood of impacts through preventive measures through Engineering controls, best practices, timing, etc. Mitigate: Offset or compensate for impacts that cannot be fully avoided/reduced through Restoration, compensation, offsets, etc. Manage: Ongoing monitoring, adaptive management, and stakeholder engagement through Environmental management plans, audits, reporting, etc.
Contractor Construction Facilities (offices, stores, garages, batching plants, stores, etc.) ལག་འབག་གི་བཟོ་སྐྱོད་མཐུན་རྐྱེན་	Land Clearing	Change in land use/ land cover Topsoil loss Soil Contamination
Construction activities for roads and facilities འཁོར་ལམ་དང་མཐུན་རྐྱེན་གྱི་དོན་ལུ་ བཟོ་སྐྱོད་ལུ་ཚུ།	Foundations/ Superstructure/ Finishing	Habitat loss: Clearing trees and undergrowth destroys nesting and feeding areas. Displacement: Animals are forced to move, often into less suitable or already occupied habitats. Road kills, disturbance of migratory routes, etc. Fragmentation: Roads and clearings split habitats, isolating populations.

Physical Environment - Construction Impacts

མཐའ་འཁོར་གནས་སྤངས། བཟོ་སྐྱོད་གི་སྐབས། ཕན་གཞི།

Project Key Activities	Sub-Activities	Potential Environmental and Social Impacts
Construction Phase བཟོ་སྐྱོད་གི་སྐབས།		
Blasting ཇུས་གསལ།	Blasting Activities Storage of Explosives Transportation of Explosives	Noise Pollution often exceeding safe thresholds for humans and wildlife. Air Pollution (Dust & harmful gases such as nitrogen oxides (NOx), carbon monoxide (CO), and sulfur dioxide (SO ₂)).
Dam Construction རྩ་མཐོན་བཟོ་སྐྱོད།	River diversion Coffer dams Tunnelling Dam Construction	Habitat loss and fragmentation and degradation: Forest clearing and reservoir creation disrupt wildlife corridors and reduce biodiversity. Aquatic ecosystem disruption: Altered river flow affects fish migration and aquatic species survival. Change in downstream flow and hydraulic regime
Electrical Mechanical Works ཐྱིག་འབྲེལ་འཕུལ་རིག་གི་ལུ།	Equipment installation Workshops	Noise pollution . Soil Contamination due to oils and lubricants Waste generation including hazardous waste Accidents, Electrocutation
Muck Disposal ས་རོ་བཀོ་སྐྱོ།		Forest degradation, Increase in traffic Air pollution due to traffic, Accidents Impacts on flora and fauna, Health and safety issues to workers and community

Management must prioritize intense dust suppression at all sources (quarries, stockpiles, haul roads)
Project is recommended to establish and maintain a suitable Water Treatment Plant (WTP) for all water supplied for domestic purposes.

Climate Change གནམ་གཤིས་འགྱུར་བ།

Greenhouse gas emission reductions associated with implementing the project

ལས་འགུལ་འགོ་བརྩམས་དང་འབྲེལ་བའི་ནང་རྒྱུ་འབྲེལ་ནི་དེ་མཁས་པ།

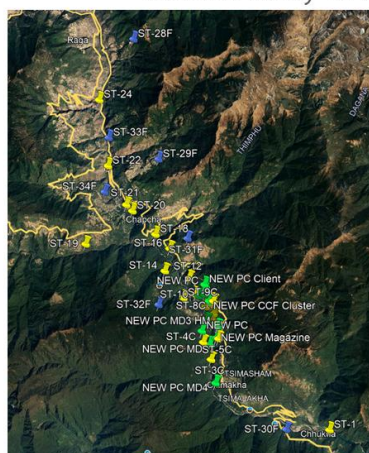
- GHG emissions reduction from Bunakha HPP would be equivalent to **5,88,548 tCO₂** equivalent annually considering a 8-hours peaking operation of the Bunakha HPP, considering baseline emission (BE) from grid connected power plants minus project emission (PE).

Biological Environment རྩི་ལྗན་གནས་སྤངས།

Aquatic survey རྩི་ལྗན་འཇུག་ཞིབ།



Terrestrial survey ས་ཆའི་



ཕྱི་ལྷན་གནས་སྟངས། - ལྷན་གནས་བརྟན་ཞིབ།

53 individual fish were recorded across two species:

-

སྐྱེ་ལྔའ་གནས་སྟངས། - རྒྱུ་གནས་བརྟག་ཞིབ།

- 241 fish individuals were recorded across 28 different species
- 26 families of macroinvertebrates
- 31 algal taxa belonging to 24 families
- 31 phytoplankton taxa
- 5 genera of Zooplankton

95

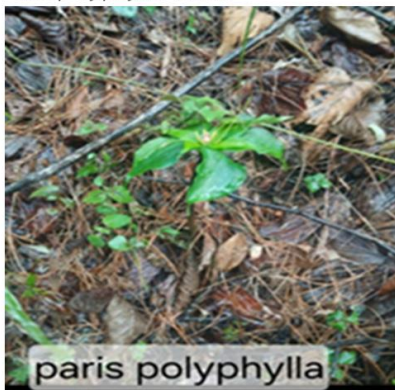
Biological Environment – Terrestrial Surveys

ཕྱི་ལོ་གནས་སྐབས་ - ས་ཆའི་བརྟག་ཞིབ།

	Pre-Monsoon	Monsoon	Remarks
Mammals	7 species	9 species	
Birds	76 species	69 species	
Herpetofauna	-	28 species *25 species of reptiles, and 3 species of amphibians	
Butterfly		9 Species	
Vegetation	46 species of trees, 42 species of shrubs, 42 species of herbs *10 invasive plant species	44 species of trees, 42 species of shrubs, 42 species of herbs and 12 species of epiphytes *21 invasive plant species	

Plants ལྗོན་ལོང་།

Paris polyphylla (herb)



Piper pedicellatum (herb)



Mammals མངལ་སྐྱེས་སྒྲིབ་ཆགས།

Himalayan Goral



Sambar Deer dung



Asiatic Black Bear



Biological Environment - Impacts on the Terrestrial Environment

སྐྱེ་ཁུངས་གནས་སྡངས། - ས་ཆའི་མཐའ་འཁོར་ལུ་ཕན་གཞོང་།

Construction Phase བཟོ་སྐྱོར་ཆེད་སྒྲུབ་ཆེད་སྒྲུབ་		
Potential increase of conflict by wildlife: རི་དྭགས་ལོ་མཚམས་པོ་སྐྱེ་ཉེན་ཁ་ཡང་ཡོད་	- Affected species: Sambar, Barking Deer, Wild Pig, Grey Langur, Himalayan Goral, Red Panda, Asiatic Black Bear, Assamese Macaque - Sambar & Asiatic Black Bear: Vulnerable (IUCN)	- Crop raiding and livestock depredation - Wildlife movement into nearby villages - Vehicle collisions from new access roads - Higher potential for human-wildlife conflict
Impacts on Conservation-Significant Flora སྐྱེ་ཁུངས་ཀྱི་ཉེན་ཁ་གསལ་གྱི་ཕྱི་རྒྱུ་	Direct clearing during excavation, road widening, camps, and reservoir formation Affected species include: Long Pipla (<i>Piper pedicellatum</i>), Leaf Spur (<i>Tetracentron sinense</i>)	- Habitat removal - Reduced natural regeneration - Microclimate alterations - Local population decline or extirpation
Impacts on Conservation-Significant Mammals སྐྱེ་ཁུངས་ཀྱི་ཉེན་ཁ་གསལ་གྱི་མངལ་སྐྱེས་སྒྲིབ་ཆགས་	Seven conservation-significant mammals recorded in the survey	- Habitat fragmentation & loss of feeding grounds - Disruption of movement corridors - Increased disturbance from construction - Greater vulnerability to poaching & roadkill
Impacts on Conservation-Significant Birds སྐྱེ་ཁུངས་ཀྱི་ཉེན་ཁ་གསལ་གྱི་ཕྱི་རྒྱུ་	Habitat loss, fragmentation & reduced food availability affect key bird species: Oriental Cuckoo, Blyth's Leaf Warbler, Kalij Pheasant, Large Hawk Cuckoo, Indian Cuckoo, Red-billed Chough, Large-billed Crow, Hill Partridge, Asian Barred Owllet	- Nest disturbance & nest theft - Capture or hunting by additional labour

སྒྲིལ་ན་གནས་སྤངས། - ས་ཆའི་མཐའ་འཁོར་ལུ་ཕན་གོང་།

Operation Phase ལག་ལེན་དངོས་ལྟར་སྐབས།		
Potential Increase in Wildlife–Human Conflict རི་དྭགས་སེམས་ཅན་དང་མིའི་བར་ན་བྱ་སྐབས་མ་བདེས་ཡར་སེང་།	■ Habitat loss, fragmentation ■ Displaced wildlife alter their movement patterns, entering nearby villages and farmlands.	Increased risks of: Crop raiding by <i>Rusa unicolor</i> (Sambar), <i>Sus scrofa</i> (Wild Pig), <i>Muntiacus muntjak</i> (Barking Deer), Livestock predation More frequent human–wildlife encounters
Increased Risk of Poaching གཏུབ་དང་མིའི་ཉེན་ཁ་ཡར་སེང་།	Noise, forest access, and ongoing human presence create opportunities for illegal hunting. Wildlife targeted for meat, particularly: Wild boar Kalij pheasant	

སྐུ་བློན་གནས་སྟངས། - རྩེ་གནས་མཐའ་འཁོར་ལུ་ཕན་གོད། བཞི་སྒྲོན་སྐབས།

Impact ཁན་དྲ་ཞུ།	Description ཁ་གསལ།
Hindrance to Fish Migration by Diversion Tunnel ཁ་ཕྱིན་པའི་ཕུག་ལུང་གི་ཕྱི་ཕྱོད་ལྟར་འཕྲུལ་བ།	Diversion tunnel blocks upstream–downstream movement, restricting access to spawning/feeding habitats of snow trout and brown trout; low flows alter migration; juvenile fish become concentrated
Loss of Riparian Habitat རྒྱ་ལྗང་ཁྱིམ་གྱི་མཉམ་མེད་ཁ་གསལ་བ།	Dam, tunnel, powerhouse, and flow alteration modify hydrology and reduce nutrient input; cutting/excavation increases turbidity; invasive species risk rises with habitat disturbance.
Soil Erosion & Silt Deposition ཁ་ཕྱིན་གྱི་མཐའ་དང་ཁ་ཁྱིམ་དེ་ལས་རྒྱར་རྒྱ་ཕྱིན་པའམ་ཕམ་པའི་རྒྱ་ཕྱིན་བ།	Crusher, quarrying, muck disposal, landslides, and road cutting increase sediment load; monsoon runoff carries loose material into streams; suspended sediment damages fish gills and degrades habitats.
Wastewater Discharge from Tunnel, Sites & Camps ཁ་ཕྱིན་གྱི་མཐའ་དང་ཁ་ཁྱིམ་དེ་ལས་རྒྱར་རྒྱ་ཕྱིན་པའམ་ཕམ་པའི་རྒྱ་ཕྱིན་བ།	Tunnel excavation generates muddy water; improper disposal of oil, grease, and chemicals contaminates river; camps release greywater and blackwater increasing BOD, causing eutrophication, lowering DO.
Stranding of Fish in Dewatered Stretch རྒྱ་ཕྱིན་གྱི་ཁ་གདང་གི་ཕྱི་ཕྱོད་ལྟར་འཕྲུལ་བ།	River diversion dries or turns river into stagnant pools; spawning grounds get buried by sediment; migratory species (Snow trout) lose breeding habitat
Fishing by Construction Workforce ཕོ་ལོ་རྒྱུད་པའི་མི་ཚུ་གིས་ཕུག་དང་བྲུ།	Easy access during low-flow periods increases fishing pressure; fish trapped in isolated pools are easily caught.

Biological Environment - Impacts on the Aquatic Environment

སྒྲིལ་གནས་སྤངས། - རྒྱ་གནས་མཐའ་འཁོར་ལུ་ཕན་གནོད།: ལག་ལེན་དངོས་ལྟར་སྤྲོས།

Impact གནོད་ཉེན།	Description (Concise for Slide) ལ་གསལ།
Physio-chemical & Biological Changes in Reservoir རྒྱ་མཐོང་ཁང་ནང་ལུ་ དངོས་ཁམས་མཐའ་འཁོར་གྱི་སྤངས་ལྟར་སྤྲོས།	Conversion of river from lotic to lentic system alters habitat; decomposition of submerged biomass reduces DO, creating hypoxic zones; algal blooms from nutrient accumulation release toxins; stagnant, sediment-laden conditions reduce suitability for native species like snow trout;
Loss & Degradation of Spawning Grounds སྒྲིལ་གནས་ལུ་ས་གནས་རྒྱ་མཐོང་ཁང་གི་དངུལ་ཕབ་འབྱུང་བ།	Excavation, riverbank cutting, diversion tunnel, and machinery operations disturb or remove gravel beds/riffles used for spawning; sedimentation from runoff and muck disposal reduces reproductive success and nursery habitat quality.
Migration Barrier by Dam རྒྱ་མཐོང་ཁང་བརྟེན་གཞིའི་སྒྲིལ་གནས་ལུ་ཕན་གནོད་ལྔ་ལྔ།	High dam blocks seasonal migration pathways; changes hydrological regime; prevents sediment and nutrient movement downstream, reducing food availability and degrading aquatic habitat.
Impact from Peaking Mode Operation འཕུལ་རྒྱུ་ཆས་མཐོང་ཁང་ལ་གཞི་བཟུང་གནོད་ཉེན།	Rapid fluctuations in water depth and velocity repeatedly dry and wet habitats; destabilize aquatic ecosystems; cause stranding and mortality of juvenile fish; disrupt migration, breeding, and feeding behavior;
Fish Entrainment & Impingement ཉུག་གཞི་ནང་ ཉེན་ཆུང་གི།	Fish passing through turbines experience injury/mortality from pressure changes, shear stress, and acceleration forces; impingement on screens/trash racks causes physical damage;

List of Affected Land Owners – Geling Gewog

Sl. No.	Name of Owner	CID No.	Plot ID	Thram No.	Total Area	Affected Area (acres)	Type of Land	Chiwog (Gewog)	Project Components
1	<u>Chungden</u>	10207000677	GEN-1407, GEN-1463	165	1.852	1.852	<u>Kamzhing</u>	<u>Geling</u>	Submergence
					0.151	0.151	Residential Land		
2	Phub Lhamo	10207000342	GEN-503	432	0.521	0.42	<u>Kamzhing</u>		
3	<u>Gangchumo</u>	10207001462	GEN-1462, GEN-459	209	0.234	0.234	Residential Land		
					4.885	4.679	<u>Kamzhing</u>		
Total area						7.336			

List of Affected Structures–Geling Gewog

Sl. No.	Owner	Permanent House	Semi-permnt. House	Store/Shack	Shed	Fence	Greenhouse	Wall
1	Mrs. Chungdhen, Geling Gewog	Y	-	-	Y	Y	Y	Y

Thank you
བཀའ་བློན་ཆེ།

Annex 1.3: Persons and institutions contacted outside of the Project affected area in the process of ESIA study, with their addresses and telephone numbers.

1. Dasho Dzongdag, Chhukha Dzongkhag Administration
2. Dasho Dzongrab, Chhukha Dzongkhag Administration
3. Planning Officer, Chhukha Dzongkhag Administration
4. Dzongkhag Engineer, Chhukha Dzongkhag Administration
5. Land Records Officer, Chhukha Dzongkhag Administration
6. Gup, Chapcha Gewog Administration
7. Mangmi, Chapcha Gewog Administration
8. Gup, Geling Gewog Administration
9. Mangmi, Geling Gewog Administration
10. Bunakha Lhakhang Lam Neten, Bunakha

Addresses and phone numbers are being collected and will be added

Annex 1.4: List of written consents from affected public and stakeholder agencies.

Not yet applicable. Will be added to the final version of the ESIA Report as available.

Annex 1.5: Minutes of Consultation Meetings

Annex 1.5.1: Public consultation in the Chanachen Village, Geling Gewog - April 2025

Group Discussion

Project: Bunakha Hydro-power project (180 MW)	Date: 25.04.2025
Meeting Location: Gewog Meeting Hall	Geog: Geling, Chhukha, Dzongkhag
Group description: 11 females, 11 males	
Number of people: 22	

Positive Impacts

11. Business Opportunities;
12. Easy transportation of agricultural products to market;
13. Possibility of better education and health facilities;
14. Employment opportunities;
15. Better roads to the communities;
16. Better market for any vegetables produced in the villages;
17. People with interest can open up shops and restaurants within the project area;
18. There could be a permanent bridge over the Wangchhu through the project which will be beneficial to the communities as well.
19. Local people with vehicles can have opportunities to deploy them in the project.

Negative Impacts

20. Dust and Noise pollution around the areas;
21. Influx of outside workers can cause problem in the communities;
22. Road condition during the construction phase may be bad;
23. The area below the Chanachen village is fragile and the construction of a dam may cause the whole village to slide down;
24. May cause flooding in the future;
25. People who will be displaced may not be compensated properly and on time;
26. The community already has water crisis/improper water supply and with the project coming, the problem may be severe.

General Suggestions from the participants

27. Small petty contract works in the project be given to the local people.
28. A proper school and a health facility be established in one of the Chiwogs of Bunakha or Chanachen so it will benefit both the project workers and the communities.
29. In case, school or health facilities are not established in the project area, then ferrying of children or sick people to the nearby school/hospital should also be entertained similar to that of the project employees and their children.
30. In case the project is planning to construct residential quarters, suggestion is that these be constructed on private land with an understanding that the same will be handed over to the land owner after the completion of the project. This was cited from the example that people quoted from the Chhukha Project where there are a lot of abandoned quarters which is a waste of resources and not benefiting anyone in the long run.
31. Some suggestions from the female groups expressed for some basic training in culinary for setting up decent restaurants in the project area.

Group Discussion

Project: Bunakha Hydro-power project (180 MW)	Date: 25.04.2025
Meeting Location: Gewog Meeting Hall	Geog: Geling, Chhukha, Dzongkhag
Group description: 11 females, 11 males	
Number of people: 22	

32. Any deaths of the imported workers be taken away from the locality for burial or cremation as burial/cremation within the area could disturb the sanctity of the area.
33. The lone house that will have to be relocated/resettled suggested that there are households who own land at Chanachen but live in Kamjee area under the same Gewog where they have their land. For resettlement, the household suggested that she could be allotted the land at Chanachen belonging to households living at Kamjee and that the replacement land be allotted to those households from Kamjee. This was supported by all the participants.
34. The participants also suggested having some sort of protection at the base of the settlement (at some existing fragile points) so that land slide or land slip can be avoided.

Annex 1.5.2: Public consultation in Bunakha, Chapcha Gewog - April 2025

Group Discussion⁶

Project: Bunakha Hydro-power project (180 MW),	Date: 25.04.2025
Meeting Location: In One of the Houses, Bunakha	Geog: Chapcha, Chhukha Dzongkhag
Group description: 11 females, 11 males	
Number of people: 22	

Information from Gup, Tshogpas, Mangmi, Gewog Administration Officers - GAOs, etc. for Chapcha and Geling Gewogs

SN	Guiding questions	Chiwogs	
		Bunakha	Chanachen
1	Are you aware about the upcoming Bunakha HPP Bunakha under Chhukha Dzongkhag?	Yes	Yes
2	What do you think can be the direct and indirect impact (positive and negative) that this project will bring on the people living along the river basin?	Direct impacts - Rural electrification leading to improving quality of life. - Economic development by supporting small and local business. - Job opportunity during constructions as well as operational phases. - Improves infrastructures such as roads, bridges, network connectivity. - Access to markets, transports, health facilities, education. - Control of floods by regulating river flow. - Recreation and tourism as scenic landscape around dam attracts tourists. Indirect impacts - Displacement & resettlement as large dam often leads to floods, forcing them to relocate. - Ecosystems often disrupted. - Degradation of pristine environment. - Loss of sacred sites. - Health risks such as waterborne diseases. - Limited local benefits such as receiving inadequate benefits sharing/compensation	Direct impacts - Improve economy of the community - Job opportunities Indirect impacts - Environmental exploitation

⁶ Participants were reluctant to sign the attendance sheet

SN	Guiding questions	Chiwogs	
		Bunakha	Chanachen
3	Are people in any way dependent on this river (Wangchhu) for their livelihood and food security?	Yes, fishing and aquatic resources which sometimes serve for food source as well as income.	Not really but regularly used by commuters to cross
4	What could be the social and economic risks that this project will bring into your village?	Social Risks - Displacement & resettlement, forcing communities to relocate. - Inadequate access to previous livelihoods. - Loss of livelihoods as jobs promised by HPP maybe temporary to local people. - Loss of sacred sites as it gets destroyed/submerged during constructions. - Inequality as poor, indigenous group gets out decisions making. - Lack basic amenities such as poor sanitation, food insecurity, proper shelters. Economic Risks - Loss of productive/arable land due to constructions. - Inadequate and delayed compensation to the affected people for their land or properties. - Jobs maybe short term. - Inflation and living maybe expensive affecting low-income people. - Profits from HPP will go to the Government, not to the local communities.	Social Risks - Health risks - Violence Economic Risks - Enhance economic and livestock production
5	What are the existing social problems in the community (e.g., rape cases, sexual harassment cases, unemployment issues, cases of domestic/gender-based violence)?	Unemployment issues as youth & graduates are without jobs. Cases of domestic/ gender-based violence.	- Unemployment issues - Only old and aged people are left in the village
6	Are there any current practices for dealing with the above social problems in the country? If so what are they?	- Yes. - Gyalsuung National Service initiated in 2019 for 18 years old includes military style training.	- Youth employment provision - Community contracting group formation

SN	Guiding questions	Chiwogs	
		Bunakha	Chanachen
		- Education on entrepreneurship, agriculture, technology etc. - Education on entrepreneurship, agriculture, technology etc. - DeSuung Volunteer Program initiated in 2011(Guardians of Peace) - Gelephu Mindfulness City, aiming to address employment opportunities and emigration.	
7	With the commencement of the project do you foresee that there will be a rise in the social problems in the area? If so, what could that be?	- Displacement of communities and people may experience emotional distress, long term hardship. - Livelihoods disruption leading to lose of arable land.	- Land slide probability - Violence probability
8	What can the project do to mitigate the social issues?	To mitigate the social issues, the project can make proactive, inclusive & sustained actions throughout all stages—planning, construction, and operation.	Proper protection and fencing at dam level or dam site
9	What are the needs in terms of capacity development that you think will be needed from the project and for whom? (Men, women and the disadvantaged)	- Should focus on skills, knowledge, and resources needed to adapt, benefit, and thrive for all Men, Women & disadvantaged group. - Technical & vocational training (masonry, carpentry, welding) - Electrical/mechanical maintenance. - Equipment handling/ safety training	- Culinary capacity building (especially women in this community) - Scientific and improved method of farming
10	What way can the Bunakha HPP intervention improve livelihood of women, men and the vulnerable people?	Job creation & local employment in constructions, security, maintenance, hospitality etc.	- Business opportunities - Employment opportunities
11	What are women's and men's perceptions of proposed interventions in improving their livelihood outcomes?	- Men's perceptions such as job opportunities, improvement of infrastructures. - Women's perceptions such as access to electricity, health, education, etc.	More population means more business opportunities

SN	Guiding questions	Chiwogs	
		Bunakha	Chanachen
12	In what way can the intervention improve livelihood of women and men (Enterprises, Income Generating Activities, productive use of the available resources.	- Skills training in constructions, mechanics, service business for men. - Facilitate home based enterprises such food processing, tailoring, hairdressing, handicrafts for women.	- Employment - Local enterprises
13	Overall, what can the project do to improve the lives of the communities of Chiwog?	- Involve all community groups in constructions. - Use local leader of the Chapcha Gewog & community-based organizations as a civil society communication bridge. - Provide fair compensation, to affected one. - Improve their infrastructures. - Helps households diversify income through small scale livestock farming, gardening, food processing & marketing. - Prioritize local hiring in constructions.	Health, education, roads, drinking water supply, irrigation and permanent bridge
14	What would be the approximate land value of the areas of influence?		Nu. 40,000 per decimal
15	How can the project involve the various stakeholders in order to minimise the impacts and maximise the benefits from the project?	- Hold community meeting. - Site selection - Resettlement planning - Livelihood restoration programs - Create stakeholder engagement committee.	Project authorities should involve local government, community, RNR sectors, Dzongkhag, Religious communities
	Any other issues and comments		- Community willing to contribute land for construction of residential structures, allow them to have residential structures on the land and handover the structures to the land owners after the project is completed. - Burial and cremation of project workers especially labourers to be taken care of and not disturb the community entity.

Annex 1.5.3: Public consultation in Bunakha, Chapcha Gewog - 22 July 2025

Agenda:

Date:	22/07/2025	Time
Venue:	Bunagu Lhakhang	
Presentation:		
1. Registration of participants		9.30-10.00 am
2. Opening session by Chapcha Gewog Administration or Dzongkhag Representative		10:00-10-15 am
3. Presentation on Project background and project components by DGPC and NextGen		10.15-10.45 am
4. Environmental and biodiversity presentation by Environmental expert/ Biodiversity specialist		10:45 -11.15 am
Break for refreshment		11.15-11.45 am
5. Social presentation by social expert		11.45 am-12.15 pm
6. Question answer session		12.15-1.00 pm
7. Break for lunch		1.00-2.00 pm
8. Focus Group Discussions (FGDs) for social, biodiversity and environment (smaller groups)		2.00-5.00 pm

Main topics:

Clarifications and community feedback regarding land compensation procedures, water supply concerns, and project implementation timelines associated with a proposed development of the Bunakha Hydro-power project. Compensation for land acquisition is for the directly affected areas, with a tiered prioritization for replacement land—beginning within the same Chiwog, extending to the Gewog, and only rarely sourced from other Dzongkhags. Urban land cannot substitute rural acquisitions, and compensation modalities differ for rural and urban landowners in accordance with Bhutan's Satshab policy of the Land Act of Bhutan 2007.

Key community concerns:

Community members expressed concern over the inadequacy of the existing water supply for agriculture, particularly during dry periods, and recommended identifying alternative sources to mitigate potential livelihood impacts. Additionally, two households reported discrepancies in the land impact assessment, noting that submerged land portions were omitted from official records, requesting for immediate verification.

Regarding project timelines, commencement is dependent upon final approval of the Detailed Project Report (DPR) and completion of all administrative and environmental clearances. Land acquisition will proceed only after formal notifications and stakeholder consultations are completed. Further updates will be issued upon finalization of the implementation schedule by the executing agency.

Response from DGPC and PCS:

The consultation meeting convened by DGPC emphasized stakeholder engagement and transparency in project planning. While expressing appreciation for community participation, DGPC clarified that no immediate decisions on land compensation would be made until a comprehensive assessment of affected land is completed, followed by a subsequent consultation to determine appropriate actions.

The Dzongkhag Land Records sector highlighted that substitute land allotment along roadsides is not possible as per directives to maintain regulatory consistency. To safeguard community water resources, technical experts will assess the feasibility of water supply infrastructure for labour camps and project offices, ensuring no adverse impact on existing sources. All Land ownership data has been collected from relevant sources, with a commitment to thoroughly review records to prevent exclusion of private land from compensation processes. Although project initiation is tentatively scheduled for late 2026, no fixed timeline has been confirmed.

Annex 1.5.4: Public consultation in Chanachen Village, Geling Gewog - 23 July 2025

Agenda:

Date:	23/07/2025	Time
Venue:	Gewog Centre at Chanachen village	
Presentations:		
1. Registration of participants		9.30-10.00 am
2. Opening session by Chapcha Gewog Administration /Dzongkhag Representative		10:00-10-15 am
3.Presentation on project background and project components by DGPC and NextGen		10.15-10.45 am
4. Environmental/Biodiversity presentation by Environmental Expert/Biodiversity Specialist		10:45 -11.15 am
Break for refreshment		11.15-11.45 am
5. Social presentation by Social Expert		11.45 am-12.15 pm
6. Question answer session		12.15-1.00 pm
7. Break for Lunch		1.00-2.00 pm
8. Focus Group Discussions for social, biodiversity and environment (smaller groups)		2.00-5.00 pm

Discussions:

The proposed dam construction project is expected to directly affect three households, prompting concerns over land replacement and broader community impacts. Current policy restricts land replacement to within the same Gewog and excludes roadside and town areas, limiting viable options for affected families. The Gewog Thrizin has requested policy reconsideration to allow roadside land replacement due to its strategic value for livelihood restoration and accessibility.

Concerns have also been raised regarding cumulative impacts on the wider village, particularly from quarrying and blasting activities in Nayeka and Gelingkha, which may pose safety and agricultural risks. The Thrizin inquired about the timing of road construction relative to the dam, noting potential community benefits and proposing roadside commercial development.

The Lam of Geling Gonpa emphasized the cultural and spiritual significance of the Gonpa, urging project authorities to respect its sanctity. He also highlighted the lack of educational infrastructure in Bunakha and Geling, advocating for a primary school to prevent family displacement. Additional concerns include the potential effects of water storage on crop yields, financial burdens during land measurement, and the impact of blasting on farming and livestock.

Affected households face challenges in securing suitable replacement land, often constrained by terrain and current policies. Flexibility in allowing land replacement across Gewogs and support in identifying cultivable plots are requested. Reference is made to the Punakha Hydropower Project, where compensation included limited land and free electricity units to the affected households. Lastly, stakeholders urge inclusion of dryland in the redevelopment and compensation framework to ensure equitable treatment of all land types.

To this the DGPC and the PCS responded accordingly:

The consultation proceedings addressed multiple concerns related to the dam construction and associated infrastructure development in the designated project area. Due to unforeseen circumstances, the Dzongkhag land officer was absent; however, a government directive was reiterated, confirming that land replacement will not be provided for properties situated along roadside alignments, in line with prevailing policy guidelines.

The project will directly affect three households and will serve as a quarry source for construction materials. Preliminary assessments confirm the suitability of stone quality, though minor disturbances from blasting are anticipated. Experts will monitor vibration levels and install equipment to assess air, water, and blasting impacts, including potential effects on domestic animals.

Simultaneous road construction, quarrying, and cement mixing will involve significant vehicular movement, rendering roadside commercial activities impractical due to dust and noise. While no guarantees were made, consultants committed to incorporating stakeholder concerns from Geling and Bunakha into their reports.

Concerns regarding agricultural impacts and land replacement costs were raised, particularly the burden on individuals to finance on their own for any land replacement cost such as surveys and bush clearings. The policy mandates that replacement land must be within the same gewog. Suggestions such as implementing a token system were noted for further review.

An expert team based in Nepal will conduct a detailed assessment of agricultural impacts. Both the government and ADB will oversee land redevelopment, with provisions for converting dryland to wetland or Tsamdro according to applicable standards and rates.

Annex 1.5.5: Key Informant Interviews in Bunakha, Chapcha Gewog - July 2025 and in the Chanachen Village, Geling Gewog - July 2025

Gewog	Chiwog	Name of the respondent	Age	Occupation	Project Awareness	Source of information	Positive impact	Negative impact	Expectation	Comments/ Suggestions
Geling	Chanachen	Mithun	45	Farmer	Yes	From LG member	Employment opportunity for youth as well as the people Business Opportunity	Blasting effect to the community people Air & Dust pollution Water Shortages	No comments	No comments
Chapcha	Bunakha	Ugyen Jamtsho	53	Farmer	Yes	Family members	Business and Employment opportunity Market Opportunity Better road condition Development of Chhukha Dzongkhag		No comments	No comments
Geling	Nyekha	Nima	61	Farmer	Yes	Family members	Business opportunity (Agriculture)- Market shed Increase in population Increase in Development activities Job opportunities for the people	Blasting effect to the community people Air & Dust pollution Water Shortages		Capacity training to the people Awareness should be given to the community
Chapcha	Dam chhu	Tshering haden	44	Restaurant owner	Yes	From husband and previous owner of the restaurant (it's been 3 months since they have started the business)	More customer Business attraction	Environment pollution	The country will be benefited due to the project	No comments
Chapcha	Dam chhu	Kabita Chhetri	34	Restaurant owner	Yes	Family members	More customer and Business growth Business attraction	Level of water will rise up which might lead to flooding Blockage, Pollution	Job opportunities for youth and people Business flow	Less customer Before there used to be few restaurants on the way but now there

Gewog	Chiwog	Name of the respondent	Age	Occupation	Project Awareness	Source of information	Positive impact	Negative impact	Expectation	Comments/ Suggestions
								and road congestions	for people who have restaurant on the way Catering services Income flow	are many restaurants and shop which leads to competition
Geling	Nyekha, Chanachen	Nima Dawa	57	Farmer	Yes	From the LG, the project workers who came in the initial phase.	- Development of the area and important infrastructures like school and hospitals. - Job opportunities for the people. - Villagers can sell their agricultural products.	In future there are chances of landslides on the areas that is near the river.	Priorities to be given to the village since they are impacted by the project like job opportunities according to their skills, hiring of vehicles, contract and even to sell their agricultural products.	
Bjaocho	Tsimalakha	Pema Zam		Shop keeper	Yes	From the family	might be able to sell more compared to now and if it goes well, they even might expand their shop.	- workers might take the things on credit and there are chances that they won't get back the money once the workers are gone. - Crime rates might increase		

Gewog	Chiwog	Name of the respondent	Age	Occupation	Project Awareness	Source of information	Positive impact	Negative impact	Expectation	Comments/ Suggestions
								like fighting and all. ▪ Where do you throw your waste/ manage your waste? ▪ they have municipal vehicle which comes to collect on certain day so their collect their waste and throw when the vehicle comes.		
Chapcha	Lobneykha	Did not want to disclose	-	Farmer	Yes, we are aware of the project	From the workers who came in the initial phase, family, neighbours etc.	▪ might get job opportunities and will help the villagers and they can sell agricultural products but these advantages will be a short lived. More than the advantages we will have more of the disadvantages. ▪ No advantages in the long run.	▪ due to blasting and its vibration it will affect our houses because we have the experience of that. When the road was constructed, we could feel its vibration and there was too much dust. ▪ We will have air pollution and dust which will hamper our crops and we might not be able to grow crops in the		▪ We don't want the quarry to be near our village and we would like the government to find other places for the quarry little far from human settlement ▪ They are not really happy about the quarry that is on the base of their village and they are highly recommending to find other

Gewog	Chiwog	Name of the respondent	Age	Occupation	Project Awareness	Source of information	Positive impact	Negative impact	Expectation	Comments/ Suggestions
								- future. - Since the quarry is on the bed rock or like on the foundation of our village, there are chances our village will be ruined due to erosion and land slide in the future. - It will affect the environment and might disrupt the water supply. - Noise pollution because quarry is nearby.		places for the quarry.
					Yes, we are aware of the project	From the workers who came in the initial phase, DGPC, LG, family, neighbours etc	- Business opportunities, they can sell their agricultural products to the people or workers and those who have shops they can have more customers. - Developmental of the areas and important infrastructure like hospital, schools and even roads.	- loss of their fertile land and since they depend on that area where project is planning to have the camp site is the only wet land that the villagers and they generate their income. - Problem of dust which might		If their land is given on lease, they are willing to give their land but they don't want to sell their land. They don't want cash compensation and they are even sceptical about being compensated with land

Gewog	Chiwog	Name of the respondent	Age	Occupation	Project Awareness	Source of information	Positive impact	Negative impact	Expectation	Comments/ Suggestions
							Job opportunities.	- affect their crops in the coming years - Will hamper the environment.		- because they are afraid that they would be compensated with land that is not good or unsuitable for cultivation because they were compensated with the land that was unsuitable for cultivation when the road was constructed. - Job opportunities or any other opportunities to be given to the villages or the gewog people since they are impacted. (First preference)

Annex 1.5.6: Public consultation in Geling Gewog office, Chhukha - 9 December 2025

Venue: Geling Gewog office, Chhukha

Date: 9 December 2025

In the past consultations, notes were taken and the community clearly mentioned their concerns. This is another opportunity to raise the other concerns.

The Consultants mentioned that the quarry location near the monastery was a concern raised during the past consultation, and that there were hopes for community development. These have been noted in the Consultant's reports which will be submitted to DGPC. The difference with this consultation is to disclose the new project component locations that are somewhat finalised.

A general feeling of consultation fatigue was expressed by the community.

General

GRM focal person: There are many levels of the GRM for disputes and grievances, which can be confusing for villagers who are uneducated. Can the Project provide clearer guidance to the community on where to go, whom to approach, and what steps need to be followed, to avoid serious issues in the future.

Consultant stated that the GRM includes appointing one focal person in each of the two villages – such as the Gup, Tshogpa, Mangmi or any other representative so that villagers have a single point of contact. If anyone in the village faces an issue, they can directly approach their designated focal person, which will make the GRM process simpler and more accessible. A GRM focal person will be appointed at Bunakha village as well.

What are the mitigation measures (thablam) for income restoration?

The Consultant shared that compensation will be provided for lost assets, relocation costs for moving to a new place, compensation for loss of income, administration and implementation service costs (transportation costs, at least some amount if not 100%), costs for monitoring and evaluation (did the land acquisition and income restoration go as planned?)

This (type of support to PAPs) is for before the Project begins?

Consultant clarified that the land replacement will be carried out before construction begins, as required by ADB.

DGPC also clarified that people are worried that compensation will be provided only after the project starts. But it is not true. All these activities are required to be completed before the Project can begin during the feasibility studies. The reason for the consultations is to avoid court cases and to ensure that the community's concerns are heard and considered in the management plans. The Project is required to issue the ownership certificates to the PAPs, and also seek environment and forest clearance. DGPC and ADB have differing standards for compensation, which will be negotiated between the two offices. Only once all the procedures are completed can the Project begin.

Commented [MC106]: Is land for land the preferred compensation mode of the AHS? And it is confirmed that there is suitable and sufficient replacement land?

Commented [R107R106]: Dzongkhag land record officials will be responsible for the allotting the substituted land.

Commented [MC108]: The response should have been that compensation has to be at replacement cost.

Commented [R109R108]: Land development cost also should be included while compensating land to land, and it has been included in the RP budget

Request for road till the Gewog Centre within the village: The Gup shared that the request for blacktopping of the village road this year has not been allowed by the government on the basis of the upcoming Bunakha Project.

NexGen shared that the Geling Gewog Road will be widened and will extend till the entry to the village on government land. The Consultant also shared that there are plans to build new roads, improve existing roads and expand the bridge.

Some participants shared concern that **if the village road is widened, there could be impacts on private land.** Private land, both wetland and dryland, were taken for the purpose of the village road before. Now, chain link fencing has been installed. How will the Project acquire the lands, which were already affected before for the same road?

DGPC noted the concerns over the village road and stated that if chain link fencing is acquired, it will be compensated for.

The Gup stated that many people from Chanachen village are living in Kamji, but they hope to return to Chanachen once the Project commences.

Dust and blasting impacts: What are the mitigation measures for the blasting and dust impacts? The Gup also stated that Chanachen is an organic village but that this status may not be possible when the Project begins because of these impacts.

DGPC clarified that blasting schedule and timings will be monitored. Before blasting, the houses will be documented to check for cracks etc. If any impacts, compensation will be provided with due diligence. For dust, sprinkling of water will be carried out and frequency will vary by season.

Consultant shared that vibration monitors for seismic monitoring will be added to the management plans and may be installed.

The Gup agreed that there will be impacts on the village and all structures and requested that compensation for structures impacted by blasting be included in the reports.

Worker influx, grazing lands, impacts on biodiversity: What are the expected impacts on the environment?

Worker influx impacts are anticipated and measures are included in the management plans.

Other measures to mitigate impacts on biodiversity will be included in the management plans as well.

Environmental baseline: As the Gup stated that there is no need to deliberate at length about environment and biodiversity topics, the Consultant shared a summary on expected impacts from dust, water shortage due to Project use (all water sources were tested and potential sources for the Project were identified; water treatment plant is being suggested due to low levels of F. coliform). The management plans also mention sewage and waste management.

Other social measures: The Consultant shared that there is potential risk of community disharmony and GBV/SEA/SH cases. Such impacts from worker influx will be mitigated through Contractor and worker awareness/training and frequent monitoring of the situation.

Commented [MC110]: Which road is this? Have LAR implications also been assessed?

Commented [R111R110]: Geling Gewog Road lies in government land.

Commented [MC112]: Build new roads? Not mentioned in earlier sections of this report

Commented [R113R112]: Access road for the project will be constructed which all fall under government land.

The Gup expressed that some issues are bound to happen with the worker influx. Chanachen village is an organic village and the only one in Chhukha but there are fears that it cannot be an organic village with the Project. Some villagers are also looking forward to employment opportunities and some may be able to hire their private vehicles. The support for the roads and bridge are welcomed and the blacktopping of the village road till the Gewog Centre will be appreciated.

Other benefits: Consultant shared that there may be opportunities for water-based tourism as mentioned in the first round of public consultations. This will depend on the feasibility studies of floating solar panels which was proposed.

Project Facilities

Quarry location: How many meters from the village are the project components (especially quarry)? Secondly, if the road connecting to the quarry is built, there is a risk of landslides for the entire village above the road. Will they be compensated for any damages?

The Consultant clarified that the proposed quarry is 380 meters away (as the crow flies) from the nearest household (Sangay Thinley, as stated by the Gup). This new location of the quarry has been selected because during the last consultation, community raised concern over the quarry location (access through the village and within 1km from Geling Gonpa). Also, the quarry is located within the submergence area. The Consultants shared that there will be impacts of blasting but that the extent will depend on the type of technology, and the safety and control measures.

NexGen clarified that the quarry was relocated near the river to avoid the use of the village road and impacts on private land. However, quarry locations are not finalised and a separate study and survey will be done by the Project to understand the quality, quantity and feasibility of the rocks at the location. If it is found that the quarry located before reaching the village has enough resources, then the quarry closest to the village (and its access road) will not be explored.

The Gup suggested that during the later studies, the villagers can show the physical site to the surveyors. There should be minimal impact on the communities.

DGPC clarified that if there are people who are affected by submergence later after the Project commences, they will be supported/compensated. Less than 10 decimal land cannot be registered as per the legislation. If only a portion of the land is affected but the PAP is left with less than 10 decimal, there is opportunity for the Project to replace the whole plot of land. **Cannot say for certain whether schools and roads will be built by the Project. At the end of the feasibility studies, a public consultation will be held with the DGPC director and clarity will be given then on what the Project can support with.**

Tshogpa shared that recently, chain link fencing was installed near the quarry site, and it has been damaged by landslide.

Project Affected Persons (PAPs)

For the PAP with the low-lying house, there has not been any compensation from the Project yet. Information is required on whether the house should be demolished or not. Are the PAPs supposed to

exit the house? Furthermore, the entire community received chain link fencing but the PAP was not eligible to receive the fencing because they will be expected to move out soon.

DGPC clarified that they will prepare and inform the public on the process for finding replacement land. A new company will be formed and a social and environment consultant/officer will convey to the PAPs on the process. However, there is no issue if PAPs go ahead and try to identify replacement land.

The issue of the chain link fencing is a very new situation and DGPC requested the Consultants to add to the report so that it can be discussed further.

The participants also expressed that without clarity on the project components and the future scenario with the Project, the community feels worry (tshagay) over any decision to sow their seeds or build new structures on their private land.

The Consultant noted the comment and shared that the cut-off date after which no further developments will be compensated will be announced by DGPC.

Closing remarks

ADB thanked the participants and shared that any development projects will have some adverse impacts but mitigation measures are required. It is important that the community is aware of the potential impacts, mitigation measures, grievance mechanism, know where to go, and respect for the legal rights to go to the court. ADB Office can also be contacted to resolve any issues. Monitoring of environmental and social risks will be carried out by DGPC and ADB. The Resettlement Action Plan will also consider some of the economic impacts. The draft RAP will be ready by January-February 2026 and it will be disclosed to the public along with a translated summary RAP. If there are any gaps in social safeguards, GRM etc., corrective actions will be taken and the community is encouraged to contact the Project employees.

The Consultant shared that through his experience with other hydropower projects in other countries in hilly and forested areas, there are many economic benefits of such projects.

Commented [MC114]: Pls explain this situation further. It is very unclear what the concern is, how it is related to the project, and thus, hard to understand whether an appropriate response was provided

Commented [R115R114]: Community did not fence the affected house, as it already fall under the submergence area.

Annex 1.5.7: Public consultation in Bunagu Village, Chhuka - 10 December 2025

Venue: Bunagu village, Chhukha

Date: 10 December 2025

Rationale of the Project: DGPC shared that the Project is being implemented because of the current energy scenario of the country. This Project is proposed to avoid importing costly electricity during the winter. Many other projects are also being considered to increase electricity generation.

General

- General comment about what benefits and support the Project will provide to the community
- **Religious and cultural scenario:** The community Lhakhang conducts rituals and Kanjur (scripture) readings. The community is presently bearing the cost by splitting between 55 households and the cost is about 15-20,00,000 per year. Can the Project support this. Additionally, rituals to propitiate the protective deities will also be required because of the disturbances caused by the Project.
- **Participation by community:** Request if the community can be supported with Project work such as hiring of vehicles, trucks and buses. For heavy vehicles like trucks, excavators, bulldozers, other machinery etc., it would be beneficial if the Project can procure the vehicles and hire drivers and peons from the community. Further, it was requested if the work can be awarded to the community members without tendering, and if the payments can be made on a monthly basis.
 - DGPC shared that as per the national regulations, tender is required but opportunities will be given to project affected communities. There will be an increase in job opportunities and the people living near the project will be considered, as long as the skills required are available.
- **Worker influx impacts:** Bunakha Project is a large-scale project and the community will be impacted by worker influx, theft of vegetables from the farms etc. What measures are in place?
 - Consultant shared that mitigation measures such as Contractor/worker awareness and orientation at the start of the Project as well as periodically throughout the construction period.
 - Measures will also be mentioned in the Labour Management Plan (LMP)
- **Blasting and dust impacts during survey work:** One lady shared that her fields and crops were damaged by the blasting impacts by soil surveyors recently. She shared that she did not receive any compensation. The Tshogpa requested if DGPC could look into this matter.
 - DGPC thanked the person for sharing about the incident and requested for more information on the exact location, frequency and intensity of the blasting. Blasting needs to follow certain standards (distance from nearest household, safety measures, temporary locations for nearby households during blasting period etc.) Generally, there will be impacts with any Project. For the affected people, the RAP report will be prepared and public consultation will be conducted in January-February, 2026. Informed the community to check the websites. Grievances are welcome before the formal GRM is established for the Project by contacting the focal person from DGPC.
- **Community grievances representative (GRM):** A repeated comment that one person should be nominated who will collect all grievances from the community and submit to the GRM.

Project Affected People

- **Sustenance allowance for PAPs:** Most of the affected land below the road is wetland which is productive land. Since the compensation rate is very low for wetland, most of the people will opt for land replacement. In this case, the replacement land will not be productive for at least 3-5 years and there will be no crop yield.
 - Will the PAPs be compensated during this period? Yes, there will be some sustenance allowance if the household has been relying on the land. All details will be included in the Resettlement Action Plan (RAP) and will be disclosed on the websites and summary will be translated to Dzongkha.
- **Administrative and regulatory costs for land replacement:** It is understood that DGPC will compensate through land replacement, if the PAP chooses. Will DGPC also bear the cost of the administrative and regulatory fees?
 - Yes, Consultants will include in the report that administrative and regulatory fees for PAPs to transfer their land ownership will be borne by DGPC. DGPC also shared that the Consultant's estimated budget will be reflected in the reports and the costs will be borne by DGPC, as is the norm for all projects. In January, 2026 during the final public disclosure, the RAP report and the PAP list will be shared.
- **Replacement land:** A PAP inquired if the replacement land can be given at the community's preference instead of following the national regulations. There are worries that the replacement land will be located in far-off locations at mountain tops, for example. They also shared that there is very limited land in the village. The government needs to understand the local context and provide some exceptions from the law.
 - DGPC clarified that the PAP can choose whether they want cash or land compensation. Replacement land will be sought from the same village, chiwog, gewog, or Dzongkhag, in that order, and in accordance with the national laws. Different Dzongkhags will be considered only if the other options are not available. DGPC and the Dzongkhag will work together to support the PAPs.
- **Replacement land:** PAP inquired if DGPC can support developing the replacement land, e.g. flattening the land. Another PAP who owns 3-4 plots in different areas inquired if a single plot can be provided as replacement.
 - If there is land in the area and to make the land flat. DGPC can make that call and it has been done in other projects. A single plot can be facilitated.
- **Replacement land:** A PAP inquired that she currently owns farming land between two Project roads and nearby to the proposed labour camp, and worries that farming may not be feasible. She also shared that it is hard to find replacement land. Can the Project provide replacement land for her?
 - DGPC clarified that replacement land will be provided.
 - The consultant shared that some small structures are built below the road, although a Dzongkhag directive was issued that **construction below the road is not allowed**. Dzongkhag will issue another letter on the bans on development. Dasho Dzongdag was not able to attend this meeting.
- **Leasing opportunities:** A person owning land below the road and above the submergence inquired about opportunities to lease out their land.
 - Below the road, if private land is not being taken by the Project, there is still an opportunity to lease out to the Contractor (income source). **The Gewog can mediate with the Contractor and the landowner.**

- There is some private land below the national highway, but above the submergence. Will they be compensated/able to lease their land to the Project?
 - DGPC shared that if there is less than 10 decimal under one plot, DGPC is not allowed to take just 5 decimals as per the national laws. Therefore, if the PAP has more than 10 decimal after land acquisition, then the land portion will be acquired.

Ancillary Facilities

There was general feedback from the community that the location of the ancillary facilities keep changing between different consultations, which is causing distrust and confusion amongst the people.

To clarify, DGPC shared the **Procedure for ESIA and feasibility studies** was explained by DGPC. Firstly a technical feasibility study (stability, soil testing, physical investigation, water volume studies and reliability etc.) is conducted and an ESIA study (animals and plant species, air and noise quality etc., some critical species, worker influx, affected land etc.). Access roads (ze song), electricity accounting and pricing depends on the Project funds. There are two main components: main is the dam and powerhouse - there will be no changes. Ancillary facilities like the labour camp, access roads, store etc., are expected to change. With the changes, ADB requires proponents to consult the public. The officers at public consultations provide all community comments to the heads of DGPC and ADB. When the locations are final and confirmed, the public will be informed.

Other questions from the community on the location of project ancillary facilities:

- **Why have the facilities locations been changed since the last consultation?** Before, the community shared that it is ok to locate the facilities on private land so that the landowners can get some income by leasing their land.
 - The Project needs ADB clearance and ADB requires that labour camps must not be located within 500 metres of the village, and the number of project affected persons must be reduced to secure the funding. This area will be falling under submergence and will need to be acquired anyway, so facilities were relocated to reduce the impact on private owners. Later, negotiations with the Contractor can be done for leasing of land.
- **Access road below the national highway:** The entry from the national highway to the temporary access road near Bunagu is designed from the north side. Is it possible to re-orient the access road so that the traffic impacts of heavy vehicles are not as intense? This road is also affecting a house, which belongs to a kidu(welfare) recipient. Can the house be avoided?
 - It was clarified that the road in question is a temporary road and will later fall in the submergence zone, along with the labour camp and contractor sheds. The permanent road for the Project is near the vegetable shed going towards Chanachen. The dam workers will be using this road. Later before construction, a separate survey will be done to avoid any structures and private land, as much as possible
- Request to locate the colony, client offices and non-labourer workers near Bunagu village?
 - The colony will be at Chhukha due to proximity. There is no need for many workers to come to the Bunagu area later. Tsimalakha and Tsimashan have a lot of houses that may be explored for

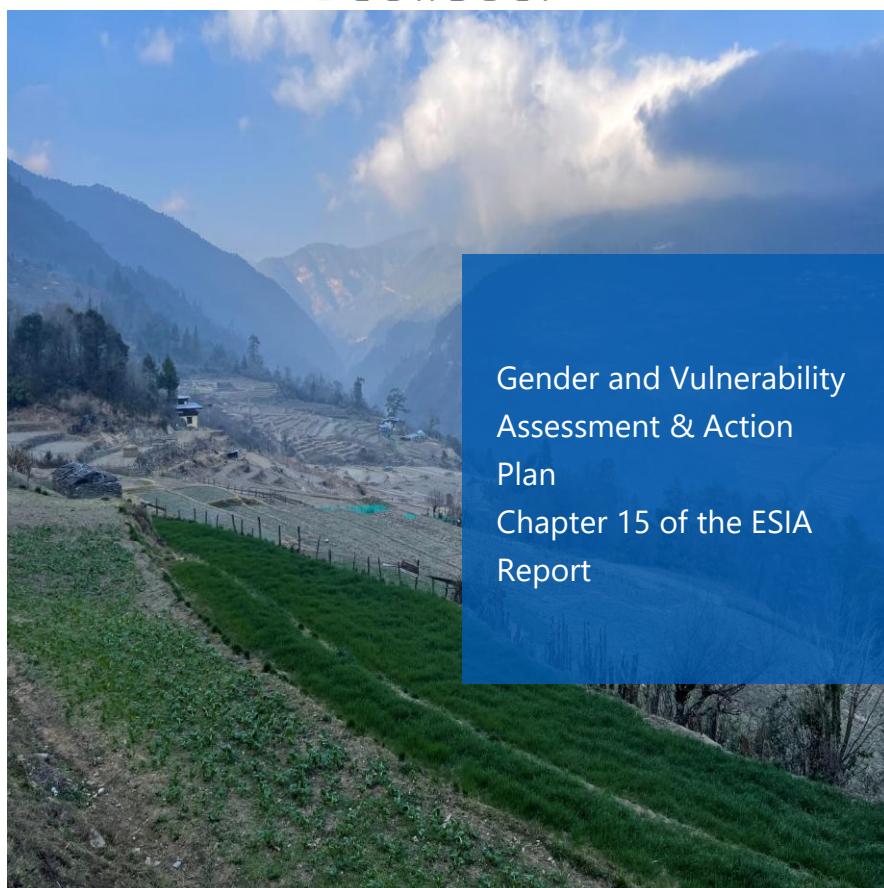
rent/lease by Project workers (non-labour) and these areas have schools and other facilities. If there is no option in Tsimalakha and Tsimasham, then the office in the Bunakha village (near old highway, next to the hotel) will be explored.

- **Labour camp location:** During the first round of public consultations, it was shared that the labour camp will be located near the village. The community prefers this location for the camps, but in this present consultation, the labour camps are located in the submergence area where the productive wetlands are located. There will be no benefits to the community from leasing the land to these temporary facilities, while the community will face most of the Project impacts (dust, reduction in crop yield (main livelihood), traffic, blasting etc.) **If ADB assesses that the community should not be affected and should be benefited, can the labour camp be kept on the private land as before.**
 - ADB clarified that they preferred if the impacts on private land were reduced. At the new location of the camp, it was decided that anyway, the land is going under submergence. At the previous location, trees will have to be cut, and it is also important to consider the environmental impact. To benefit both social and environment areas, the labour camp was moved. ADB also shared that at least 500 meters is needed between village and labour camp (worker influx, disharmony impacts).
 - NexGen shared that one of the labour camps was moved to Chanachen, because of proximity to other facilities (batching, crusher etc) and it is not feasible for workers to travel everyday to Chanachen from Bunakha. The biggest labour camp is still located at Bunagu, as well as the EM store.
 - NexGen shared that we cannot say for certain that the labour camp has to stay at the present location. This will need to be discussed with DGPC whether the labour camp can be moved back to the previous location.

Closing

- **ADB:** [Adding summary]
- **Chapcha Gup:** Thanked DGPC, ADB, and experts for coming to Bunakha and explaining the process for grievances and impacts. It would be beneficial if the timeframe for land replacement and compensation is clarified. Gup expressed that he is happy that the Project will give opportunities to PAPs. As for the land replacement mechanism of the Project, the Gup shared that if 1:1 acre replacement land cannot be provided, then a house/shop can be constructed for the PAPs to be able to have some income from sales/business.

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Gender and Vulnerability
Assessment & Action
Plan
Chapter 15 of the ESIA
Report

Consultancy Services for Review and Update of DPR and ESIA of
Bunakha Hydropower Project

Druk Green Power Corporation Ltd.

ENGINEERING  CONSULTING

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List of Abbreviations

ADB	Asian Development Bank
Aol	Area of Influence
BTN	Bhutanese Ngultrum
CBO	Community-Based Organization
DGPC	Druk Green Power Corporation
ESMU	Environment and Social Management Unit
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
GBV	Gender-Based Violence
GRM	Grievance Redress Mechanism
GVA&AP	Gender and Vulnerability Assessment & Action Plan
HH	Household
HIV/AIDS	Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome
HPP	Hydropower Project
LGBT+	Lesbian, Gay, Bisexual, Transgender and others
NGEP	National Gender Equality Policy
PAP	Project Affected Person
PIU	Project Implementation Unit
RP	Resettlement Plan
SEA	Sexual Exploitation and Abuse
SEAH	Sexual Exploitation, Abuse and Harassment
SEP	Stakeholder Engagement Plan
SH	Sexual Harassment
USD	United States Dollar

1 Gender and Vulnerability Assessment & Action Plan

1.1 Objective

The primary objective of the Gender and Vulnerability Assessment & Action Plan (GVA&AP) is to ensure equivalent participation of women, girls, and vulnerable people in the Project lifecycle and decision-making processes, by defining specific targets and performance indicators. While the Resettlement Plan (RP), Stakeholder Engagement Plan (SEP), and Grievance Redress Mechanisms (GRM), and benefit sharing plans put in place the Project's commitments towards the local community and specifically the PAPs, the GVA&AP is aimed at identifying specific measures within or complementary to these plans which allow for gender and vulnerable persons inclusion and parity.

1.2 Applicability

The GVA&AP applies to the Bunakha HPP, its Area of Influence (AoI - see Chapter [Error! Reference source not found.](#) [Fehler! Verweisquelle konnte nicht gefunden werden.](#) 4 of ESIA) and its entire lifecycle. It is to be considered as a living document, to be updated regularly based on the emerging needs and patterns for engagement with the various stakeholders.

1.3 Applicable Reference Framework

1.3.1 National gender equality policy, 2020 (amended in 2023)

The National Gender Equality Policy (NGEP), 2020 (amended in 2023), is grounded in the principle that empowering all individuals—women and girls, men and boys, and LGBT+ persons—to fully develop their capabilities and achieve their potential, free from stereotypes, stigma, and discrimination, benefits families, communities, and society as a whole. The policy framework addresses gender equality across five interconnected domains: political, economic, social, educational, and health. Progress in any one domain is expected to positively influence the others, advancing comprehensive gender equality. NGEP is committed to challenging and transforming entrenched gender norms and practices within each domain through a coordinated, multi-sectoral approach embedded in its operational strategies. The policy also explicitly includes persons with disabilities and senior citizens, ensuring an inclusive and equitable approach.

Achieving gender equality in decision-making roles across governance sectors remains a persistent challenge. The government emphasizes inclusive participation of women and LGBT+ individuals as essential to national development and good governance. Greater diversity in leadership enhances accountability, service delivery, and public trust. To address this, policy measures include creating enabling environments, supporting leadership networks, instituting affirmative actions, promoting advocacy and capacity building, conducting research, improving data collection, integrating LGBT+ representation in national statistics, recognizing transgender identity rights, ensuring non-discrimination in electoral processes, and expanding access to digital resources and participation in the armed forces. These efforts aim to dismantle stereotypes and foster inclusive leadership at all levels.

NGEP outlines the Royal Government of Bhutan's commitment to fostering inclusive development by promoting gender and LGBT+ equality across social, economic, and legislative domains. The policy emphasizes active community participation, particularly among disadvantaged groups, and the creation of multi-stakeholder platforms to facilitate dialogue and resource sharing. Legislative reforms are proposed to recognize the specific needs of women and LGBT+ individuals, shifting from formal equality to substantive equality through inclusive legal terminology. Gender and LGBT+ concerns will be mainstreamed into all government policies using established protocols and screening tools, supported by capacity-building initiatives. In the social domain, the policy targets gender-based violence (GBV), harmful cultural practices, and access to justice, aiming to create safe, inclusive environments and improve public awareness. It mandates institutional mechanisms, data systems, and legal reviews to support survivors and prevent discrimination.

1.3.2 Asian Development Bank gender policy (2023)

ADB's Gender Policy (2023) ~~builds-on~~**builds** its long-standing commitment to gender equality, with updated strategies to deepen impact and accelerate progress. The policy reflects its commitment to inclusive development and its role in shaping equitable futures across the investment. ADB has exceeded its Strategy 2030 gender mainstreaming targets and is now pushing for more transformative approaches. This includes embedding gender equality deeper into infrastructure, climate resilience, and investment. It highlights the need for ~~inclusive~~**an inclusive** job.

1.4 Gender Situation in the Project Site

The data indicates that the female population exceeds the male population; however, the female illiteracy rate is approximately 38%, compared to only 25% among males. Similarly, school enrollment rates for females are lower than those for males, although the trend reverses when it comes to dropout rates. Females exhibit a higher dropout rate after secondary education, and very few women attain education beyond this level.

Women's roles remain largely confined to domestic responsibilities, including cooking, child-rearing, caring for the elderly, and other household tasks, with limited opportunities for engagement outside the home.

It is noted that more than 70% of land and other property is owned by females, indicating that women have greater access to property ownership.

Women are likely to experience differential impacts from the Project's construction compared to men.

1.4.1 Social and health risks associated with workforce influx

The Project will require a large number of skilled and unskilled workers, most of whom are expected to migrate from outside the Project area. This influx will increase interaction between migrant workers and local communities. While such engagement may foster economic and social exchange, it also poses potential risks, particularly related to sexually oriented behaviors that may arise from either group. These interactions could lead to incidents of Sexual Exploitation and Abuse (SEA), Sexual Harassment (SH), and heightened vulnerability to sexually transmitted infections, including HIV/AIDS.

To mitigate these risks, it is essential to implement regular and structured orientation programs for both incoming workers and community members. These sessions should address appropriate sexual conduct, the legal and ethical implications of SEA/SH, and the transmission and prevention of HIV/AIDS. Culturally sensitive communication strategies must be employed to ensure messages are accessible and respectful of local norms while reinforcing zero-tolerance policies on sexual misconduct. A Code of Conduct should be developed, and all workers must be sensitized and required to sign it prior to engagement in the Project.

In parallel, targeted awareness campaigns within host communities should address domestic violence, which may be exacerbated by social stressors linked to demographic shifts and economic pressures. These campaigns should be integrated into broader gender-based violence (GBV) prevention frameworks and coordinated with local health and social welfare agencies.

1.5 Other Vulnerable Groups at the Project Site

The vulnerable population within the Project area primarily includes women and girls, elderly individuals, and single-member households, all of whom may be adversely affected by Project activities such as involuntary resettlement and restricted access to resources due to their social and demographic circumstances.

The survey recorded two (2) single-member households — one male and one female, both elderly. The male household member is a devout religious practitioner closely affiliated with Bunakha Lhakhang, indicating a strong spiritual connection and potential reliance on religious institutions. The female household member, while living alone, receives consistent care and assistance from extended family members residing outside the immediate community, who maintain regular contact and provide emotional and material support through frequent visits.

In addition to these single-member households, there are nine (9) female residents aged over 70 years and six (6) male residents within the same age bracket. Although these individuals are not entirely isolated, as they live with other household members who provide daily care and companionship, their advanced age presents challenges such as mobility limitations, health concerns, and risk of social exclusion. These factors underscore the need for targeted interventions and inclusive planning to ensure that the specific needs of these vulnerable groups are adequately addressed throughout the Project lifecycle.

1.6 Consultation of Women and other Vulnerable Groups

As part of the field survey, consultations were conducted with stakeholders, including women's groups, elderly people to assess the potential impacts of the Bunakha Project from a gender-sensitive perspective, with particular emphasis on women's experiences and concerns. It shall be noted that at time of the consultations, girls were not present, as in the affected villages, school-aged children live near distant schools for most of the year - see Chapter **Error! Reference source not found.** **Fehler! Verweisquelle konnte nicht gefunden werden.** 7.3.8 of ESIA.

Commented [MC1]: No one below the poverty line?
No vulnerable ethnic minorities?

Commented [P2R1]: None of the AP fall BPL and ethnic minority

Commented [MC3]: Consultations with older community members and single person households (who also happen to be older as per the above section)

Commented [R4R3]: Updated

These discussions revealed that women may experience differential impacts arising from land and asset acquisition processes, as well as from broader Project activities. A key concern expressed by nearly all participants was the need to involve women throughout the Project cycle, particularly in decisions related to land acquisition.

Participants emphasized that any land temporarily used for Project purposes should be returned to its original owners in the same condition upon completion of construction. They stressed the importance of having their voices respected in decision-making processes and requested mechanisms that would enable constructive participation during implementation. Additionally, they recommended establishing a healthcare facility within the Project area to address immediate health needs and provide long-term support to the community. Participants also highlighted the need for grievance management systems and benefit-sharing mechanisms.

Further suggestions included organizing training on health-related issues and enforcing rules for workers to maintain harmonious relationships with the community. Many participants expressed interest in establishing small-scale business ventures near the Project site, particularly those providing goods and services to Project personnel. To support this, they requested training in basic culinary skills to enable them to operate food service enterprises catering to the workforce.

In response, women participants proposed the formulation of a dedicated action plan to ensure their meaningful participation in Project implementation.

Commented [MC5]: Any such envisaged? Not clear in previous sections of this ESIA

Commented [P6R5]: It summarized the expectation expressed by the participants during the consultations

Commented [MC7]: And what were the project responses to this feedback from community members? Pls clarify

Commented [P8R7]: Positively noted the expectations

1.7 Gender Mainstreaming

The Project is identified as a significant opportunity for gender mainstreaming, with the potential to generate both skilled and unskilled employment for women. Furthermore, promoting women's participation in institutional development and green jobs is among the key recommendations outlined in the GVA&AP. Specific measures and targets include fostering small and medium enterprises, supported by initiatives for capacity building and skill enhancement.

1.8 GVA&AP

The Bunakha HPP's GVA&AP is presented in [Table 1](#) as a framework to identify gender-specific and vulnerability-related impacts of the Project and propose measures to address them. If applied, the Bunakha HPP's GVA&AP will ensure that women and vulnerable groups are actively included in Project benefits, decision-making, and mitigation strategies. The plan typically outlines targeted actions, capacity-building initiatives, and monitoring mechanisms to promote equity and minimize adverse impacts.

Table 1: Gender and Vulnerability Assessment & Action Plan for the Bunakha HPP

Activities	Actions	Target	Timeline	Responsibilities (see Chapter 1.9.15.9)
Output:1 Construction of hydropower plant and transmission line				
1.1 Participatory and meaningful consultation and information sharing	Meaningful consultation shall be guaranteed to disseminate information and encourage participation of community members in the different stages of implementation of the ESMP	Minimum participation: 33% women and socially excluded groups	Project planning period and construction phase. Year 1 begins after the recruitment of service provider	BHPL ESHS Team (Communication Officer) with support from the PSC Community Liaison/Stakeholder Officer
1.2 Grievance redress procedure	At least two women shall manage the grievance redress procedure to be established by DGPC. Grievances received from women shall be treated with high priority. Women social mobilisers shall be recruited by DGPC from each Project affected ward.	At least one women/girl will be employed as social mobilizer from project affected community	Project planning, preparation and construction phases	BHPL ESHS Team (Communication Officer and Social Safeguard Officer), supported by the PSC Community Liaison/Stakeholder Officer
1.3 Facilitating access to local jobs, creating gender and social inclusive workplaces	Prepare a sex-disaggregated inventory of (i) local people available/interested in working on the Project (ii) their existing skill levels (iii) required training Work sites to have segregated toilet facilities for women	Target: 120 local jobs at least 15% women (this is a high-level estimation based on field experience and consultation) Target 1 women toilet per 20 workers	Entire Project cycle Project planning, preparation and construction phases	BHPL ESHS Team (Social Safeguard Officer), supported by the Communication Officer and monitored by the PSC Social & Resettlement Specialist
1.4 Restoration of livelihood affected by resettlement with new skill training	- Skill trainings to be provided to physically/economically affected HHs, including female headed, and those below poverty line - Vocational/skill training provided project affected HHs on new skill supporting project job opportunities. Training opportunities and potential trainees shall be identified through a needs assessment	Target: Minimum 33% women Target: 33% women	Entire Project cycle Project planning, preparation and construction phases	BHPL ESHS Team (Social Safeguard Officer), monitored by the PSC Social & Resettlement Specialist

Commented [MC9]: When should this needs assessment be carried out, and when should the training program be in place vis-a-vis onset of civil works? Pls clarify

Commented [P10R9]: Prior finalization and implementation of LRP

Activities	Actions	Target	Timeline	Responsibilities (see Chapter 1.91.915.9)
Output: 2 Livelihood restoration program in the project area implemented				
Social and gender inclusive community development: through creation of opportunities and enhancement of skills, income generation, education, and health	- Assess the baseline conditions and livelihood benefit opportunities in the Project area at the onset of community development planning and implementation process - Training on informal cottage industry skills and opportunities, including sewing, arts and crafts, veterinary services, agro-forestry, etc. as relevant. - Micro Enterprise Development training and financial support through seed capital. - Support the formation/affiliation to "skills and knowledge-based" community groups (e.g. community-based organizations, CBOs) supporting (i) health, (ii) agriculture, (iii) cottage industries and micro-enterprises, (iv) access to markets, etc. Participation should be promoted to achieve as much critical mass as possible - Establish campaigns to raise awareness about basic health, safety, SEAH, hygiene and nutrition issues, with a special focus on improving the quality of life of girls/women (pre/post maternal care), - Monitor and evaluate the results of the implementation of the RP, by documenting challenges, opportunities, successes, recommendations and lessons learnt. Include social and gender inclusive indicators to report on	Target: All project affected HHs	Entire Project cycle	BHPL ESHS Team (Social Safeguard Officer and Communication Officer), with supervision by the PSC Social & Resettlement Specialist and Community Liaison/Stakeholder Officer
		Target: 100 persons; 33% women/SEP Target: min. 500 persons; 33% women/SEP	Activities are to be defined at the onset of construction activities during year 1	
		Target: minimum 2 groups, 1 in each municipality wards Target: 150 persons; 33% girls/women		

Commented [MC13]: Affected by LAR? Pls clarify

Commented [P14R13]: Correct

Commented [MC11]: Including SEAH?

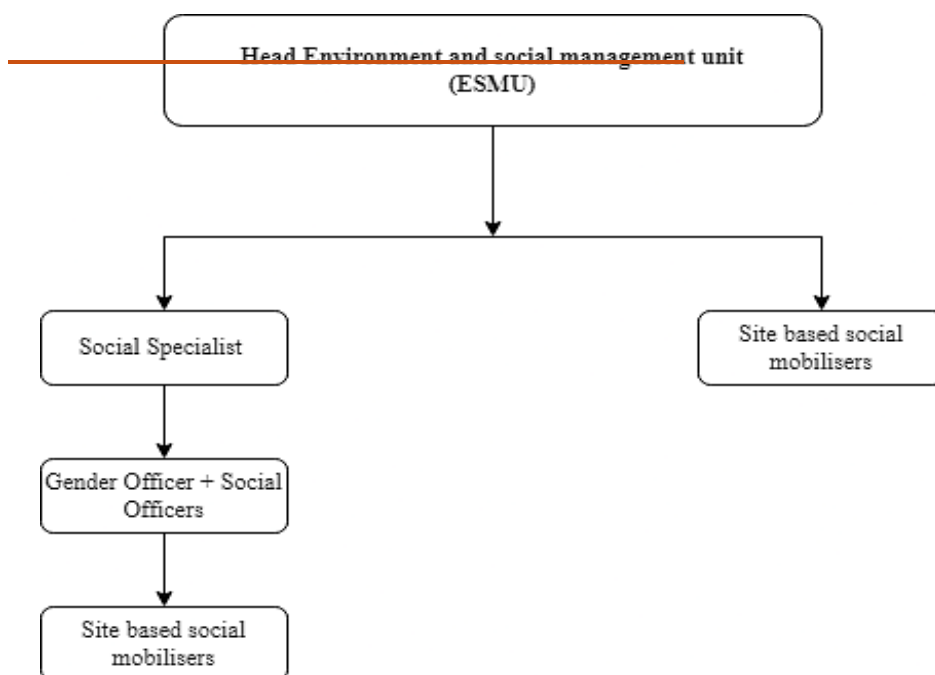
Commented [P12R11]: Correct

1.9 Implementing Arrangements

The Project recognizes the importance of ensuring meaningful engagement and participation of women and other vulnerable groups. To achieve this, it is recommended that the Project prioritizes the implementation of the GVA&AP. DGCP shall nominate a designated officer to serve as the Gender Focal Person/Social Officer, while the Environment and Social Management Unit (ESMU) will assume overall responsibility for implementing the ESIA and associated environmental and social risk management instruments. Additionally, Gender Officers and Social Mobilizers will be recruited as needed to ensure effective implementation plan

The Project recognizes the importance of ensuring meaningful participation of women and other vulnerable groups throughout the project lifecycle. To achieve this, BHPL will implement the GVA&AP through its Environmental, Social, Health and Safety (ESHS) Team. The Communication Officer and Social Safeguard Officer will lead the implementation of gender and social inclusion activities, stakeholder engagement, and grievance management, with support from the Environmental Safeguard Officer and OHS Officer, as required. The Project Supervision Consultant (PSC), through the Social and Resettlement Specialist and Community Liaison/Stakeholder Officer, will provide independent supervision, compliance monitoring, and reporting on the implementation of the GVA&AP. Where necessary, community facilitators or social mobilizers may be engaged to support awareness programmes, consultations, and community outreach in the project-affected areas

(Figure 1Figure 1Figure 1).



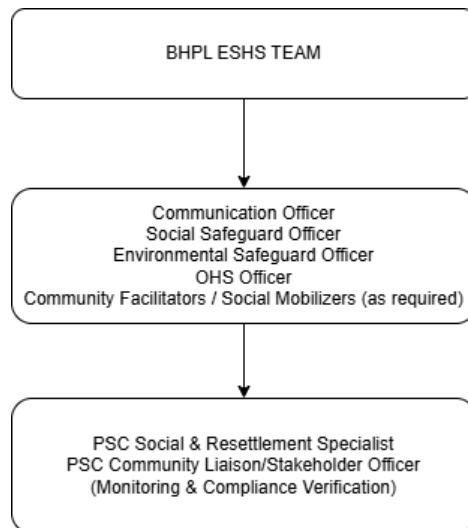


Figure 1: Outline of the suggested GVA&AP implementation structure

1.9.1 Training requirements

The Project will periodically assess the adequacy and capacity of ESMU team members regarding their understanding of social safeguard documents and the GVA&AP. Provisions for refresher training will be maintained to strengthen their competencies.

The Project will periodically assess the capacity and competency of the BHPL ESHS Team in implementing the Environmental and Social Management Plan (ESMP), Gender and Vulnerable Groups Action Plan (GVGAP), Stakeholder Engagement Plan (SEP), and other applicable social safeguard instruments. Refresher training and capacity-building programmes will be provided, as necessary, to strengthen staff knowledge and skills. The Project Supervision Consultant (PSC) will support BHPL by reviewing implementation, identifying capacity gaps, and recommending additional training where required.

In addition, targeted training for community women shall be provided, as identified during consultations. These training courses will include life skills development and awareness programs on various health issues, including HIV/AIDS and other communicable diseases.

1.9.2 Financial resources

The Project will allocate an adequate budget to implement the ESIA and E&S mitigation plans including the GVA&AP. It is estimated that about ~~USD 10000Nu.~~ 1,293,000 required to implement the GVAP. The recruitment of field-based Social Mobilisers and Consultants will be included in the budget.

Commented [MC15]: Preliminary budget for this should be developed

Commented [P16R15]: Added

Table 2: Estimated budget breakdown

Budget Item	BTN (Nu.)	Remarks
Skill & Vocational Training (livelihood restoration, cottage industries, micro-	235,000	Output 2 - targets 100–500 persons, 33% women

enterprise)		
Community Health & SEAH Awareness Campaigns	141,000	HIV/AIDS, GBV, maternal care campaigns mentioned
Consultation & Participation Events	100,000	Min. 33% women participation target, meaningful consultation
Grievance Redress Mechanism Setup	700,000	Women-managed GRM, social mobilizers per ward
Contingency (10%)	117,600	Living document - unforeseen gender/vulnerability needs
Total	1,293,600	

*Note: 7 May 2026 exchange rate

1.9.3 Documentation monitoring and reporting

The GVA&AP is a living document, meaning it should be reviewed and revised periodically to ensure its relevance and comprehensiveness throughout the Project's lifecycle. This flexibility is essential because gender dynamics and requirements for achieving gender parity cannot be fully anticipated at the outset of the Project. Therefore, the plan shall undergo regular reviews (annually) by the BHPL Environmental, Social, Health and Safety (ESHS) Team, taking into account evolving needs, project implementation progress, and applicable policy and regulatory requirements.

The GVA&AP is a living document, meaning it should be reviewed and revised periodically to ensure its relevance and comprehensiveness throughout the Project's lifecycle. This flexibility is essential because gender dynamics and requirements for achieving gender parity cannot be fully anticipated at the outset of the Project. Therefore, the plan must undergo regular reviews (annually) by the ESMU, taking into account evolving needs and framework requirements.

The ESMU-ESHS shall report on the implementation of the actions and achievement of the targets of the GVA&AP as follows:

- Monthly during the 6-years construction period
- Annually during operationthe operation period.

These reports shall comprehensively cover all Project-related components to ensure inclusive monitoring and evaluation.

Commented [MC17]: How often do you recommend this be reviewed?

Commented [P18R17]: Annually

Draft

Biodiversity Action Plan

Bunakha Hydropower Project

Druk Green Power Corporation Ltd.

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Abbreviations

ADB	Asian Development Bank
AOI	Area of Influence
AOH	Area of Habitat
BAP	Biodiversity Action Plan
BC	Biological Corridor
BCWMP	Biodiversity Conservation and Wildlife Management Plan
CAP	Compensatory Afforestation Plan
CBD	Convention on Biological Diversity
CBO	Community-Based Organization
CH	Critical Habitat
CHA	Critical Habitat Assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CR	Critically Endangered
DD	Data Deficient
DECC	Department of Environment and Climate Change
DFO	Divisional Forest Office
DGPC	Druk Green Power Corporation
DoE	Department of Energy
DoFPS	Department of Forests and Park Services
EAAA	Ecologically Appropriate Area of Assessment
EN	Endangered
EPT	Ephemeroptera, Plecoptera, Trichoptera
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
FCMP	Fisheries Conservation and Management Plan
FNCA	Forest and Nature Conservation Act
FNCRR	Forest and Nature Conservation Rules and Regulations
GIS	Geographic Information System
HPP	Hydropower Project
IBA	Important Bird and Biodiversity Area
IBAT	Integrated Biodiversity Assessment Tool
IFC	International Finance Corporation
IESC	Important Environmental and Social Component
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
LC	Least Concern
MOENR	Ministry of Energy and Natural Resources
NEC	National Environment Commission
NG	Net Gain
NNL	No Net Loss
NT	Near Threatened
PS6	Performance Standard 6
RGoB	Royal Government of Bhutan
SRP	Species Rescue Plan
VU	Vulnerable

1 INTRODUCTION

1.1 Background and Rationale for Developing BAP

Biological diversity, or biodiversity, refers to the variability among living organisms from all sources, including terrestrial, aquatic, and associated ecosystems, encompassing diversity within species, between species, and of ecosystems. Biodiversity underpins ecosystem functioning and supports ecosystem services that contribute directly to human well-being.

The Bunakha Hydropower Project (HPP), located on the Wangchhu River in Bhutan, lies within a biologically sensitive Himalayan landscape characterized by diverse forest ecosystems, riverine habitats, and high ecological connectivity. As part of the Environmental and Social Impact Assessment (ESIA), comprehensive biodiversity baseline studies, multi-seasonal surveys, and a Critical Habitat Assessment (CHA) have been undertaken.

The Critical Habitat Assessment (CHA) confirms that the Project Area of Influence (AOI) contains Critical Habitat (CH), as defined under the Asian Development Bank Safeguard Policy Statement (ADB SPS, 2009). Critical Habitat is triggered by eight qualifying biodiversity features, including internationally and nationally recognized biodiversity areas such as Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs), together with globally threatened species. The White-bellied Heron (*Ardea insignis*) has been identified as a precautionary Critical Habitat trigger based on available information and application of the precautionary principle under ADB SPS (2009) and IFC Performance Standard 6. A targeted field survey will be undertaken to confirm the species' current use of the Project Area of Influence, and the Critical Habitat Assessment will be updated as necessary based on the survey findings. In addition, several species have been identified as near-threshold or of socio-economic and cultural importance, including Red Panda, Dhole, Tiger, Golden Mahseer, and Rufous-necked Hornbill, which require precautionary management despite not meeting formal Critical Habitat thresholds.

The project is also located within a cascade of hydropower developments along the Wangchhu River (including Chukha and Tala), which introduces cumulative pressures on biodiversity, particularly aquatic ecosystems.

In this context, the Biodiversity Action Plan (BAP) has been developed to translate CHA and ESIA findings into a structured, implementable framework for biodiversity conservation and management. The BAP adopts a Critical Habitat-driven approach and is aligned with the requirements of ADB SPS (2009), IFC Performance Standard 6 (PS6), and Bhutan's national environmental regulations.

1.2 Regional Overview

The Bunakha Hydropower Project is located within the Wangchhu River basin in western Bhutan, a region characterized by steep mountainous terrain, high ecological connectivity, and diverse forest ecosystems. The river system spans multiple ecological gradients, supporting a mosaic of habitats including broad leaf forests, mixed forests, and riparian vegetation.

The Area of Influence (AOI), as defined in the Critical Habitat Assessment, extends beyond the immediate project footprint to include terrestrial and aquatic ecosystems, downstream ecological linkages, and cumulative interactions with other hydropower projects within the Wangchhu basin. This broader

ecological context highlights the importance of managing biodiversity at both site-specific and landscape scales.

The basin supports a wide range of species, including threatened, endemic, migratory, and congregatory species identified through the CHA. The presence of KBAs and IBAs within the broader landscape further elevates the conservation significance of the region.

1.3 Project Description

The Bunakha Hydropower Project is a storage hydropower development designed to harness the energy potential of the Wangchhu River. The project comprises a diversion dam, water conveyance system, powerhouse, and associated infrastructure.

The diversion of river flow and creation of a physical barrier have implications for aquatic connectivity, sediment transport, and habitat conditions, particularly for species identified under the Critical Habitat Assessment. These potential impacts are addressed through targeted mitigation and biodiversity management measures outlined in this BAP.

1.3.1 Main Dam

The project includes a diversion dam or weir structure located on the Wangchhu River, designed to impound water and divert it into the headrace system. The structure incorporates intake facilities, spillway arrangements, and sediment management provisions to ensure operational efficiency and structural safety.

The presence of the dam alters the natural flow regime of the river and introduces a physical barrier within the aquatic system. This can affect longitudinal connectivity, sediment transport processes, and habitat conditions downstream. Such changes have implications for aquatic biodiversity, particularly for species dependent on flow continuity and habitat heterogeneity.

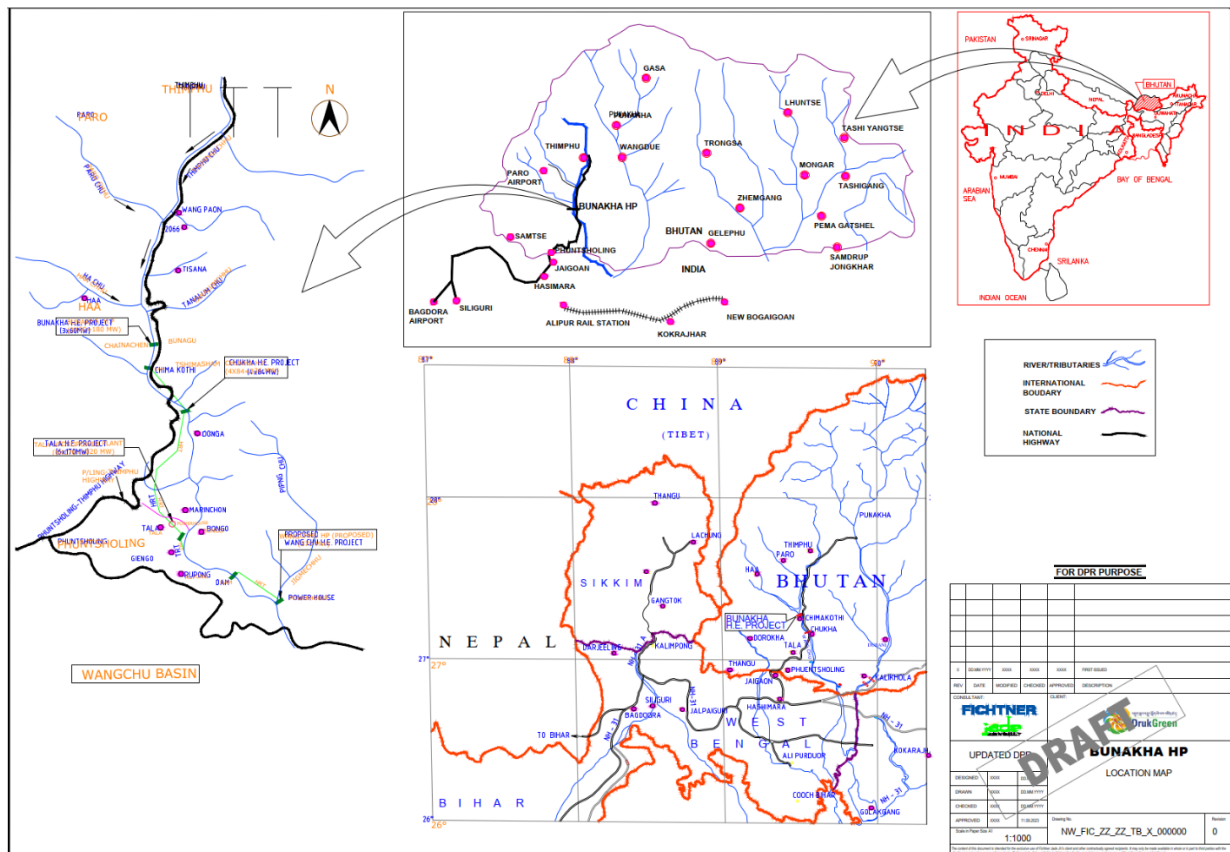


Figure 1 Bunakha HPP Location Map

Source: DPR, 2026

1.3.2 Powerhouse

The powerhouse is designed to generate electricity using water conveyed from the diversion structure through tunnels or channels. The system includes turbines, generators, and associated infrastructure, with water discharged back into the river through a tailrace system.

The diversion of water results in reduced flow stretches between the dam and the tailrace outlet, potentially affecting aquatic habitats and ecological processes within this section. Construction and operation of the powerhouse may also lead to localized disturbances, although these are typically temporary and can be mitigated through appropriate environmental management measures.

1.4 Geographic Scope of the Biodiversity Action Plan

The geographic scope of this Biodiversity Action Plan is aligned with the Area of Influence (AOI) defined in the Critical Habitat Assessment. The AOI includes areas affected by direct project activities, associated facilities, and indirect and cumulative impacts.

The aquatic component of the AOI includes river stretches upstream of the dam, the dewatered section between the dam and powerhouse, and downstream reaches influenced by altered flow regimes. It also considers connectivity with upstream and downstream hydropower projects within the Wangchhu cascade, particularly the Chukha and Tala hydropower plants.

For terrestrial biodiversity, the AOI is defined as a 10 km buffer around the project components, encompassing habitats potentially affected by construction, infrastructure development, and disturbance.

For aquatic and water-dependent biodiversity, the AOI extends downstream through the Wangchhu River basin to areas where changes in flow regime and sediment transport are anticipated.

In addition, the BAP considers the Ecologically Appropriate Area of Assessment (EAAA) and Area of Habitat (AOH) defined as key species in the CHA. These spatial units capture species-specific habitat requirements, ecological connectivity, and cumulative impact pathways, ensuring that biodiversity management measures are appropriately scaled.

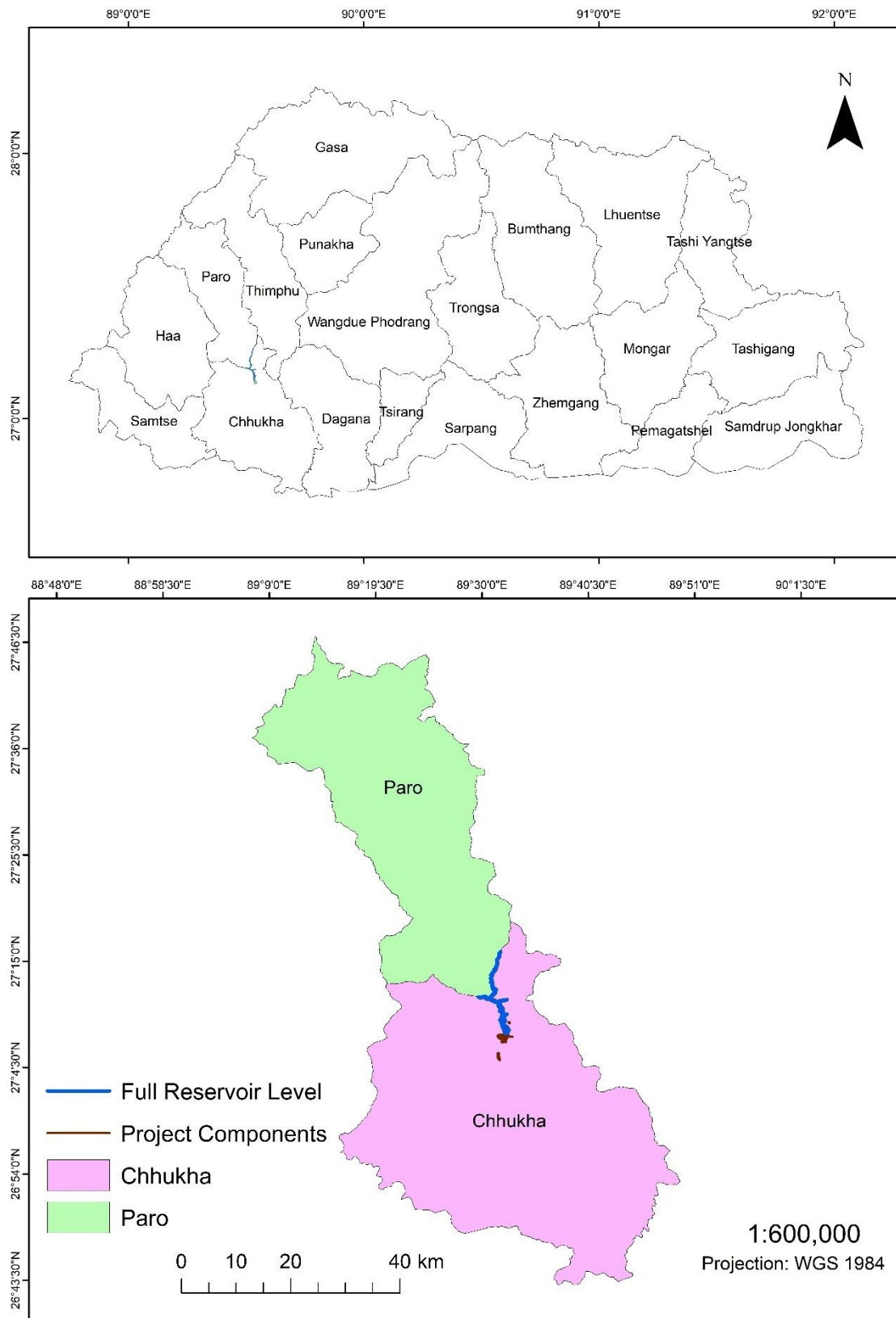


Figure 2 Project Location

1.5 Objectives and Scope of the BAP

The primary objective of the BAP is to ensure compliance with ADB SPS (2009) and IFC PS6 requirements for biodiversity conservation, particularly in the context of Critical Habitat.

- Specifically, the BAP aims to:
- Ensure no measurable adverse impacts on Critical Habitat values
 - Achieve and verify No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat through application of the mitigation hierarchy, implementation of the Biodiversity Accounting Framework (BAF), biodiversity restoration, biodiversity enhancement measures, long-term monitoring and adaptive management.
 - Address both direct and cumulative impacts at the basin scale
 - Establish a monitoring and adaptive management framework

1.5.1 Actions to Mitigate the Impact of Changes in Flow Regime and Barrier Created by the Dam

The alteration of the natural flow regime and the creation of a physical barrier by the dam represent key ecological impacts of the project, particularly for aquatic biodiversity and riverine ecosystem processes.

Reduction in flow within the diversion reach is expected to result in decreased water depth and velocity, leading to reduced habitat availability for fish and macroinvertebrates, disruption of ecological processes, and potential impacts on species of conservation importance identified under the Critical Habitat Assessment.

To address these impacts, an environmental flow regime will be implemented as the primary mitigation measure, in accordance with the Environmental Flow Management Plan (EFMP). The environmental flow regime will be designed to maintain downstream ecological functions by preserving wetted habitat, supporting aquatic species, maintaining sediment transport processes, and sustaining riparian ecosystem interactions.

Monitoring of environmental flow compliance and associated ecological responses will be undertaken as part of the BAP monitoring framework, and results will inform adaptive management to ensure that biodiversity objectives, including No Net Loss and Net Gain requirements, are achieved.

1.5.2 Actions Arising out of Cumulative Impact Assessment

The Project forms part of the Wangchhu hydropower cascade, where cumulative impacts on aquatic ecosystems may arise from successive flow regulation, habitat fragmentation, and altered ecological processes. Consequently, biodiversity management extends beyond the immediate project footprint and considers basin-scale ecological connectivity and long-term ecosystem function.

The BAP incorporates cumulative impact management through environmental flow implementation, coordinated biodiversity monitoring, adaptive management, and periodic review of ecological performance. Detailed assessment of cumulative impacts is presented in Chapter 5, while the corresponding mitigation and monitoring measures are described in Chapters 6 and 9, respectively

1.6 Outline of BAP

This Biodiversity Action Plan is structured as follows:

- **Section 1:** Introduction (project context, objectives, scope)
- **Section 2:** Regulatory and institutional framework
- **Section 3:** Stakeholder consultation summary
- **Section 4:** Biodiversity baseline (aquatic and terrestrial)
- **Section 5:** Impact assessment (including cumulative impacts)
- **Section 6:** Biodiversity conservation and enhancement measures
- **Section 7:** Institutional arrangements
- **Section 8:** Implementation plan
- **Section 9:** Monitoring and evaluation framework
- **Section 10:** Budget and financing
- **Section 11:** Adaptive management

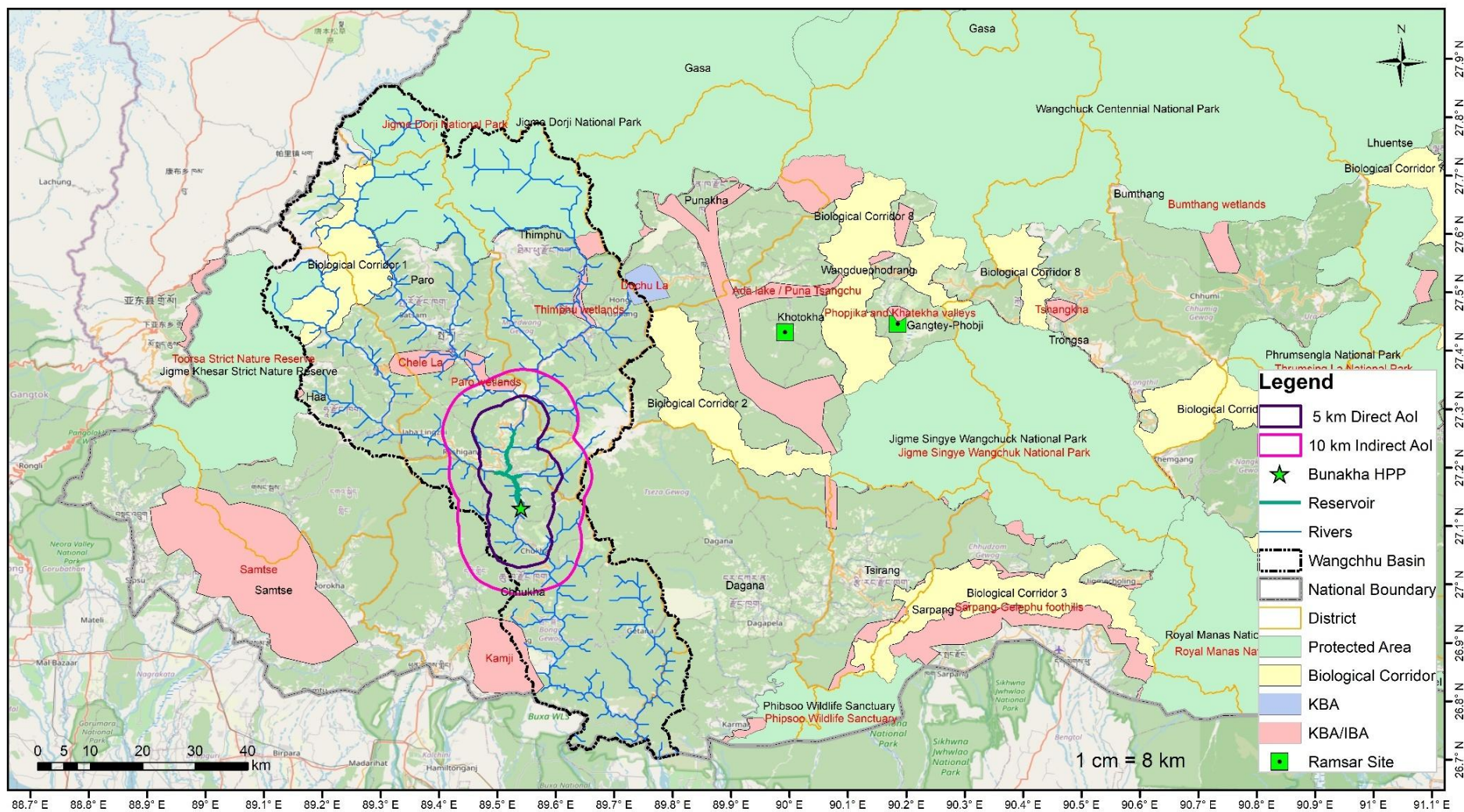


Figure 3 Aol of Bunakha HPP and nearby protected areas

2 REGULATORY AND INSTITUTIONAL FRAMEWORK

2.1 National Regulatory Framework

The Bunakha Hydropower Project is governed by the environmental and biodiversity conservation framework of the Royal Government of Bhutan, which emphasizes sustainable development, conservation of natural resources, and maintenance of ecological integrity. Bhutan's constitutional mandate requires maintaining at least 60% forest cover, reflecting the country's strong commitment to environmental conservation. The primary legislation relevant to biodiversity management includes the

- i. **Forest and Nature Conservation Act (2023) & FNCRR (2023):** The Forest and Nature Conservation Act and its associated rules provide the legal framework for forest, wildlife, and biodiversity conservation in Bhutan. These provisions regulate activities such as forest clearance, wildlife protection, and habitat conservation, ensuring that development projects are undertaken in an environmentally sustainable manner. The framework also establishes the basis for the designation and management of protected areas and biological corridors, which are critical for maintaining ecological connectivity and supporting species conservation across the landscape.
- ii. **Environmental Assessment Act (2000) & Environmental Clearance Regulation (2016):** The Environmental Assessment Act and the Regulation for Environmental Clearance of Projects mandate that hydropower developments undergo a comprehensive environmental assessment process. This includes the preparation of an Environmental and Social Impact Assessment (ESIA), Environmental and Social Management Plan (ESMP), and associated biodiversity management measures. The framework requires that Environmental Clearance (EC) be obtained prior to project implementation, ensuring that potential environmental impacts are identified, assessed, and appropriately mitigated before construction activities commence.
- iii. **National Biodiversity Strategy and Action Plan (NBSAP):** The National Biodiversity Strategy and Action Plan (NBSAP) provide the overarching national framework for biodiversity conservation and the sustainable use of biological resources in Bhutan. It promotes the integration of biodiversity considerations into sectoral planning and development processes, ensuring that economic activities, including hydropower development, are aligned with long-term conservation objectives and ecological sustainability.
- iv. **Compensatory Afforestation Requirements (DoFPS):** Forest loss associated with development activities is required to be offset through compensatory afforestation, generally following a 1:1 replacement ratio in accordance with national practice. The selection of species and the design of plantation programs are subject to approval and guidance from the Department of Forests and Park Services (DoFPS), ensuring that afforestation efforts are ecologically appropriate and aligned with local habitat conditions.
- v. **Protected Areas and Biological Corridors:** Protected areas and biological corridors are legally designated under the Department of Forests and Park Services (DoFPS) and play a critical role in conserving biodiversity. These designated areas are essential for maintaining ecological connectivity across the landscape, facilitating species movement, and supporting long-term ecosystem stability and resilience.

2.2 Institutional Framework in Bhutan

The implementation and oversight of biodiversity-related measures for the Bunakha Hydropower Project involve several national institutions, with defined roles and responsibilities.

- i. **National Environment Commission (NEC):** The NEC serves as the apex regulatory body responsible for environmental policy, regulation, and issuance of environmental clearance. NEC ensures that the project complies with national environmental laws and standards, including biodiversity conservation requirements.
- ii. **Department of Forests and Park Services (DoFPS):** The DoFPS, under the Ministry of Energy and Natural Resources, is the key authority responsible for forest management, wildlife conservation, and biodiversity protection. DoFPS plays a central role in:
 - Approval of forest land use and vegetation clearance
 - Oversight of compensatory afforestation programs
 - Management of protected areas and biological corridors
 - Guidance on biodiversity conservation measures and species protection
- iii. **Divisional Forest Offices (DFO):** Divisional Forest Offices (DFOs), such as the relevant forest division covering the Bunakha area, are responsible for field-level implementation, monitoring, and enforcement of forestry and biodiversity regulations. Facilities such as government nurseries (e.g., regional nurseries under DoFPS) may support afforestation programs.
- iv. **Department of Energy (DoE) and Druk Green Power Corporation (DGPC):** The DoE and DGPC, as the project proponent and implementing agency, are responsible for ensuring that biodiversity management measures outlined in the ESIA, ESMP, and BAP are effectively implemented throughout the project lifecycle.

Coordination among these institutions is essential to ensure compliance, effective monitoring, and adaptive management of biodiversity impacts.

2.3 International Conventions and Commitments

Bhutan is a signatory to several international environmental conventions that are relevant to biodiversity conservation and are reflected in national policies and project requirements.

These include:

- i. **Convention on Biological Diversity (CBD):** CBD promotes the conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of benefits arising from genetic resources. The CBD provides an overarching framework for biodiversity management and underpins Bhutan's national biodiversity strategies.
- ii. **Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES):** Bhutan is also a party to the CITES, which regulates trade in endangered species.
- iii. **Ramsar Convention on Wetlands:** Bhutan is also a party to the Ramsar Convention on Wetlands, which promotes the conservation and wise use of wetlands of international importance.

These international commitments reinforce the need for robust biodiversity assessment, conservation planning, and monitoring within the Bunakha HPP, particularly in relation to species of conservation concern and ecologically sensitive habitats.

2.4 ADB Safeguard Policy Statement (2009)

The Bunakha Hydropower Project is subject to the requirements of the Asian Development Bank Safeguard Policy Statement (ADB SPS, 2009), which establishes policy principles for environmental protection and biodiversity conservation in ADB-financed projects.

Under SPS, projects are required to apply the mitigation hierarchy to biodiversity impacts, prioritizing avoidance, minimization, restoration, and offsetting of residual impacts. The policy requires that projects achieve No Net Loss of biodiversity for natural habitats and, where critical habitats are present, ensure that project activities do not lead to measurable adverse impacts on critical habitat values.

- The SPS also requires:
- Identification of biodiversity values and critical habitats through appropriate assessment
- Implementation of mitigation measures to maintain ecological functions
- Monitoring of biodiversity outcomes
- Consideration of cumulative impacts

In the context of Bunakha HPP, SPS requirements are particularly relevant given the presence of ecologically sensitive riverine systems and the cumulative effects of multiple hydropower projects within the Wangchhu basin. The BAP has been developed to ensure compliance with these requirements and to provide a structured approach to achieving biodiversity conservation objectives.

- Projects located in Critical Habitat must demonstrate that:
- There are no measurable adverse impacts on the critical habitat
- The project does not reduce the population of endangered or critically endangered species
- The project does not lead to loss of habitat that compromises ecosystem viability
- Mitigation measures achieve at least No Net Loss, and preferably Net Gain

2.5 IFC Performance Standard 6 (PS6)

The Biodiversity Action Plan is also aligned with the requirements of IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources (PS6), which provides internationally recognized guidance on biodiversity risk management.

PS6 requires projects to identify biodiversity risks and impacts, classify habitats as modified, natural, or critical, and implement measures to achieve No Net Loss in natural habitats and Net Gain in critical habitats. The standard emphasizes the importance of maintaining ecosystem services, protecting species of conservation concern, and ensuring long-term ecological sustainability.

The BAP integrates these requirements by defining conservation actions, monitoring frameworks, and adaptive management mechanisms tailored to the project context. A Critical Habitat Assessment conducted for the Bunakha Hydropower Project confirms the presence of Critical Habitat based on species-level and site-level triggers. The BAP is therefore designed to ensure that project implementation is consistent with PS6 requirements, including achieving Net Gain for biodiversity values and maintaining ecological integrity within the defined Area of Habitat (AOH).

2.6 Integration of ADB SPS and IFC PS6 Requirements

While both ADB SPS and IFC PS6 emphasize biodiversity conservation and application of the mitigation hierarchy, there are differences in their specific requirements. For ADB-financed projects such as Bunakha HPP, compliance with ADB SPS (2009) takes precedence. However, IFC PS6 is used as a complementary framework, particularly for Critical Habitat Assessment and defining Net Gain requirements.

- In practice, the BAP adopts a harmonized approach by:
 - ADB SPS provides the primary safeguard requirements governing biodiversity management;
 - IFC PS6 provides the technical framework for Critical Habitat identification and biodiversity performance objectives;
 - the Critical Habitat Assessment establishes the ecological basis for identifying biodiversity priorities; and
 - this Biodiversity Action Plan translates those findings into practical mitigation, monitoring, implementation, and adaptive management measures.

This integrated approach ensures that the Bunakha Hydropower Project aligns with international best practices while meeting lender-specific safeguard requirements. The Critical Habitat Assessment provides the technical basis for identifying biodiversity priorities, defining management areas (AOI, EAAA, and AOH), and establishing conservation targets. The Biodiversity Action Plan operationalizes these requirements by translating CHA findings into targeted mitigation measures, monitoring frameworks, and adaptive management mechanisms.

Accordingly, this Biodiversity Action Plan operationalizes these requirements by translating CHA findings into species-specific mitigation measures, monitoring frameworks, and adaptive management mechanisms, ensuring compliance throughout the project lifecycle.

2.7 Implementation Framework and Linkage to ESIA and CHA

The Biodiversity Action Plan (BAP) is developed as an implementation instrument of the ESIA and is fully aligned with the findings of the Critical Habitat Assessment (CHA). It translates identified biodiversity risks, including those related to habitat loss, fragmentation, alteration of flow regimes, and cumulative impacts, into specific mitigation, monitoring, and enhancement measures.

The BAP is structured in accordance with the mitigation hierarchy, prioritizing avoidance and minimization of impacts on natural and critical habitats, followed by restoration and, where necessary, compensatory measures to achieve No Net Loss (NNL) and Net Gain (NG) in line with ADB SPS (2009) requirements.

All biodiversity management measures are spatially aligned with the Area of Influence (AOI), Ecologically Appropriate Area of Assessment (EAAA), and Area of Habitat (AOH) defined in the CHA. These spatial units ensure that biodiversity management actions are scaled appropriately to species-specific habitat requirements, ecological connectivity, and cumulative impact pathways.

- The BAP establishes clear linkages between:
 - Impact pathways identified in Section 5
 - Mitigation and enhancement measures defined in Section 6
 - Monitoring indicators and adaptive management triggers presented in Section 9

This integrated approach ensures traceability, accountability, and effective implementation throughout the project lifecycle.

The BAP is supported by a Biodiversity Accounting Framework (BAF), which provides the methodology for preliminary biodiversity accounting and will be progressively updated throughout detailed design, construction and operation to verify achievement of No Net Loss and Net Gain. The framework shall establish baseline biodiversity units, quantify residual impacts following avoidance, minimization and restoration measures, and determine additional conservation measures required to demonstrate No Net Loss for natural habitats and Net Gain for Critical Habitat in accordance with ADB SPS (2009) and IFC Performance Standard 6.

2.8 Biodiversity Accounting Framework (BAF)

To demonstrate compliance with the biodiversity objectives of the Asian Development Bank Safeguard Policy Statement (2009) and IFC Performance Standard 6, implementation of this Biodiversity Action Plan shall be supported by a Biodiversity Accounting Framework (BAF). The framework will provide a transparent and scientifically robust methodology for quantifying biodiversity losses and gains throughout the Project lifecycle and for demonstrating achievement of No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat.

The BAF has been established as the framework for biodiversity accounting. A preliminary biodiversity accounting based on the currently available project footprint, ESIA, CHA and Land Requirement Chart has been completed and will be progressively refined during detailed design and implementation following confirmation of restoration areas and biodiversity enhancement measures. Biodiversity units shall be derived from habitat extent, ecological condition, strategic conservation significance, landscape connectivity, and habitat distinctiveness. The methodology shall also consider restoration success, temporal losses, implementation risks, and uncertainty factors to ensure conservative estimation of biodiversity outcomes.

The preliminary biodiversity accounting establishes the initial baseline biodiversity units using the available biodiversity baseline surveys, Critical Habitat Assessment, ESIA and Land Requirement Chart. The biodiversity accounting will be refined prior to commencement of construction using the final project footprint, confirmed restoration areas and any additional ecological information collected during pre-construction surveys. Biodiversity losses resulting from permanent habitat conversion, temporary disturbance, habitat degradation, altered ecological processes, and fragmentation shall be quantified following implementation of all avoidance, minimization, and restoration measures under the mitigation hierarchy.

Residual biodiversity losses remaining after implementation of all practicable mitigation measures shall be compensated through additional biodiversity conservation actions and biodiversity offsets designed specifically to achieve the Project's biodiversity objectives. These measures may include habitat restoration, ecological enhancement, strengthening ecological connectivity, protection of high-value habitats, species recovery programs, invasive species management, and other conservation interventions identified through adaptive management. All biodiversity offset measures shall be demonstrably additional to statutory mitigation obligations, including compensatory afforestation required under Bhutanese legislation.

The Biodiversity Accounting Framework will be periodically updated by suitably qualified biodiversity specialists throughout construction and operation using monitoring results and restoration outcomes. Biodiversity accounting shall be integrated with the Project's biodiversity monitoring program to evaluate ecological performance, verify progress toward No Net Loss and Net Gain objectives, and identify any need for corrective actions.

Verification of biodiversity outcomes shall be undertaken through periodic comparison of monitored biodiversity units against baseline conditions and established biodiversity performance targets. Where monitoring demonstrates that biodiversity outcomes are below the required performance thresholds, additional mitigation, restoration, enhancement, or biodiversity offset measures shall be implemented through the adaptive management process until compliance with Project biodiversity objectives is achieved.

The BAF shall serve as the primary mechanism for demonstrating biodiversity performance to DGPC, regulatory agencies, and the Asian Development Bank throughout the Project lifecycle and shall provide objective evidence that implementation of the BAP is achieving measurable biodiversity outcomes consistent with international good practice.

2.9 Institutional Responsibilities for BAP Implementation

Implementation of the Biodiversity Action Plan (BAP) requires coordinated participation among the Project Proponent, contractors, regulatory agencies, and specialist consultants to ensure that biodiversity commitments are effectively integrated into all phases of project development. Overall responsibility for implementation rests with Druk Green Power Corporation (DGPC), which will ensure that adequate financial, technical, and human resources are available and that biodiversity management measures are incorporated into project planning, construction, operation, and environmental management systems.

Contractors will be responsible for implementing site-specific mitigation and management measures in accordance with the BAP and associated sub-plans, including the Biodiversity Conservation and Wildlife Management Plan, Fisheries Conservation and Management Plan, Compensatory Afforestation Plan, and Species Rescue Plan. Contractors will also be required to maintain records of biodiversity-related incidents and report regularly to DGPC.

The Department of Forests and Park Services (DoFPS) will provide regulatory oversight and technical guidance, including approval of forest clearance, supervision of compensatory afforestation, and monitoring of wildlife conservation measures. Divisional Forest Offices will support field-level supervision and enforcement.

The National Environment Commission (NEC) will oversee compliance with environmental clearance conditions and review monitoring reports submitted as part of project compliance.

Independent biodiversity specialists may be engaged, where required, to undertake specialist surveys, verify biodiversity performance, support implementation of the Biodiversity Accounting Framework, and provide technical advice on adaptive management. Regular coordination among DGPC, contractors, regulatory agencies, and technical specialists will ensure that biodiversity management measures remain effective and responsive throughout the Project lifecycle.

Detailed institutional arrangements, reporting lines, implementation of responsibilities, and coordination mechanisms are presented in Chapter 7 of this Biodiversity Action Plan.

3 Summary of Stakeholder Consultations

3.1 Objective of Consultations

Stakeholder consultations for the Bunakha Hydropower Project were conducted as an integral component of the ESIA and in accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (2009). The consultations aimed to ensure meaningful engagement with project-affected people and other interested stakeholders throughout the project lifecycle.

- The objectives of stakeholder consultations were to:
- Disseminate information on project design, potential impacts, and mitigation measures
- Obtain stakeholder feedback to inform project planning and decision-making
- Identify social, environmental, and biodiversity-related concerns, including those relevant to Critical Habitat
- Ensure inclusive participation, particularly of vulnerable groups
 - Strengthen transparency and build trust between the project proponent and stakeholders

Consultations were designed as a two-way process, combining information disclosure with feedback collection, ensuring that stakeholder inputs influence project design and biodiversity management strategies. The consultation process also supported the Critical Habitat Assessment (CHA) by providing local knowledge on species occurrence, ecological conditions, and resource use patterns.

3.2 Summary of Consultations

Stakeholder consultations were conducted across multiple stages of the ESIA process, including the inception phase (January 2025), baseline surveys (April–July 2025), and impact disclosure phase (December 2025). These consultations were carried out through institutional meetings, public consultations, focus group discussions, and key informant interviews in the project-affected areas, particularly Bunakha and Chanachen villages under Chapcha and Geling Gewogs.

Particular attention was given to capturing local knowledge on species occurrence, habitat use, and ecological changes, which supported validation of Critical Habitat Assessment findings. This included identification of biodiversity sensitivities such as wildlife presence, riverine ecosystem dependence, and habitat connectivity, which were subsequently integrated into biodiversity management planning.

Multiple consultation events were undertaken across different project phases, with active participation from local residents, including women and vulnerable groups. This inclusive engagement ensured that biodiversity-related concerns—such as impacts on aquatic ecosystems, wildlife disturbance, and habitat connectivity—were identified and integrated into the design of mitigation measures and the Biodiversity Action Plan.

3.2.1 Government Institutions

- Consultations were undertaken with key government agencies, including:
- Chhukha Dzongkhag Administration (CDA)
- Gedu Divisional Forest Office
- Department of Water (DoW)

- Department of Environment and Climate Change (DECC)

These consultations confirmed the ecological significance of the project area and supported the identification of Critical Habitat triggers, particularly in relation to threatened and protected species. Forest authorities highlighted the presence and potential range of important wildlife species and emphasized the need for robust biodiversity assessment and strict compliance with national forest and wildlife regulations.

Institutional stakeholders also provided guidance on survey methodologies, permitting requirements, and the integration of existing biodiversity data into the ESIA process. Particular emphasis was placed on maintaining ecological integrity in forest and riverine habitats, protecting wildlife movement corridors, and ensuring that environmental flow requirements are incorporated to safeguard aquatic biodiversity.

These inputs directly informed the Critical Habitat Assessment and contributed to the identification and validation of Critical Habitat triggers, particularly for threatened species and ecologically sensitive riverine habitats. They also guided the development of mitigation measures outlined in Section 5, with a focus on habitat protection, wildlife conservation, and aquatic ecosystem management.

3.2.2 Non-Governmental Organizations

Consultations with non-governmental organizations (NGOs), community-based organizations (CBOs), and environmental stakeholders provided important perspectives on biodiversity conservation priorities and risks. These stakeholders emphasized the need to protect ecologically sensitive areas, including natural habitats and potential Critical Habitat zones identified in Section 4.

Concerns were raised regarding habitat fragmentation, disturbance to threatened species, and long-term ecosystem degradation. NGOs highlighted the importance of maintaining ecological connectivity, particularly for wide-ranging species, and recommended the application of a precautionary approach in areas where Critical Habitat may be present.

Stakeholders also emphasized the need to align biodiversity management measures with good international practice, particularly IFC Performance Standard 6, including the achievement of no net loss for natural habitats and net gain where Critical Habitat is affected. In addition, they recommended the establishment of robust biodiversity monitoring systems and the integration of community-based conservation approaches.

These inputs strengthened BAP by reinforcing the need for a comprehensive and adaptive approach to biodiversity management, as reflected in the mitigation hierarchy and monitoring framework presented in Section 5.

3.2.3 Private Sector

Private sector stakeholders, including the project proponent (DGPC), consultants, and contractors, were engaged to ensure that biodiversity considerations are effectively integrated into project design, construction, and operation. These stakeholders acknowledged the importance of incorporating CHA findings into project planning and ensuring compliance with ESIA requirements and lender safeguards.

Discussions focused on the practical implementation of mitigation measures, including minimizing habitat disturbance during construction, integrating biodiversity considerations into engineering design, and ensuring timely and effective restoration of disturbed areas. There was also recognition of

the need to align biodiversity management measures with construction schedules and operational constraints while maintaining compliance with ADB SPS requirements.

Private sector stakeholders also identified opportunities to enhance biodiversity outcomes through habitat restoration, compensatory afforestation, and support for local conservation initiatives. Their commitment to implementing monitoring and adaptive management measures is reflected in the BAP provisions described in Section 5.

3.3 Addressing Stakeholder Concerns

Stakeholder concerns identified during consultations have been systematically integrated into the Biodiversity Action Plan through alignment with the mitigation hierarchy and Critical Habitat requirements. Key concerns included impacts on riverine habitats and fisheries, disturbance to species of conservation importance, disruption of wildlife movement corridors, alteration of aquatic ecosystems due to flow regulation, and cumulative impacts associated with the Wangchhu hydropower cascade.

These concerns have been addressed through a combination of avoidance, minimization, and enhancement measures embedded within project design and biodiversity management planning. Avoidance measures prioritize protection of high-value habitats, including Critical Habitat areas, while minimization measures focus on controlling construction activities, restricting access to sensitive areas, and preventing pollution. Aquatic ecosystem impacts are addressed through environmental flow implementation, habitat protection, and fisheries management, while terrestrial biodiversity impacts are mitigated through habitat restoration, maintenance of ecological connectivity, and species protection measures. Cumulative impacts are addressed through basin-level considerations and long-term monitoring, supported by adaptive management mechanisms.

Table 1: Linkage between CHA triggers, Stakeholders Concerns and BAP Measures

SN	CHA Trigger / Feature	CHA Qualification Basis (ADB SPS / IFC PS6)	Key Stakeholder Concerns	Impact Pathway	BAP Mitigation / Management Measures	Residual Impact
1	White-bellied Heron (<i>Ardea insignis</i>)	CR species qualifies under Criterion 1; extremely small global population	Disturbance to riverine habitat, breeding and feeding areas	Flow alteration, sedimentation, construction disturbance in river corridor	• Maintain environmental flows • Protect riverine habitat and sandbars • Restrict construction near sensitive stretches • Long-term species monitoring	Low - Moderate
2	<i>Drepanostachyum annulatum</i> (bamboo)	Restricted-range / habitat-specific species (Criterion 2)	Loss of understory vegetation and habitat degradation	Vegetation clearance, land conversion	• Avoid high-density patches • Compensatory plantation using native bamboo • Habitat restoration in disturbed forest areas	Low
3	<i>Strobilanthes accrescens subsp. accrescens</i>	Restricted distribution plant species (Criterion 2)	Loss of endemic/ rare flora	Site clearing and disturbance	• Micro-siting to avoid locations • Translocation (if feasible) • Restoration using native species	Low
4	<i>Carex speciosa subsp. pinetorum</i>	Restricted-range sedge species (Criterion 2)	Loss of specialized habitat	Land disturbance and soil alteration	• Avoidance of sensitive microhabitats • Rehabilitation of disturbed areas • Monitoring of regeneration	Low

SN	CHA Trigger / Feature	CHA Qualification Basis (ADB SPS / IFC PS6)	Key Stakeholder Concerns	Impact Pathway	BAP Mitigation / Management Measures	Residual Impact
5	<i>Cephalaeschna triadica</i> (insect)	Indicator species linked to riparian ecosystem (Criterion 2)	Degradation of riparian and aquatic habitat	Water quality change, sedimentation	• Riparian buffer protection • Sediment and erosion control • Water quality monitoring	Low
6	<i>Pedicularis amplicollis</i>	Restricted-range plant species (Criterion 2)	Loss of rare plant habitat	Vegetation removal	• Avoidance where feasible • Habitat restoration • Native species replantation	Low

Table 2: Qualified Critical Habitat

SN	CHA Feature	CHA Basis	Stakeholder Concerns	Impact Pathway	BAP Measures	Residual Impact
7	Kamji KBA/IBA	Internationally recognized biodiversity area (Criterion 6)	Landscape-level biodiversity loss, disturbance	Indirect and cumulative impacts	• Avoid high-impact activities • Maintain ecological connectivity • Monitoring of biodiversity values	Low
8	Paro Wetland KBA/IBA	KBA/IBA designation (Criterion 6)	Impacts on wetland-dependent species	Hydrological alteration (indirect)	• Maintain flow regime • Prevent sedimentation • Monitoring of wetland ecology	Low

Source: Critical Habitat Assessment of Bunakha HPP

Stakeholder consultations have played a critical role in informing the Biodiversity Action Plan by ensuring that biodiversity priorities, including the six confirmed Critical Habitat trigger species and associated habitats identified in Section 4, are effectively integrated into project planning and management. The BAP reflects a participatory, evidence-based, and adaptive approach, linking stakeholder concerns directly to mitigation and management measures presented in Section 5.

Through alignment with ADB SPS requirements and international good practice, the consultation process has strengthened the BAP by ensuring that biodiversity management measures are scientifically robust, socially inclusive, and operationally feasible, thereby supporting the long-term conservation of biodiversity within the project area.

4 BIODIVERSITY VALUES

The biological resources within the Bunakha Hydropower Project Area of Influence (AOI) have been broadly categorized into aquatic and terrestrial components for the purpose of establishing baseline conditions and identifying potential threats arising from project activities. This classification enables a systematic assessment of biodiversity values and supports the development of targeted mitigation and conservation measures under the Biodiversity Action Plan (BAP).

The baseline status of biological resources has been established based on a combination of primary field surveys, seasonal biodiversity assessments, and secondary data sources. These include multi-seasonal aquatic and terrestrial biodiversity surveys undertaken as part of the Environmental and Social Impact Assessment (ESIA), as well as the Critical Habitat Assessment (CHA), which provides a detailed evaluation of biodiversity values within the project's Area of Influence, Ecologically Appropriate Area of Assessment (EAAA), and Area of Habitat (AOH).

The baseline assessment draws upon the following key studies and data sources:

- Multi-seasonal aquatic ecology assessments (pre-monsoon, monsoon, and post-monsoon) conducted for the Bunakha Hydropower Project, covering fish, macroinvertebrates, plankton communities, and water quality parameters
- Terrestrial biodiversity surveys undertaken as part of the ESIA, including vegetation, mammals, birds, and herpetofauna assessments
- Critical Habitat Assessment (CHA) conducted for the Bunakha Hydropower Project, identifying species of conservation importance, habitat sensitivity, and ecological connectivity requirements
- Secondary literature and national biodiversity databases, including IUCN Red List, Bhutan's Forest and Nature Conservation framework, and relevant ecological studies

These sources collectively provide a comprehensive understanding of biodiversity patterns, seasonal dynamics, and ecological processes within the project area. The baseline also forms the foundation for identifying biodiversity sensitivities, assessing project impacts, and designing appropriate mitigation, management, and enhancement measures in line with ADB Safeguard Policy Statement (2009) and IFC Performance Standard 6.

4.1 Aquatic Biodiversity

The Wangchhu River within the Bunakha Hydropower Project Area of Influence (AOI) supports a diverse and dynamic aquatic ecosystem comprising fish, macroinvertebrates, phytoplankton, periphyton, and associated riparian habitats. Aquatic biodiversity has been assessed through multi-seasonal surveys (pre-monsoon, monsoon, and post-monsoon), capturing variability in hydrology, habitat conditions, and ecological processes. The river system demonstrates generally good ecological integrity, with seasonal fluctuations in species richness and community composition driven by flow variability and habitat availability. These aquatic biodiversity values contribute to Critical Habitat triggers identified in the CHA, particularly for aquatic-dependent species.

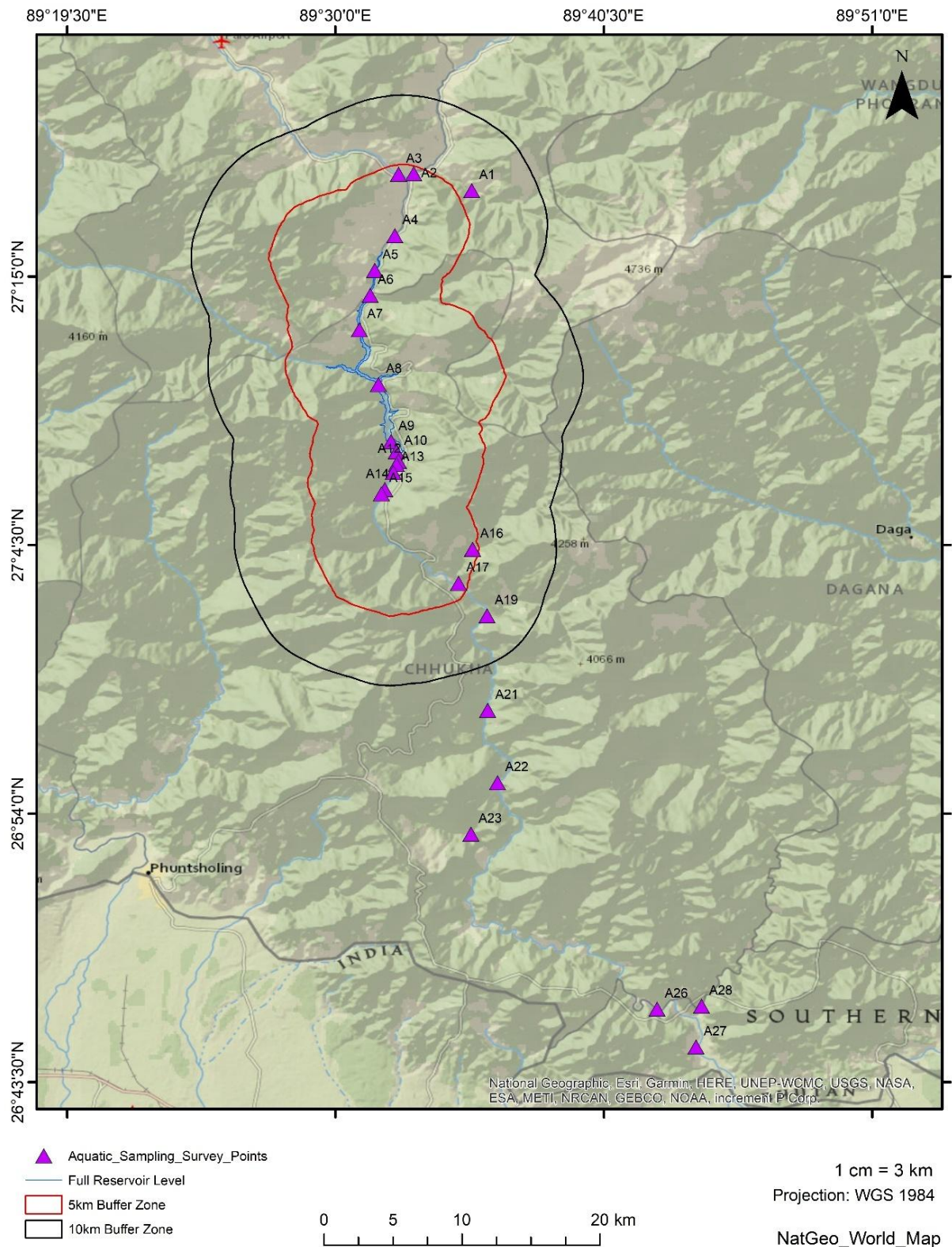


Figure 4 Aquatic Sampling Survey Points

4.1.1 Overview of Fish Fauna

Fish fauna within the project area are characteristic of Himalayan River systems, dominated by cold-water and rheophilic species adapted to fast-flowing, well-oxygenated environments. Across seasonal surveys, the fish community is composed primarily of cyprinid species, including Snow Trout (*Schizothorax richardsonii*), mahseer (*Tor putitora*), and other native taxa such as *Neolissochilus hexagonolepis* and *Opsarius barna*. Introduced species such as Brown Trout (*Salmo trutta*) are also present in certain tributaries.

The distribution of fish species varies along the river continuum, with upstream sections supporting fewer species due to steep gradients and lower habitat diversity, while downstream reaches exhibit higher species richness and more complex community structures. This pattern reflects natural ecological gradients and the influence of habitat heterogeneity within the basin.

Table 3: Summary of Fish Fauna Recorded Across Seasons

Parameter	Pre-monsoon	Monsoon	Post-monsoon
No. of species	2	28	12
Dominant species	<i>Schizothorax richardsonii</i> , <i>Salmo trutta</i>	<i>Neolissochilus hexagonolepis</i> , <i>Opsarius barna</i>	<i>Neolissochilus hexagonolepis</i> , <i>Schizothorax richardsonii</i>
Ecological condition	Low activity (low flow)	High productivity	Stabilization phase

4.1.2 Fish Diversity

Fish diversity in the Wangchhu River exhibits strong seasonal variation. During the pre-monsoon season, species' richness is relatively low, with only two species recorded, reflecting reduced flow conditions and limited habitat availability. In contrast, the monsoon season supports significantly higher diversity, with 28 species recorded across the study area, indicating increased habitat connectivity and ecological productivity. The post-monsoon season shows moderate diversity, with 12 species recorded, representing a transition towards ecological stabilization.

Diversity indices (e.g., Shannon index) demonstrate a clear longitudinal gradient, with higher diversity and evenness observed in downstream sections compared to upstream areas. This pattern highlights the ecological importance of downstream habitats and their role in supporting biodiversity under varying hydrological conditions.

Table 4: Seasonal Fish Diversity and Ecological Interpretation

Season	Species Richness	Ecological Interpretation
Pre-monsoon	Low	Limited habitat, low flow
Monsoon	High	Increased connectivity and productivity
Post-monsoon	Moderate	Ecological stabilization

4.1.3 Fish Migration and Movement Patterns

Fish species within the Wangchhu River exhibit movement patterns influenced by seasonal flow regimes, habitat availability, and life cycle requirements. Native species such as Snow Trout and mahseer are known to undertake localized and seasonal movements for spawning, feeding, and refuge seeking.

Increased connectivity during the monsoon season facilitates upstream and downstream movement, while reduced flows during pre-monsoon periods may restrict mobility and limit access to critical habitats.

The river system functions as a longitudinal ecological corridor, allowing for dispersal and genetic exchange among fish populations. The proposed dam may disrupt longitudinal connectivity, affecting migratory pathways.

Table 5: Fish Movement Characteristics in Project Area

Movement Type	Description	Seasonal Influence
Longitudinal migration	Upstream–downstream movement for spawning	Peak during monsoon
Local movement	Habitat-scale movement for feeding/refuge	Occurs year-round
Connectivity dependence	Requires uninterrupted river flow	Sensitive to barriers

4.1.4 Fish Species Recommended for Consideration in the BAP

Based on conservation status, ecological importance, and sensitivity to hydrological changes, several fish species are recommended for focused consideration within the Biodiversity Action Plan. These include species of conservation concern such as *Tor putitora* (Endangered), *Schizothorax richardsonii* (Vulnerable), and *Semiplotus semiplotus* (Vulnerable), which are indicative of high ecological value and require targeted management measures.

In addition, dominant and ecologically important species such as *Neolissochilus hexagonolepis* and *Opsarius barna* should be considered due to their role in maintaining ecological balance and supporting aquatic food webs. These species collectively represent key ecological receptors for assessing project impacts and designing mitigation and conservation strategies.

Table 6: Key Fish Species for BAP Consideration

Scientific Name	Common Name	IUCN Status	Significance
<i>Tor putitora</i>	Golden Mahseer	EN	Conservation priority, migratory
<i>Schizothorax richardsonii</i>	Snow Trout	VU	Indicator species, cold-water fish
<i>Semiplotus semiplotus</i>	–	VU	Native species of concern
<i>Neolissochilus hexagonolepis</i>	Copper Mahseer	LC	Ecologically dominant
<i>Opsarius barna</i>	Barna Baril	LC	Common riverine species

The total number of Fish species recorded across the three seasonal surveys is presented in the combined biodiversity report, with detailed species lists provided in Annex 1.

4.1.5 Threats to Fish Fauna

Fish populations within the project area are subject to a range of natural and anthropogenic pressures. Key threats include alteration of flow regimes, habitat fragmentation, and sedimentation, which can affect spawning habitats and food availability. The presence of multiple hydropower projects within the Wangchhu basin introduces cumulative impacts, particularly through changes in flow continuity and habitat connectivity.

Localized disturbances, including infrastructure development and human activities, may also contribute to habitat degradation. Additionally, the presence of introduced species such as Brown Trout may exert competitive pressure on native species. These factors collectively highlight the vulnerability of fish communities to hydrological and ecological changes.

Table 7: Key Threats to Aquatic Biodiversity

Threat Type	Description	Potential Impact
Flow alteration	Reduced environmental flow	Habitat loss, spawning disruption
Barrier effect	Dam construction	Migration blockage
Sedimentation	Construction activities	Habitat degradation
Cumulative impacts	Cascade hydropower projects	Reduced connectivity
Invasive species	Brown Trout	Competition with native species

4.1.6 Habitat Assessment

Aquatic habitats within the project area are characterized by a range of physical conditions, including riffles, pools, and runs, which support diverse biological communities. Substrate composition varies from coarse boulders and cobbles in upstream sections to finer sediments in downstream areas, influencing habitat suitability for different species.

Habitat integrity assessments indicate that most sites fall within natural to moderately modified conditions, reflecting relatively low levels of disturbance. However, localized impacts are observed in areas influenced by existing infrastructure and human activities, particularly in downstream and dam-affected sections.

Seasonal variations in flow significantly influence habitat availability, with monsoon conditions enhancing habitat connectivity and ecological productivity, while low-flow conditions during pre-monsoon periods reduce habitat extent and complexity.

Table 8: Aquatic Habitat Characteristics

Habitat Type	Characteristics	Ecological Importance
Riffles	Fast flow, coarse substrate	Oxygenation, spawning
Pools	Deep, slow-moving water	Refuge habitat
Runs	Moderate flow	Feeding zones

4.1.7 Macro-invertebrates

Macroinvertebrate communities in the Wangchhu River serve as important indicators of ecological health and water quality. The surveys recorded diverse macroinvertebrate assemblages, including pollution-sensitive taxa such as Ephemeroptera, Plecoptera, and Trichoptera (EPT groups), indicating good water quality and well-oxygenated conditions.

During the monsoon season, a high diversity of macroinvertebrates was recorded, with 26 families across 11 orders, while pre-monsoon and post-monsoon surveys showed relatively lower but still representative diversity. Variations in macroinvertebrate diversity across sites reflect differences in habitat conditions, flow regimes, and localized disturbances.

Overall, macroinvertebrate communities confirm that the river maintains a healthy ecological status, with conditions suitable for supporting diverse aquatic life.

Table 9: Macroinvertebrate Summary

Parameter	Observation
Total families (monsoon)	26 families
Dominant group	Baetidae
Indicator taxa	EPT groups
Ecological status	Good water quality

4.1.8 Riparian Vegetation

Riparian vegetation along the Wangchhu River plays a critical role in maintaining aquatic ecosystem health by stabilizing riverbanks, regulating water temperature, and providing organic inputs to the aquatic food web. Vegetation cover also supports habitat connectivity for both aquatic and terrestrial species.

Within the project area, riparian zones are generally well-developed, particularly in less disturbed upstream sections. However, localized disturbances are observed near construction areas, settlements, and infrastructure, which may lead to reduced vegetation cover and increased erosion risk.

The condition of riparian vegetation is closely linked to overall habitat integrity and is an important component of biodiversity conservation within the BAP framework.

Table 10: Role of Riparian Vegetation

Function	Description
Bank stabilization	Prevents erosion
Habitat support	Provides shelter and food
Water regulation	Maintains temperature and quality
Connectivity	Supports ecological corridors

4.2 Terrestrial Biodiversity

The terrestrial ecosystems within the Bunakha Hydropower Project Area of Influence (AOI) comprise a diverse range of habitat types, including broadleaf forests, blue pine forests, mixed conifer forests, shrublands, and meadow ecosystems. These habitats support a wide variety of flora and fauna and reflect the ecological heterogeneity of the mid-Himalayan landscape.

Terrestrial biodiversity has been assessed through multi-seasonal surveys conducted during pre-monsoon, monsoon, and post-monsoon periods, covering approximately 34–39 sampling plots across representative habitat types. The combined assessment integrates seasonal variability and provides a comprehensive baseline of species diversity, ecological structure, and conservation significance.

Overall, the combined surveys recorded 176 terrestrial species across major taxa, comprising flora and fauna groups, confirming that the project area supports moderate to high biodiversity with significant ecological and conservation value.

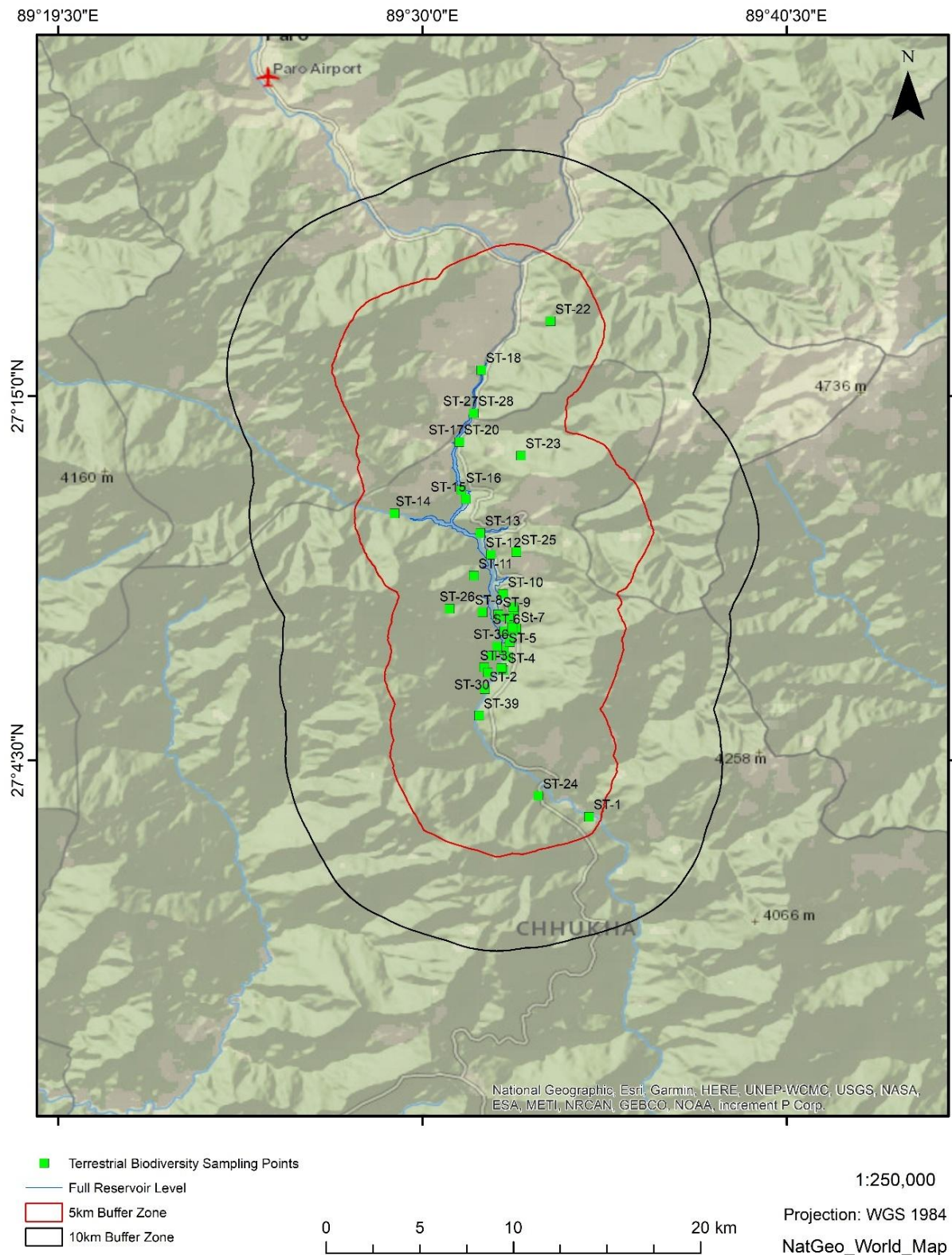


Figure 5 Terrestrial Biodiversity Sampling Points

4.2.1 Terrestrial Flora

Vegetation surveys conducted across all three seasons recorded a total of 139 plant species, comprising 43 tree species, 42 shrub species, 42 herb species, and 12 epiphyte species. The vegetation is dominated by native Himalayan species, with broadleaf forests representing the most diverse and ecologically significant habitat type.

Forest structure analysis, including basal area, density, and Importance Value Index (IVI), indicates relatively intact ecosystems falling within natural to moderately modified categories. Several plant species of national and international conservation importance were identified, including species listed under Bhutan's Forest and Nature Conservation Act (FNCA, 2023) and IUCN Red List categories.

Invasive plant species were observed primarily in disturbed areas such as roadsides and open sites; however, their distribution remains localized and does not currently dominate vegetation structure. The total number of tree species recorded across the three seasonal surveys is presented in the combined biodiversity report, with detailed species lists provided in Annex 2.

4.2.2 Mammals

Across all three seasonal surveys, a total of 9 mammal species were recorded within the Bunakha Hydropower Project Area of Influence (AOI), representing herbivores, carnivores, and omnivores associated with forest ecosystems. The recorded assemblage reflects the ecological integrity of the landscape and the availability of diverse habitats within the mid-Himalayan region.

Species of conservation importance recorded include the Red Panda (*Ailurus fulgens*), Asiatic Black Bear (*Ursus thibetanus*), and Sambar Deer (*Rusa unicolor*), all of which are listed under IUCN threatened categories and protected under Bhutanese legislation. The presence of these species highlights the ecological significance of the project area and its role in supporting forest-dependent fauna.

The Critical Habitat Assessment (CHA) further identifies several mammal species within the broader Ecologically Appropriate Area of Assessment (EAAA) that are of high conservation importance. While some species, such as the Red Panda and Dhole (*Cuon alpinus*), do not meet formal Critical Habitat thresholds, they are classified as near-threshold species and require precautionary management due to their conservation status and ecological sensitivity.

Mammal distribution within the AOI is strongly associated with forest habitats, particularly broadleaf and mixed forests, which provide suitable cover, foraging resources, and movement corridors. The project landscape forms part of a larger ecological network that supports wildlife movement and maintains landscape-level connectivity within the Wangchhu basin. Evidence from field observations and stakeholder inputs indicates ongoing wildlife movement and occasional human-wildlife interactions, suggesting that ecological connectivity remains functionally intact.

However, terrestrial mammals are sensitive to habitat fragmentation, disturbance, and loss of connectivity arising from infrastructure development. In the context of cumulative impacts from hydropower development within the Wangchhu cascade, maintaining habitat continuity and minimizing disturbance will be critical for sustaining viable mammal populations.

The total number of mammal species recorded across all three seasons is summarized in the combined biodiversity assessment, with detailed species-level information provided in Annex 3.

4.2.3 Avifauna (Birds)

Avifaunal diversity within the Bunakha Hydropower Project area is high, reflecting the heterogeneity of habitats including broadleaf forests, mixed forests, and riparian corridors along the Wangchhu River. Based on combined seasonal surveys, a high diversity of bird species was recorded across the Area of Influence (AOI), representing resident, migratory, and habitat-specialist species associated with forest and riverine ecosystems.

The avifaunal assemblage includes forest-dependent species, riparian specialists, and generalist species, indicating a structurally diverse and functionally intact ecosystem. Broadleaf forests and riparian zones were identified as key habitats supporting high species richness and ecological functions, particularly for insectivorous and frugivorous bird communities.

The Critical Habitat Assessment (CHA) further confirms that the project landscape and its broader Ecologically Appropriate Area of Assessment (EAAA) support several species of high conservation significance. Notably, the White-bellied Heron (*Ardea insignis*), a Critically Endangered species, is known to occur within the Wangchhu river basin and its Area of Habitat (AOH), with confirmed records in downstream stretches and adjacent river systems. Given its extremely small global population and dependence on riverine habitats, even low numbers within the broader landscape are sufficient to trigger Critical Habitat under ADB SPS criteria.

In addition to Critical Habitat-triggering species, several bird species identified through IBAT screening and CHA analysis fall within near-threshold categories, including migratory and range-restricted species that utilize the project landscape and surrounding habitats. These species are associated with forest interiors, elevational gradients, and riparian ecosystems, highlighting the ecological connectivity of the area.

Seasonal variation in avifaunal diversity is evident, with higher detectability during monsoon and post-monsoon periods due to increased breeding activity, food availability, and favorable climatic conditions. While some species were not directly recorded within the immediate project footprint, the presence of suitable habitats within the AOI and EAAA indicates potential occurrence and ecological use of the landscape.

Overall, the avifaunal diversity within the Bunakha HPP area, combined with the presence of globally threatened and CHA-relevant species, underscores the ecological importance of the project area and the need for targeted biodiversity management and mitigation measures. The total number of bird species recorded across all seasons is provided in the combined biodiversity report, with the full checklist included in Annex 4.

4.2.4 Herpetofauna

The surveys recorded a total of 28 herpetofauna species, comprising reptiles, amphibians, and one turtle species. These species are associated with moist forest habitats, riparian zones, and microhabitats such as leaf litter and rocky substrates.

Herpetofauna diversity shows strong seasonal variation, with higher activity during the monsoon period due to favorable moisture conditions. Amphibians serve as sensitive indicators of environmental conditions and habitat quality.

The recorded species include both widespread and regionally significant taxa, some of which have been considered in the Critical Habitat Assessment process. The total number of herpetofauna species

recorded across all seasons is presented in the combined biodiversity assessment, with detailed species information provided in Annex 5.

4.2.5 Threats to Terrestrial Biodiversity

Despite relatively high ecological integrity, terrestrial biodiversity within the project area is subject to several pressures, particularly associated with infrastructure development and human activities.

Table 11: Key Threats to Terrestrial Biodiversity

Threat Type	Description	Potential Impact
Habitat loss	Vegetation clearance for dam, reservoir, and infrastructure	Reduction in habitat availability
Habitat fragmentation	Roads, transmission lines, and construction zones	Disruption of wildlife movement
Disturbance	Noise, vibration, and human presence	Behavioral changes in wildlife
Invasive species	Spread in disturbed areas	Competition with native flora
Resource use	Local extraction of forest resources	Degradation of habitats
Cumulative impacts	Cascade hydropower development	Landscape-level ecological changes

These threats are particularly significant in the context of cumulative impacts within the Wangchhu basin, where multiple hydropower projects may influence ecological connectivity and species movement. Species identified in the Critical Habitat Assessment are especially sensitive to such disturbances and require targeted management under the Biodiversity Action Plan.

4.3 Critical Habitat Values

The Critical Habitat Assessment (CHA) conducted for the Bunakha Hydropower Project confirms that Critical Habitat (CH) is present within the project's Area of Influence (AOI) and the broader Wangchhu river basin landscape, in accordance with the criteria defined under the Asian Development Bank Safeguard Policy Statement (ADB SPS, 2009).

The assessment was based on field surveys, IBAT screening, secondary data, and expert consultation, evaluating biodiversity values against internationally recognized criteria. The analysis identified six species and two internationally recognized biodiversity areas (Key Biodiversity Areas/Important Bird and Biodiversity Areas – KBA/IBA) that meet the thresholds for Critical Habitat designation.

4.3.1 Critical Habitat Determination

A Critical Habitat Assessment (CHA) was undertaken for the Bunakha Hydropower Project in accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (2009) and International Finance Corporation Performance Standard 6 (PS6). The assessment applied internationally recognized criteria to determine whether biodiversity features within the Project Area of Influence (AOI) qualify as Critical Habitat.

The CHA confirms that Critical Habitat is present within the AOI, triggered by a combination of species-level and site-level attributes. These include the occurrence of globally threatened species, restricted-range species, and the presence of internationally recognized biodiversity areas such as Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs). Critical Habitat is primarily associated

with riverine ecosystems, riparian habitats, and adjoining forested landscapes that support species of high conservation significance.

The identification of Critical Habitat triggers necessitates compliance with stringent biodiversity requirements, including the demonstration of no measurable adverse impacts on Critical Habitat values, maintenance of population viability of qualifying species, and achievement of Net Gain in accordance with ADB SPS and IFC PS6.

4.3.2 Critical Habitat Trigger Species and Areas

Table 12: Confirmed Critical Habitat Triggers

Category	Scientific Name / Site	Common Name	IUCN Status	Basis of CH Trigger
Species				
Bird	<i>Ardea insignis</i>	White-bellied Heron	CR	Critically Endangered species
Plant	<i>Drepanostachyum annulatum</i>	–	EN	Restricted distribution
Plant	<i>Strobilanthes accrescens</i> subsp. <i>accrescens</i>	–	VU	Limited distribution
Plant	<i>Carex speciosa</i> subsp. <i>pinetorum</i>	–	VU	Restricted range
Insect	<i>Cephaeschna triadica</i>	–	DD	Range-restricted species
Plant	<i>Pedicularis amplicollis</i>	–	DD	Limited distribution
Protected Areas				
Site	Kamji KBA/IBA	–	–	Internationally recognized biodiversity area
Site	Paro Wetland KBA/IBA	–	–	Internationally recognized biodiversity area

The White-bellied Heron (*Ardea insignis*) is of particular significance due to its extremely small global population and strong dependence on riverine habitats. Although the species was not directly recorded during field surveys, confirmed records within the Wangchhu basin and the presence of suitable habitat indicate that the Area of Habitat (AOH) has the potential to support the species. Given its conservation status, even the potential presence of a small number of individuals is sufficient to trigger Critical Habitat under ADB SPS criteria.

As the current occurrence and use of the Project Area of Influence by the White-bellied Heron require confirmation through an additional targeted survey, the species continues to be treated as a precautionary Critical Habitat trigger. Until the survey is completed, all mitigation and monitoring measures described in this BAP shall remain applicable.

4.3.3 Near-Threshold and Conservation Priority Species

- In addition to confirmed Critical Habitat triggers, the CHA identified several species of conservation importance that do not meet the quantitative thresholds for Critical Habitat but require precautionary management due to their ecological and conservation significance.
- These include species such as:

Table 13: Near-Threshold and Conservation Priority Species

Common Name	Scientific Name
Rufous-necked Hornbill	<i>Aceros nipalensis</i>
Red Panda	<i>Ailurus fulgens</i>
Dhole	<i>Cuon alpinus</i>

Common Name	Scientific Name
Tiger	<i>Panthera tigris</i>
Golden Mahseer	<i>Tor putitora</i>
Rufous-fronted Tit	<i>Aegithalos iouschistos</i>
Fire-tailed Myzornis	<i>Myzornis pyrrhura</i>
Black-throated Prinia	<i>Prinia atrogularis</i>
Satyr Tragopan	<i>Tragopan satyra</i>
Himalayan Forest Thrush	<i>Zootera salimalii</i>

These species are associated with forest and riverine habitats within the AOI and are sensitive to habitat disturbance, fragmentation, and changes in ecological connectivity. Although not classified as Critical Habitat triggers, they are treated as high conservation priority species within the BAP, and mitigation measures are designed to ensure their protection.

4.3.4 Key Critical Habitats and Ecological Features

- Critical Habitat within the project landscape is associated with the following ecological features:
- Riverine ecosystems, supporting aquatic species and water-dependent birds
- Riparian zones, providing feeding, breeding, and movement corridors
- Broadleaf and mixed forests, supporting mammalian and avian diversity
 - Landscape-level ecological connectivity, linking habitats across the Wangchhu basin

These habitats are functionally interconnected and play a critical role in maintaining ecological processes and species viability.

4.3.5 Spatial Framework (AOI, EAAA, AOH)

- The Critical Habitat Assessment defines a spatial framework to guide biodiversity management:
- Area of Influence (AOI): Includes project footprint, associated facilities, and downstream areas influenced by flow alteration
- Ecologically Appropriate Area of Assessment (EAAA): Represents the broader ecological landscape within which species populations and ecological processes operate
 - Area of Habitat (AOH): Refers to species-specific habitat areas critical for survival, reproduction, and movement

This framework ensures that biodiversity management measures are appropriately scaled and aligned with species-specific ecological requirements and cumulative impact pathways.

4.3.6 Sensitivity of Critical Habitat to Project Impacts

- Critical Habitat values within the project area are highly sensitive to:
 - Alteration of flow regimes, affecting aquatic ecosystems and river-dependent species
 - Barrier effects of dam infrastructure, disrupting longitudinal connectivity
 - Habitat loss and fragmentation, particularly in terrestrial ecosystems
 - Cumulative impacts, arising from cascade hydropower development within the Wangchhu basin
- Aquatic ecosystems and river-dependent species, particularly the White-bellied Heron, are especially vulnerable due to their reliance on undisturbed river systems and habitat continuity.

4.3.7 Implications for Biodiversity Action Plan

- The presence of Critical Habitat imposes strict requirements under ADB SPS (2009). Accordingly, the project must ensure that:
- There are no measurable adverse impacts on Critical Habitat values
- The project does not reduce populations of Critically Endangered or Endangered species
- Ecological functions and habitat integrity are maintained
- Net Gain is achieved for Critical Habitat values through targeted conservation measures

The Biodiversity Action Plan incorporates these requirements through species-specific conservation actions, habitat protection measures, monitoring programs, and adaptive management strategies aligned with the findings of the Critical Habitat Assessment.

4.4 Protected Areas and Areas of Biodiversity Importance

The Bunakha Hydropower Project is not located within any legally designated Protected Area of Bhutan. However, the project lies within a biologically significant landscape characterized by high ecological connectivity and proximity to areas of recognized biodiversity importance.

The Critical Habitat Assessment (CHA) identifies the presence of internationally recognized biodiversity areas within the broader Ecologically Appropriate Area of Assessment (EAAA), including the Kamji Key Biodiversity Area (KBA) / Important Bird and Biodiversity Area (IBA) and the Paro Wetland KBA/IBA. These areas are designated based on their importance for supporting species of global conservation significance, including threatened and range-restricted species.

Although these KBAs/IBAs do not spatially overlap with the immediate project footprint, the Wangchhu river system and associated habitats form part of a larger ecological network that supports species movement and ecological processes across the landscape. Riverine and riparian habitats within the project Area of Influence (AOI) are functionally linked to downstream and adjacent habitats that contribute to the ecological integrity of these biodiversity areas.

In addition, Bhutan's national conservation framework includes a system of biological corridors designed to maintain landscape-level connectivity between protected areas. While the project is not located within a formally designated protected area, it lies within a landscape that contributes to ecological connectivity and supports species identified in the Critical Habitat Assessment.

Given this context, potential project impacts on biodiversity must be considered not only at the site level but also in terms of indirect and cumulative effects on connected ecosystems and biodiversity areas. The Biodiversity Action Plan therefore incorporates measures to maintain ecological connectivity, protect sensitive habitats, and address cumulative impacts in line with ADB SPS (2009) requirements.

5 IMPACT ASSESSMENT

5.1 Approach and Methodology

The biodiversity impact assessment for the Bunakha Hydropower Project has been undertaken using a structured cause–pathway–receptor–impact framework in accordance with the Fichtner methodology and aligned with the Asian Development Bank Safeguard Policy Statement (2009) and IFC Performance Standard 6 (PS6). The assessment integrates a multi-criteria evaluation of impact magnitude, receptor sensitivity, and overall significance across all project phases, including design and pre-construction, construction, operation, and decommissioning.

The assessment considers key Important Environmental and Social Components (IESCs), including Critical Habitat and ecological connectivity, terrestrial and aquatic ecosystems, riparian systems, flora and pollinators, and ecosystem services. It incorporates mitigation measures defined under the Biodiversity Conservation and Wildlife Management Plan (BCWMP), Fisheries Conservation and Management Plan (FCMP), Species Rescue Plan (SRP), Greenbelt Development Plan (GDP), and Compensatory Afforestation Plan (CAP), ensuring application of the mitigation hierarchy of avoidance, minimization, restoration, and offsetting.

The assessment is further aligned with the Critical Habitat Assessment (CHA), including consideration of the Area of Influence (AOI), Ecologically Appropriate Area of Assessment (EAAA), and Area of Habitat (AOH), thereby ensuring that biodiversity impacts are evaluated at both project and landscape scales.

5.2 Identification of Key Impact Pathways

This assessment identifies several key pathways through which project activities influence biodiversity within the AOI.

Land-based interventions, including vegetation clearance, infrastructure development, access road construction, and spoil disposal, result in direct habitat loss, fragmentation, and modification of habitat structure. Hydrological alterations associated with river diversion and flow regulation affect aquatic habitats, ecological processes, and seasonal flow variability.

Barrier effects created by the dam and associated infrastructure disrupt longitudinal connectivity for aquatic species and influence movement pathways for terrestrial fauna. Disturbance pressures, including noise, vibration, artificial lighting, and workforce presence, lead to behavioral changes, temporary displacement, and habitat avoidance.

In addition, increased accessibility to previously undisturbed areas introduce risks of poaching, resource extraction, and human–wildlife interactions. Disturbance of soil and vegetation also creates favorable conditions for invasive species' establishment and spread. Changes in sediment transport and river morphology further influence habitat quality and ecological processes.

These pathways operate both independently and cumulatively, particularly in the context of existing hydropower developments within the Wangchhu basin.

5.2.1 Qualitative Assessment of Impacts on Critical Habitat and Ecological Connectivity

The CHA confirmed the presence of Critical Habitat within the Project Area of Influence (AOI) based on qualifying biodiversity features including the Critically Endangered, White-bellied Heron (*Ardea insignis*), restricted-range plant and invertebrate species, and internationally recognised Key Biodiversity Areas (KBAs) and Important Bird and Biodiversity Areas (IBAs). Building upon the CHA findings, this section evaluates the potential effects of project activities on these Critical Habitat values.

The qualitative assessment considered the ecological sensitivity of each Critical Habitat feature together with the nature, extent, duration, reversibility, likelihood, and significance of potential impacts arising during construction and operation. The assessment also considered direct, indirect, induced, and cumulative impact pathways identified through the ESIA and Cumulative Impact Assessment.

Potential impacts are associated primarily with vegetation clearance, reservoir impoundment, alteration of river flow and sediment transport, construction-related disturbance, temporary habitat fragmentation, and increased human activity. Of these, changes to riverine habitats present the greatest ecological sensitivity because they may influence habitat quality for the White-bellied Heron and other aquatic biodiversity dependent on natural hydrological processes.

The White-bellied Heron is considered the most sensitive Critical Habitat trigger due to its extremely small global population and dependence on undisturbed riverine habitats. Although no confirmed breeding or nesting sites occur within the Project footprint, construction activities and localized changes in hydraulic conditions may temporarily affect habitat suitability within portions of the Area of Habitat (AOH). Restricted-range plant species and the endemic dragonfly *Cephalaeschna triadica* may experience localized habitat disturbance where permanent infrastructure overlaps suitable habitats; however, these impacts remain confined to relatively small areas compared with their broader Area of Habitat and Ecologically Appropriate Area of Assessment (EAAA).

Internationally recognized biodiversity areas, including the Kamji KBA/IBA and Paro Wetland KBA/IBA, occur within the broader ecological landscape but outside the Project footprint. Consequently, no direct loss or conversion of these biodiversity areas is anticipated, while indirect effects are expected to remain limited due to the localized nature of project activities.

Overall, before implementation of mitigation measures, the significance of potential impacts ranges from Low to High depending on the ecological sensitivity of the biodiversity feature, with riverine Critical Habitat supporting the White-bellied Heron representing the highest sensitivity.

Table 14: Qualitative Assessment of Potential Impacts on Critical Habitat

Critical Habitat Feature	Principal Impact Pathway	Ecological Sensitivity	Magnitude	Duration	Pre-Mitigation Significance
White-bellied Heron (<i>Ardea insignis</i>)	Flow alteration, construction disturbance, localized habitat modification	Very High	Moderate	Long-term	High
<i>Drepanostachyum annulatum</i>	Vegetation clearance	High	Low	Permanent	Moderate

<i>Strobilanthes accrescens</i> subsp. <i>accrescens</i>	Habitat disturbance	High	Low	Permanent	Moderate
<i>Carex speciosa</i> subsp. <i>pinetorum</i>	Habitat modification	High	Low	Permanent	Moderate
<i>Pedicularis amplicollis</i>	Temporary habitat disturbance	Moderate	Low	Temporary	Low
<i>Cephalaeschna triadica</i>	Stream and riparian habitat alteration	Moderate	Low	Long-term	Low–Moderate
Kamji KBA/IBA	Indirect disturbance	High	Negligible	Temporary	Low
Paro Wetland KBA/IBA	Indirect disturbance	High	Negligible	Temporary	

5.3 Quantitative Assessment of Critical Habitat Impacts

A preliminary quantitative assessment of biodiversity impacts has been undertaken using the currently available engineering design, Land Requirement Chart (LRC), Environmental and Social Impact Assessment (ESIA), and Critical Habitat Assessment (CHA). The assessment quantifies the anticipated project footprint and associated habitat disturbance following application of the mitigation hierarchy and provides the basis for the Biodiversity Accounting Framework (BAF). While the BAF establishes the methodology for demonstrating No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat, the final biodiversity accounting will be completed following confirmation of restoration areas and biodiversity enhancement measures during detailed design and implementation.

Based on the approved Land Requirement Chart, the Bunakha Hydropower Project will require approximately 1,139.87 acres of land, comprising approximately 883.67 acres of permanent land requirement and 256.20 acres of temporary land requirement. Permanent land requirements include the reservoir (submergence area), dam infrastructure, powerhouse, roads and associated permanent facilities, while temporary land requirements comprise construction camps, batching plants, quarries, muck disposal sites, temporary access roads and other construction-related facilities. Temporary disturbance areas will be rehabilitated progressively following completion of construction in accordance with the ESMP and associated restoration programmes.

Table 15: Preliminary Quantitative Assessment of Biodiversity Disturbance

Biodiversity Component	Baseline Condition	Permanent Disturbance	Temporary Disturbance	Mitigation / Restoration Status	Biodiversity Accounting Status
Natural terrestrial habitats	Forest and associated natural habitats within the Project AOI	883.67 acres	256.20 acres	Progressive rehabilitation of temporary construction areas; compensatory afforestation and biodiversity restoration to be implemented	Preliminary

Biodiversity Component	Baseline Condition	Permanent Disturbance	Temporary Disturbance	Mitigation / Restoration Status	Biodiversity Accounting Status
				following confirmation by the Dzongkhag	
Riverine habitat	Inundation area, and dewatered zone (between Bunakha Dam and back end of Chhukha Reservoir)	Permanent alteration of river habitat through impoundment and modified flow regime	None	Environmental Flow implementation, aquatic habitat enhancement, riparian restoration and adaptive management	Preliminary
Riparian vegetation	Natural riparian vegetation along the Wangchhu River	Localized clearing within the permanent project footprint	Temporary disturbance adjacent to construction areas	Native riparian vegetation restoration and erosion control	Preliminary
Critical Habitat values	Eight Critical Habitat qualifying features identified through the CHA	No direct removal of qualifying Critical Habitat features; localized disturbance may occur	Temporary construction-related disturbance	Species-specific mitigation, monitoring and adaptive management	Verification pending

The preliminary quantitative assessment represents the biodiversity loss component of the Biodiversity Accounting Framework using the currently available project footprint and disturbance estimates. The corresponding biodiversity gains from ecological restoration, biodiversity enhancement and biodiversity offsets cannot yet be fully quantified because the final restoration sites and restoration extents will be determined in consultation with the Dzongkhag and relevant regulatory authorities during detailed design and implementation. Consequently, the present assessment provides a preliminary biodiversity balance rather than a final demonstration of No Net Loss or Net Gain.

Following confirmation of restoration areas and implementation of biodiversity enhancement measures, the Biodiversity Accounting Framework will be updated using habitat-based biodiversity units that incorporate habitat extent, ecological condition, conservation significance, connectivity and restoration success. The updated accounting will quantify baseline biodiversity units, residual biodiversity losses, biodiversity gains achieved through restoration and enhancement measures, and the resulting net biodiversity outcome for both natural habitats and Critical Habitat values. This updated assessment will provide the quantitative basis for verification of No Net Loss for natural habitats and Net Gain for Critical Habitat in accordance with ADB Safeguard Policy Statement (2009) and IFC Performance Standard 6.

5.4 Residual Impact Assessment

Following implementation of the mitigation hierarchy, including avoidance, minimization, restoration and proposed biodiversity enhancement measures, most terrestrial construction-related impacts are expected to be reduced to low residual significance. Temporary impacts associated with construction activities, including vegetation clearance, workforce presence, temporary access roads, quarries, muck disposal areas and construction facilities, are expected to be substantially reduced through progressive rehabilitation, restoration of disturbed areas and implementation of the Environmental and Social Management Plan (ESMP). For terrestrial biodiversity, no direct loss of the biodiversity features that qualify Critical Habitat is anticipated. Residual impacts on the confirmed Critical Habitat trigger species are therefore expected to remain low, provided that the prescribed species-specific mitigation, habitat protection measures, monitoring and adaptive management actions described in this BAP are fully implemented. For aquatic biodiversity, implementation of the environmental flow regime will maintain ecological processes, wetted habitat and downstream ecosystem functions within the diversion reach. Nevertheless, operation of the project will result in the permanent modification of natural river habitat through flow regulation and reservoir impoundment. Although environmental flow implementation is expected to substantially reduce ecological impacts, it will not fully replace the ecological characteristics of the existing free-flowing river system. Accordingly, a residual impact on riverine habitat remains following application of the mitigation hierarchy.

This residual impact does not necessarily constitute a measurable adverse impact on the biodiversity values qualifying Critical Habitat, provided that ecological functions supporting the qualifying biodiversity features are maintained and biodiversity performance objectives are achieved through implementation of the Biodiversity Action Plan. However, quantitative verification of this outcome will depend on implementation of the Biodiversity Accounting Framework, long-term ecological monitoring and confirmation of biodiversity gains achieved through restoration, biodiversity enhancement and, where necessary, biodiversity offsets.

Accordingly, the current assessment concludes that while residual impacts on the identified Critical Habitat qualifying features are expected to remain low following implementation of the prescribed mitigation measures, quantitative demonstration of No Net Loss for natural habitats and Net Gain for Critical Habitat remains preliminary pending completion of the Biodiversity Accounting Framework using confirmed restoration areas, biodiversity enhancement measures and monitoring results. For the White-bellied Heron (*Ardea insignis*), the residual impact assessment remains precautionary because confirmation of the species' current use of the Project Area of Influence is subject to completion of the additional field survey. Until the survey results become available, the species will continue to be treated as a Critical Habitat trigger and the precautionary mitigation measures described in this BAP will remain applicable.

Table 16: Preliminary Residual Impact Assessment for Critical Habitat Features

Critical Feature	Habitat	Pre-Mitigation Significance	Key Mitigation Measures	Residual Significance
White-bellied Heron (<i>Ardea insignis</i>)		High	Environmental flow management plan, riverine habitat protection, disturbance control, restriction of activities in sensitive	Low (Provisional*)

Critical Feature	Habitat	Pre-Mitigation Significance	Key Mitigation Measures	Residual Significance
			river reaches, long-term species monitoring	
	<i>Drepanostachyum annulatum</i>	Moderate	Micro-siting, vegetation clearance minimization, habitat restoration	Low
	<i>Strobilanthes accrescens</i> subsp. <i>accrescens</i>	Moderate	Habitat avoidance, restoration and monitoring	Low
	<i>Carex speciosa</i> subsp. <i>pinetorum</i>	Moderate	Habitat protection and restoration	Low
	<i>Pedicularis amplicollis</i>	Low	Restricted construction footprint and habitat restoration	Low
	<i>Cephalaeschna triadica</i>	Low - Moderate	Stream protection, Environmental Flow implementation, water quality management, and habitat restoration	Low
	Kamji KBA/IBA	Low	No direct project activities within designated area; maintenance of ecological connectivity and biodiversity monitoring	Negligible
	Paro Wetland KBA/IBA	Low	No direct project activities within the designated area; maintenance of downstream environmental flows and ecological monitoring	Negligible

***Note:** The residual impact significance presented above represents the expected outcome following implementation of the mitigation hierarchy, including avoidance, minimization, restoration, and biodiversity management measures described in this BAP. The residual significance ratings are considered preliminary and will be verified through implementation of the Biodiversity Accounting Framework (BAF), long-term biodiversity monitoring, confirmation of restoration outcomes, and, where necessary, biodiversity enhancement and biodiversity offset measures. The assessment for the White-bellied Heron (*Ardea insignis*) remains precautionary. Quantitative demonstration of No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat will be completed following confirmation of restoration areas and biodiversity enhancement measures.

5.5 Compliance with ADB SPS Critical Habitat Requirements

The BHPP is located within an Area of Influence (AOI) that contains Critical Habitat, as confirmed through the Critical Habitat Assessment (CHA) undertaken in accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (ADB SPS, 2009) and IFC Performance Standard 6 (PS6). Consequently, Project implementation shall comply with the specific biodiversity requirements applicable to Critical Habitat throughout the Project lifecycle.

Compliance with the Critical Habitat requirements of ADB SPS (2009) is being achieved through application of the mitigation hierarchy, beginning with avoidance of sensitive habitats during project planning and design, followed by minimization of unavoidable impacts through engineering design optimization, implementation of environmental flow releases, restriction of construction activities within ecologically sensitive areas, timing of construction to avoid sensitive biological periods, pollution prevention measures, and restoration of temporarily disturbed habitats. Residual impacts remaining after implementation of these measures will be addressed through biodiversity enhancement measures and, where necessary, biodiversity offsets in accordance with the Biodiversity Accounting Framework (Section 6.9). Based on the findings of the ESIA, Critical Habitat Assessment (CHA), and the impact assessment presented in Sections 5.3–5.5, implementation of the mitigation hierarchy and biodiversity management measures described in this BAP is expected to avoid measurable adverse impacts on the biodiversity values for which Critical Habitat has been designated. The current assessment indicates that ecological functions supporting Critical Habitat are expected to be maintained through implementation of environmental flows, protection of riparian habitats, maintenance of ecological connectivity, species-specific mitigation measures, habitat restoration and adaptive management. Quantitative verification of these biodiversity outcomes will be undertaken through implementation of the Biodiversity Accounting Framework and long-term ecological monitoring.

Compliance with ADB SPS also requires demonstration that the Project will not result in measurable reductions in the population viability of Critically Endangered or Endangered species or measurable adverse impacts on the biodiversity values qualifying Critical Habitat. Based on the current ESIA, Critical Habitat Assessment and the mitigation measures incorporated within this BAP, implementation of the Environmental Flow Management Plan, Fisheries Conservation and Management Plan, Compensatory Afforestation Plan, Species Rescue Plan and adaptive management measures is expected to maintain the long-term ecological viability of Critical Habitat trigger species and associated habitats. For the White-bellied Heron (*Ardea insignis*), this conclusion remains precautionary pending completion of the additional targeted field survey.

Verification of No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat will be undertaken through implementation of the Biodiversity Accounting Framework, long-term biodiversity monitoring and periodic evaluation of biodiversity performance indicators. The preliminary biodiversity accounting presented in this BAP establishes the biodiversity loss component using the currently available project footprint, Land Requirement Chart, ESIA and Critical Habitat Assessment. Quantitative verification of NNL and NG will be completed following confirmation of restoration areas, biodiversity enhancement measures and, where necessary, biodiversity offsets. Monitoring results will be compared against baseline ecological conditions and established biodiversity performance targets to determine whether the Project is achieving its biodiversity objectives.

Compliance with Critical Habitat requirements shall be verified throughout construction and operation through implementation of the monitoring program presented in Section 9. Monitoring results shall be reviewed periodically by DGPC and qualified biodiversity specialists to assess the effectiveness of mitigation measures and determine whether the Project remains on track to achieve its biodiversity performance objectives and to verify progress towards No Net Loss for natural habitats and Net Gain for Critical Habitat. Where monitoring identifies any measurable decline in Critical Habitat attributes, deterioration of ecological condition, reduction in biodiversity performance indicators, or unexpected impacts attributable to Project activities, additional avoidance, restoration, enhancement, or biodiversity

offset measures shall be implemented through the adaptive management framework until compliance with ADB SPS requirements is re-established.

Table 17 summarizes how the Project satisfies each of the principal biodiversity requirements of ADB SPS (2009) for projects located within Critical Habitat.

Table 17: Demonstration of Compliance with ADB SPS (2009) Critical Habitat Requirements

ADB SPS Critical Habitat Requirement	Project Compliance
No measurable adverse impacts on the Critical Habitat that could impair its high biodiversity value or ecological function.	The qualitative and quantitative assessments indicate that impacts are localized and substantially reduced through avoidance, minimization, environmental flow implementation, habitat restoration, and species-specific management measures. Residual impacts are assessed as Low or Negligible and are not expected to impair Critical Habitat values.
The Project is not anticipated to reduce the population of any recognized Critically Endangered or Endangered species or result in habitat loss that compromises the persistence of a viable and representative ecosystem.	No direct impacts on confirmed breeding or nesting sites of Critical Habitat trigger species are anticipated. The majority of suitable habitat remains intact within the EAAA and AOH, maintaining habitat availability, ecological connectivity, and long-term population viability.
Any lesser impacts are appropriately mitigated.	The mitigation hierarchy has been applied through project design optimization, minimization of vegetation clearance, environmental flow releases, habitat restoration, biodiversity enhancement measures, long-term monitoring, and adaptive management. These measures are incorporated into this Biodiversity Action Plan and associated management plans.

5.6 Impacts on Critical Habitat and Ecological Connectivity

The project is located within Bhutan's legally designated biological corridor network, which serves as a key landscape-level ecological linkage and supports species triggering Critical Habitat under IFC PS6. The assessment confirms that project activities will result in localized habitat fragmentation, modification of vegetation structure, and increased edge effects within the project footprint.

During the design and pre-construction phase, the alignment of infrastructure and reservoir extent introduces risks to sensitive habitats and ecological connectivity. The construction phase represents the period of highest impact due to vegetation clearance, excavation, noise, and increased human presence, which may disrupt wildlife movement and lead to temporary displacement. During operation, permanent infrastructure and reservoir formation will result in long-term modification of habitat structure and movement pathways at the project scale. Decommissioning may allow partial ecological recovery; however, residual impacts associated with long-term landscape alteration are expected to persist.

Although regional ecological connectivity within the broader corridor network is expected to remain intact, localized impacts on movement pathways and habitat integrity are significant at the project level. These impacts are characterized as long-term and partially reversible, particularly when combined with cumulative pressures from existing hydropower projects in the basin.

Mitigation measures focus on maintaining functional connectivity through avoidance of high-sensitivity areas, minimizing vegetation clearance, retaining habitat corridors, implementing anti-poaching measures, restricting workforce access, and enhancing connectivity through compensatory afforestation and habitat restoration. These measures are aligned with CHA-defined conservation priorities and spatial units, including AOH and EAAA, and are implemented through the BCWMP and associated plans.

5.7 Impact on Terrestrial Habitats, Flora and Faunal Communities

Terrestrial biodiversity will be affected primarily through vegetation clearance, land take, and infrastructure development. These activities result in direct habitat loss, fragmentation, and modification of habitat structure within the AOI. The creation of edges and disturbed areas may alter species composition and increase exposure to anthropogenic pressures.

Construction-related disturbances, including noise, vibration, and human presence, may lead to temporary displacement, avoidance behavior, and disruption of ecological interactions. Permanent land-use changes associated with reservoir formation and infrastructure will result in long-term habitat modification, particularly in forested areas.

Impacts on flora include the loss of native vegetation and potential disruption of pollinator networks and ecological processes. Disturbed areas, including roadsides and construction sites, may facilitate the introduction and spread of invasive plant species, further affecting habitat quality and ecosystem integrity.

Mitigation measures include controlled vegetation clearance restricted to approved areas, implementation of the Species Rescue Plan for flora and fauna, progressive restoration using native species, invasive species management, and compensatory afforestation combined with assisted natural regeneration. These measures are designed to restore habitat structure, enhance ecological connectivity, and support long-term ecosystem recovery.

Residual impacts are expected to remain at the project scale due to permanent land-use change; however, they are considered manageable through restoration measures and long-term monitoring aligned with CHA requirements.

5.8 Impacts on Aquatic Biodiversity and Riverine Systems

The diversion of river flow and operation of the dam will alter the natural hydrological regime of the Wangchhu River, particularly within the dewatered stretch between the dam and powerhouse.

These changes are expected to reduce water depth and flow velocity, resulting in decreased habitat availability, altered sediment transport, and reduced ecological connectivity. Consequently, aquatic species, including fish and macroinvertebrates, may experience habitat loss, reduced reproductive success, and changes in distribution.

Species of conservation importance and Critical Habitat triggers, including river-dependent species such as the White-bellied Heron, may also be affected through reduction in suitable feeding habitats and changes in river morphology.

These impacts are further influenced by cumulative effects associated with upstream and downstream hydropower projects within the Wangchhu basin.

Aquatic biodiversity is particularly sensitive to changes in flow regime, connectivity, and habitat conditions. The project will alter the natural hydrological regime of the Wangchhu River, especially within the diversion reach between the dam and the powerhouse.

Reduced flows in this stretch may affect habitat availability, water depth, and ecological processes, particularly during low-flow periods. The dam will act as a barrier to fish movement, limiting longitudinal connectivity and restricting access to upstream and downstream habitats. Changes in sediment transport may alter substrate composition, affect spawning and feeding habitats for aquatic species.

Riparian and interface ecosystems will also be affected due to changes in water levels, bank stability, and vegetation composition, potentially reducing the ecological linkage between terrestrial and aquatic environments.

Mitigation measures include the implementation of environmental flows to maintain ecological functions, fish rescue and relocation during dewatering, avoidance of in-stream works during breeding periods, sediment and water quality management, and restoration of aquatic and riparian habitats. The Fisheries Conservation and Management Plan provide the primary framework for addressing aquatic impacts, supported by long-term monitoring and adaptive management.

Despite these measures, residual impacts related to altered flow regimes and reduced connectivity are expected to persist at the project scale, particularly during operation.

5.9 Impacts on Ecosystem Services

Impacts on biodiversity are closely linked to changes in ecosystem services. The project may influence provisioning services such as fisheries and forest resources, although direct dependence by local communities within the immediate AOI is limited. Regulating services, including sediment control, erosion regulation, and hydrological processes, may be affected due to land disturbance and flow alteration.

Supporting services, particularly habitat provision and ecological productivity, will be influenced by habitat modification and fragmentation. Cultural services associated with landscape value and biodiversity significance may also be affected, particularly in ecologically sensitive areas identified under the CHA.

Mitigation measures, including habitat restoration, afforestation, and environmental flow management, are designed to maintain ecosystem functionality and support long-term service provision.

5.10 Cumulative Impacts

The Bunakha Hydropower Project is located within a river basin already influenced by hydropower developments, including the Chukha and Tala projects. The assessment confirms that cumulative impacts arise primarily from progressive habitat modification, flow regulation, and increased anthropogenic pressures across the basin.

Aquatic ecosystems are particularly vulnerable to cumulative effects due to multiple barriers and altered flow regimes, which may affect ecological continuity and species movement. Similarly, incremental fragmentation of terrestrial habitats may influence ecological connectivity over time.

Cumulative impacts are therefore characterized as progressive and basin-wide rather than isolated to individual projects. Addressing these impacts requires coordinated management approaches, including standardized mitigation measures, basin-level monitoring, and adaptive management. These impacts may result in a progressive reduction in ecological functionality at the basin scale if not effectively managed through coordinated mitigation and monitoring measures.

5.11 Linkage to Biodiversity Action Plan Measures

The impacts identified in this section are directly linked to specific mitigation, management, and monitoring measures defined in the Biodiversity Action Plan to ensure full traceability and compliance with ADB SPS (2009) and IFC PS6 requirements.

Impacts on terrestrial habitats, including vegetation clearance and habitat fragmentation, are addressed through the Biodiversity Conservation and Wildlife Management Plan and the Compensatory Afforestation Plan, which include measures for habitat restoration, ecological connectivity, and native species plantation.

Impacts on aquatic biodiversity arising from flow alteration, habitat modification, and barrier effects are addressed through the Fisheries Conservation and Management Plan, including environmental flow implementation, protection of critical aquatic habitats, and long-term monitoring of fish populations.

Impacts on species of conservation importance, including Critical Habitat trigger species, are addressed through targeted measures such as habitat protection, disturbance control, species-specific monitoring, and, where required, implementation of the Species Rescue Plan.

Impacts on ecosystem services are addressed through measures to maintain ecological functions, including restoration of riparian vegetation, protection of water quality, and support for community-based conservation initiatives.

Cumulative impacts associated with the Wangchhu hydropower cascade are addressed through coordinated management approaches, including long-term monitoring, adaptive management, and alignment of mitigation measures with basin-level ecological processes.

"The above linkages are operationalized through the combined mitigation and monitoring matrix presented in Section 9, where each impact pathway is linked to specific indicators, monitoring requirements, and responsible entities to ensure compliance and accountability."

6 BIODIVERSITY CONSERVATION AND MITIGATION MEASURES

6.1 Overview

Mitigation measures for the Bunakha Hydropower Project have been developed to address identified impacts on aquatic and terrestrial biodiversity, critical habitats, ecological connectivity, and ecosystem services. These measures are aligned with the Critical Habitat Assessment (CHA), Environmental Flow Management Plan (EFMP), Fisheries Conservation and Management Plan (FCMP), and applicable requirements under ADB Safeguard Policy Statement (2009) and IFC Performance Standard 6.

The mitigation framework is structured to address key impact pathways, including habitat loss and fragmentation, hydrological alteration, barrier effects, disturbance, and access-induced impacts. Each mitigation measure defined in this section is directly linked to the monitoring indicators presented in **Error! Reference source not found.** ensuring a clear and traceable framework for implementation, monitoring, and adaptive management.

6.2 Aquatic Biodiversity and Riverine Systems

The project will alter the natural flow regime of the Wangchhu River, particularly within the diversion reach between the dam and powerhouse, and may influence downstream ecological conditions within the cascade system. These changes may affect aquatic habitat availability, ecological processes, and species composition.

6.2.1 Environmental Flow Implementation

An environmental flow regime will be implemented as the primary mitigation measure to address hydrological alterations. Environmental flows will be released through regulated outlet structures in accordance with the Environmental Flow Management Plan (EFMP).

The flow regime will maintain minimum flows and seasonal variability to sustain aquatic habitats, ecological processes, and downstream water uses. It will also ensure continuity of the wetted channel within the diversion reach and support ecological connectivity.

Environmental flow implementation will maintain:

- adequate wetted habitat for aquatic organisms,
- critical habitats such as spawning and refuge areas,
- water quality conditions suitable for aquatic life,
- sediment transport processes required for channel stability, and
- ecological interactions between aquatic and riparian systems.

Coordination with upstream and downstream hydropower projects (e.g., Chukha and Tala) will be pursued, where feasible, to minimize cumulative impacts at the basin scale.

6.2.2 Aquatic Habitat and Ecology Management

Aquatic habitats, including riffles, pools, and spawning areas, will be protected from disturbance. Habitat degradation due to altered flow or sediment imbalance will be mitigated through flow regulation and sediment management.

Water quality will be maintained within acceptable limits through strict control of construction-related pollution, prohibition of waste discharge into water bodies, and implementation of erosion and sediment control measures.

Macroinvertebrate communities and other aquatic ecological indicators will be monitored to assess ecosystem health and inform adaptive management.

6.2.3 Fisheries Conservation and Connectivity

A Fisheries Conservation and Management Plan (FCMP) will be implemented to support conservation of fish species, including those of conservation importance. Measures will include protection of critical habitats, monitoring of species diversity and abundance, and regulation of anthropogenic pressures.

Fish movement and ecological connectivity will be supported through maintenance of adequate flow conditions and continuity of aquatic habitats.

6.2.4 Riparian and Riverine Ecosystem Management

Riparian vegetation will be protected and restored to maintain bank stability, regulate microclimate, and support ecological interactions between terrestrial and aquatic systems.

Special attention will be given to habitats of species of conservation importance, including river-dependent species such as the White-bellied Heron. Disturbance in sensitive riparian zones will be minimized through controlled access and construction planning.

6.3 Terrestrial Biodiversity Management

6.3.1 Habitat Loss and Fragmentation

Habitat loss and fragmentation resulting from vegetation clearance and infrastructure development will be minimized through strict demarcation of the project footprint and avoidance of high-sensitivity areas identified in the CHA.

Vegetation clearance will be limited to approved areas, and progressive restoration will be implemented using native species.

6.3.2 Wildlife Conservation and Disturbance Control

Measures will be implemented to minimize disturbance to mammals, birds, and herpetofauna. These include restriction of construction activities in sensitive habitats, maintenance of habitat connectivity, and prevention of hunting, trapping, and wildlife harassment.

Disturbance will be further reduced through scheduling of construction activities and restriction of night-time work in ecologically sensitive areas.

The White-bellied Heron will continue to receive precautionary management throughout project implementation. Targeted monitoring and the additional field survey will be undertaken to confirm the species' use of the Project Area of Influence. Results of the survey will be incorporated into the Biodiversity Accounting Framework and future revisions of the Biodiversity Action Plan, with mitigation measures adjusted through the adaptive management process where necessary.

6.3.3 Vegetation Restoration and Invasive Species Management

Compensatory afforestation and habitat restoration will be implemented in accordance with national requirements and DoFPS guidance, focusing on degraded areas and ecological connectivity.

Measures to control invasive species will include monitoring, early detection, and removal of invasive plants, with restoration activities prioritizing native species.

6.3.4 Species Rescue and Protection

A Species Rescue Plan will be implemented prior to and during construction to relocate flora and fauna from impact zones to suitable habitats. Topsoil will be conserved and reused to support vegetation recovery.

6.4 Construction-Related Environmental Management

6.4.1 Soil, Erosion, and Sediment Control

Erosion control measures will be implemented at all construction sites, including slope stabilization, drainage management, and sediment traps to prevent sediment runoff into water bodies.

6.4.2 Waste and Pollution Management

All solid and hazardous waste will be managed in accordance with approved waste management plans. Disposal of waste into natural habitats will be strictly prohibited.

6.4.3 Noise and Disturbance Control

Noise-generating activities will be controlled, particularly near sensitive receptors and wildlife habitats. Activities will be scheduled to minimize disturbance.

6.4.4 Access Control and Workforce Management

Access-induced impacts, including poaching and resource extraction, will be controlled through enforcement of a strict code of conduct, restricted access to sensitive areas, and coordination with the Department of Forests and Park Services (DoFPS).

6.5 Ecosystem Services Management

The project will alter aquatic habitats and ecological processes primarily through changes in flow regime, sediment transport, and habitat connectivity. Environmental flow implementation, in accordance with the Environmental Flow Management Plan (EFMP), will serve as the primary mitigation measure to maintain ecological integrity within the river system. These measures are implemented in alignment with the Environmental Flow Management Plan (EFMP).

Environmental flows will be managed to sustain aquatic habitat availability, maintain ecological processes, support fish and macroinvertebrate communities, and preserve riverine ecosystem functions.

Supporting services, including habitat provision and ecological productivity, will be maintained through conservation of key habitats and restoration of disturbed areas. Cultural ecosystem services will be safeguarded through protection of ecologically sensitive areas and integration of conservation considerations into project design and operation.

6.6 Cumulative Impact Management

Given the presence of multiple hydropower projects within the Wangchhu basin, mitigation measures incorporate a basin-level perspective. Environmental flow implementation will consider cumulative impacts, and coordination with upstream and downstream hydropower operators will be pursued where feasible.

Long-term monitoring will assess cumulative effects on aquatic ecosystems and ecological connectivity, while restoration and afforestation measures will contribute to maintaining landscape-level ecological integrity.

6.7 Institutional Measures and Adaptive Management

Implementation of biodiversity mitigation measures will be undertaken through a coordinated institutional framework involving the Project Proponent, contractors, and relevant regulatory authorities. Druk Green Power Corporation (DGPC) will have overall responsibility for implementation of the Biodiversity Action Plan (BAP), including integration of biodiversity requirements into project design, construction, and operation. Contractors will be responsible for site-level implementation of mitigation measures in accordance with the BAP and associated sub-plans, under the supervision of DGPC.

The Department of Forests and Park Services (DoFPS) will provide regulatory oversight and technical guidance, particularly in relation to forest management, wildlife conservation, and implementation of compensatory afforestation and habitat restoration measures. Compliance with environmental clearance conditions and biodiversity requirements will be ensured through regular supervision, monitoring, and reporting mechanisms.

Monitoring of biodiversity indicators will be undertaken in accordance with the framework presented in Section 9 and **Error! Reference source not found.** Monitoring results will be systematically reviewed to assess the effectiveness of mitigation measures and identify deviations from expected ecological outcomes.

6.7.1 Capacity Building and Compliance

Training programs will be conducted for project staff and contractors to enhance awareness of biodiversity conservation requirements, environmental compliance, and implementation of mitigation measures. These programs will include biodiversity induction, species protection, and environmental code of conduct. Monitoring and reporting systems will be maintained to ensure adherence to environmental obligations.

6.7.2 Community Engagement and Grievance Redress

A Grievance Redress Mechanism (GRM) will be implemented to address community concerns related to biodiversity and environmental impacts. The mechanism will ensure timely resolution of grievances and facilitate continuous stakeholder engagement throughout the project lifecycle.

6.7.3 Adaptive Management Framework

An adaptive management approach will be applied to ensure that biodiversity objectives are achieved. Monitoring results and trigger exceedances identified in **Error! Reference source not found.** will be

used to guide corrective actions. Where monitoring indicates non-compliance with environmental flow requirements, decline in biodiversity indicators, habitat degradation, or other adverse trends, appropriate measures will be implemented.

Corrective actions may include adjustment of environmental flow releases, strengthening of habitat protection and restoration measures, and implementation of additional mitigation actions where required. This approach ensures that biodiversity management remains responsive to changing environmental conditions and cumulative pressures.

The adaptive management framework supports the achievement of No Net Loss for natural habitats and Net Gain for Critical Habitat in accordance with ADB Safeguard Policy Statement (2009) and IFC Performance Standard 6.

6.8 Integration with Biodiversity Action Plan Implementation

All mitigation measures are integrated within the Biodiversity Action Plan and linked directly to the impact assessment presented in Section 5 and the monitoring framework in section 9.10.**Error! Reference source not found.**

Implementation will be carried out through designated sub-plans, ensuring clear responsibilities, timelines, and monitoring requirements. This integrated approach supports compliance with ADB SPS requirements for No Net Loss and contributes to Net Gain for Critical Habitat in accordance with IFC Performance Standard 6.

6.9 Biodiversity Accounting Framework and Biodiversity Offset Strategy

To demonstrate compliance with the biodiversity objectives of the Asian Development Bank Safeguard Policy Statement (2009) and IFC Performance Standard 6, this Biodiversity Action Plan adopts a Biodiversity Accounting Framework (BAF) to quantify biodiversity losses and gains throughout the Project lifecycle and to support verification of No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat. A preliminary biodiversity accounting has been undertaken using the currently available project footprint, Land Requirement Chart (LRC), biodiversity baseline surveys, Environmental and Social Impact Assessment (ESIA), and Critical Habitat Assessment (CHA). This preliminary assessment quantifies the anticipated permanent and temporary habitat disturbance associated with the Project and provides the biodiversity loss component of the accounting framework. The biodiversity gain component cannot yet be fully quantified because the final restoration areas, biodiversity enhancement measures and biodiversity offset locations will be confirmed in consultation with the Dzongkhag and relevant regulatory authorities during detailed design and implementation.

The Biodiversity Accounting Framework applies a habitat-based accounting methodology using Biodiversity Units (BU) as the principal metric for measuring ecological change. Biodiversity Units incorporate both habitat quantity and ecological quality to provide a transparent and scientifically robust assessment of biodiversity performance.

The biodiversity metric shall incorporate the following components:

Parameter	Description
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Habitat Area	Area affected or restored (ha)
Habitat Condition	Ecological quality score
Strategic Significance	Importance of habitat for Critical Habitat values
Connectivity	Contribution to landscape connectivity
Recovery Time	Time required to achieve target ecological condition
Implementation Risk	Probability of successful restoration or biodiversity offset implementation

Biodiversity Units (BU) shall be calculated as:

$$\text{BU} = \text{Habitat Area} \times \text{Habitat Condition} \times \text{Strategic Significance} \times \text{Connectivity Weight}$$

The Biodiversity Accounting Report shall quantify:

- Baseline biodiversity units
- Biodiversity units permanently lost
- Biodiversity units temporarily affected
- Biodiversity units restored through rehabilitation
- Biodiversity units generated through enhancement measures
- Biodiversity units generated through biodiversity offsets

Overall net biodiversity outcome. The preliminary biodiversity accounting presented in this BAP quantifies the anticipated biodiversity loss component using the currently available project footprint. Following confirmation of restoration areas and biodiversity enhancement measures, the Biodiversity Accounting Framework will be updated to quantify biodiversity gains and determine the overall net biodiversity outcome.

No Net Loss for natural habitats will be demonstrated where total biodiversity gains equal or exceed residual biodiversity losses following implementation of restoration, biodiversity enhancement and biodiversity offset measures. For Critical Habitat, biodiversity gains shall exceed residual biodiversity impacts to demonstrate measurable Net Gain consistent with ADB SPS (2009) and IFC PS6.

Additionality of Biodiversity Offset Measures

Biodiversity offsets implemented under the Project shall satisfy the principle of additionality, whereby conservation outcomes are demonstrably additional to those that would occur in the absence of the Project or are already required under existing legal or regulatory obligations.

Accordingly, statutory compensatory afforestation required under Bhutanese legislation, including the mandatory 1:1 compensatory afforestation, shall be implemented to satisfy national regulatory requirements but shall not be considered biodiversity offsets for demonstrating No Net Loss (NNL) or Net Gain (NG).

- Biodiversity offset measures contributing to NNL and NG shall therefore comprise conservation actions additional to statutory requirements. Subject to the final biodiversity accounting and residual impact assessment, these measures may include:
- Restoration of degraded native forest outside mandatory compensatory afforestation areas;
- Restoration and enhancement of degraded riparian habitats within the Wangchhu Basin;

- Enhancement of habitat for Critical Habitat trigger species, including the White-bellied Heron (*Ardea insignis*);
- Restoration and enhancement of fish spawning and aquatic habitats;
- Removal and long-term management of invasive plant species within priority habitats;
- Long-term conservation management agreements for high-value habitats; and
- Community-based biodiversity conservation programs that deliver measurable ecological improvements.

The final biodiversity offset package will be determined following confirmation of restoration areas, completion of the detailed design, and refinement of the Biodiversity Accounting Framework. All proposed biodiversity offset measures will be independently reviewed to confirm compliance with the principles of additionality, ecological equivalence, permanence, measurability and long-term conservation effectiveness, consistent with ADB SPS (2009) and IFC Performance Standard 6.

The Biodiversity Accounting Framework will be updated periodically using ecological monitoring data collected during construction and operation. Where monitoring indicates that biodiversity outcomes fall below the required performance thresholds, additional restoration, biodiversity enhancement or biodiversity offset measures will be implemented through the adaptive management process until biodiversity performance objectives are achieved.

The Biodiversity Accounting Framework will serve as the primary mechanism for demonstrating biodiversity performance to DGPC, the Department of Forests and Park Services, the Department of Environment and Climate Change, and the Asian Development Bank throughout the Project lifecycle.

7 INSTITUTIONAL ARRANGEMENTS

7.1 Overview

Implementation of the BAP will be undertaken through a lifecycle-based institutional framework.

Project Proponent (DGPC): Overall responsibility for BAP implementation across all phases, including financing, supervision, compliance monitoring, and reporting.

Construction Phase (Contractors): Contractors will be responsible for implementation of all biodiversity mitigation and management measures during construction, including:

- Habitat protection and restoration
- Wildlife protection measures
- Pollution and disturbance control
- Implementation of environmental flow provisions where applicable

Operation Phase (DGPC / Plant Head): DGPC will assume full responsibility during operation, including:

- Environmental flow releases and compliance
- Aquatic and terrestrial biodiversity monitoring
- Maintenance of afforestation and restoration areas
- Implementation of adaptive management measures

Regulatory Authorities (DoFPS and DECC): Provide oversight, approvals, and compliance monitoring throughout all phases.

This ensures continuity of biodiversity management beyond construction and full compliance with SPS requirements

7.2 Key Institutions and Roles

7.2.1 Project Proponent (Druk Green Power Corporation – DGPC)

DGPC will serve as the lead implementing agency, responsible for overall coordination of biodiversity management, integration of BAP measures into project activities, and supervision of contractor performance. A dedicated Environmental and Social Unit will oversee day-to-day implementation, monitoring, and reporting.

DGPC shall ensure that all biodiversity-related requirements are integrated into contractor contractual obligations, including performance-based compliance indicators. Non-compliance with biodiversity management measures shall trigger corrective actions, including work suspension where necessary, as per project environmental management procedures.

7.2.2 Contractors

- Contractors will implement all site-specific biodiversity mitigation measures and sub-plans in accordance with the BAP and ESMP. They will be responsible for ensuring that construction

activities comply with biodiversity management requirements and for reporting any incidents or non-compliance.

7.2.3 Department of Forests and Park Services (DoFPS)

- DoFPS will provide technical oversight and regulatory supervision, including monitoring of forest clearance, wildlife conservation measures, and compensatory afforestation programs.

7.2.4 Department of Environment and Climate Change (DECC)

- DECC will ensure compliance with environmental clearance conditions and review periodic monitoring reports submitted by DGPC.

7.3 Institutional Structure and Coordination

Coordination among institutions will be maintained through regular reporting, joint inspections, and review meetings. Monitoring results will be used to inform adaptive management, ensuring continuous improvement in biodiversity outcomes.

7.4 Implementation of Sub-Plans

- The BAP is operationalized through a set of interrelated sub-plans, each addressing specific aspects of biodiversity management.
- The Biodiversity Conservation and Wildlife Management Plan (BCWMP) address terrestrial biodiversity and ecological connectivity
- The Fisheries Conservation and Management Plan (FCMP) address aquatic biodiversity and flow-related impacts
- The Species Rescue Plan (SRP) addresses pre-construction and construction phase risks to flora and fauna
 - The Compensatory Afforestation Plan and Greenbelt Development Plan address habitat restoration and connectivity enhancement

Each sub-plan includes specific actions, timelines, and responsibilities, and is implemented under the overall supervision of the Project Proponent.

7.5 Capacity Building and Training

Capacity building is essential to ensure effective implementation of biodiversity management measures.

- Training programs will be conducted for project personnel and contractors, focusing on:
- Biodiversity awareness and conservation requirements
- Identification of sensitive habitats and species
- Implementation of mitigation measures and sub-plans
- Compliance with environmental regulations and code of conduct
 - Prevention of poaching and resource extraction

Training will be conducted prior to construction and periodically during project implementation.

7.6 Reporting and Documentation

Monitoring and implementation progress will be documented and reported through periodic environmental and social monitoring reports.

- These reports will include:
- Status of mitigation measure implementation
- Monitoring results and trend analysis
- Identification of non-compliance and corrective actions
 - Updates on biodiversity indicators and conservation outcomes

Reports will be submitted to regulatory authorities, including DECC and DoFPS, and to financing institutions as required.

7.7 Adaptive Management and Accountability

Adaptive management is a key component of the institutional framework. Monitoring results will be used to evaluate the effectiveness of mitigation measures and inform adjustments where necessary.

Clear accountability mechanisms are established to ensure compliance at all levels. Non-compliance will trigger corrective actions, including modification of mitigation measures, additional training, or enforcement actions.

The institutional framework ensures that biodiversity management remains responsive to changing conditions and aligns with project objectives and regulatory requirements.

7.8 Institutional Arrangements and Responsibilities

Implementation of the Biodiversity Action Plan (BAP) will be undertaken through a coordinated institutional framework involving the Project Proponent, contractors, and relevant regulatory authorities, in accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (2009).

The Project Proponent, Druk Green Power Corporation (DGPC), will have overall responsibility for implementation of the BAP across all phases of the project, including planning, construction, and operation. DGPC will ensure that biodiversity requirements are integrated into project design, contractual obligations, and operational procedures, and will oversee compliance through supervision, monitoring, and reporting mechanisms.

During the construction phase, contractors will be responsible for site-level implementation of all biodiversity mitigation and management measures specified in the BAP and associated sub-plans. These include habitat protection, species management, restoration activities, and implementation of environmental flow provisions where relevant. Contractors will operate under the supervision of DGPC and the Engineer and will be contractually obligated to comply with all biodiversity-related requirements.

During the operation phase, DGPC (or the designated plant head) will assume full responsibility for continued implementation of biodiversity measures. This includes maintenance of environmental flow releases, long-term monitoring of aquatic and terrestrial biodiversity, upkeep of restoration and afforestation areas, and implementation of adaptive management measures where required.

The Department of Forests and Park Services (DoFPS) will provide regulatory oversight and technical guidance throughout all project phases, particularly in relation to forest management, wildlife conservation, and implementation of compensatory afforestation and habitat restoration measures.

This institutional arrangement ensures that responsibility for biodiversity management extends beyond construction and is maintained throughout the project lifecycle.

7.9 Additional Conservation Actions for Globally Recognized Areas

In accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (2009), additional conservation actions are required where projects are located within or influence areas of global biodiversity importance.

Within the broader ecological landscape of the project, Kamji and Paro Wetland are identified as areas of high biodiversity significance, contributing to regional ecological connectivity and supporting species of conservation importance, including Critical Habitat-trigger species identified in the CHA.

- To ensure compliance with the principles of No Net Loss (NNL) and Net Gain (NG), the Project will implement the following additional conservation actions:
- Strengthening ecological connectivity between forest and riverine habitats to maintain species movement corridors
- Implementation of targeted conservation measures for Critical Habitat-trigger species, including habitat protection and disturbance minimization
- Restoration and enrichment planting in degraded habitats using native species in consultation with DoFPS
- Support to government-led conservation initiatives and coordination with protected area and corridor management programs
- Extension of biodiversity monitoring to these areas with adaptive management triggers linked to species population trends and habitat condition

These measures are additional to standard mitigation and are designed to ensure that biodiversity values in globally recognized areas are maintained or enhanced in accordance with SPS requirements.

8 IMPLEMENTATION PLAN

8.1 Overview

The Biodiversity Action Plan (BAP) will be implemented over the entire lifecycle of the project, including pre-construction, construction, operation, and decommissioning phases. The duration of the BAP is aligned with the project design life, ensuring that biodiversity management commitments extend beyond construction and are sustained throughout operation.

Implementation will be phased as follows:

- Pre-construction Phase: Integration of biodiversity measures into design, finalization of sub-plans, and baseline validation
- Construction Phase: Full implementation of mitigation measures, including habitat protection, species management, environmental flow releases, and monitoring
- Operation Phase: Long-term implementation of biodiversity measures, including environmental flow compliance, biodiversity monitoring, habitat maintenance, and adaptive management
- Decommissioning Phase: Ecological restoration and site rehabilitation

8.2 Phase-wise Implementation

8.2.1 Design and Pre-Construction Phase

During the design and pre-construction phase, biodiversity management shall focus on avoiding and minimizing impacts through incorporation of biodiversity considerations into project planning, engineering design, and construction planning. The Critical Habitat Assessment and Biodiversity Action Plan shall be integrated into final project design to avoid or minimize impacts on ecologically sensitive habitats, species of conservation concern, and ecological connectivity.

DGPC shall be responsible for ensuring that biodiversity commitments contained in the ESIA, BAP, and associated environmental management plans are incorporated into contract documents and construction specifications. Baseline biodiversity surveys, biodiversity accounting baseline establishment, habitat mapping, and pre-construction monitoring shall be completed prior to commencement of major civil works. Contractors shall prepare site-specific biodiversity management procedures consistent with the requirements of this BAP, while obtaining all necessary regulatory approvals and environmental permits before construction begins.

8.2.2 Construction Phase

During construction, implementation shall focus on effective application of the mitigation hierarchy through avoidance, minimization, rehabilitation, and restoration measures. Contractors shall implement all biodiversity mitigation measures specified in this BAP and associated sub-plans, including the Biodiversity Conservation and Wildlife Management Plan, Environmental Flow Management Plan, Fisheries Conservation and Management Plan, Species Rescue Plan, Compensatory Afforestation Plan, and Pollution Prevention measures.

Construction activities shall be planned to minimise disturbance to Critical Habitat, riverine ecosystems, riparian vegetation, and wildlife movement corridors. Environmental flow releases shall be maintained where required, vegetation clearance shall be restricted to approved working areas, erosion and sediment control measures shall be implemented, and wildlife disturbance shall be minimized through access control, timing restrictions, and environmental supervision.

DGPC shall supervise implementation of biodiversity commitments through regular inspections, compliance monitoring, and review of contractor performance. Monitoring results shall be used to verify implementation effectiveness, assess biodiversity performance, and initiate adaptive management where required.

8.2.3 Operation Phase

During operation, biodiversity management shall focus on maintaining long-term ecological integrity, environmental flow compliance, ecological connectivity, and achievement of Project biodiversity objectives. Operational monitoring shall evaluate environmental flow releases, fish communities, macroinvertebrates, riparian habitats, terrestrial biodiversity, Critical Habitat attributes, and restoration success in accordance with the monitoring framework presented in Section 9.

Implementation of the BAF shall continue throughout operation to verify achievement of No Net Loss for natural habitats and Net Gain for Critical Habitat. Biodiversity monitoring results shall be reviewed periodically by DGPC and qualified biodiversity specialists to evaluate ecological performance and determine whether additional management interventions are required.

Where monitoring identifies declining ecological trends or measurable Project-related impacts on biodiversity values, adaptive management measures shall be implemented promptly, including modification of operational procedures, enhancement of restoration programs, strengthening of conservation measures, or implementation of additional biodiversity offset actions where necessary.

8.3 Implementation Schedule

The implementation schedule will be aligned with the overall project timeline and will ensure that mitigation measures are implemented in a timely manner.

Pre-construction activities will be completed prior to commencement of major construction works. Construction-phase measures will be implemented continuously throughout the construction period, with monitoring conducted at defined intervals. Operation-phase measures will be implemented throughout the operational life of the project, supported by periodic monitoring and adaptive management.

The schedule will be updated periodically based on project progress and monitoring results.

8.4 Integration with Project Management

The BAP will be integrated into the overall project management system to ensure effective implementation.

This includes:

- Inclusion of biodiversity requirements in contract documents
- Integration of mitigation measures into construction planning and scheduling
- Coordination between engineering, environmental, and social teams
- Use of monitoring data to inform decision-making

This integrated approach ensures that biodiversity management is not treated as a standalone activity but is embedded within project execution.

8.5 Duration and Phasing of BAP Implementation

The Biodiversity Action Plan will be implemented over the entire lifecycle of the project, with phase-specific activities defined as follows:

- Pre-construction Phase: Integration of biodiversity considerations into project design, confirmation of baseline conditions, and finalization of biodiversity-related sub-plans.
- Construction Phase: Implementation of all mitigation measures, including habitat protection, species management, environmental flow releases, and biodiversity monitoring.
- Operation Phase: Continued implementation of biodiversity management measures, including environmental flow compliance, long-term monitoring of aquatic and terrestrial biodiversity, maintenance of restored habitats, and adaptive management.
- Decommissioning Phase: Site restoration and ecological rehabilitation to ensure long-term sustainability of biodiversity values.

The duration of the BAP is therefore aligned with the project design life, with intensive implementation during construction and sustained monitoring and management during operation.

Table 18: Key Actions, Responsibilities, and Milestones for Implementation of this BAP

SN	Project Phase	Key Actions	Responsibility	Milestones / Deliverables
1	Design & pre-construction	Integrate biodiversity considerations into project design and alignment (avoid sensitive habitats, corridors)	DGPC; Design Consultants	Biodiversity-sensitive design finalized; alignment approved
2		Finalize and approve sub-plans (BCWMP, FCMP, SRP, Afforestation, Greenbelt)	DGPC; DoFPS; Environmental Specialists	Approved sub-plans prior to construction
3		Demarcate project footprint and sensitive ecological areas (CHA-based)	Contractor; DGPC; Biodiversity Specialist	Site demarcation completed and verified
4		Establish environmental flow (E-flow) requirements and monitoring systems	DGPC; Environmental Specialist	E-flow regime defined and monitoring system operational
5		Conduct pre-construction biodiversity surveys and baseline validation	Biodiversity Specialist; DGPC	Baseline data confirmed and documented
6		Conduct training and awareness programs for staff and contractors	DGPC; Contractor	Training completed; attendance records maintained
7	Construction	Implement controlled vegetation clearance within approved footprint	Contractor; DGPC	No unauthorized clearing; compliance verified
8		Implement Species Rescue Plan (flora and fauna relocation)	Contractor; Biodiversity Specialist	Species rescued and relocated prior to clearing
9		Enforce workforce code of conduct and access restrictions	Contractor; DGPC	Zero tolerance for poaching; compliance records maintained
10		Implement sediment control, erosion management, and site stabilization	Contractor; DGPC	No sediment discharge into water bodies; site stabilized
11		Implement environmental flow releases and aquatic protection measures	DGPC; Contractor	E-flow maintained throughout construction

SN	Project Phase	Key Actions	Responsibility	Milestones / Deliverables
12		Undertake progressive restoration and compensatory afforestation	Contractor; DGPC; DoFPS	Plantation completed; survival rate $\geq 80\%$
13		Conduct biodiversity monitoring (terrestrial, aquatic, connectivity)	Biodiversity Specialist; DGPC	Monitoring reports submitted periodically
14	Operation	Maintain environmental flows and aquatic habitat conditions	DGPC	Continuous compliance with E-flow requirements
15		Monitor ecological connectivity and wildlife movement	DGPC; Biodiversity Specialist	Periodic monitoring reports showing stable/improving trends
16		Maintain and monitor afforestation and restoration areas	DGPC; DoFPS	Sustained vegetation cover and habitat recovery
17		Implement adaptive management based on monitoring results	DGPC; Environmental Specialist	Corrective actions implemented where required
18	Decommissioning	Plan and implement controlled dismantling of infrastructure	DGPC	Decommissioning plan approved and implemented
19		Restore affected habitats using native species	DGPC; Contractor	Restoration completed and verified
20		Conduct post-restoration ecological monitoring	DGPC; Biodiversity Specialist	Habitat recovery confirmed through monitoring

9 MONITORING AND EVALUATION FRAMEWORK

9.1 Approach and Objectives

The monitoring and evaluation framework for the Biodiversity Action Plan (BAP) has been developed to ensure effective implementation of mitigation measures defined in Section 6 and to verify that biodiversity outcomes are consistent with the objectives of No Net Loss for natural habitats and Net Gain for Critical Habitat, in accordance with the Asian Development Bank Safeguard Policy Statement (2009) and IFC Performance Standard 6.

- The framework is designed to:
- Track the effectiveness of mitigation and enhancement measures
- Verify compliance with sub-plans including BCWMP, FCMP, SRP, Compensatory Afforestation Plan, and Greenbelt Development Plan
- Detect early signs of ecological change or unintended impacts
- Support adaptive management through feedback mechanisms
 - Ensure alignment with Critical Habitat Assessment (CHA) requirements, including Area of Influence (AOI), Area of Habitat (AOH), and ecological connectivity considerations

Monitoring is structured around key biodiversity receptors and impact pathways identified in Section 5 and mitigation measures defined in Section 6, ensuring direct traceability between impact, mitigation, and monitoring.

9.2 Monitoring Principles and Strategy

Monitoring will be impact-driven, receptor-based, and activity-linked, rather than relying solely on generic ambient monitoring.

- Monitoring locations will be defined based on:
- Proximity to sensitive receptors (e.g., critical habitat zones, river stretches, forest areas)
- Active construction areas and disturbance zones
- Ecological hotspots identified in the CHA
 - Downstream and upstream influence zones

Monitoring frequency will be activity-based, with increased intensity during high-impact phases such as vegetation clearance, in-stream works, and peak construction periods, and reduced frequency during stable operational phases.

Indicators will be measurable, enforceable, and outcome-oriented, focusing on ecological responses and compliance verification rather than descriptive observations.

9.3 Monitoring of Critical Habitat and Ecological Connectivity

Monitoring of Critical Habitat and ecological connectivity focuses on verifying that project activities do not result in measurable adverse impacts on habitat functionality or species movement.

Wildlife movement patterns will be monitored using camera traps and field surveys in identified corridor areas and near infrastructure zones. Particular attention will be given to species identified in the CHA, including those triggering Critical Habitat.

- Monitoring will assess:
- Presence and frequency of wildlife movement across the project area
- Evidence of habitat use, avoidance, or displacement
- Effectiveness of maintained or restored corridors
 - Incidence of human–wildlife interaction or disturbance

Monitoring will be conducted regularly during construction and periodically during operation, with higher frequency in sensitive zones.

If monitoring indicates reduced wildlife movement or increased disturbance, adaptive measures such as strengthening corridor connectivity, enhancing habitat restoration, or further restricting disturbance will be implemented through the BCWMP.

9.4 Monitoring of Terrestrial Habitats, Flora, and Faunal Communities

Monitoring of terrestrial biodiversity will focus on assessing habitat condition, vegetation recovery, and species presence.

- Key parameters include:
- Extent of vegetation clearance versus approved footprint
- Success of restoration and afforestation (survival rate, species diversity, canopy development)
- Regeneration of native vegetation in disturbed areas
- Occurrence and spread of invasive plant species
 - Evidence of fauna presence and habitat utilization

Restoration success will be evaluated through survival rates of planted species, with corrective measures such as replanting or soil improvement implemented where required.

Invasive species monitoring will include periodic inspection of disturbed areas, with removal and control measures implemented as necessary.

Monitoring will be conducted throughout construction and continue during operation to ensure long-term ecological recovery.

9.5 Monitoring of Aquatic Biodiversity and Riverine Systems

Monitoring of aquatic biodiversity and riverine systems will be undertaken to assess the effectiveness of mitigation measures, particularly the implementation of environmental flows, and to ensure the maintenance of ecological integrity within the regulated river system.

The monitoring program will focus on key indicators related to flow regime, aquatic ecology, water quality, and habitat condition, and will be implemented throughout the construction and operation phases.

Environmental flow monitoring will include continuous or periodic measurement of discharge downstream of the dam to verify compliance with prescribed environmental flow requirements.

Monitoring will ensure that flow releases are consistent with the Environmental Flow Management Plan and that seasonal variability is maintained.

Aquatic ecological monitoring will include periodic assessment of fish communities, macroinvertebrates, and other aquatic biota to evaluate changes in species diversity, abundance, and community structure. Particular attention will be given to species of conservation importance and those identified under the Critical Habitat Assessment.

Water quality monitoring will be conducted to assess parameters such as dissolved oxygen, temperature, turbidity, and other relevant indicators to ensure that conditions remain suitable for aquatic life.

Monitoring of river morphology and sediment dynamics will be undertaken to assess changes in channel structure, sediment transport, and habitat availability resulting from altered flow regimes.

Riparian vegetation monitoring will be conducted to evaluate the condition and recovery of riverbank vegetation, which plays a critical role in supporting aquatic ecosystems and maintaining ecological connectivity.

The monitoring program will include clearly defined thresholds and triggers for corrective action. In cases where deviations from environmental flow requirements are observed, or where monitoring indicates adverse trends in aquatic biodiversity or habitat condition, appropriate corrective measures will be implemented. These may include adjustment of flow releases, modification of operational practices, or implementation of additional habitat restoration measures.

Monitoring results will be systematically documented and reported as part of the project's environmental and social monitoring framework. These findings will inform adaptive management decisions, ensuring that mitigation measures remain effective and responsive to changing environmental conditions.

The monitoring framework will be aligned with the Environmental Flow Management Plan and integrated with the overall Biodiversity Action Plan monitoring system to ensure consistency, efficiency, and comprehensive coverage of ecological parameters.

9.6 Monitoring of Ecosystem Services

Monitoring of ecosystem services will focus on indirect indicators of ecological functionality.

- This includes:
- Effectiveness of erosion control and slope stabilization measures
- Stability of restored habitats and vegetation cover
- Maintenance of riparian buffers and ecological interfaces
- Indicators of ecosystem productivity and habitat quality

Although ecosystem services are not always directly measurable, proxy indicators such as vegetation cover, soil stability, and habitat condition will be used to assess functionality.

Monitoring results will inform adaptive management to ensure continued delivery of ecosystem services.

9.7 Monitoring of Cumulative Impacts

Cumulative impact monitoring will be undertaken to assess broader ecological trends beyond the immediate project footprint.

- This includes:
- Long-term trends in aquatic biodiversity and river health
- Changes in ecological connectivity across the landscape
 - Combined effects of multiple hydropower projects on habitat integrity

Monitoring will be coordinated, where feasible, with other hydropower projects and relevant authorities to ensure consistency and basin-level understanding.

Findings from cumulative monitoring will inform adaptive management and may trigger additional mitigation measures where necessary. Monitoring will include basin-level indicators such as flow variability, habitat connectivity, and ecological response to cumulative hydropower operations.

9.8 Monitoring Implementation and Responsibilities

Monitoring will be implemented by the Project Proponent through designated environmental and biodiversity specialists, with support from contractors and supervision by relevant authorities.

- Key roles include:
- Project Proponent: Overall responsibility for implementation and compliance
- Contractors: Site-level monitoring and implementation of mitigation measures
- Environmental Specialists: Data collection, analysis, and reporting
 - DoFPS and relevant authorities: Oversight, guidance, and verification

All monitoring activities will be documented and reported in regular environmental monitoring reports.

9.9 Adaptive Management and Reporting

Adaptive management will be applied to ensure that biodiversity objectives are achieved throughout the project lifecycle. Where monitoring results indicate non-compliance with environmental flow requirements, decline in biodiversity indicators, habitat degradation, or exceedance of trigger thresholds defined in Section 9.11 **Error! Reference source not found.**, corrective actions will be implemented.

These actions may include modification of environmental flow releases, enhancement of habitat restoration measures, strengthening of species protection interventions, or revision of management practices. Monitoring frequency may also be increased in response to identified risks or uncertainties.

This adaptive approach ensures that biodiversity management remains responsive to observed conditions and aligned with the principles of no net loss and, where applicable, net gain.

9.10 Verification of No Net Loss and Net Gain

The primary objective of biodiversity monitoring is to verify whether implementation of the Biodiversity Action Plan (BAP) is achieving No Net Loss (NNL) of natural habitats and Net Gain (NG) for Critical Habitat in accordance with the Asian Development Bank Safeguard Policy Statement (2009) and IFC

Performance Standard 6. Monitoring shall therefore focus not only on the implementation of mitigation measures but also on evaluating measurable biodiversity outcomes throughout the Project lifecycle using the Biodiversity Accounting Framework (BAF).

The preliminary biodiversity accounting presented in this BAP establishes the initial assessment of biodiversity losses based on the available project footprint, Land Requirement Chart (LRC), Environmental and Social Impact Assessment (ESIA), and Critical Habitat Assessment (CHA). The biodiversity gain component cannot yet be fully quantified because restoration areas, biodiversity enhancement measures and any biodiversity offset sites will be confirmed in consultation with the Dzongkhag and relevant regulatory authorities during detailed design and implementation. Accordingly, quantitative demonstration of No Net Loss and Net Gain has not yet been completed and will be verified progressively through implementation of the Biodiversity Accounting Framework and long-term ecological monitoring. Verification shall be undertaken through the Biodiversity Accounting Framework (Section 6.9), which integrates baseline biodiversity information, habitat condition assessments, ecological monitoring results, and biodiversity performance indicators into a structured biodiversity accounting process. Monitoring data shall be collected at regular intervals during pre-construction, construction, operation and, where necessary, decommissioning to evaluate changes in habitat quality, ecological functions, ecological connectivity and species populations relative to baseline conditions.

Verification of biodiversity outcomes shall be based on a combination of habitat-level and species-level indicators, including changes in habitat extent and ecological condition, maintenance of ecological connectivity, environmental flow compliance, restoration success, occurrence and abundance of Critical Habitat trigger species, fish community composition, macroinvertebrate diversity, riparian vegetation condition, invasive species occurrence, and other ecological indicators identified within the monitoring framework. These indicators collectively provide objective evidence for evaluating progress towards achieving No Net Loss for natural habitats and Net Gain for Critical Habitat.

Monitoring results shall be evaluated against biodiversity performance targets established through the baseline studies, Critical Habitat Assessment and Biodiversity Accounting Framework. Performance evaluations shall determine whether biodiversity values remain stable, improve over time, or exhibit unexpected declines attributable to Project activities. Particular attention shall be given to the biodiversity values qualifying Critical Habitat, maintenance of ecological processes, implementation of environmental flows, restoration success, and the effectiveness of biodiversity enhancement measures. Where monitoring demonstrates that biodiversity performance is below the established targets, or where measurable adverse impacts on Critical Habitat attributes are detected, DGPC shall initiate the adaptive management process described in Section 11. Corrective actions may include refinement of mitigation measures, enhancement of habitat restoration programs, modification of environmental flow releases, implementation of additional biodiversity conservation measures, strengthening of ecological connectivity, or implementation of supplementary biodiversity enhancement or biodiversity offset measures, where required, to restore progress towards achieving the Project's biodiversity objectives. Verification reports summarizing biodiversity performance, monitoring results, implementation progress, biodiversity accounting updates and adaptive management actions shall be prepared periodically throughout construction and operation and submitted as part of the Project's environmental monitoring and compliance reporting. These reports shall provide transparent evidence of the Project's biodiversity performance and document progressive verification of No Net Loss for

natural habitats and Net Gain for Critical Habitat as the Biodiversity Accounting Framework is updated with restoration outcomes, biodiversity enhancement measures and long-term monitoring results.

9.11 Monitoring Framework, Frequency and Responsibilities

Monitoring will be undertaken through a structured and measurable framework to assess the effectiveness of mitigation measures and ensure compliance with biodiversity objectives.

Monitoring Frequency

Construction Phase

- **Critical Habitat / High Sensitivity Areas:** Monthly to quarterly monitoring
- **Moderate Sensitivity Areas:** Quarterly monitoring
- **General Project Area:** Biannual monitoring

Operation Phase

- **Environmental Flow:** Continuous monitoring through automated systems with monthly reporting
- **Fish and Aquatic Biodiversity:** Seasonal monitoring (pre-monsoon and post-monsoon)
- **Macroinvertebrates:** Seasonal monitoring
- **Birds:** Seasonal monitoring (including migratory periods where relevant)
- **Mammals:** Annual monitoring using field surveys and camera trapping where required
- **Vegetation and Restoration Areas:** Biannual monitoring for first 3 - 5 years, followed by annual monitoring

Monitoring Locations

- Monitoring will be conducted at:
- Upstream, dewatered, and downstream river stretches
- Critical Habitat areas identified in the CHA
- Forest habitats within the AOI
- Afforestation and restoration sites
 - Ecologically sensitive zones and connectivity corridors

Responsibilities

- Contractors: Construction phase monitoring
- DGPC: Operation phase monitoring and reporting
 - DoFPS/DECC: Oversight and compliance verification

Data Management and Reporting

Monitoring results will be compiled, analyzed, and reported periodically to assess trends, compliance, and effectiveness of mitigation measures.

Table 19: Framework for Monitoring of Indicators of Bunakha Hydropower Project

Monitoring of environmental flows and aquatic biodiversity will be undertaken in alignment with the Environmental Flow Management Plan (EFMP). Monitoring results will inform adaptive management and ensure maintenance of ecological integrity and compliance with ADB SPS (2009) and IFC PS6 requirements.

SN	Aspect	Indicator	Data Required	Method	Monitoring Responsibility	Trigger / Threshold	Corrective Action
1	Environmental Flow Compliance	Compliance with prescribed environmental flow (as per EFMP)	Discharge (m ³ /s)	Flow meters / gauging stations	DGPC / Operator	> 10% deviation from prescribed flow	Immediate adjustment of flow release in accordance with EFMP
2	Seasonal Flow Variability	Maintenance of seasonal flow variability in accordance with EFMP	Monthly discharge data	Hydrological analysis	DGPC / Consultant	Deviation from seasonal pattern over one monitoring cycle	Revise operational flow release schedule as per EFMP
3	Aquatic Habitat Availability	Wetted habitat availability (depth, velocity, wetted perimeter) relative to baseline	Hydraulic parameters	Field survey	Consultant	> 20% reduction compared to baseline/reference	Increase environmental flow / habitat restoration
4	Fish Diversity and Abundance	Species richness, abundance (CPUE), including species of conservation importance	Fish sampling data	Electrofishing / netting	Fisheries Expert	Declining trend over two consecutive monitoring cycles	Review environmental flow regime and FCMP measures
5	Macroinvertebrate Diversity	Shannon Index and EPT taxa composition	Sampling data	Kick sampling	Consultant	Decline beyond baseline variability over two cycles	Investigate flow regime and water quality
6	Water Quality	DO, temperature, turbidity, pH (within Bhutan standards and baseline range)	Water quality data	Field instruments	Contractor / DGPC	Exceedance of national standards	Identify source and implement control measures
7	Sediment Transport and Morphology	Sediment load and channel morphology affecting habitat structure	Sediment data	Visual inspection and sampling	Consultant	Measurable alteration in channel structure	Adjust flow regime / sediment management

SN	Aspect	Indicator	Data Required	Method	Monitoring Responsibility	Trigger / Threshold	Corrective Action
8	Riparian Vegetation	Riparian vegetation cover, condition, and regeneration	Vegetation survey data	Field inspection	Contractor / DoFPS	Visible degradation or loss	Restoration and replantation
9	Species of Conservation Importance (e.g., White-bellied Heron)	Availability of shallow riverine feeding/nesting habitat (flow-dependent)	Habitat observation data	Field survey	Biodiversity Expert	Reduction in habitat suitability	Adjust flow and restrict disturbance
10	Fish Movement and Migration	Evidence of fish movement and distribution	Field observation data	Surveys	Fisheries Expert	Restricted movement over two cycles	Improve flow regime / connectivity measures
11	Aquatic Connectivity	Continuity of wetted channel in diversion reach (as per EFMP)	Flow continuity data	Field verification	Consultant	Dry or disconnected river sections	Immediate restoration of flow
12	Pollution and Sedimentation	Presence of turbidity, oil, or pollutants	Water quality / visual data	Inspection	Contractor	Visible contamination or abnormal turbidity	Stop source and implement mitigation
13	Construction Impacts (Aquatic)	Compliance with in-stream activity restrictions	Site records	Inspection	Contractor / Engineer	Unauthorized activities in river	Stop work and enforce controls
14	Downstream Water Use	Availability of water for downstream users	Community feedback	Consultation	DGPC	Repeated complaints or shortages	Adjust flow and stakeholder coordination
15	Cumulative Impacts (Cascade)	Basin-level flow alteration relative to baseline/cascade scenario	Flow comparison data	Basin-level analysis	DGPC / Authority	Significant downstream alteration	Coordinate with upstream/downstream HPPs
16	Compliance with EFMP	Implementation of EFMP provisions (audit-based)	Monitoring/audit reports	Review / audit	DGPC / Independent Monitor	Non-compliance with EFMP	Immediate corrective action and reporting

SN	Aspect	Indicator	Data Required	Method	Monitoring Responsibility	Trigger / Threshold	Corrective Action
17	Mammals	Presence and activity signs of key mammal species	Field survey data	Camera traps / transects	Biodiversity Expert	Decline over two monitoring cycles	Strengthen habitat protection and reduce disturbance
18	Avifauna (Birds)	Species richness and abundance (priority species)	Bird survey data	Point count / transect	Biodiversity Expert	Declining trend over two cycles	Habitat protection and disturbance control
19	Herpetofauna	Presence and distribution of amphibians/reptiles	Field observations	Visual encounter survey	Biodiversity Expert	Absence from previously recorded habitats	Habitat restoration and protection
20	Terrestrial Flora	Vegetation cover and species composition	Vegetation survey data	Field sampling	Contractor / DoFPS	Reduction from baseline condition	Replantation and restoration
21	Forest Habitat	Area of habitat disturbed vs restored	GIS / field data	Mapping and survey	DGPC / Contractor	Deviation from restoration targets	Accelerate restoration measures
22	Invasive Species	Presence and spread of invasive species	Field observation	Survey	Contractor / DoFPS	Increase in invasive species coverage	Removal and control measures
23	Soil Erosion	Evidence of erosion at project sites	Site inspection data	Visual inspection	Contractor	Erosion beyond control measures	Reinforce erosion control
24	Waste Management	Compliance with waste disposal procedures	Waste records	Inspection	Contractor	Improper disposal observed	Immediate corrective action
25	Noise and Disturbance	Noise levels near sensitive receptors	Noise data	Monitoring equipment	Contractor	Exceedance of standards	Restrict activities / mitigation
26	Ecosystem Services	Availability of ecosystem services (water, forest resources)	Community feedback	Consultation	DGPC	Decline or complaints reported	Mitigation and stakeholder engagement
27	Community Grievances	Number and type of grievances related to biodiversity	GRM records	Review	DGPC	Repeated unresolved complaints	Strengthen GRM response
28	Training and Awareness	Number of trainings conducted	Training records	Review	Contractor / DGPC	Training not conducted as planned	Conduct training immediately

SN	Aspect	Indicator	Data Required	Method	Monitoring Responsibility	Trigger / Threshold	Corrective Action
29	Reporting Compliance	Timely submission of monitoring reports	Reports	Review	DGPC	Delay or incomplete reporting	Enforce compliance
30	Adaptive Management	Implementation of corrective actions based on monitoring	Monitoring records	Review	DGPC / Consultant	Repeated trigger exceedance without action	Revise management measures
31	Biodiversity Accounting	Biodiversity Units demonstrate achievement of No Net Loss for natural habitats and Net Gain for Critical Habitat	Biodiversity accounting data	BAF	Independent Biodiversity Specialist / DGPC	Biodiversity performance below Project targets	Implement additional restoration, enhancement or biodiversity offset measures through adaptive management
32	Critical Habitat	No measurable decline in Critical Habitat extent, ecological condition, or functionality relative to baseline	Habitat surveys, GIS mapping, ecological monitoring	Field survey and GIS analysis	DGPC / Biodiversity Specialist	Any measurable Project-attributable decline	Investigate cause and implement additional mitigation, habitat restoration or biodiversity offset measures
33	Offset Performance	Achievement of biodiversity performance targets	Annual biodiversity monitoring and Biodiversity Accounting Report	Review of monitoring data and independent verification	DGPC	Biodiversity monitoring indicates declining trend or failure to meet>NNL/NG objectives	Activate Adaptive Management Framework and implement additional mitigation or offset measures

Table 20: Impact- Mitigation- Monitoring Linkage

Impact	Mitigation Measure	Monitoring Indicator	Frequency	Responsibility
Flow alteration	Environmental flow release	Flow compliance	Continuous	DGPC
Fish habitat loss	Habitat protection, FCMP	Fish diversity	Seasonal	DGPC
Habitat loss	Afforestation	Survival rate	Biannual	DGPC
Wildlife disturbance	Access control	Species sightings	Annual	DGPC
Construction disturbance	Noise/dust control	Complaints, levels	Monthly	Contractor

10 BUDGET AND FINANCING

10.1 Overview

Adequate financial resources are essential for the effective implementation of the Biodiversity Action Plan. The project proponent will allocate sufficient budget to cover all aspects of biodiversity management, including mitigation measures, monitoring programs, capacity building, and adaptive management.

Implementation of the Biodiversity Action Plan shall be supported by adequate financial resources throughout the Project lifecycle to ensure effective implementation of mitigation measures, biodiversity monitoring, adaptive management, and demonstration of biodiversity performance. In addition to routine biodiversity management activities, the budget includes provision for implementation and periodic updating of the Biodiversity Accounting Framework (BAF), additional biodiversity surveys where required (including confirmation surveys for the White-bellied Heron), biodiversity enhancement and restoration measures, long-term ecological monitoring, biodiversity performance verification, adaptive management actions, and implementation of biodiversity offsets where required to demonstrate No Net Loss for natural habitats and Net Gain for Critical Habitat in accordance with ADB SPS (2009) and IFC Performance Standard 6.

The budget will be integrated into the overall project cost and will be updated periodically based on implementation requirements and monitoring results.

10.2 Budget Components

- The budget for biodiversity management will include the following components:
 - **Implementation of Sub-Plans:** Costs associated with Biodiversity Conservation and Wildlife Management Plan (BCWMP), Fisheries Conservation and Management Plan (FCMP), Species Rescue Plan (SRP), Compensatory Afforestation Plan (CAP), and Greenbelt Development Plan (GDP).
 - **Habitat Restoration and Afforestation:** Costs for plantation, maintenance, and monitoring of restoration areas
 - **Biodiversity Monitoring:** Costs for surveys, equipment (e.g., camera traps), and data analysis
 - **Capacity Building and Training:** Costs for training programs and awareness activities
 - **Regulatory Compliance and Coordination:** Costs associated with coordination with DoFPS and other authorities
 - **Adaptive Management:** Contingency funds for additional mitigation measures based on monitoring outcomes

Budget allocations are directly aligned with mitigation measures defined in Section 6 and monitoring requirements presented in Table 21

Table 21: Consolidated Budget for BAP Implementation

SN	Budget Function	Sub-Plan / Source	Key Activities	Project Phase	Estimated Cost (BTN)
1	Biodiversity Protection	Species Rescue Plan (SRP)	Pre-clearance flora and fauna rescue, relocation to suitable habitats, ex-situ conservation (as required), anti-poaching measures, workforce code of conduct enforcement, biodiversity awareness programmes, additional targeted surveys for priority species (including White-bellied Heron, where required)	Pre-construction + Construction	Refer Budget from SRP
2	Habitat Restoration & Offset	Compensatory Afforestation Plan (CAP)	Compensatory plantation (~535.88 ha), site preparation, planting, soil conservation, fencing, maintenance, survival monitoring, assisted natural regeneration, biodiversity enhancement measures and restoration activities supporting the Biodiversity Accounting Framework	Pre-construction + Construction + Early Operation	Refer Budget from CAP
3	Habitat Restoration & Offset	Greenbelt Development Plan (GDP)	Slope stabilization, spoil disposal site restoration, roadside plantation, buffer zone development, erosion control through vegetation, ecological restoration contributing to biodiversity gains	Construction + Operation	Refer budget from CAP
4	Aquatic Biodiversity Management	Fisheries Conservation and Management Plan (FCMP)	Fish rescue during dewatering, support to environmental flow implementation (ecological monitoring), aquatic habitat protection, invasive species control, community awareness on sustainable fishing, aquatic ecological monitoring supporting biodiversity accounting	Construction + Operation	Refer budget from FCMP
5	Biodiversity Monitoring	Cross-cutting (SRP + FCMP + CAP)	Wildlife surveys (mammals, birds, herpetofauna), camera trapping, aquatic monitoring (fish, macroinvertebrates), habitat condition assessment, riparian monitoring, data analysis and reporting, implementation and periodic updating of the Biodiversity Accounting Framework (BAF), biodiversity performance verification, data analysis and reporting	All Phases	8,000,000
6	Institutional Strengthening	BCWMP (umbrella) + BAP	Biodiversity Management Committee (BMC) operation, coordination with DoFPS, supervision of sub-plan	All Phases	6,000,000

SN	Budget Function	Sub-Plan / Source	Key Activities	Project Phase	Estimated Cost (BTN)
			implementation, compliance monitoring, periodic reporting and audits, independent review of biodiversity performance where required		
7	Capacity Building & Awareness	SRP + BCWMP	Worker induction on biodiversity, anti-poaching training, community awareness programs, stakeholder engagement, training on environmental compliance, training on Biodiversity Accounting Framework implementation and biodiversity monitoring	Pre-construction + Construction	3,000,000
8	Adaptive Management & Contingency	All Plans	Corrective actions based on monitoring triggers, additional ecological studies, enhancement measures for critical habitat, unforeseen biodiversity impact mitigation, additional biodiversity offset measures (where required), adaptive management actions arising from Biodiversity Accounting Framework verification	All Phases	8,000,000
TOTAL					~25,000,000 BTN

The consolidated budget includes financial provision for implementation of the Biodiversity Accounting Framework (BAF), biodiversity performance verification, long-term ecological monitoring, adaptive management, additional targeted biodiversity surveys (including the White-bellied Heron, where required), biodiversity enhancement measures and, where necessary, biodiversity offset implementation. Budget allocations will be reviewed periodically throughout detailed design, construction and operation to ensure that sufficient resources remain available to demonstrate No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat in accordance with ADB SPS (2009) and IFC Performance Standard 6.

10.3 Financing Mechanism

Implementation of this BAP shall be financed by DGPC as an integral component of Project implementation. Adequate financial resources shall be allocated to implement biodiversity mitigation, monitoring, restoration, adaptive management, capacity building, biodiversity accounting, and reporting throughout the pre-construction, construction, operation, and where applicable, decommissioning phases of the Project.

Funding shall be provided for all biodiversity management measures identified under this Biodiversity Action Plan, including implementation of the Environmental Flow Management Plan, Fisheries Conservation and Management Plan, Biodiversity Conservation and Wildlife Management Plan, Species Rescue Plan, habitat restoration programs, ecological monitoring, long-term biodiversity surveys, stakeholder engagement, independent specialist support, and adaptive management measures.

Where implementation of the BAF identifies residual biodiversity losses following application of the mitigation hierarchy, DGPC shall allocate sufficient financial resources to implement additional biodiversity conservation measures necessary to achieve No Net Loss (NNL) for natural habitats and Net Gain (NG) for Critical Habitat in accordance with the requirements of the Asian Development Bank Safeguard Policy Statement (2009).

Biodiversity offset measures implemented to achieve Project biodiversity objectives shall be demonstrably additional to all statutory environmental obligations and shall not rely upon compensatory afforestation or other mitigation measures that are legally required under Bhutanese legislation. Statutory compensatory afforestation required under national legislation constitutes regulatory compliance and shall not be counted as a biodiversity offset or as a biodiversity gain for the purposes of demonstrating No Net Loss or Net Gain. Only conservation measures that generate measurable biodiversity benefits beyond legal requirements shall be considered when evaluating Project biodiversity performance.

Financial provisions for biodiversity management shall be periodically reviewed throughout Project implementation to ensure adequate resources remain available for monitoring, adaptive management, habitat restoration, biodiversity offsets where required, and long-term conservation commitments arising from implementation of this BAP.

10.4 Cost Optimization

Cost efficiency will be achieved through integration and optimization of biodiversity measures within overall project implementation. This includes the use of existing government nursery facilities for sourcing planting materials, integration of greenbelt development with engineering and slope stabilization works, and coordination with the Department of Forests and Park Services (DoFPS) for implementation and technical support. Biodiversity monitoring programs will be combined across terrestrial and aquatic components and aligned with the project's broader environmental monitoring system. In addition, restoration and afforestation activities will be synchronized with construction schedules to maximize efficiency. This integrated approach ensures optimal use of resources while maintaining the effectiveness of biodiversity conservation outcomes.

11 ADAPTIVE MANAGEMENT

11.1 Adaptive Management Framework

Adaptive management will be implemented to ensure that biodiversity objectives, including No Net Loss and Net Gain, are achieved.

Corrective actions will be triggered where monitoring indicates:

- Non-compliance with environmental flow requirements
- Decline in key species populations
- Habitat degradation or failure of restoration measures
- Exceedance of defined ecological thresholds

Corrective Actions May Include:

- Adjustment of environmental flow releases
- Enhancement of habitat restoration measures
- Strengthening of species protection strategies
- Revision of construction or operational practices
 - Increased monitoring frequency

This adaptive approach ensures continuous improvement and responsiveness to ecological changes.

11.2 Adaptive Management Process

- The adaptive management process includes:
- Collection of monitoring data as defined in Section 9
- Analysis of monitoring results to identify trends and deviations
- Evaluation of the effectiveness of mitigation measures
- Identification of necessary corrective actions
- Implementation of revised or additional measures

This process ensures that biodiversity management is responsive and evidence based.

11.3 Triggers for Adaptive Management

- Adaptive management actions will be triggered by:
- Non-compliance with mitigation measures
- Deviation from environmental flow requirements
- Decline in biodiversity indicators, including species presence and habitat condition
- Failure of restoration measures (e.g., low survival rates)
- Increase in invasive species or disturbance incidents

Triggers and corresponding corrective actions are defined in the monitoring matrix.

11.4 Continuous Improvement

The BAP will be treated as a dynamic document, subject to periodic review and update based on monitoring results, regulatory requirements, and stakeholder feedback.

Lessons learned during implementation will be incorporated into project management practices to improve effectiveness.

11.5 Reporting and Feedback

Adaptive management actions and outcomes will be documented in environmental monitoring reports. Feedback from regulatory authorities, including DoFPS and DECC, will be incorporated into decision-making.

This ensures transparency, accountability, and continuous improvement in biodiversity management.

Annex 1: List of Fish Species Recorded During the Survey, Showing Genus, Species, and their IUCN Red List Conservation Status

S.N	Scientific Name	Common Name	IUCN Status	Season of Record
1	<i>Schizothorax richardsonii</i>	Snow Trout	VU	S1, S2, S3
2	<i>Salmo trutta</i>	Brown Trout	LC	S1, S2, S3
3	<i>Neolissochilus hexagonolepis</i>	Copper Mahseer	NT	S2, S3
4	<i>Psilorhynchus arunachalensis</i>		DD	S2
5	<i>Psilorhynchus balitora</i>		LC	S2, S3
6	<i>Pseudochinensis sulcata</i>		LC	S2, S3
7	<i>Opsarius barna</i>	Barna Fish	LC	S2, S3
8	<i>Opsarius vagra</i>		LC	S2, S3
9	<i>Opsarius bendelisis</i>		LC	S2
10	<i>Xenentodon cancila</i>		LC	S2
11	<i>Channa quinquefasciata</i>		NE	S2
12	<i>Diano dangila</i>		LC	S2
13	<i>Devario aequipinnatus</i>		LC	S2, S3
14	<i>Tor putitora</i>	Golden Mahseer	EN	S2
15	<i>Parachiloganis hodgarti</i>	Bathbalanga	LC	S2, S3
16	<i>Paracanthocobitis abutwebi</i>		NE	S2
17	<i>Schistura</i> sp.	Gadera	LC	S2
18	<i>Garra annandalei</i>		LC	S2, S3
19	<i>Garra birostris</i>		NE	S2, S3
20	<i>Garra</i> sp. 1			S2
21	<i>Garra</i> sp. 2			S2
22	<i>Badis badis</i>		LC	S2
23	<i>Pethia conchoniis</i>		LC	S2
24	<i>Mystus</i> sp.	Jantura	LC	S2
25	<i>Semiplotus semiplotus</i>		VU	S2, S3
26	<i>Aborichthys elongatus</i>		LC	S2
27	<i>Glyptothorax</i> sp.		LC	S2
28	<i>Amblyceps apangi</i>		LC	S2
29	<i>Batasio merianiensis</i>		DD	S2

Note: S1 = Pre-monsoon (March 2025), S2 = Monsoon (Aug–Sep 2025), S3 = Post-monsoon (Nov–Dec 2025). Species occurrence reflects seasonal hydrological variability and detectability; absence in each season does not necessarily indicate true absence

Annex 2: List of Dominant Tree Species Recorded

SN	Scientific Name	English Name	Local Name
1	<i>Acer campbellii</i>	Himalayan Maple	
2	<i>Actinodaphne obovata</i>	Laurel	
3	<i>Alnus nepalensis</i>	Himalayan Alder	Utis
4	<i>Benthamedia capitata</i>	Himalayan Dogwood	
5	<i>Betula alnoides</i>	Himalayan Birch	
6	<i>Brassiopsis hainla</i>	Aralia Tree	
7	<i>Carpinus viminea</i>	Himalayan Hornbeam	
8	<i>Castanopsis spp.</i>	Chinquapin	Katus
9	<i>Celtis tetrandia</i>	Himalayan Nettle Tree	
10	<i>Cinnamomum glanduliferum</i>	Wild Cinnamon	
11	<i>Corylus ferox</i>	Himalayan Hazel	
12	<i>Dodecadenia grandiflora</i>	Evergreen Laurel	
13	<i>Eurya acuminata</i>	Eurya	
14	<i>Lithocarpus elegans</i>	Stone Oak	
15	<i>Lithocarpus fenestratus</i>	Stone Oak	
16	<i>Lyonia ovalifolia</i>	Fetterbush	
17	<i>Michelia doltsopa</i>	Magnolia	
18	<i>Persea spp.</i>	Wild Avocado	
19	<i>Picea spinulosa</i>	Himalayan Spruce	
20	<i>Pieris formosa</i>	Andromeda Tree	
21	<i>Pinus wallichiana</i>	Blue Pine	Gobre Salla
22	<i>Populus ciliata</i>	Himalayan Poplar	
23	<i>Prunus carmesina</i>	Wild Cherry	
24	<i>Prunus nepalensis</i>	Nepal Cherry	
25	<i>Quercus glauca</i>	Japanese Blue Oak	
26	<i>Quercus griffithii</i>	Oak	
27	<i>Quercus lamellosa</i>	Brown Oak	
28	<i>Quercus lanata</i>	Woolly-leaved Oak	
29	<i>Quercus oxyodon</i>	Sharp-toothed Oak	
30	<i>Quercus semecarpifolia</i>	Himalayan Oak	
31	<i>Rhododendron arboreum</i>	Tree Rhododendron	Lali Gurans
32	<i>Rhododendron griffithianum</i>	Rhododendron	
33	<i>Rhus spp.</i>	Sumac	
34	<i>Salix wallichiana</i>	Himalayan Willow	
35	<i>Schoepfia jasminodora</i>	Schoepfia	

SN	Scientific Name	English Name	Local Name
36	<i>Symplocos paniculata</i>	Symplocos	
37	<i>Symplocos racemosa</i>	Symplocos	
38	<i>Symplocos ramosissima</i>	Symplocos	
39	<i>Symplocos sumuntia</i>	Symplocos	
40	<i>Tetradium fraxinifolium</i>	Evodia Tree	
41	<i>Toricellia tiliifolia</i>	Toricellia	
42	<i>Tsuga dumosa</i>	Himalayan Hemlock	
43	<i>Viburnum cylindricum</i>	Viburnum	
44	<i>Zanthoxylum armatum</i>	Nepal Pepper	Timur

This annex presents the tree species recorded in the project area, reflecting forest composition and ecological characteristics.

Annex 3: List of Mammals

S.N.	Species	IUCN Status	Type of Record	Habitat Observed	Season of Record
1	Wild Pig (<i>Sus scrofa</i>)	LC	Tracks, sightings, signs	Forest slopes, disturbed forest edges	S1, S2, S3
2	Barking Deer (<i>Muntiacus muntjak</i>)	LC	Tracks and sightings	Broadleaved forest and riverine areas	S1, S2, S3
3	Himalayan Black Bear (<i>Ursus thibetanus</i>)	VU	Signs, livestock predation report	Forest near settlements	S1, S2, S3
4	Assamese Macaque (<i>Macaca assamensis</i>)	NT	Direct sightings	Forest canopy and forest edges	S2, S3
5	Sambar (<i>Rusa unicolor</i>)	VU	Tracks and signs	Dense forest habitats	S1, S2, S3
6	Himalayan Goral (<i>Naemorhedus goral</i>)	NT	Direct sightings	Rocky slopes and cliffs	S2, S3
7	Yellow-throated Marten (<i>Martes flavigula</i>)	LC	Direct observation	Mixed forest areas	S2, S3
8	Dhole (<i>Cuon alpinus</i>)	EN	Signs and tracks	Forest habitats	S2, S3
9	Himalayan Grey Langur (<i>Semnopithecus schistaceus</i>)	LC	Direct sightings	Forest canopy and open forest	S2, S3
10	Leopard Cat (<i>Prionailurus bengalensis</i>)	LC	Signs and sightings	Forest edge and dense vegetation	S2, S3

Note: This annex lists mammal species recorded at the survey sites. S1 = pre-monsoon, S2 = monsoon, S3 = post-monsoon. Mammal records are based on direct sightings and indirect evidence (tracks, scats, and local information). Absence in a season reflects detectability constraints rather than confirmed absence.

Annex 4: List of Birds

SN	Common Name	Scientific Name	IUCN Status	FNCA Bhutan 2023	Season of Record
1	Alpine Thrush	<i>Zoothera mollissima</i>	LC	Nil	S3
2	Ashy Drongo	<i>Dicrurus leucophaeus</i>	LC	Nil	S1, S2
3	Asian Barred Owlet	<i>Glaucidium cuculoides</i>	LC	Schedule III	S1
4	Ashy-throated Warbler	<i>Phylloscopus maculipennis</i>	LC	Nil	S3
5	Bay Woodpecker	<i>Blythipicus pyrrhotis</i>	LC	Nil	S3
6	Black Bulbul	<i>Hypsipetes leucocephalus</i>	LC	Nil	S1, S2, S3
7	Black-headed shrike Babbler	<i>Pteruthius rufiventer</i>	LC	Nil	S1
8	Black-throated Tit	<i>Aegithalos concinnus</i>	LC	Nil	S1, S2, S3
9	Blue Whistling Thrush	<i>Myophonus caeruleus</i>	LC	Nil	S1, S2, S3
10	Black-winged Cuckooshrike	<i>Coracina melaschistos</i>	LC	Nil	S1
11	Blue-fronted Redstart	<i>Phoenicurus frontalis</i>	LC	Nil	S3
12	Blyth's Leaf Warbler	<i>Phylloscopus reguloides</i>	LC	Schedule III	S1, S2, S3
13	Brown Dipper	<i>Cinclus pallasii</i>	LC	Nil	S1, S2, S3
14	Brown Parrotbill	<i>Cholornis unicolor</i>	LC	Nil	S1, S2, S3
15	Brownish-flanked Bush Warbler	<i>Cettia pallidipe</i>	LC	Nil	S1
16	Buff-barred Warbler	<i>Phylloscopus pulcher</i>	LC	Nil	S1
17	Chestnut-bellied Nuthatch	<i>Sitta cinnamoventris</i>	LC	Nil	S3
18	Chestnut-crowned Laughingthrush	<i>Garrulax erythrocephalus</i>	LC	Nil	S1, S3
19	Crested Kingfisher	<i>Megaceryle lugubris</i>	LC	Nil	S3
20	Crimson sunbird	<i>Aethopyga siparaja</i>	LC	Nil	S1
21	Common Green Magpie	<i>Cissa chinensis</i>	LC	Nil	S1

SN	Common Name	Scientific Name	IUCN Status	FNCA Bhutan 2023	Season of Record
22	Common Hoopoe	<i>Upupa epops</i>	LC	Nil	S1, S2
23	Common Stonechat	<i>Saxicola torquata</i>	LC	Nil	S1, S2
24	Darjeeling Woodpecker	<i>Dendrocopos darjellensis</i>	LC	Nil	S1, S2, S3
25	Eurasian Cuckoo	<i>Cuculus canorus</i>	LC	Nil	S1
26	Eurasian Wren	<i>Troglodytes troglodytes</i>	LC	Nil	S3
27	Eurasian Jay	<i>Garrulus glandarius</i>	LC	Nil	S1, S2, S3
28	Great Cormorant	<i>Phalacrocorax carbo</i>	LC	Nil	S3
29	Great Barbet	<i>Psilopogon virens</i>	LC	Nil	S1, S2, S3
30	Grey Bushchat	<i>Saxicola ferreus</i>	LC	Nil	S1
31	Grey-backed Shrike	<i>Lanius tephronotus</i>	LC	Nil	S1, S2
32	Grey-winged Blackbird	<i>Turdus boubol</i>	LC	Nil	S1, S2
33	Golden-throated Barbet	<i>Psilopogon franklinii</i>	LC	Nil	S1
34	Green-backed Tit	<i>Parus monticolus</i>	LC	Nil	S1, S2, S3
35	Green-tailed Sunbird	<i>Aethopyga nipalensis</i>	LC	Nil	S1, S2
36	Grey-headed Canary Fycatcher	<i>Culicicapa ceylonensis</i>	LC	Nil	S1, S2
37	Grey-hooded Warbler	<i>Phylloscopus xanthoschistos</i>	LC	Nil	S3
38	Grey-sided Laughingthrush	<i>Garrulax caeruleus</i>	LC	Nil	S3
39	Himalayan Bluetail	<i>Tarsiger rufilatus</i>	LC	Nil	S3
40	Hill Partridge	<i>Arborophila torqueola</i>	LC	Schedule III	S1, S2, S3
41	Hodgson's Redstart	<i>Phoenicurus ochruros</i>	LC	Schedule I	S1
42	House Crow	<i>Corvus splendens</i>	LC	Nil	S1, S2
43	Hume's Warbler	<i>Phylloscopus humei</i>	LC	Nil	S1, S2
44	Indian Cuckoo	<i>Cuculus micropterus</i>	LC	Schedule III	S1, S2

SN	Common Name	Scientific Name	IUCN Status	FNCA Bhutan 2023	Season of Record
45	Indian Nuthatch	<i>Sitta castanea</i>	LC	Nil	S1
46	Kalij Pheasant	<i>Lophura leucomelanos</i>	LC	Schedule III	S1, S2
47	Large-billed Crow	<i>Corvus macrorhynchos</i>	LC	Schedule III	S1, S2
48	Large Hawk Cuckoo	<i>Hierococyx sparveroides</i>	LC	Schedule III	S1
49	Lesser Yellownap	<i>Picus chlorolophus</i>	LC	Nil	S1
50	Lemon-rumped Warbler	<i>Phylloscopus chloronotus</i>	LC	Nil	S2
51	Long-tailed Minivet	<i>Pericrocotus ethologus</i>	LC	Nil	S1, S2
52	Maroon Oriole	<i>Oriolus traillii</i>	LC	Nil	S1, S2
53	Mountain Hawk Eagle	<i>Nisaetus nipalensis</i>	LC	Nil	S1
54	Mrs Gould's Sunbird	<i>Aethopyga gouldiae</i>	LC	Nil	S1, S2
55	Nepal Fulvetta	<i>Alcippe nipalensis</i>	LC	Nil	S1, S2
56	Olive-backed Pipit	<i>Anthus hodgsoni</i>	LC	Nil	S1
57	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	LC	Nil	S1, S2
58	Oriental White-eye	<i>Zosterops palpebrosus</i>	LC	Nil	S1, S2
59	Pied Bushchat	<i>Saxicola caprata</i>	LC	Nil	S1
60	Plumbeous Water Redstart	<i>Phoenicurus fuliginosus</i>	LC	Nil	S1, S2
61	Red-billed Chough	<i>Pyrrhocorax pyrrhocorax</i>	LC	Schedule III	S1
62	Red-faced Liocichla	<i>Liocichla phoenicea</i>	LC	Nil	S1
63	Red-tailed Minla	<i>Minla ignotincta</i>	LC	Nil	S1, S2
64	Red-headed Bullfinch	<i>Pyrrhula erythrocephala</i>	LC	Nil	S2, S3
65	Rusty-fronted Barwing	<i>Actinodura egertoni</i>	LC	Nil	S2, S3
66	Red-vented Bulbul	<i>Pycnonotus cafer</i>	LC	Nil	S1
67	Rufous-bellied Woodpecker	<i>Dendrocopos hyperythrus</i>	LC	Nil	S1, S2

SN	Common Name	Scientific Name	IUCN Status	FNCA Bhutan 2023	Season of Record
68	Rufous Sibia	<i>Heterophasia capistrata</i>	LC	Nil	S1, S2
69	Rufous-breasted Accentor	<i>Prunella strophiate</i>	LC	Nil	S2, S3
70	Rufous-gorgeted Flycatcher	<i>Ficedula strophiate</i>	LC	Nil	S2, S3
71	Rufous -vented Yuhina	<i>Yuhina occipitalis</i>	LC	Nil	S1, S2
72	Scaly-breasted Wren-Babbler	<i>Pnoepyga albiventer</i>	LC	Nil	S2, S3
73	Scarlet Minivet	<i>Pericrocotus flammeus</i>	LC	Nil	S1, S2
74	Short-billed Minivet	<i>Pericrocotus brevirostris</i>	LC	Nil	S1
75	Sikkim Treecreeper	<i>Certhia discolor</i>	LC	Nil	S1, S2
76	Small Niltava	<i>Niltava macgrigoriae</i>	LC	Nil	S2
77	Spotted Nutcracker	<i>Nucifraga caryocatactes</i>	LC	Nil	S1, S2
78	Spotted Laughingthrush	<i>Lanthocincla ocellata</i>	LC	Nil	S1, S2
79	Spotted Forktail	<i>Enicurus maculatus</i>	LC	Nil	S2
80	Streak-breasted Scimitar Babbler	<i>Pomatorhinus ruficollis</i>	LC	Nil	S1, S2
81	Striated Bulbul	<i>Pycnonotus striatus</i>	LC	Nil	S1
82	Striated Laughingthrush	<i>Grammatoptila striata</i>	LC	Nil	S1, S2
83	Stripe-throated Yuhina	<i>Yuhina gularis</i>	LC	Nil	S1, S2
84	Verditer Flycatcher	<i>Eumyias thalassina</i>	LC	Nil	S1, S2
85	White Wagtail	<i>Motacilla alba</i>	LC	Nil	S2
86	White-spectacled Warbler	<i>Seicercus affinis</i>	LC	Nil	S1, S2
87	White-tailed Nuthatch	<i>Sitta himalayensis</i>	LC	Nil	S1, S2
88	White-throated Fantail	<i>Rhipidura albicollis</i>	LC	Nil	S2
89	White-throated Laughingthrush	<i>Garrulax albogularis</i>	LC	Nil	S1, S2
90	White-capped Water Redstart	<i>Phoenicurus leucocephalus</i>	LC	Nil	S1, S2

SN	Common Name	Scientific Name	IUCN Status	FNCA Bhutan 2023	Season of Record
91	Whiskered Yuhina	<i>Yuhina flavicollis</i>	LC	Nil	S1, S2
92	Yellow-billed Blue Magpie	<i>Urocissa flavirostris</i>	LC	Nil	S1, S2
93	Yellow-bellied Fantail	<i>Chelidorhynch hypoxanthus</i>	LC	Nil	S1
94	Yellow-browed Fulvetta	<i>Alcippe cinereiceps</i>	LC	Nil	S1
95	Yellow-browed Warbler	<i>Phylloscopus inornatus</i>	LC	Nil	S1
96	Yellow-vented Warbler	<i>Phylloscopus cantator</i>	LC	Nil	S1
97	Golden Bush Robin	<i>Tarsiger chrysaeus</i>	LC	Nil	S2, S3

Note: This annex provides a list of bird species recorded across the project area and three survey seasons are indicated as S1 = Pre-monsoon (March 2025), S2 = Monsoon (Aug–Sep 2025), S3 = Post-monsoon (Nov–Dec 2025).

Annex 5: List of Herpetofauna Species Recorded

SN	Scientific Name	Common Name	Family	IUCN Status	Season of Record
Amphibians					
1	<i>Duttaphrynus melanostictus</i>	Asian Common Toad	Bufonidae	LC	S2, S3
2	<i>Fejervarya limnocharis</i>	Paddy Field Frog	Dicroglossidae	LC	S2
3	<i>Hoplobatrachus tigerinus</i>	Indian Bullfrog	Dicroglossidae	LC	S2, S3
Reptiles (Snakes)					
4	<i>Ptyas mucosa</i>	Oriental Rat Snake	Colubridae	LC	S1, S3
5	<i>Boiga trigonata</i>	Common Cat Snake	Colubridae	LC	S3
6	<i>Coelognathus helena</i>	Trinket Snake	Colubridae	LC	S1
7	<i>Ahaetulla nasuta</i>	Green Vine Snake	Colubridae	LC	S3
8	<i>Rhabdophis subminiatus</i>	Red-necked Keelback	Colubridae	LC	S2
9	<i>Amphiesma stolatum</i>	Buff-striped Keelback	Colubridae	LC	S2, S3
10	<i>Xenochrophis piscator</i>	Checkered Keelback	Colubridae	LC	S2
11	<i>Oligodon arnensis</i>	Kukri Snake	Colubridae	LC	S1
12	<i>Lycodon aulicus</i>	Common Wolf Snake	Colubridae	LC	S3
13	<i>Elaphe radiata</i>	Radiated Rat Snake	Colubridae	LC	S1
14	<i>Dendrelaphis tristis</i>	Bronze-back Tree Snake	Colubridae	LC	S3
15	<i>Naja naja</i>	Indian Cobra	Elapidae	LC	S1, S2
16	<i>Bungarus caeruleus</i>	Common Krait	Elapidae	LC	S1
17	<i>Python bivittatus</i>	Burmese Python	Pythonidae	VU	S3
18	<i>Trimeresurus albolabris</i>	White-lipped Pit Viper	Viperidae	LC	S2, S3

SN	Scientific Name	Common Name	Family	IUCN Status	Season of Record
19	<i>Trimeresurus erythrurus</i>	Himalayan Pit Viper	Viperidae	LC	S3
20	<i>Daboia russelii</i>	Russell's Viper	Viperidae	LC	S1
Reptiles (Lizards)					
21	<i>Calotes versicolor</i>	Oriental Garden Lizard	Agamidae	LC	S1, S2, S3
22	<i>Japalura variegata</i>	Himalayan Agamid	Agamidae	LC	S3
23	<i>Hemidactylus frenatus</i>	Common House Gecko	Gekkonidae	LC	S1, S2, S3
24	<i>Hemidactylus brookii</i>	Brook's Gecko	Gekkonidae	LC	S1, S2, S3
25	<i>Eutropis carinata</i>	Common Skink	Scincidae	LC	S1, S3
26	<i>Eutropis macularia</i>	Bronze Grass Skink	Scincidae	LC	S2
27	<i>Sphenomorphus indicus</i>	Forest Skink	Scincidae	LC	S3
Reptiles (Turtle)					
28	<i>Indotestudo elongata</i>	Elongated Tortoise	Testudinidae	EN	S3

Note: This annex provides a list of Herpetofauna species recorded across the project area and *three survey seasons are indicated as S1 = Pre-monsoon (March 2025), S2 = Monsoon (Aug–Sep 2025), S3 = Post-monsoon (Nov–Dec 2025).*

Annex 6: List of Invasive Plant Species Recorded

SN	Scientific Name	Common Name	Origin	Habitat	Risk Level	Season of Record
1	<i>Ageratina adenophora</i>	Crofton Weed	Invasive	Roadside, slopes	High	S1, S2, S3
2	<i>Chromolaena odorata</i>	Siam Weed	Invasive	Open disturbed land	High	S2
3	<i>Lantana camara</i>	Lantana	Invasive	Forest edge	High	S1, S3
4	<i>Mikania micrantha</i>	Mile-a-minute	Invasive	Moist forest, riparian	High	S3
5	<i>Parthenium hysterophorus</i>	Congress Weed	Invasive	Roadsides, settlements	High	S1, S2
6	<i>Bidens pilosa</i>	Blackjack	Invasive	Agricultural edges	Moderate	S1
7	<i>Xanthium strumarium</i>	Cocklebur	Invasive	Riverbanks	Moderate	S2, S3
8	<i>Eupatorium spp.</i>	Eupatorium	Invasive	Disturbed forest	Moderate–High	S2
9	<i>Ageratum conyzoides</i>	Billygoat Weed	Invasive	Open disturbed land	Moderate	S1
10	<i>Oxalis latifolia</i>	Wood Sorrel	Invasive	Moist disturbed soil	Moderate	S1
11	<i>Amaranthus spinosus</i>	Spiny Amaranth	Exotic	Open land	Low–Moderate	S1, S2, S3
12	<i>Cassia tora</i>	Sickle Senna	Exotic	Roadside	Low	S1
13	<i>Datura stramonium</i>	Jimson Weed	Exotic	Disturbed soil	Low	S1
14	<i>Solanum nigrum</i>	Black Nightshade	Exotic	Agricultural margins	Low	S2
15	<i>Solanum torvum</i>	Turkey Berry	Exotic	Shrubland	Low–Moderate	S3
16	<i>Ipomoea purpurea</i>	Morning Glory	Exotic	Disturbed vegetation	Moderate	S1
17	<i>Ipomoea carnea</i>	Pink Morning Glory	Invasive	Moist areas	High	S2, S3
18	<i>Ricinus communis</i>	Castor Plant	Exotic	Waste land	Low	S1
19	<i>Argemone mexicana</i>	Mexican Poppy	Exotic	Dry disturbed areas	Low	S1
20	<i>Cynodon dactylon</i>	Bermuda Grass	Invasive	Open land	Moderate	S1, S2
21	<i>Imperata cylindrica</i>	Cogon Grass	Invasive	Degraded slopes	High	S1, S2
22	<i>Pennisetum purpureum</i>	Elephant Grass	Exotic/Invasive	Disturbed land	Moderate	S2
23	<i>Saccharum spontaneum</i>	Wild Sugarcane	Invasive	Riverbanks	Moderate	S2, S3
24	<i>Setaria spp.</i>	Foxtail Grass	Invasive	Open land	Low–Moderate	S1
25	<i>Commelina benghalensis</i>	Dayflower	Invasive	Moist soil	Moderate	S2, S3

Note: This annex provides a list of invasive plant species recorded across the project area and *three survey seasons are indicated as S1 = Pre-monsoon (March 2025), S2 = Monsoon (Aug–Sep 2025), S3 = Post-monsoon (Nov–Dec 2025).*

Annex 7: Aquatic Survey



Spawning grounds washed away by the floods in October 2025 @November 2025



Measuring depth & velocity



Cast net fishing



Macroinvertebrates & phytoplankton sampling



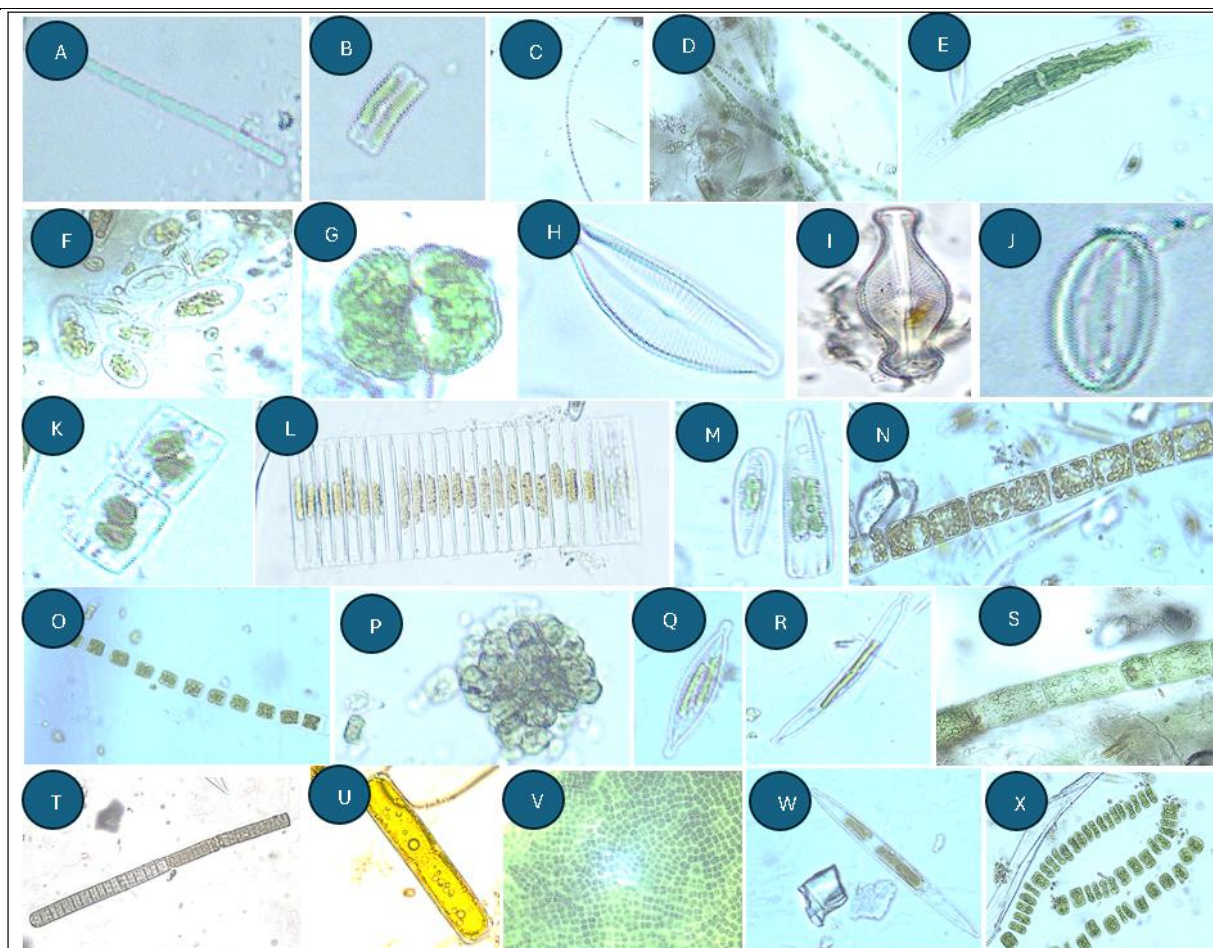
Tor putitora

Opsarius bendelensis

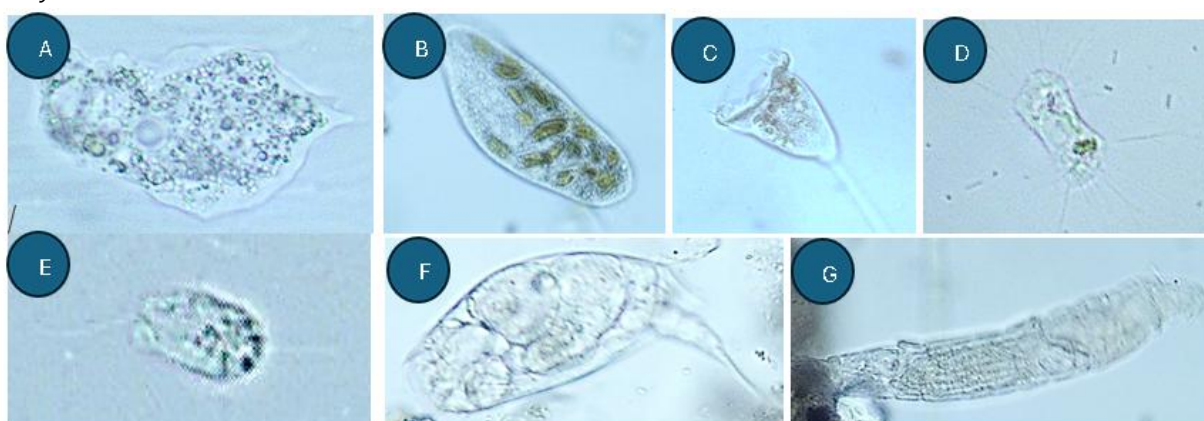


Opsarius barna

Salmo trutta



Phytoplanktons recorded from the sampling sites during post/monsoon survey: A-Anabaena; B-Achnanthes, C-Aulacoseira; D-Chaetophora, E- Closterium, F-Cocconies, G-Cosmarium, H-Cymbella, I-Didymosphenia, J-Diplonies, K-Eunotia, L-Fragilaria, M-Gomphonema, N-Melosira, O-Microspora, P-Microcystis, Q-Navicula, R-Nitzschia, S-Oedogonium, T-Oscillatoria, U-Pinnularia, V-Prasiola formosana, W-Synedra, X-Ulothrix.



Zooplanktons recorded from the sampling sites during post/monsoon survey: A- Amoeba, Ciliophora: B- Paramecium; C- Vorticella, Endomyxa; D- Leptophrys, Euglenozoa: E-Anisonema, Rotifera: F- Lepadella, G- Philodina

Annex 8: Birds Sighted during Terrestrial Survey

	
Blue-fronted Redstart Female	Blue-fronted Redstart
	
Brown Dipper	Chestnut-bellied Rock Thrush
	
Chestnut-crowned Laughingthrush	Eurasian Jay



Gray-hooded Warbler



Great Barbet



Great Cormorant



Himalayan Bluetail



Kalij Pheasant



Lesser Yellownappe



Plumbeous Water Redstart



Red-headed Bullfinch



Red-vented Bulbul



Rufous Sibia



Rufous-breasted Accentor



Rusty-fronted Barwina



Scaly Thrush



Snow Pigeon



Spotted Elachura



Spotted Forktail



Spotted Nutcracker



Staited Bulbul



Straited Laughingthrush



Streak-Breasted Scimitar Babbler

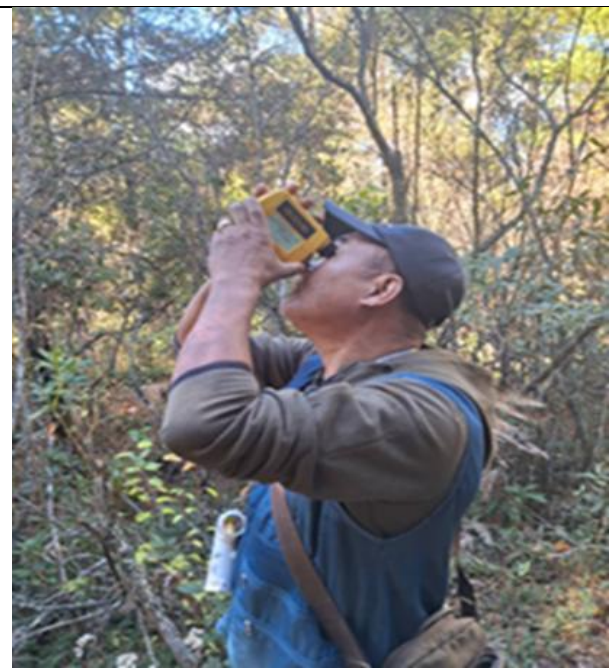


Wall creeper



White capped Redstart

Annex 9: Terrestrial Survey and Mammals Sighted

	
Tree height measured with range finder	Canopy cover measured with densiometer
	
<i>Muntiacus muntjak</i> (Barking Deer)	<i>Naemorhedus goral</i> (Himalayan goral)
	
<i>Semnopithecus entellus</i> (Grey langur)	<i>Ursus thibetanus</i> (Asiatic Black Bear)



Sample plot numbered on the tree



Asiatic Black Bear dung



Draft eDNA Report of the Bunakha Hydropower Project

Summary

This report presents an environmental DNA (eDNA) metabarcoding assessment of fish diversity conducted across the proposed Bunakha Hydropower Project (HPP). The study provides a molecular baseline of ichthyofaunal assemblages within the Wangchhu River basin, using water samples collected across five sampling stations and analysed through high-throughput Illumina sequencing and bioinformatic processing using the MiFish-U 12S rRNA amplicon approach.

All five collected samples yielded successful sequencing results and were retained for analysis, recovering a combined total of 292,450 high-quality reads across the survey transect. A total of 20 valid fish species were identified following biogeographic screening. 19 anomalous species detections were recorded, comprising 12 marine species, one deep-sea species, and six freshwater taxa not previously documented from Bhutan's natural river systems. These were excluded from ecological analyses following biogeographic and ecological validation, while being retained in the dataset for transparency. Their distribution was markedly uneven across the transect, with most anomalous detections concentrated at CNR02, suggesting a localised anthropogenic contamination source; most plausibly processed fish products at or upstream of the station. CNR03 was entirely free of anomalous detections, representing the most ecologically coherent station in the dataset.

Among the validated taxa, Cyprinidae dominated the species assemblage, with additional representation from Danionidae, Sisoridae, Nemacheilidae, Balitoridae, Botiidae, Cobitidae, Clariidae, and Anguillidae. Ecologically and conservation-significant species included the Near Threatened - IUCN Status Copper Mahseer (*Neolissochilus hexagonolepis*), detected across three stations with peak abundance at CNR03, and the Near Threatened-IUCN Status Indian Mottled Eel (*Anguilla bengalensis*), recorded at CNR03, confirming the presence of high-value freshwater habitats supporting sensitive biodiversity within the project area of influence.

This report underscores the importance of integrating aquatic biodiversity conservation into the planning and design of the Bunakha reservoir to safeguard the ecological integrity of the river system. The findings provide a scientifically defensible baseline for future biodiversity monitoring, environmental flow assessment, and adaptive management,

advocating for a balanced approach to hydropower development and freshwater conservation within the Bunakha river basin.

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Chapter One

Introduction

1.1 Background

Aquatic biodiversity forms a critical component of environmental assessments for hydropower development, particularly in river systems where project activities may influence fish communities and associated aquatic ecological processes. As part of the Environmental and Social Impact Assessment (ESIA) for the proposed Bunakha reservoir, an environmental DNA (eDNA)-based assessment was undertaken to generate preliminary baseline information on fish diversity within the project basin.

Environmental DNA metabarcoding was employed as a complementary and non-invasive approach to assess fish species occurrence across the project area. The method involves the collection of water samples from which trace quantities of genetic material shed by aquatic organisms are extracted, amplified using universal fish-specific primers (MiFish-U, targeting the 12S ribosomal RNA gene), and sequenced on a high-throughput Illumina platform. Taxonomic identities are subsequently assigned through comparison against curated reference databases, enabling simultaneous detection of multiple fish species from a single water sample without the need for physical capture or direct observation. A total of five water samples were collected from representative locations distributed across the proposed project area of influence, spanning an upstream-to-downstream gradient along the Bunakha river system.

Preliminary analysis recovered 39 species-level detections across the five stations. Following biogeographic and ecological validation, taxa19 anomalous detections were excluded from the final dataset. These comprised 12 marine species, one deep-sea species, and six freshwater taxa not previously documented from Bhutan's natural river systems, and were considered artefacts arising from processed fish product contamination, reference database mis-assignments, or low-frequency sequencing artefacts.

Twenty valid fish species belonging to nine families — Cyprinidae, Danionidae, Sisoridae, Nemacheilidae, Balitoridae, Botiidae, Cobitidae, Clariidae, and Anguillidae identified as ecologically plausible records representative of the Bunakha river fish assemblage. These included species of conservation and ecological significance, notably the Near

Threatened Copper Mahseer (*Neolissochilus hexagonolepis*) and the Near Threatened Indian Mottled Eel (*Anguilla bengalensis*), both detected at station CNR03 within the project area of influence.

The findings indicate the presence of a taxonomically diverse fish community within the Bunakha river system and highlight the applicability of eDNA metabarcoding as an effective tool for rapid aquatic biodiversity assessment in Himalayan River environments. As a preliminary molecular investigation, these findings provide an important baseline for understanding fish diversity within the proposed hydropower landscape and contribute to identifying ecological values that require consideration during project planning, environmental flow assessment, and impact mitigation design.

Chapter Two

Materials and Methods

2.1 Study Area

The study area focused on the Bunakha Hydropower Project, a proposed 180 MW reservoir-based hydroelectric facility located on the Wangchhu River in Chukha District, Bhutan. Project features three turbines with a combined capacity of 180 MW and a reservoir capacity of 211.3 million cubic meters. Currently at the permitting stage, the project aims to commence construction in 2026 and achieve commercial operation by 2032. A total of five sampling sites were identified and established for the study (Figure 1).



Figure 1: Study area showing the Area of Influence and eDNA sample collection sites ($n = 5$)

2.2 Field Sampling, Laboratory Procedures and Bioinformatic Processing

Environmental DNA (eDNA) metabarcoding was employed to assess fish diversity within the proposed Bunakha reservoir area using standardised molecular and bioinformatic

procedures widely applied in freshwater biodiversity monitoring (Miya et al., 2015; Thomsen & Willerslev, 2015).

A total of five water samples were collected across the basin from representative sampling locations selected to capture spatial variation in fish assemblages potentially influenced by the proposed development (Table 1). All the samples yielded successful amplification and sequencing results and were retained for downstream analysis (Figure 2).

Table 1: Aquatic sampling locations and corresponding coordinates of eDNA collection sites across the study area.

Sl. No.	Plot ID	Sample ID	Latitude	Longitude
1	A3	CNR 01	27.27674607	89.53883129
2	A2	CNR 02	27.31710705	89.55108272
3	A27	CNR 03	26.74800256	89.73525555
4	A5	CNR 04	27.25408365	89.52577664
5	A21	CNR 05	26.96733761	89.599401247

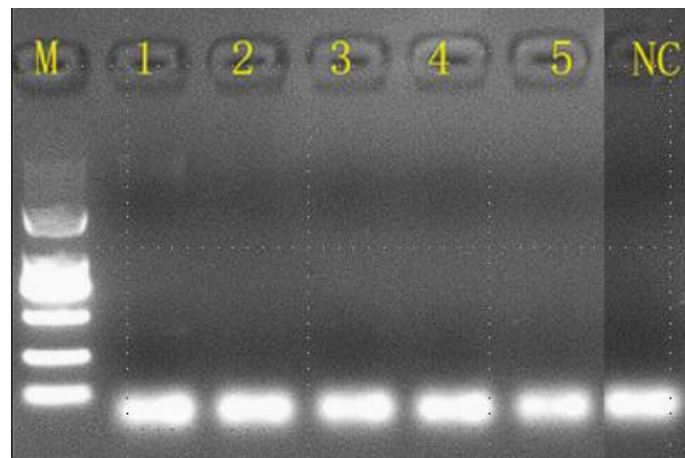


Figure 2: Agarose gel electrophoresis showing successful MiFish-U 12S rRNA PCR amplification across all five Bunakha eDNA samples (lanes 1–5: CNR01–CNR05) at the expected amplicon size of ~163–182 bp. M: 100 bp DNA ladder; NC: no-template negative control.

Water sample of 1 litre were filtered using sterile 0.45 μm membrane filters to capture extracellular and intracellular DNA fragments suspended in the water column. DNA was extracted from filter membranes using silica-column extraction protocols designed for low-concentration environmental DNA recovery while minimizing co-extracted inhibitors.

Fish-specific metabarcoding targeted the mitochondrial 12S rRNA region using the MiFish-U universal primer set (Miya et al., 2015), which has demonstrated broad taxonomic coverage for freshwater fish detection. To reduce stochastic amplification effects and improve detection reliability, each sample was amplified in triplicate PCR reactions, after which amplicons were pooled for sequencing.

Sequencing was performed on the Illumina MiSeq platform using paired-end 2 × 300 bp chemistry. Raw sequence data were processed in QIIME 2 using the DADA2 denoising workflow (Callahan et al., 2016), including quality filtering, chimera removal, paired-end merging, and inference of amplicon sequence variants (ASVs). Taxonomic assignment was conducted using reference matching against the MiFish 12S reference database, supported by the SILVA database where appropriate, with a minimum confidence threshold of 0.80 applied for species-level assignments.

2.3 Taxonomic Validation and Biogeographic Filtering

As eDNA metabarcoding can occasionally generate erroneous or biogeographically implausible species assignments due to incomplete reference libraries, sequence similarity limitations, or taxonomic misclassification, all species detections underwent taxonomic validation prior to ecological interpretation (Ficetola et al., 2016).

Following initial taxonomic assignment, detected taxa were screened against regional ichthyofaunal records, species distribution information, and ecological plausibility. Species records inconsistent with the freshwater Himalayan context of the study area were treated as implausible detections and excluded from ecological diversity analyses, while retained in the dataset for transparency and documentation.

Excluded taxa were grouped into three categories:

1. Marine species assignments: taxa ecologically incompatible with inland freshwater environments and considered likely database-related artefacts.
2. Deep-sea species assignments: taxa with distributions wholly inconsistent with the study system and therefore excluded as improbable detections.
3. Species not documented from Bhutan: freshwater taxa lacking verified occurrence records in Bhutan and treated conservatively pending independent confirmation.

This biogeographic filtering approach ensured that biodiversity analyses were based only on validated and ecologically plausible taxa while maintaining transparency regarding anomalous assignments.

2.4 Diversity Computation

Fish diversity was assessed using species-level diversity indices calculated from validated taxa only. Prior to analysis, ASVs assigned to the same species were pooled to avoid inflation of diversity estimates due to multiple sequence variants representing single taxa. Species diversity was quantified using Shannon diversity (H') (Shannon & Wiener, 1949), Simpson diversity ($1-D$) (Simpson, 1949), and Pielou's evenness (J') (Pielou, 1966) (Equation 1–3).

Shannon diversity:

$$H' = -\sum_{i=1}^S p_i \ln p_i \dots\dots\dots \text{Equation 1}$$

Simpson diversity:

$$1 - D = 1 - \sum_{i=1}^S p_i^2 \dots\dots\dots \text{Equation 2}$$

Pielou's evenness:

$$J' = \frac{H'}{\ln(S)} \dots\dots\dots \text{Equation 3}$$

where p_i represents the proportional sequence abundance of specie and S represents total species richness.

Chapter Three

Results and Discussion

3.1. Summary of Fish Diversity and Distribution

Environmental DNA (eDNA) metabarcoding analysis of five samples from the Bunakha river system recovered a total of 292,450 high-quality sequence reads across five sampling stations (CNR01–CNR05), yielding 20 valid fish species distributed across three orders and nine families (Table 3). The assemblage was dominated by Cypriniformes, with Cyprinidae representing the most species-rich family, complemented by additional representation from Danionidae, Nemacheilidae, Sisoridae, Balitoridae, Botiidae, Cobitidae, Clariidae, and Anguillidae.

The validated dataset included ecologically and conservation-significant species, notably the Near Threatened Copper Mahseer (*Neolissochilus hexagonolepis*), detected across three stations (CNR02, CNR03, and CNR05), and the Near Threatened Indian Mottled Eel (*Anguilla bengalensis*), recorded exclusively at CNR03. Species richness varied considerably among stations: CNR02 supported the highest number of valid taxa (14 species), followed by CNR03 (12 species), CNR05 (5 species), and CNR04 (2 species). CNR01 yielded no species-level assignments, a result attributable to reference database gaps for high-altitude Himalayan taxa rather than the absence of fish from the reach.

In addition to valid taxa, 19 anomalous species detections were excluded from ecological analyses following biogeographic and ecological validation. These comprised 12 marine species, one deep-sea species, and six freshwater taxa not previously reported from Bhutan's natural river systems. The spatial distribution of these exclusions was markedly uneven: CNR03 carried a single exclusion (*Hemimyzon pengi*, a Mekong basin balitorid loach not reported from Bhutan), while CNR02 concentrated the majority (13 species), attributable primarily to food product contamination from processed marine fish. CNR01, CNR04, and CNR05 each carried between one and three exclusions.

3.2. Taxonomic Validation and Anomalous Species

Initial bioinformatic processing of the five Bunakha sampling stations (CNR01–CNR05) recovered both valid fish detections and a number of anomalous species assignments requiring taxonomic screening. Following biogeographic validation against published records of Bhutanese freshwater fish fauna, 20 fish species representing nine families

were retained as ecologically plausible taxa for biodiversity analyses (Table 3). These included species of conservation importance, notably the Copper Mahseer (*Neolissochilus hexagonolepis*), detected across three stations (CNR02, CNR03, and CNR05), and Indian Mottled Eel (*Anguilla bengalensis*), recorded exclusively at CNR03. An additional 19 anomalous detections were identified and excluded from ecological diversity analyses while retained in the dataset for transparency. These comprised 12 marine species, one deep-sea species, and six freshwater taxa not reported from Bhutan.

Table 2: Summary of anomalous eDNA detections, including species identity, read counts, taxonomic confidence, exclusion category, and ecological justification for removal from downstream biodiversity analyses.

Station	Species	Reads	Confidence	Category	Reason for Exclusion
CNR01	<i>Oncorhynchus clarkii</i>	223	0.73	Not reported from Bhutan	Cutthroat Trout; North American salmonid; not reported from Bhutan in any published ichthyological survey; not documented as naturalised in Bhutanese river systems; low confidence (0.733) consistent with database mismatch to an unsequenced Himalayan salmonid ASV
CNR02	<i>Sardina pilchardus</i>	3,244	1	Marine	European Pilchard; obligate marine pelagic fish of the NE Atlantic and Mediterranean; physiologically impossible in a landlocked Himalayan freshwater system; confidence 1.000 confirms correct DNA identification — source is processed fish product contamination (canned sardines are widely traded across South Asian inland markets)
	<i>Scomber scombrus</i>	301	0.93	Marine	Atlantic Mackerel; strictly marine epipelagic fish of the NE Atlantic and Mediterranean; cannot occur in Bhutan; most plausibly attributable to canned mackerel contamination

Station	Species	Reads	Confidence	Category	Reason for Exclusion
	<i>Mullus surmuletus</i>	164	0.98	Marine	Striped Red Mullet; demersal marine fish of the Mediterranean and eastern Atlantic; no freshwater phase; impossible in Bhutan
	<i>Hippoglossoides robustus</i>	89	0.96	Marine	Flathead Flounder; demersal marine flatfish of the North Pacific; not distributed in South Asia; impossible in Bhutan
	<i>Merlangius merlangus</i>	88	0.74	Marine	Whiting; demersal marine gadoid of the NE Atlantic; low confidence (0.749) indicates weak database match; impossible in Bhutan
	<i>Trachurus japonicus</i>	80	0.95	Marine	Japanese Horse Mackerel; marine pelagic fish of the western Pacific and Indian Ocean coastal zones; no freshwater tolerance; impossible in landlocked Bhutan
	<i>Dicentrarchus labrax</i>	65	0.99	Marine	European Seabass; marine diadromous fish of the Atlantic and Mediterranean; no natural freshwater population in Asia; impossible in Bhutan

Station	Species	Reads	Confidence	Category	Reason for Exclusion
	<i>Chrysichthys nigrodigitatus</i>	45	1.00	Not reported from Bhutan	Largehead Catfish; freshwater claroteoid endemic to West and Central African rivers (Niger, Congo, Volta); not reported from Bhutan or any Himalayan drainage; confidence 1.000 confirms correct DNA identification — most likely attributable to processed or smoked Chrysichthys fish product, which is exported from West Africa to Asian markets
	<i>Trachinus draco</i>	41	0.99	Marine	Greater Weever; venomous benthic marine fish of the NE Atlantic and Mediterranean; impossible in Bhutan
	<i>Cubiceps pauciradiatus</i>	35	0.97	Marine	Smalleye Cigar Fish; epipelagic oceanic fish of the tropical Atlantic; impossible in Bhutan; likely index-hopping or food contamination artefact
	<i>Solea solea</i>	30	1.00	Marine	Common Sole; demersal marine flatfish of the NE Atlantic and Mediterranean; confidence 1.000 confirms correct DNA — source is processed fish product; impossible as a living organism in Bhutan
	<i>Clupea pallasii</i>	22	0.80	Marine	Pacific Herring; anadromous and marine fish of the North Pacific; not distributed in South Asia; impossible in Bhutan

Station	Species	Reads	Confidence	Category	Reason for Exclusion
	<i>Trisopterus luscus</i>	22	1	Marine	Pouting; small demersal marine gadoid of the NE Atlantic; confidence 1.000 confirms correct DNA — contamination from processed fish product; impossible as a living fish in Bhutan
CNR03	<i>Hemimyzon pengi</i>	62	0.95	Not reported from Bhutan	Balitorid hillstream loach first described from Xishuangbanna, Menghai County, Yunnan Province, the People's Republic of China (Zheng et al., 1982), in the lower Mekong drainage; subsequently documented from Laos (Kottelat & Xin-Luo, 1988); no published record from the Brahmaputra drainage system or Bhutan in any ichthyological survey; the Mekong and Brahmaputra are geographically and hydrologically separate river systems with no natural connectivity for small benthic rheophilic loaches; the high confidence score (0.946) reflects genuine sequence similarity between the detected ASV and the reference entry, most likely because an unsequenced Himalayan balitorid shares close 12S homology with this Mekong congener; plausible at genus level but species-level assignment cannot be confirmed without conventional ichthyological survey

Station	Species	Reads	Confidence	Category	Reason for Exclusion
CNR04	<i>Enteromius radiatus</i>	67	0.711	Not reported from Bhutan	African Barb; freshwater cyprinid restricted to sub-Saharan Africa (Niger, Volta, Congo river systems); not reported from Bhutan or the Brahmaputra basin in any published survey; low confidence (0.711) diagnostic of database mis-assignment — an unsequenced Asian cyprinid ASV matched to its nearest African congener in the reference database
	<i>Piaractus mesopotamicus</i>	27	0.826	Not reported from Bhutan	Pacu; large freshwater Characid endemic to South American river basins (Paraná, Paraguay); not reported from Bhutan or anywhere in Asia; most likely a database mis-assignment artefact arising from the absence of a closely related Asian taxon in the reference database
	<i>Oncorhynchus clarkii</i>	19	0.733	Not reported from Bhutan	Cutthroat Trout; North American salmonid; not reported from Bhutan; low confidence (0.733) consistent with database mismatch; same mechanism as CNR01 detection

Station	Species	Reads	Confidence	Category	Reason for Exclusion
CNR05	<i>Enteromius radiatus</i>	17	0.711	Not reported from Bhutan	African Barb; sub-Saharan African freshwater cyprinid; not reported from Bhutan; same database mis-assignment mechanism as CNR04; recurrence at both CNR04 and CNR05 suggests a specific unsequenced Asian cyprinid ASV in this river system consistently matching <i>Enteromius radiatus</i> in the reference database
	<i>Tenualosa reevesii</i>	15	1	Not reported from Bhutan	Reeves' Shad (Chinese Hilsa); anadromous clupeoid native to major lowland river systems of the People's Republic of China (Yangtze, Pearl, Min Rivers); not reported from Bhutan, northeastern India, or the Brahmaputra basin; confidence 1.000 confirms genuine DNA identification — most likely contamination from dried Chinese shad, widely traded across Asian food markets
	<i>Bathypterois grallator</i>	8	0.756	Deep-sea	Tripodfish; strictly abyssal/bathypelagic fish at 200–5,000 m ocean depth; physically impossible in a Himalayan river system; low confidence (0.756) and very low read count (8) consistent with Illumina index-hopping artefact during multiplexed sequencing

3.2.1. Marine Species

Twelve marine taxa were excluded from ecological analyses as biologically implausible freshwater occurrences and interpreted as probable food-derived contamination signals. All twelve detections were concentrated exclusively at CNR02, with no marine species recorded at any other Bunakha station. The species detected comprised *Sardina pilchardus* (3,244 reads; confidence 1.000), *Scomber scombrus* (301 reads; confidence 0.930–0.968), *Mullus surmuletus* (164 reads; confidence 0.980), *Hippoglossoides robustus* (89 reads; confidence 0.960), *Merlangius merlangus* (88 reads; confidence 0.749), *Trachurus japonicus* (80 reads; confidence 0.953), *Dicentrarchus labrax* (65 reads; confidence 0.993), *Trachinus draco* (41 reads; confidence 0.890–0.991), *Cubiceps pauciradiatus* (35 reads; confidence 0.976), *Solea solea* (30 reads; confidence 1.000), *Clupea pallasii* (22 reads; confidence 0.806), and *Trisopterus luscus* (22 reads; confidence 1.000).

The predominance of high-confidence assignments within this group, seven of the twelve species returning confidence scores of ≥ 0.953 , with four at 1.000 confirms that the detections represent genuine DNA of those species rather than weak database matches. However, all twelve are obligate marine fish with Atlantic, Mediterranean, or North Pacific distributions and no capacity for freshwater residence. Their occurrence in a landlocked Himalayan river system is physiologically and biogeographically impossible. The most parsimonious explanation is food product contamination: all twelve species are commercially processed as canned, dried, or salted fish products that are widely distributed through South Asian retail and wholesale networks, and DNA from such products can enter water bodies through domestic wastewater, market runoff, or refuse disposal (Deiner et al., 2017; Keskin, 2014; Tsuji et al., 2017) in the catchment upstream of the sampling point. The spatial concentration of all twelve detections at the single station CNR02 further supports a localised contamination source at or upstream of that reach rather than a systemic methodological failure.

3.2.2. Deep-Sea Taxa

One deep-sea taxon, *Bathypterois grallator* (Tripodfish), was detected at CNR05 (8 reads; confidence 0.756). *Bathypterois grallator* is a strictly abyssal and bathypelagic fish

restricted to ocean depths of 200–5,000 m and has no biological capacity to occur in any freshwater system. Given the low read count, near-threshold confidence score, and the ecological impossibility of its presence in a Himalayan River, this detection was interpreted as a sequencing artefact, most plausibly attributable to Illumina index-hopping during multiplexed sequencing. This mechanism produces trace-level cross-sample read contamination at low frequency and is a recognised source of spurious low-abundance detections in multiplexed eDNA datasets (Pansu et al., 2015), particularly where reference libraries include sequences from deep-sea biodiversity surveys processed on the same sequencing platform (Schnell et al., 2015).

3.2.3. Freshwater Species Not Reported from Bhutan

Six freshwater taxa (*Oncorhynchus clarkii*, *Enteromius radiatus*, *Piaractus mesopotamicus*, *Chrysichthys nigrodigitatus*, *Hemimyzon pengi*, and *Tenuulosa reevesii*) were excluded from ecological analyses based on documented biogeographic absence from Bhutan's natural river systems. Unlike marine or deep-sea exclusions, these species are physiologically capable of inhabiting freshwater environments and therefore represent a scientifically distinct category of anomalous detection. Their exclusion is based not on ecological impossibility but on the absence of any documented occurrence in Bhutanese ichthyofaunal records.

This distinction carries two important implications. First, none of these taxa has been recorded from, or documented as introduced into, Bhutan's natural river systems in any published ichthyological survey (Changlu et al., 2021; DoL, 2017; Gurung et al., 2013; NRDCR&LF, 2020). Their presence therefore cannot be supported by existing biogeographic evidence. Should future surveys document verified introductions or naturalised populations of any of these species in Bhutan, they would warrant reassessment as potentially valid records. Second, the confidence scores associated with these detections provide a further diagnostic basis for their interpretation. *Oncorhynchus clarkii* was detected at CNR01 (223 reads; confidence 0.733) and CNR04 (19 reads; confidence 0.733); *Enteromius radiatus* at CNR04 (67 reads; confidence 0.711) and CNR05 (17 reads; confidence 0.711); and *Piaractus mesopotamicus* at CNR04 (27 reads; confidence 0.826). These low to near-threshold confidence scores are diagnostic of weak database matches to unrepresented regional taxa and support their interpretation as mis-

assignments of unsequenced Bhutanese cyprinid or salmonid ASVs to their nearest available database neighbours from other continents.

In contrast, *Chrysichthys nigrodigitatus* (45 reads at CNR02; confidence 1.000) and *Tenualosa reevesii* (15 reads at CNR05; confidence 1.000) returned maximum confidence scores, indicating correct identification of the DNA present in the sample. For these two species, the mechanism is not database mis-assignment but food product contamination: *Chrysichthys nigrodigitatus* is a West and Central African claroteoid catfish widely exported as a processed food commodity to Asian markets, while *Tenualosa reevesii* (Reeves' Shad or Chinese Hilsa) is a commercially important anadromous clupeoid from Chinese river systems whose dried form is traded extensively across Asia. *Hemimyzon pengi* (62 reads at CNR03; confidence 0.946) presents a distinct interpretive case within this category. Unlike the low-confidence mis-assignments above, its high confidence score (0.946) indicates a strong sequence match to the reference entry. However, *Hemimyzon pengi* is a balitorid hillstream loach first described from Yunnan Province, the People's Republic of China, and subsequently documented from the Mekong River basin in Laos and Vietnam (Zheng et al., 1982). It has no published record from the Brahmaputra drainage system or from Bhutan in any ichthyological survey. The Mekong and Brahmaputra are geographically and hydrologically separate drainage systems with no natural connectivity for small benthic rheophilic species. The high confidence score reflects the genuine similarity between the detected ASV sequence and the *H. pengi* reference entry, most likely because an unsequenced Himalayan balitorid loach shares close 12S sequence similarity with this Mekong congener.

3.3 Bhutan-Valid Fish Community

A total of 20 validated fish species were detected across the five Bunakha sampling stations. Species composition and station-wise read distributions are presented in Table 3. Cyprinids dominated the assemblage across all stations, with additional representation from Danionidae, Sisoridae, Nemacheilidae, Balitoridae, Botiidae, Cobitidae, Clariidae, and Anguillidae.

Although *Glyptothorax laosensis* has not been formally reported from Bhutan's documented ichthyofaunal records, it was retained for ecological interpretation owing to the strong congruence between its native habitat requirements and the conditions present

within the study area. *Glyptothorax laosensis* is a rheophilic sisorid catfish originally described from fast-flowing, high-gradient river systems in neighbouring regions of Southeast Asia and the eastern Himalayan periphery (Thomson & Page, 2006), which are ecologically comparable to the habitats surveyed in the Bunakha river system. Its detection across three stations (CNR02, CNR03, and CNR05) at consistent but low read abundances further supports an ecologically plausible occurrence rather than an artefactual signal.

Labeo rohita is not native to Bhutan and is widely recognised as a cultured and aquaculture-associated species across South Asia. Its detection at CNR02 (51 reads), CNR04 (5,928 reads), and CNR05 (47 reads), with a pronounced concentration at CNR04, is most plausibly attributed to aquaculture escape, downstream transport from stocked water bodies, or secondary contamination from fish handling and markets rather than an established wild population within the Bunakha river system.

The occurrence of *Labeo boggut* and several undescribed or provisionally identified taxa, including *Barilius* sp. CBM ZF 11313, *Garra* sp. CBM:ZF:12699, *Garra* sp. CBM:ZF:12697, *Garra* sp. CBM ZF 11369, *Garra* sp. CBM:ZF:12700, *Schistura* sp. CBM:ZF:15599, *Pangio* sp. CBM:ZF:11822, and *Devario* cf. *regina* CBM ZF 11307 is considered biogeographically plausible given their regional distribution in adjacent Brahmaputra basin river systems. Several of these represent voucher-based provisional designations from northeastern Indian surveys conducted in close geographic proximity to Bhutan. Their presence in the eDNA dataset is consistent with the known ichthyofaunal affinities of the region; however, formal confirmation of their occurrence in Bhutan requires targeted conventional ichthyological surveys and taxonomic verification.

Table 3: Distribution of validated fish species across sampling stations (CNR01–CNR05), including family-level classification and read abundance per station based on eDNA metabarcoding results.

Species	Family	CNR01	CNR02	CNR03	CNR04	CNR05
<i>Schizothorax</i> sp. TJH1	Cyprinidae	–	993	875	4,336	2,284
<i>Labeo rohita</i>	Cyprinidae	–	51	–	5,928	47
<i>Neolissochilus hexagonolepis</i>	Cyprinidae	–	547	3,420	–	485
<i>Barilius bendelisis</i>	Danionidae	–	1,196	–	–	–

Species	Family	CNR01	CNR02	CNR03	CNR04	CNR05
<i>Labeo boggut</i>	Cyprinidae	–	207	625	–	–
<i>Cyprinion semiplotum</i>	Cyprinidae	–	87	581	–	–
<i>Barilius</i> sp. CBM ZF 11313	Danionidae	–	246	130	–	–
<i>Garra</i> sp. CBM:ZF:12699	Cyprinidae	–	209	88	–	–
<i>Devario</i> cf. <i>regina</i> CBM ZF 11307	Danionidae	–	–	157	–	–
<i>Glyptothorax laosensis</i>	Sisoridae	–	10	121	–	18
<i>Anguilla bengalensis</i>	Anguillidae	–	–	89	–	–
<i>Aborichthys elongatus</i>	Nemacheilidae	–	–	78	–	–
<i>Botia rostrata</i>	Botiidae	–	–	55	–	–
<i>Schistura</i> sp. CBM:ZF:15599	Nemacheilidae	–	55	–	–	–
<i>Pangio</i> sp. CBM:ZF:11822	Cobitidae	–	–	47	–	–
<i>Garra</i> sp. CBM:ZF:12697	Cyprinidae	–	41	–	–	–
<i>Garra</i> sp. CBM ZF 11369	Cyprinidae	–	26	–	–	–
<i>Cabdio morar</i>	Danionidae	–	15	–	–	–
<i>Clariidae</i> sp.	Clariidae	–	–	–	–	12
<i>Garra</i> sp. CBM:ZF:12700	Cyprinidae	–	9	–	–	–

3.3.1. Sequencing Output and Diversity Metrics

Across the five sampling stations, a total of 292,450 reads were recovered, of which 23,068 reads (7.9%) corresponded to validated fish taxa retained for biodiversity analysis (Table 4).

CNR01 yielded no valid species-level assignments despite recovering 37,237 reads and 1,794 ASVs, a result attributable to reference database incompleteness for high-altitude Himalayan taxa rather than fish absence from the reach. Species-level diversity varied markedly among the remaining four stations, reflecting clear spatial differences in community structure along the river continuum.

CNR02 exhibited the highest species richness (14 valid taxa; $H' = 1.854$; $J' = 0.702$), characterised by a taxonomically diverse mid-elevation assemblage dominated by *Barilius bendelisis*, *Schizothorax* sp. TJH1, and *Neolissochilus hexagonolepis*, with a wide range of secondary cyprinid and nemacheilid taxa. The high evenness at this station reflects the relatively balanced read distribution across its many constituent species. CNR02 also carried the highest anomalous detection burden in the dataset (13 excluded

species, predominantly marine), underlining the influence of a localised anthropogenic contamination source at or upstream of that reach.

CNR03 was the second richest station (12 valid taxa; $H' = 1.558$; $1-D = 0.662$; $J' = 0.627$) and was the only station entirely free of marine or deep-sea anomalous detections, making it the most ecologically coherent and analytically reliable station in the Bunakha dataset. It was strongly dominated by *Neolissochilus hexagonolepis* (3,420 reads), with *Schizothorax* sp. TJH1, *Labeo boggut*, and *Cyprinion semiplotum* as secondary components alongside a diverse assemblage of smaller cyprinid, loach, sisorid, and anguillid taxa.

CNR04 showed the lowest evenness among stations with valid detections ($H' = 0.681$; $J' = 0.983$ across only two species), driven by the near co-dominance of *Labeo rohita* (5,928 reads) and *Schizothorax* sp. TJH1 (4,336 reads). This two-species dominance structure, despite the highest read depth of any station in the survey (72,165 reads), most likely reflects the influence of aquaculture-associated *Labeo rohita* at this reach rather than a genuinely depauperate native fish community. CNR04 also carried three exclusions, all freshwater taxa not reported from Bhutan, attributed to database mis-assignment of unsequenced local cyprinid ASVs.

CNR05 returned five valid species ($H' = 0.601$; $J' = 0.373$), dominated by *Schizothorax* sp. TJH1 (2,284 reads) with secondary contributions from *Neolissochilus hexagonolepis*, *Labeo rohita*, *Glyptothorax laosensis*, and *Clariidae* sp. The low evenness at this station reflects the strong numerical dominance of *Schizothorax* relative to the remaining taxa.

Table 4: Summary of sequencing output and diversity metrics for validated fish taxa across sampling stations (CNR01–CNR05), including total reads, species richness, diversity indices (Shannon H' , Simpson $1-D$, Pielou's evenness J'), number of excluded species and ASV-level Shannon diversity.

Station	Total Reads	Valid Spp.	Valid Reads (%)	H'	$1-D$	J'	Excl. Spp.	ASV H' (raw)**
CNR 01	37,237	0*	0 (0.0%)	N/A	N/A	N/A	1	6.521
CNR 02	57,115	14	3,692 (6.5%)	1.854	0.789	0.702	13	7.057
CNR 03	67,660	12	6,266 (9.3%)	1.558	0.662	0.627	1	7.003

Station	Total Reads	Valid Spp.	Valid Reads (%)	H'	1-D	J'	Excl. Spp.	ASV H' (raw)**
CNR 04	72,165	2	10,264 (14.2%)	0.681	0.488	0.983	3	6.683
CNR 05	58,273	5	2,846 (4.9%)	0.601	0.327	0.373	3	7.219

Note: * CNR01 zero valid species-level assignments; database gap for high-altitude Himalayan taxa

*ASV-level H' for methodological transparency only

3.3.2. Conservation-Priority Taxa

Two conservation-priority taxa were recorded within the validated Bunakha eDNA dataset, both of significant ecological and conservation importance within Himalayan River systems.

The Near Threatened Copper Mahseer (*Neolissochilus hexagonolepis*) was detected across three stations; CNR02 (547 reads), CNR03 (3,420 reads), and CNR05 (485 reads) with its highest read abundance recorded at CNR03. The strong signal at CNR03 and its consistent detection across three non-contiguous stations suggest a spatially distributed resident population rather than a transient occurrence and collectively indicate a continuous habitat corridor supporting this species throughout a substantial portion of the Bunakha survey reach. CNR03 is identified as the priority conservation monitoring station for this species within the Bunakha system, given both the magnitude of its eDNA signal and the ecological quality of that reach as reflected by the diversity and composition of its co-occurring fish assemblage.

The Near Threatened Indian Mottled Eel (*Anguilla bengalensis*) was detected exclusively at CNR03 (89 reads). As a catadromous species that migrates between freshwater feeding grounds and marine spawning areas, the detection of *Anguilla bengalensis* at CNR03 confirms longitudinal connectivity between the sampled reach and downstream lowland river systems, as the species requires unobstructed passage through the river corridor to complete its life cycle. Its occurrence at the same station as the peak Copper Mahseer signal further reinforces the conservation significance of the CNR03 reach within the Bunakha river system.

3.4 Limitations of the Present Study

The number of fish species detected through this eDNA metabarcoding survey is lower than those reported from the three baseline surveys conducted for the project. This

difference reflects known biological, methodological, and technical limitations of eDNA approaches rather than reduced ecological diversity.

Environmental DNA concentrations are highly sensitive to hydrological conditions. Sampling during monsoon and post-monsoon-influenced high-flow periods likely resulted in substantial dilution, increased turbidity, and accelerated DNA degradation, reducing detection probability for some taxa.

Taxonomic resolution was also constrained by the incompleteness of available reference databases for Bhutanese freshwater fishes. As a result, a proportion of sequence variants could not be resolved to species level, particularly within diverse genera such as *Schizothorax* and *Garra*.

In addition, the short 12S MiFish fragment limits discrimination among closely related species, which may lead to reduced apparent species richness in taxonomically complex groups. Detection probability is also species-dependent, with benthic, small-bodied, or low-shedding taxa likely underrepresented in the dataset.

Finally, the single-time-point sampling design does not capture seasonal variation in fish assemblages driven by migration and hydrological change, meaning that the observed diversity represents a temporal snapshot rather than a complete annual inventory.

Chapter Four

Conclusion

This eDNA metabarcoding survey provides a baseline assessment of fish diversity within the proposed Bunakha Hydropower Project area, identifying 20 valid fish species across five sampling stations along the river continuum. Although 19 anomalous detections were recorded and excluded from ecological interpretation comprising 12 marine species, one deep-sea species, and six freshwater taxa not previously reported from Bhutan the validated dataset revealed a taxonomically diverse and ecologically structured freshwater fish assemblage characteristic of a mid- to high-altitude Himalayan River system.

The assemblage is dominated by Cyprinidae, with additional representation from Danionidae, Sisoridae, Nemacheilidae, Balitoridae, Botiidae, Cobitidae, Clariidae, and Anguillidae. The survey recorded two conservation-priority taxa: the Near Threatened Copper Mahseer (*Neolissochilus hexagonolepis*), detected consistently across three stations with peak abundance at CNR03, and the Near Threatened Indian Mottled Eel (*Anguilla bengalensis*), recorded at CNR03, confirming longitudinal connectivity of the river corridor. Spatial patterns indicate marked variation in species richness and community evenness along the river gradient, with CNR02 and CNR03 supporting the highest diversity and CNR04 characterised by a two-species dominance structure most plausibly associated with aquaculture-related *Labeo rohita* input. CNR01 yielded no species-level assignments, reflecting reference database limitations for high-altitude Himalayan taxa rather than the absence of fish from that reach.

Despite methodological constraints inherent to eDNA approaches including the late monsoon-period sampling conditions that reduce eDNA detection sensitivity, the short amplicon length of the MiFish-U 12S assay, and the current incompleteness of reference databases for Bhutanese freshwater taxa the findings offer a scientifically defensible foundation for biodiversity assessment, environmental flow planning, and future aquatic monitoring within the Bunakha river basin. The results are best interpreted as a minimum species richness estimate, and repeat surveys during the low-water season (December–January) and pre-monsoon period (April–May) are recommended to achieve a more complete characterisation of the fish community and to confirm the status of conservation-priority species within the project area of influence.

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Sample Collection Photographs



