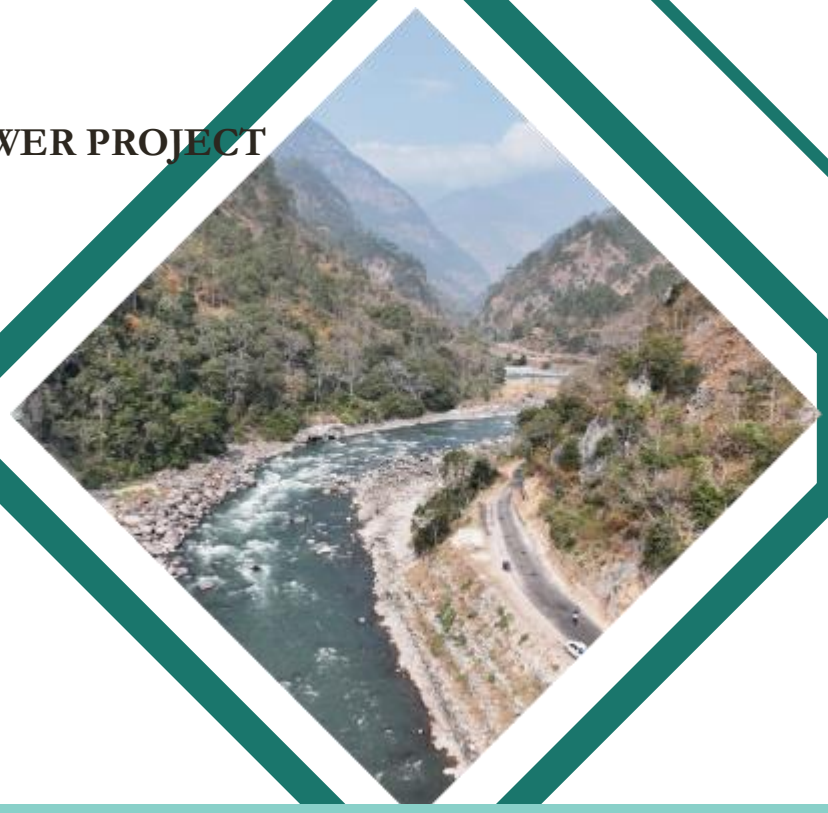
ENVIRONMENT & SOCIAL IMPACT ASSESSMENT (ESIA)

EXECUTIVE SUMMARY

DRAFT

1125 MW DORJILUNG HYROPOWER PROJECT
MONGAR AND LHUENTSE
BHUTAN



MARCH 2025

DRUK GREEN POWER CORPORATION LIMITED (DGPC)
THIMPHU, BHUTAN

Disclaimer:

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

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

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

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

Contents

List of Acronyms

AoI	Area of Influence	GLOF	Glacial Lake Outburst Flood
BC-7	Biological Corridor #7	GRM	Grievance Redress Mechanism
BMP	Biodiversity Management Plan	GWh	Gigawatt hours
BWS	Bumdeling Wildlife Sanctuary	HRT	Headrace Tunnel
C-ESMP	Contractor Environmental and Social Management Plan	LALRP	Land Acquisition and Livelihood Restoration Plan
CCFs	Contractor Construction Facilities	LMP	Labour Management Procedures
CIA	Cumulative Impact Assessment	masl	Meters above sea level
DGPC	Druk Green Power Corporation Limited	MDDL	Minimum Drawdown Level
DHPP	Dorjilung Hydropower Project	Mg/L	Milligram per Litre
DoECC	Department of Environment and Climate Change	MW	Megawatt
DOFPS	Department of Forests and Park Services	NECS	National Environment Commission Secretariat
E&S	Environmental and Social	OHS	Occupational Health and Safety
EFA	Environmental Flow Assessment	OE	Owner's Engineer
EFlow	Environmental Flow	PNP	Phrumsengla National Park
EFMP	EFlow Management Plan	PIU	Project Implementation Unit
EHS	Environmental Health and Safety	RAP	Resettlement Action Plan
EPC	Engineering, Procurement, and Construction	RMNP	Royal Manas National Park
EPR	Emergency Preparedness and Response	RoW	Right of Way
ESF	Environmental and Social Framework	SEA/SH	Sexual Exploitation and Abuse/Sexual Harassment
ESHS	Environmental, Social, Health, and Safety	SEP	Stakeholder Engagement Plan
ESIA	Environmental and Social Impact Assessment	TL	Transmission Line
ESS	Environmental and Social Standards	VEC	Valued Environmental Component
FSL	Full Supply Level		

1 Introduction

The Royal Government of Bhutan (RGoB), through Druk Green Power Corporation Limited (DGPC), is planning to implement the Dorjilung Hydropower Project (the Project or DHPP), with anticipated financial support from the World Bank. This initiative is a critical component of Bhutan's sustainable energy strategy, aimed at harnessing hydropower potential within the Kuri-Gongri River Basin to foster economic development and regional energy security. The Project entails developing a 1,125-megawatt (MW) run-of-river hydropower facility designed to generate approximately 4,504 gigawatt hours (GWh) of electricity annually, contributing significantly to the country's clean energy capacity.

Located in the Mongar and Lhuentse districts (*Dzongkhags*) in eastern Bhutan, the Project encompasses a 139.5-meter-high dam and supporting infrastructure such as a headrace tunnel and underground powerhouse. DGPC has undertaken a comprehensive Environmental and Social Impact Assessment (ESIA) aligned with Bhutan's regulatory requirements and the World Bank's Environmental and Social Framework (ESF) to mitigate and manage environmental and social impacts. This document provides the executive summary of the ESIA, highlighting key findings, mitigation measures, and strategies to promote environmental sustainability and social inclusivity.

1.1 Background

Bhutan's energy sector is predominantly characterized by its reliance on hydropower, which serves as the cornerstone of its economy and a vital source of revenue. Hydropower contributes over 30% of Bhutan's GDP, accounting for nearly 40% of the government's revenue. With significant untapped hydropower potential estimated at over 30,000 MW, Bhutan's energy strategy aims to harness this resource to advance sustainable development, reduce poverty, and strengthen regional energy security. As a country committed to environmental conservation, Bhutan has emphasized clean energy generation, making hydropower development a primary pathway for economic growth that aligns with its environmental goals.

The demand for electricity within Bhutan is relatively low due to its small population and limited industrial base, but domestic demand is rising steadily with economic growth and rural electrification efforts. Bhutan has successfully expanded its generation capacity to meet local needs while maintaining surplus energy for export, primarily to India. These exports are critical, providing a substantial revenue stream that funds social and infrastructure development within Bhutan. Over recent decades, Bhutan's installed capacity has reached approximately 2,453 MW, with ambitious plans to develop an additional 20,000 MW by the early 2040s. Projects like the DHPP play a crucial role in achieving this target.

1.2 The Proposed Project

Project Proponent. DGPC, Bhutan's national electricity utility company established in 2007, is the project's executing agency. DGPC operates and manages Bhutan's significant hydropower assets, including Basochhu (64 MW), Chhukha (336 MW), Kurichhu (60 MW), Mangdechhu (720 MW), and Tala (1,020 MW). DGPC's mission is to efficiently develop and operate renewable energy projects, primarily hydropower, to fuel Bhutan's energy needs sustainably. Committed to environmental stewardship and community well-being, DGPC actively supports social and environmental initiatives aligned with Bhutan's Gross National Happiness development philosophy. DGPC has engaged an international consulting firm, Studio Pietrangeli Consulting Engineers, Italy, to prepare the detailed engineering design of the Project from 2022 to 2024.

Location: The DHPP is located on the Kurichhu River within the Kuri-Gongri River Basin in eastern Bhutan (Figure 1). The project site lies in a remote, mountainous region with rugged terrain. The nearest major town is Mongar, approximately 30 km away, which provides essential regional infrastructure and services. The DHPP damsite is also located about 36 km upstream of the existing Kurichhu Hydropower Plant (60 MW).

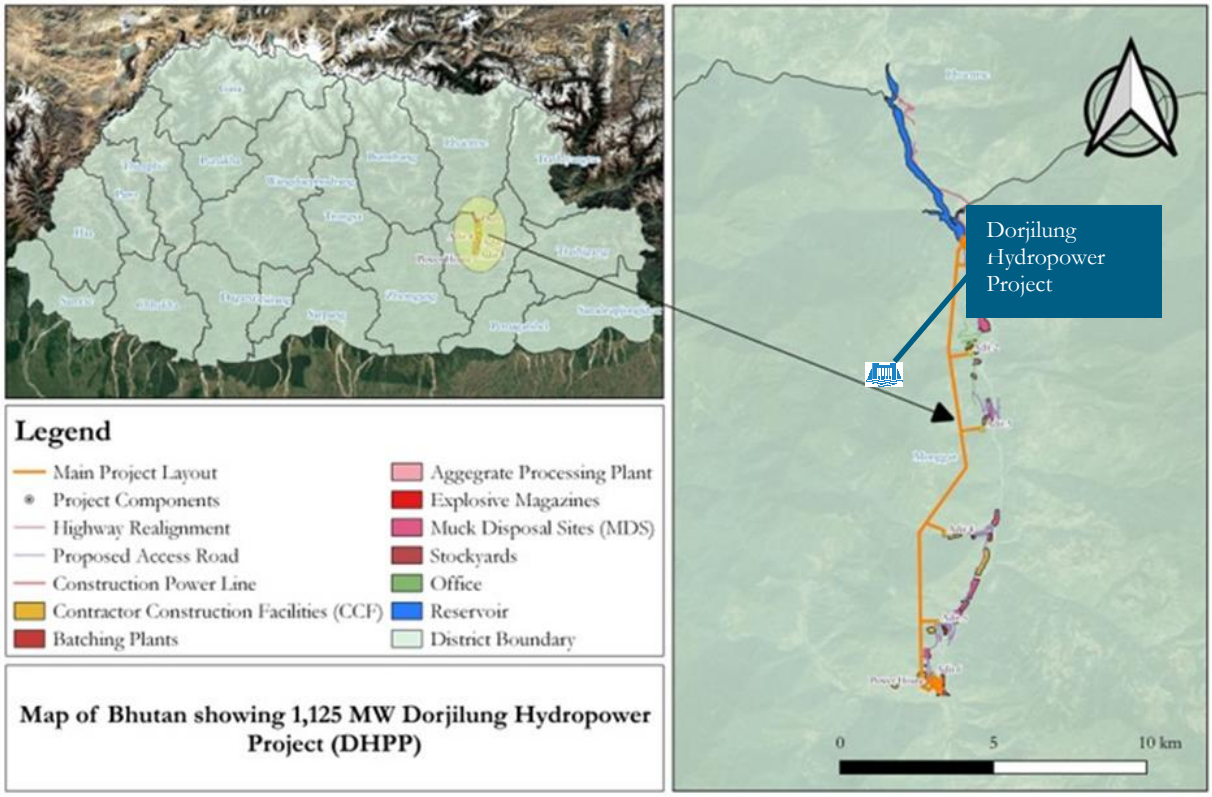


Figure 1: Location of Dorjilung Hydropower Project in Bhutan

Project Components: The Project's main components are summarized below, and the detailed project description is given in Section 3.

- **Dam and Reservoir**: A 139.5-meter-high concrete gravity dam will create a reservoir with a total storage capacity of 44.17 million cubic meters (MCM) and a surface area of approximately 145.82 hectares at the full supply level (FSL). The reservoir area extends 6.80 km upstream of the dam axis. The reservoir's FSL will be 850 meters, while the minimum drawdown level (MDDL) will be 840 meters.
- **Power Generation Facilities**: The powerhouse will be underground, located approximately 16 kilometres downstream from the dam and close to Lingmethang township. It will house six vertical Francis turbines, each with a capacity of 187.5 MW. Water from the reservoir will be diverted to the powerhouse through a 14.97 km headrace tunnel (HRT).
- **Peaking Mode Operation:** The project will operate in peaking mode with a daily operation of 8 hours, which will reduce the water flow in a 16 km stretch of the river between the dam and the powerhouse.
- **Ancillary Infrastructure:** The project also requires extensive ancillary facilities, including access roads, muck disposal sites, contractor facilities, stockyards, batching plants, and quarries.

1.3 Environmental and Social Assessment

Studies for ESIA: The ESIA for the Project is based on extensive field studies and data collected by Artelia France and Phuensum Consultancy Services of Bhutan, appointed as the independent environmental and social consultant (the Consultant) by DGPC. The Consultant led the ESIA to ensure compliance with the World Bank ESF, working closely with DGPC's design teams to compile comprehensive baseline data, assess potential impacts, and develop effective mitigation measures. A multidisciplinary team of specialists contributed to the ESIA, including experts in environment, e-flow, biodiversity, social sciences, gender, cultural heritage, and public health. Extensive consultations were conducted to engage stakeholders and incorporate their insights into the project's planning and mitigation strategies.

E&S Documents Prepared for the Project. In addition to the ESIA, the Consultant prepared the following environmental and social (E&S) documents for the project: the Environmental and Social Management Plan (ESMP), which details protocols for impact management throughout construction and operation; the Cumulative Impact Assessment (CIA), addressing basin-wide implications of DHP alongside other regional developments; the Biodiversity Management Plan (BMP), to address impacts to general biodiversity, protected areas and critical habitat features; and E-Flow Management Plan to assess the environmental flow requirements for the dewatered reach between the dam and tailrace and sustain the aquatic ecology. The documentation also includes Labour Management Procedures (LMP) to manage labour risks, a Stakeholder Engagement Plan (SEP) to ensure ongoing community participation and a Land Acquisition and Livelihood Restoration Plan (LALRP) to address the needs of those impacted by land requirements. These documents have been reviewed by the independent E&S panel of experts engaged by DGPC, the E&S team of the Project Implementation Unit (PIU) and the World Bank.

Contents of this Executive Summary: Following this introductory chapter, Chapter 2 provides an overview of Bhutan's legal and administrative framework and applicable World Bank Environmental and Social Standards (ESS). Chapter 3 presents a detailed project description. Chapter 4 provides an analysis of project alternatives. Chapter 5 describes the baseline physical, biological, and socio-economic environment surrounding the project. Potential adverse effects of the DHPP are discussed in Chapter 6, while cumulative impacts, including concerns related to other hydropower developments in the Kuri-Gongri Basin, are presented in Chapter 7. Mitigation and monitoring measures are outlined in the Environmental and Social Management Plan (ESMP), summarized in Chapter 8, which details institutional responsibilities and arrangements. Lastly, Chapter 9 summarizes all stakeholder consultations, along with their feedback and proposed disclosure arrangements.

2 Legal and Regulatory Framework

2.1 Applicable Legislation in Bhutan

Bhutan's legal framework requires that hydropower projects adhere to stringent environmental and social standards as defined by the following key regulations:

- Environmental Assessment (EA) Act, 2000: Mandates the preparation of Environmental Impact Assessments (EIA) for major infrastructure projects to evaluate and mitigate environmental impacts.
- National Environmental Protection Act 2007 is a general legislation that provides a foundational basis for the country's environmental protection policies and legislation and strengthens the institutional framework for environmental protection
- Forest and Nature Conservation Act, 2023: This act governs the protection of forested areas and biodiversity, with provisions to conserve critical habitats within project areas.
- Water Act of Bhutan, 2011: Provides a regulatory framework for water resource management, emphasizing adequate environmental flows (E-Flows) to safeguard aquatic ecosystems.
- Labour and Employment Act, 2007: Ensures the protection of labor rights, health, and safety during construction and operational phases.
- Land Act of Bhutan, 2007: Governs land acquisition, compensation, and related land management requirements.
- Environmental Guidelines for Hydropower Projects, 2012 and Power Transmission Line Projects 2012: Outlines environmental and social standards for hydropower and power lines development, guiding compliance across all project stages.

2.1.1 Environmental Clearance Requirements for the Project

The DHP is classified as a "red category" under the Environmental Assessment Act of 2000, necessitating a rigorous Environmental Clearance (EC) process. According to Section 15 of the Act and Sections 8 and 24 of the Regulation for Environmental Clearance of Projects, 2016, separate ECs are required for quarries and power transmission lines.

For red-category projects (excluding industrial projects), the EC process includes the following steps:

- Submission of Terms of Reference (ToR): The applicant submits a draft ToR to the Competent Authority (CA) for review, which is then forwarded to the Department of Environment and Climate Change (DoECC) for endorsement.
- Endorsement and Preparation of ESIA: The DoECC issues an endorsed ToR to the applicant, based on which the ESIA report is prepared and submitted.
- Review by Environmental Assessment and Technical Committee (EATC): The CA forwards the ESIA, submitted by the applicant, to the DoECC, where the EATC makes the final decision on EC issuance, rejection, or need for further studies. Public announcements are required per Section 28 of the EA Act, 2000.

The current status of Environmental Clearance for the Project. The ToR for the EIA study has been approved by the DoECC. The ESIA report of the Project, after review and approval by the World Bank, will be submitted to DoECC to obtain the EC for the Project.

2.2 Applicable World Bank Standards and Guidelines

2.2.1 Environmental and Social Framework

The World Bank, as the financier of the DHPP, requires that the project align with its ESF. The following Environmental and Social Standards (ESS) of the ESF are relevant to the Project.

- **ESS 1: Assessment and Management of Environmental and Social Risks and Impacts**. This standard applies to the DHPP as it is a high-risk project requiring a comprehensive ESIA. DGPC prepared a comprehensive ESIA address E&S risk and impacts across all project stages to ensure outcomes align with World Bank ESS 1.
- **ESS 2: Labor and Working Conditions**. ESS 2 applies due to the large workforce anticipated during construction, with over 6,000 workers, including a high proportion of foreign labor. DGPC prepared an LMP with procedures to ensure fair treatment, safe working conditions, and worker rights for all project-related employees.
- **ESS 3: Resource Efficiency and Pollution Prevention and Management**. The project's construction and operations will consume significant resources and produce waste, necessitating ESS 3. The DGPC has prepared an ESMP to address energy efficiency, pollution prevention, and waste management to minimize environmental impacts.
- **ESS 4: Community Health and Safety**. This standard is relevant due to potential community health and safety risks arising from the influx of workers, construction activities, increased traffic and dam safety. DGPC has engaged a team of independent technical and E&S panel of experts to review and approve the project designs and plans.
- **ESS 5: Land Acquisition, Restrictions on Land Use, and Involuntary Resettlement:** The DHPP will require over 800 acres of land, impacting both public and private lands. DGPC has prepared LALRP in accordance with ESS 5 requirements to ensure that displacement impacts are minimized and affected households are compensated or resettled appropriately.
- **ESS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources.** Given the project's impacts on Biological Corridor 7, natural habitats, including the dewatering of a river section, and critical habitat species (such as Bengal Tiger), ESS 6 applies to safeguard biodiversity and manage natural resources sustainably. The DGPC has prepared a BMP in accordance with ESS 6 requirements.
- **ESS 8: Cultural Heritage**. The standard is relevant to protect cultural heritage from project impacts. The project design considers cultural heritage, as reservoir levels are adjusted to avoid impacting *Autsho* Chorten, a significant cultural site. A Cultural Heritage Management Plan (CHMP) is prepared to ensure the protection and preservation of cultural heritage throughout the project lifecycle.
- **ESS 10: Stakeholder Engagement and Information Disclosure.** As a high-risk project, the DHPP requires comprehensive stakeholder engagement and information disclosure. ESS 10 supports transparent and continuous engagement with stakeholders to enhance project sustainability and community acceptance. A SEP is prepared to address these requirements.

Applicability of ESS 7: Indigenous Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities

A detailed screening was conducted to assess the applicability of ESS 7, which addresses Indigenous Peoples and their rights in the context of the DHPP. Based on comprehensive consultations, site assessments, and

demographic analyses, it was determined that ESS 7 does not apply to the project. The project area does not contain communities that meet the World Bank's criteria for Indigenous Peoples as defined under ESS 7, including considerations of distinct social, cultural, and economic identities tied to specific territories. The World Bank has concurred with the assessment.

2.2.2 Other World Bank Guidelines

Other World Bank guidelines and good practices relevant to the Project and complied with by DGPC in preparing the E&S instruments are given below:

- **World Bank Group Environmental, Health, and Safety (EHS) Guidelines**: Referenced for General Industry Best Practices (GIIP) and set performance standards acceptable to the World Bank, achievable with current technology. Relevant EHS Guidelines and Resources for the DHPP include:
- General EHS Guidelines: Covers cross-cutting environmental, health, and safety issues for all industries.
- EHS Approaches for Hydropower Projects: Provide guidance to address impacts and risks associated with hydropower development.
- Construction Materials Extraction Guidelines: Provides guidance on materials extraction specific to construction.
- Electric Power Transmission and Distribution Guidelines: Covers safe power transmission from generation facilities to distribution points.
- Guideline on Labor Influx Risks: Addresses social and environmental risks from temporary labor influx, including worker camps.
- Good Practice Handbook for Environmental Flows: Advises on managing environmental flows for hydropower projects to protect downstream ecosystems.
- Good Practice Note on Gender and GBV: Guides on addressing risks of sexual exploitation, abuse, and harassment in large civil works.
- Guides for Community-Based GRM and Workplace Harassment Prevention: Supports developing grievance mechanisms and workplace policies on harassment.
- Good Practice Handbook on Cumulative Impact Assessment: Assists in identifying and managing cumulative impacts for the private sector in emerging markets.

3 Project Description

3.1 Proposed Project Facilities and Civil Works

The proposed project activities are categorized into the following categories to explain the project description:

- **Preparatory works** include access roads to the main construction facilities, realignment of existing roads that will be submerged in the proposed reservoir, and power supply for construction purposes.
- **Hydropower facilities** include the construction of the dam, head race, and tail race tunnels, as well as diversion/adit tunnels, underground powerhouse, and power transmission lines.
- **Ancillary facilities** to support construction activities, such as contractors' facilities, including labor camps, storage yards, workshops, batching plants and muck disposal sites.

A location map showing all these facilities is given in Figure 2.

3.1.1 Preparatory Works

The preparatory works for the Project include the following activities to facilitate the construction of main hydropower facilities and will be carried out over an 18-month period:

- **Access Roads to the Main Construction Sites**: A total of 27.58 km of new access roads (at 10 locations) will be constructed to reach key project components, including the dam site, adit portals, headrace tunnel (HRT), surge shaft, and powerhouse, facilitating the transport of construction materials and equipment.
- **Highway Submergence and Realignment**: The project will submerge approximately 5.4 km of the Mongar to Lhuentse Highway near Autsho. The new Rewan to Autsho section of the highway will be realigned to 10.60 km (up from the current 6.80 km). This realignment includes 8.45 km of new road and a 750-meter tunnel.
- **Temporary Power Supply:** The main construction activities will require approximately 15 MW of power during construction. This demand will be met by constructing a new 132/33 kV substation at Rewan. The substation will connect to the existing 132 kV Kilikhar-Tangmachhu transmission line, which will be upgraded (18 km long). From this substation, power will be distributed to various construction sites, including the dam, tunnel adits, and powerhouse areas.
- **Existing** Farm **Road Improvements:** Approximately 8.93 km of the farm road will be improved, including widening and other enhancements.

3.1.2 Hydropower Facilities

The key facilities related to hydropower construction include the following, which will be carried out over a period of 60 months.

- **Dam:** The dam will be made of random fill material with an impervious core and roller-compacted concrete cladding on the downstream face. The dam's crest length is 241 meters, and it features six spillway gates, each measuring 9.0 meters wide by 15.1 meters high, with a design discharge of 451 m^3/s. The project will operate with a gross head of 300.45 meters.
- **Coffer Dams and Diversion Tunnels**: Two coffer dams will be constructed—one upstream and one downstream of the main dam to facilitate water diversion. Two diversion tunnels, each 11 meters in diameter and 929.33 meters and 821.66 meters long, respectively, will be constructed to divert the water.

- **Headrace Tunnel (HRT**): A 14.97-km-long, 11-meter-diameter tunnel to convey water from the dam to the underground powerhouse.
- **Adit Tunnels**: Six adit tunnels, with a combined length of 4,698.35 meters, will be constructed to provide access to the HRT for construction and excavation purposes.
- **Underground Powerhouse**: The powerhouse will house six Francis turbines, each with a capacity of 187.5 MW, for a total installed capacity of 1,125 MW.
- **Tailrace Tunnels:** Two tailrace tunnels, 8 meters in diameter, will return water to the Kurichhu River, approximately 3.5 km upstream of the existing Kurichhu Hydropower Plant. Tunnel 1 is 350 meters long, and Tunnel 2 is 360 meters long.
- **Transmission Line**: Power generated by DHPP will be transmitted via a 400 kV line to the existing Durungri substation, located about 40 km south of the powerhouse. Two potential transmission corridors have been identified, with the final alignment to be confirmed through detailed surveys.

3.1.3 Ancillary Facilities

The proposed ancillary facilities will include the following.

- **Contractor Construction Facilities (CCFs):** Nine CCFs will be established at strategic locations near the construction sites, each equipped with Labor camps for worker accommodation, site offices for operational management, storage warehouses for materials, workshops for equipment maintenance, parking areas for heavy machinery, and Fabrication yards for material preparation. DGPC staff will reside in existing accommodations near Autsho, Gyelpozhing, and Lingmethang, while most contracted workers (mainly foreign) will be housed within the CCFs.
- **Stockyards:** Four stockyards, covering about 21.46 acres, will be established near adits and the dam site to store construction materials.
- **Explosive Magazines:** Five explosive storage magazines, spanning 2.85 acres, will secure explosives needed for tunnelling and excavation.
- **Material Storage Areas:** At batching plants, dedicated areas will store cement, fly ash, and other bulk materials. Conveyors will facilitate efficient handling and transport.
- **Muck Disposal Sites (MDS):** Twelve muck disposal sites, with a total area of approximately 198.74 acres, will manage waste from tunnelling, dam construction, and excavation.
- **Office Building:** A non-residential complex at the powerhouse will include offices, storage, and some recreational facilities, supporting administrative needs during the operation and maintenance phase.

3.2 Resource Requirements

Construction Material: The Project will require significant materials for its construction. These include:

- **Cement**: About 405,000 metric tons of cement will be needed throughout the construction period.
- **Steel**: About 65,000 metric tons of steel will be used for reinforcement in concrete structures and other applications.
- **Aggregates**: About 1,460,000 cubic meters of aggregates will be required, primarily sourced from nearby quarries.
- **Sand**: About 300,000 cubic meters of sand are anticipated to be used in concrete production and other construction activities.

Borrow and Quarry Areas: To meet the resource requirements, borrow and quarry areas have been identified near the project sites. The key locations include:

- **Quarries**: Two main quarry sites will be developed in Tsakaling and Saling Gewogs, providing the majority of aggregates and construction material.
- **Borrow Areas**: Sand and other minor aggregates will be sourced from Natural Resources Development Corporation Limited (NRDCL) sand mining operations near Gyelpozhing and Authso.

Construction Equipment: The Project will require extensive construction equipment, including excavators, bulldozers, dump trucks, concrete mixers, cranes, and drilling equipment. About 10 water tankers will be used for dust control and construction. To meet material demands, the following will be established:

- **Two crushing plants** will be established with a capacity of 300 and 750 tons per hour.
- **Five batching plants** will be installed with capacities ranging from 40 to 720 cubic meters per hour.

Manpower Requirements: The labour requirement for the Project will include direct workers and contracted works. The approximate manpower requirements of the Project are estimated below.

- **Construction Phase**: During the peak construction period, the project will require around 6,350 workers, approximately 90% of whom will be foreign labor. DGPC will mobilize an additional 466 Bhutanese workers for various activities.
- **Operational Phase**: Once the project becomes operational, a smaller workforce of approximately 219 workers will be required for operations and maintenance.

3.3 E&S Considerations in Project Design

Climate Resilience: DHPP's designs incorporate climate resilience measures to mitigate risks from floods and glacial lake outburst floods (GLOFs), ensuring long-term sustainability. The design flood values include a design flood of 16,225 m^3/s, a check flood of 20,123 m^3/s, and a Probable Maximum Flood (PMF) of 11,885 m^3/s, factoring in potential GLOFs. The dam break analysis confirmed resilience to GLOF events, supplemented by an early warning system and remote monitoring for glacial lake conditions.

Geophysical Risks: Given Bhutan's seismically active location, the DHPP design incorporates measures to withstand potential earthquakes, referencing significant past events such as the Shillong (1897, magnitude 8.7) and Assam (1950, magnitude 8.5) earthquakes. A Seismic Hazard Assessment identified regional fault lines, ensuring the dam's resilience to moderate to high-intensity quakes, supported by a seismic monitoring system to track ground vibrations. The project area, prone to landslides, has seven major identified landslide sites. Mitigation measures, including erosion control, slope stabilization, and continuous monitoring, will be implemented to protect the dam and infrastructure from landslide impacts.

E-flow Releases: The Project designs incorporate Environmental Flow (E-flow) releases to maintain the health of aquatic ecosystems within the dewatered reach and protect riverine biodiversity. A base E-flow of 6 m^3/s is designated for the dry season with provisions for adjusting flow.

3.4 Operational Procedures

The operational procedures for the DHPP reservoir are designed to balance power generation needs with environmental and safety considerations. The reservoir will be managed through a diurnal storage system, facilitating continuous peaking operations with up to 8 hours of energy generation. The reservoir's Full Reservoir Level (FRL) is set at 850 meters above sea level (masl), with a Minimum Drawdown Level (MDDL) of 840 meters. Seasonal sediment management will involve annual flushing during the monsoon period, typically in July and August, to maintain reservoir capacity and prevent excessive sediment accumulation.

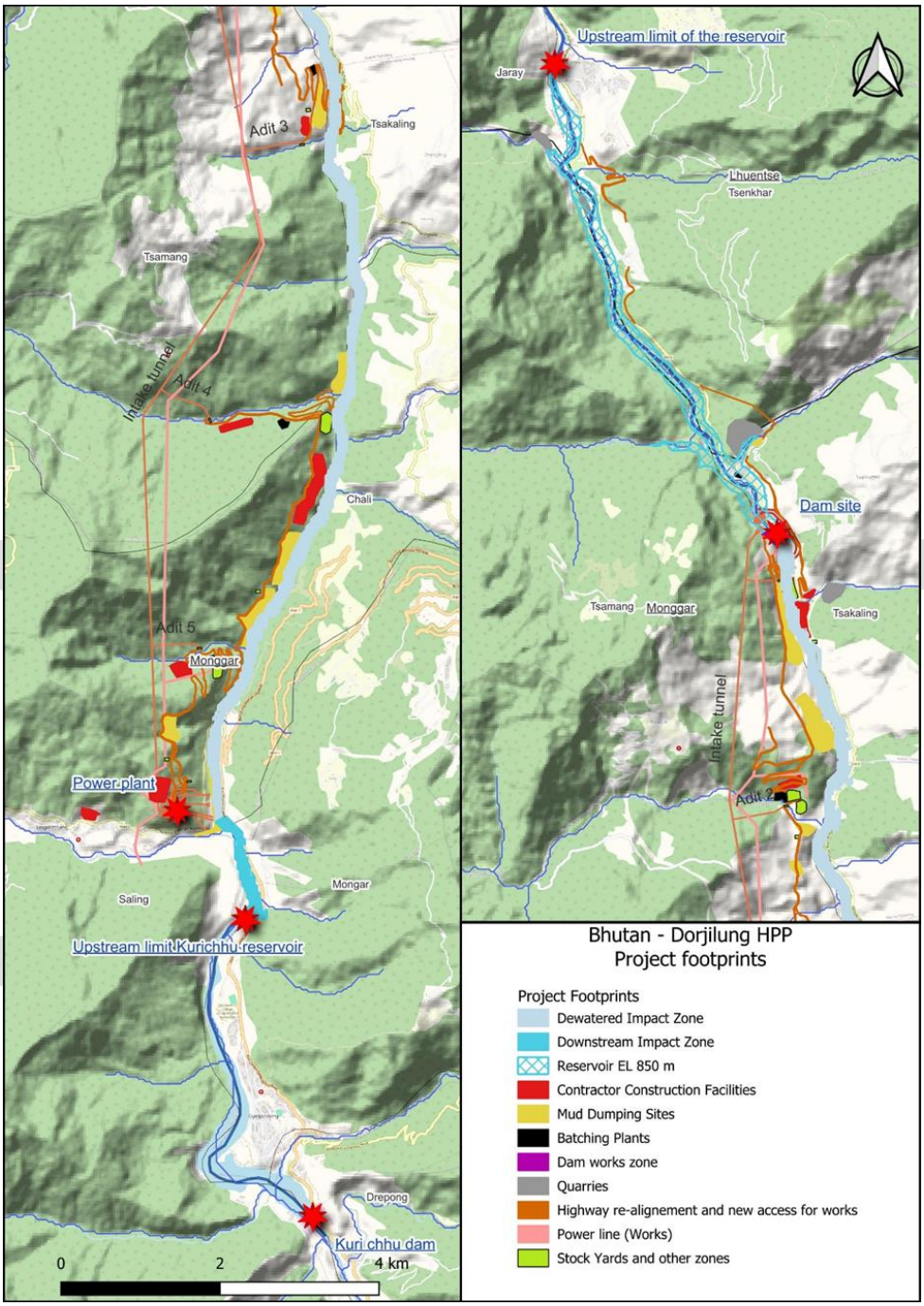


Figure 2: Proposed Layout of DHPP

4 Analysis of Alternatives

The feasibility and detailed designs of DHPP from 2011 to 2024 underwent a comprehensive analysis of alternatives, considering technical, environmental, and social factors to minimize the project's adverse impacts. The selected alternatives in the Project minimize environmental and social impacts.

4.1 Without Project Alternative

The "Without Project" scenario would avoid the E&S impacts associated with the construction and operation of the DHPP. However, it would also mean forgoing a significant opportunity to harness Bhutan's abundant hydropower potential, estimated at 37 GW, of which only 7.5% has been utilized. This alternative would fail to meet Bhutan's increasing electricity demand and limit economic benefits from renewable energy generation, both for domestic use and export. Hydropower export revenues are essential to Bhutan's economy, especially with limited alternative income sources, and forgoing DHP would pose considerable risks to national development and the economy.

4.2 System Alternatives

Alternatives to hydropower generation, such as wind, solar, and thermal power, were considered. While Bhutan possesses theoretical potential for both wind and solar energy, the country's mountainous terrain, high installation costs, and variable energy output make these alternatives less viable than hydropower. Solar and wind technologies have limited development and would not sufficiently meet the energy demands addressed by the DHPP. Thermal generation, although technically feasible, would result in much higher greenhouse gas emissions, making hydropower the most environmentally and economically sustainable option.

4.3 Location Alternatives

Various location alternatives for the DHPP's major components, including the dam, powerhouse, and ancillary facilities, were assessed.

Earlier feasibility studies proposed three location alternatives for the dam site. Alternative I, located near Autsho Township, would have resulted in the complete submergence of the town, displacing over 1,500 residents and destroying key infrastructure such as schools and healthcare facilities. Hence, this alternative was rejected. Alternative II moved the dam further downstream, reducing the impact on Autsho but still affecting smaller settlements and requiring substantial infrastructure adjustments. While it minimized some flooding, this option still posed challenges regarding road realignments and social disruptions. Alternative III, the final selected location, places the dam upstream of Autsho, fully preserving the township and its population. Although this option required more complex technical solutions, including additional excavation and tunnelling, it was chosen due to its significant social benefits and its ability to prevent the flooding of Autsho, thus balancing environmental, social, and technical considerations.

Similarly, the powerhouse site was shifted downstream to optimize energy output while minimizing environmental and social disruptions. The current location was chosen to balance technical efficiency and reduced land acquisition.

4.4 Design and Technology Alternatives

Several design and technology alternatives were considered, focusing on dam height, tunnel configurations, and sediment management techniques. Nine scenarios were evaluated for the Full Supply Level (FSL) of the reservoir. The optimal FSL of 850 masl was selected to prevent the flooding of Autsho while ensuring adequate water storage for energy generation. Design adjustments to the powerhouse and headrace tunnel also helped

mitigate environmental impacts. For sediment management, advanced modelling techniques ensured that sediment flushing would minimize disruptions to the downstream aquatic environment.

4.5 Construction Alternatives

Construction alternatives focused on reducing the project's environmental footprint. One significant change involved shifting construction facilities from the left to the right bank of the Kurichhu River to reduce lengths of access road construction and limit land clearing. Further, alternatives for muck disposal sites, road alignments, and contractor construction facilities were evaluated. The preferred construction methods and locations were selected based on their ability to minimize land disturbance, especially in forested areas, while ensuring efficient project delivery.

4.6 Operational Alternatives

Operational alternatives include run-of-river (RoR) and peaking-run-of-river (PRoR) modes. While RoR would maintain a more natural flow regime, it would not provide the required energy during peak demand periods. Also, the close proximity of the Kurichhu HPP reservoir downstream of the DHPP dewatered reach minimizes adverse impacts of peaking flow releases. PRoR, the selected alternative, allows the project to store and release water during high-demand periods, ensuring a balance between energy generation and environmental considerations. The PRoR option minimizes the reservoir size, reducing the ecological impact. Nine alternatives for the dam height and, thus, the size of the reservoirs was considered before selecting the current option.

4.7 Transmission Line Alternatives

Two transmission line (TL) routes are proposed for power evacuation from the DHPP to the Durungri substation. The proposed transmission corridors have approximate lengths of 33.5 km (TL1) and 39.5 km (TL2). The transmission voltage is 400 kV, with a generation voltage of 13.8 kV. According to Bhutan Power Corporation standards, the transmission line Right of Way (RoW) will be 48 meters, with a minimum tree clearance distance of 5.5 meters. Towers will be spaced at approximately 350 meters, within a 300–500 meters range, suitable for a 400 kV line. Additional studies will be needed to select the final alignment to minimize forest clearing, avoid settlements, and constructability.

5 Environmental and Social Baseline

Definition of Project Area of Influence: The Area of Influence (AoI) for assessing the baseline conditions in the Project area includes the following Direct and Indirect zones**.**

- **The Direct AoI** encompasses the immediate footprint of all project facilities, including both temporary and permanent installations and the submergence area created by the reservoir. This area extends to a 5-km radius from the main facilities. For terrestrial flora, the impact zone is further refined to the project footprint plus a buffer of 50–100 meters. For aquatic impacts, the downstream AoI ends at the existing Kurichhu HPP reservoir, which acts as a flow modulation basin for DHPP's peaking operations, while the upstream extent reaches the Yungichhu HPP, located approximately 30 km upstream. Socio-economically, the Direct AoI includes 56 villages across 7 blocks (*gewogs*).
- **The Indirect AoI** includes an additional buffer of 10 km around the Direct AoI to capture broader environmental and social interactions. This includes parts of the larger Biodiversity Corridor #7, which protects the movements of migratory and mobile species. The aquatic influence may extend downstream and upstream based on species' migratory patterns. For terrestrial wildlife, especially threatened or mobile species, the Indirect AoI considers population dynamics and habitat continuity. Additionally, socio-economic studies encompass the broader Mongar and Lhuentse districts.

5.1 Physical Environment

Physiography: The DHPP is located within the scenic valley of the Kurichhu River in eastern Bhutan, where the river flows through high ridges and deep valleys carved into the landscape. The region surrounding the project site is characterized by rising peaks and steep hills, with elevations ranging from 1,000 to 2,500 masl. Further south, the river descends to an altitude between 500 and 1,000 masl. The area is sparsely populated, with approximately 56 villages and hamlets within the direct AoI. Dense forests cover much of the region, providing essential habitats and biodiversity corridors that are largely intact. The project area also includes agricultural land used primarily for subsistence farming.

Climate: The DHPP is situated in Bhutan's Humid Subtropical Zone, characterized by a mean annual temperature ranging from 31°C in August to 8°C in January. December to February are the colder months, with an average temperature of 8°C and regular frosts. The project area experiences distinct wet and dry seasons, with an average annual rainfall between 840 mm at Autsho and 900 mm at Mongar. June to September are monsoon months with heavy rainfall. Some areas of the project catchment receive up to 1,700 mm annually. Bhutan's climate in the project area is projected to become warmer and wetter due to climate change, potentially affecting project operations.

Hydrology: Kurichhu River originates from the glaciated northern slopes of the Higher Himalayan Range in eastern Tibet. The river's two main upper branches, Lhobrakchhu and Hamachhu, converge to form the Kurichhu. Flowing southward through a narrow, deep gorge, the Kurichhu spans approximately 264 km, draining a basin area of 9,374 km^2 before joining the Gongrichhu. The mean annual flow at the dam site is 280 m3/s with a mean maximum of 1,350 m^3/s and a mean minimum of 60 m^3/s. The river flows are generally higher from June to October, coinciding with monsoon, and with reduced flows from December to March, coinciding with the dry season. The calculated Probable Maximum Flood (Design Flood) for Dorjilung HPP is 11,885 m3/s. A 25–year return period flood (2,152 m^3/s) has been selected for the construction flood design event.

Geology: The DHPP area's geology is part of the Shumar Formation, comprising alternating layers of quartzite, phyllite, and mica schist, with bands of carbonate and gypsum. The soils in the project area are predominantly sandy and gravelly, with low organic content.

Seismicity: The DHPP is situated in a seismically active region of the Eastern Himalayas, characterized by historical occurrences of moderate to high-intensity earthquakes. Notable past seismic events include the Shillong Earthquake of 1897 with a magnitude of 8.7 and the Assam Earthquake of 1950 with a magnitude of 8.5. Additionally, significant regional earthquakes, such as the Srimangal earthquake (1918, magnitude 7.6) and the Bihar-Nepal border earthquake (1934, magnitude 8.3), highlight the tectonic activity near Bhutan. Comprehensive seismic hazard assessments have been conducted to identify active fault lines and assess potential risks. The project's dam and related infrastructure have been designed to withstand such seismic events, and a robust monitoring system will be in place to track seismic activity and enhance safety measures.

Sedimentation: The sediment load in the Kurichhu River primarily consists of sand and gravel with minimal fine material, resulting in low organic matter content and reduced potential for organic pollution. This sediment composition is largely attributed to the rugged topography and high erosion rates within the catchment. Sediment transport in the river is predominantly concentrated during the monsoon season when heavy rainfall and steep gradients amplify erosional processes. Annual sediment loads range from approximately 3.18 million tons to 18.37 million tons, with suspended sediment concentrations varying significantly between 0.35 mg/L and 6,838 mg/L.

Floods and Other Natural Hazards: The Kurichhu basin has experienced historical flood events, often resulting from multiple natural triggers. Floods in the basin can occur due to sudden blockages by landslides along the river or its tributaries, causing overtopping and subsequent outbursts. Another risk is the sudden release of water from ice barriers or glacial lakes, which can lead to significant flooding downstream. A GLOF study identified 109 glacier lakes in the Kuri basin. The region has also witnessed heavy floods during prolonged and intense storms, as well as during extreme snow and glacier melting events. The area is also prone to landslides and rockfalls due to the steep slopes and cliffs (several active areas in the Project area) and wildfire during winter (drier season).

Water, Air and Noise Quality: Water quality analysis, based on 60 samples from the project area, indicates Class A quality of National Environment Commission Secretariat (NECS) criteria, with only slight organic contamination from human and animal sources. The air quality in the DHPP area is generally excellent, with pollutants such as PM2.5, NO_2, SO_2, and CO well below NECS and World Health Organization (WHO) guidelines. Noise levels in the project area are also low, consistently below the recommended thresholds of 65 decibels (dB) by NECS and 55 dB for residential areas as per World Bank EHS guidelines.

5.2 Biological Environment

Terrestrial Ecosystems: Eastern Bhutan has three main ecosystems: the alpine, temperate, and subtropical.

- The alpine zone (above 4,000 masl) features alpine meadows and scrublands dominated by species like Rhododendron and juniper and medicinal herbs such as Aconitum and Gentiana. Key fauna includes Snow leopard, Lynx, Blue sheep, and Musk deer.
    - The temperate zone (2,000–4,000 masl) consists mainly of Fir forests, Mixed Conifers, and blue pine forests, supporting species like Red Panda, Capped Langur, Bengal Tiger, and Clouded Leopard.

- The subtropical zone (150–2,000 masl) encompasses dense jungles along foothills and riverbanks with high rainfall. Dominant flora includes species like Shorea robusta and Bombax ceiba, while fauna includes Water buffalo, Golden langur, Sambar, and Gaur.

Natural and Modified Habitats. Within the DHPP AOI (a 10 km radius), the land cover primarily comprises natural habitats, with 93.41% of the area categorized as natural habitat and 6.59% as modified habitat.

- **Natural habitats**: Broadleaf Forest dominates, covering 65.84% of the AoI, followed by Chirpine forests (20.55%), shrubs (3.59%), and mixed conifer forests (1.94%). Other minor natural habitats include riparian forests (0.48%), rivers (0.69%), meadows (0.17%), and areas impacted by landslides (0.13%).
- **Modified habitats:** Comprising 6.59% of the AoI, these include agricultural lands like Chhuzhing (0.71%) and Kamzhing (3.67%), as well as orchards (0.01%), built-up areas (0.21%), and roads/tracks with buffer zones (1.98%)

Protected areas: The Project area is located near the following legally gazetted protected areas:

- **Phrumsengla National Park (PNP)**: Covering 906.65 km², PNP conserves Bhutan's temperate ecosystems and connects to four other protected areas through Biological Corridors. Its diverse habitat range supports over 1,000 plant species (21 endemic), 70 mammal species (including endangered species like the Bengal Tiger, Red Panda, and Musk Deer), 364 bird species, and other reptiles, amphibians, and butterflies. Although DHPP does not lie within PNP, it is located about 2 to 3 km at some places from DHPP, and a small section of the DHPP AOI (about 9% or 83 km²) overlaps with PNP.
- **Bumdeling Wildlife Sanctuary (BWS)**: Spanning 1,534.24 km², BWS protects mid- and high-altitude ecosystems in eastern Bhutan, featuring warm broadleaved forests, alpine scrubs, and lakes. Its biodiversity includes 966 plant species, 52 mammal species (including endangered species like the Tiger, Red Panda, Musk Deer and Wild Dog), 356 bird species, and unique fauna like the endemic butterfly *Bhutanitis ludlowi*. BWS is located outside the DHPP AoI.
- **Biological Corridor 7 (BC-7):** Connecting PNP and BWS, BC-7 encompasses 420 km² and protects migratory routes for species such as the Tiger and Red Panda. The project's AOI (30 km²), including reservoir footprint (1.5 km²), will intersect the southern arm of BC-7, widening the river from 50 to 200 meters (due to reservoir formation from the dam), impacting habitat connectivity in the corridor.

Field surveys and terrestrial species recorded: Detailed field studies in the project area during May and October 2023 identified 286 plant species of 93 families (including two endangered and one vulnerable), 22 reptiles (one vulnerable), 2 amphibians, and 11 mammal species. The camera trapping study for the DHPP, conducted from December 2023 to February 2024, captured images of 23 mammal species within the project's AoI. Key findings included sightings of threatened species, such as the endangered Bengal Tiger, Dhole (or Asiatic Wild Dog), and Red Panda. In addition, vulnerable species, including the Asiatic Black Bear, Clouded Leopard, and Marbled Cat, were recorded alongside other fauna.

Birds. The bird survey in the project area identified 198 bird species, including significant species, including the Endangered Pallas's Fish-eagle. The Kalij Pheasant showed high relative abundance and a broad distribution across the region. The key biodiversity areas located close to the project area are PNP and Kori La, and they include five threatened bird species.

Aquatic ecosystems: The Kurichhu River mainstream has a width of over 50 meters, with fast-flowing currents (0.4–4 m/s) and a mineral substrate dominated by gravel, rocks, and boulders, with occasional sandy patches. The tributaries are narrower, ranging from 5 to 8.5 meters, and also exhibit fast currents (0.2–3.6 m/s) with diverse substrates of large stones and blocks. Some tributaries, such as Khalangzey and Kharicchu, feature complex habitats, including pools, large boulders, and riparian vegetation. The average dissolved oxygen of the rivers is 7.6 mg/L, pH is 7.4, the temperature is 18°C, total dissolved solids 90 mg/L, and turbidity is 4 NTU. Field surveys indicate the presence of 9 types of micro invertebrates, 14 zooplanktons, 32 phytoplankton, 6 species of riparian flora and no presence of aquatic flora in both the main river and tributaries.

Aquatic ecological surveys and species recorded: A comprehensive fish survey, including environmental DNA (e-DNA) analysis, was conducted spanning two seasons: pre-monsoon (April–May 2023) and post-monsoon (October 2023). The study identified at least 19 fish species within the Kurichhu River and its tributaries. Key species documented include the migratory Indian Mottled Eel, Snow Trout (a vulnerable species), and three endemic catfish species.

Spawning behaviour of fish: For Snow Trout, the primary spawning period occurs in April and May, with evidence suggesting continued spawning until late autumn (September–October), as indicated by the presence of small fingerlings recorded from September to December 2019. The species prefers shallow, gravelly riverbanks in larger rivers with slow currents or smaller stream reaches for spawning. The snow trout migrates from the rivers to tributaries during high-flow periods and returns to the main river during low-flow periods.

5.3 Critical Habitat Assessment

The Critical Habitat Assessment for the Project highlighted the following key findings:

- **Terrestrial Habitats**: The Biological Corridor #7 is designated a critical habitat within the project's Area of Influence due to its importance for endangered species, particularly the Bengal Tiger, Dhole and Red Panda. This corridor provides vital ecological functions, through sustaining prey populations and maintaining genetic continuity for threatened predators.
- **Aquatic Habitats**: The Kurichhu River downstream of the project serves as an aquatic natural habitat, sustaining a healthy aquatic ecosystem including migratory fish species and broader ecosystem dynamics. This relatively pristine and ecologically valuable section of the river plays a key role in maintaining the river's biodiversity.
- **Critical Habitat Species**: The assessment identified several critical habitat species within the AoI based on ESS6 criteria. Critical habitat qualifying species that will potentially be impacted by the DHC have relevance to the Project as they require measures to achieve net gain. These species include:
  - **Mammals:** Bengal Tiger (*Panthera tigris*), Dhole (*Cuon alpinus*), Red Panda (*Ailurus fulgens*) and Capped Langur (*Trachypithecus pileatus tenebricus*).
  - **Birds:** Pallas's Fish-eagle (*Haliaeetus leucoryphus*)
  - **Fish:** Three range-restricted catfish (*Creteuchiloglanis bumdelingensis, Parachiloglanis bhutanensis*, and *P. dangmechuensis*)
  - **Flora:** *Hoya Bhutanica* (family Apocynaceae)

5.4 Social and Economic Environment

Demographics and Religion: The project area is located in Mongar and Lhuentse districts, which are predominantly rural with small, scattered villages. The people in the project area are predominantly Buddhists,

with Kurmaeds as the dominant socio-cultural group across most gewogs, while Chhaling Gewog uniquely notes the presence of Chhalips as a distinct socio-cultural group, both of which enrich the region's cultural diversity and influence its traditions, dialects, and social practices. Communities are characterized by close-knit familial and social networks. Dzongkha and local dialects are commonly spoken, with some proficiency in English. Communities are structured around settlements with key boundaries such as rivers, forests, and highways, providing natural resources and connectivity.

The population in the six gewogs across the two districts of the project area totals approximately 18,750 people, with an average population density of 18 people per km^2. A socio-economic survey conducted in May 2023, covering 508 households, recorded a population of about 1,906 individuals, with an average household size of 3.75 members. Gender distribution is nearly balanced, with 51% male and 49% female. Youth (under 15 years) account for 30% of the population, while the elderly (above 65 years) constitute 12%. The majority of the population (58%) falls within the working-age group (15–64 years), highlighting the significant potential for integration into project-related employment opportunities.

Land Use: Land use in the project area primarily revolves around subsistence agriculture, with households cultivating rice, maize, millet, and vegetables. Some commercial farming of fruits like oranges and avocados has also been reported. Farming challenges include wildlife interference, pests, and limited access to markets. Farmers rely on traditional tools and techniques but are gradually adopting improved methods like electric fencing and crop rotation. Business activities are small-scale, with general shops and restaurants being common. In addition, many households engage in community forestry and manage small private forests for fuelwood, fodder, and timber.

Land Ownership: Land tenure is a combination of private ownership and community-managed forests. A significant portion of the land in the project's AOI is categorized as forest land, which is critical for sustaining local livelihoods. Women own land in some households, but decisions on land sale or lease are typically made by male family members. Land ownership patterns reveal a mix of private holdings and community land use, with 80% of households holding formal Thram (land title certificates). Smallholders dominate, with an average plot size of 1.5 acres. Community land provides critical resources, including firewood and grazing areas. Land-use disputes are minimal due to Bhutan's strong regulatory frameworks, ensuring well-defined property boundaries and usage rights.

Economics and Livelihoods: Agriculture is the dominant livelihood, with households practicing both subsistence and commercial farming. Crops include vegetables, fruits like oranges and avocados, and staples like rice and maize. Farming challenges include wildlife interference, pests, and limited access to markets. Farmers rely on traditional tools and techniques but are gradually adopting improved methods like electric fencing and crop rotation. Cardamom cultivation is the primary cash crop, with over 60% of households participating in its production. Livestock farming is an integral part of household livelihoods, with cattle, poultry, and goats being the most common livestock. Some residents also engage in seasonal migration to urban centers for wage labor and remittances, which contribute to household incomes. Business activities are small-scale, with general shops and restaurants being common. Despite these activities, rural poverty remains high, with limited access to external markets and job opportunities. The average annual household income is $1,500, with significant disparities between lower and higher-income households. Seasonal variations in income are tied to harvest cycles, impacting financial stability. Households allocate approximately 60% of their income to food and basic necessities. Education and healthcare expenditures constitute 15%, while savings are minimal due to high subsistence demands.

Access to Credit and Savings: Formal banking services are limited, with only 40% of households accessing institutional credit. Informal savings groups are prevalent, facilitating small loans for emergencies and agricultural inputs. Financial literacy remains low, restricting efficient credit utilization and savings growth.

Community Services and Infrastructure: Access to basic services is limited in the project area. Road connectivity is poor, and many villages are only accessible by footpaths or limited vehicular roads. Communities rely on shared infrastructure, including farm roads, irrigation systems, and schools. Road conditions are often poor, limiting market access and increasing transport costs. Electricity is available from the 60 MW Kurichhu Hydropower Plant. Water supply is derived from natural springs, but in many cases, these are unreliable during the dry season. Educational infrastructure, from early childcare and education centres to high schools, is available.

Community Health and Wellbeing: Health indicators in the region reflect the challenges of rural living, with common health issues including alcohol liver disease (141 in-patient hospital cases in 2021), circulatory disorders (89 cases), cancers (71 cases), pneumonia (35 cases), and sepsis (32 cases). Health infrastructure consists of 14 and 22 primary health centres in Lhuentse and Mongar districts, respectively, a hospital in each district and a regional referral hospital in Mongar and health posts in major settlements. Both districts have 27 doctors and 141 nurses. Traditional healers play a significant role in local healthcare practices.

Gender and Vulnerability: In the Project area, gender roles remain traditionally defined, with women primarily responsible for household chores and caregiving, leading to a "time poverty" that limits their economic engagement. Women actively participate in agriculture, household management, and small-scale businesses. However, they face barriers such as limited access to resources and market opportunities. Women participate actively in household decision-making, yet representation in local governance remains low. Female-headed households are more likely to be affected by poverty. Vulnerable groups identified include female-headed households, elderly, disabled individuals, and youth. Vulnerable groups comprise 15% of the population. Economic vulnerability is heightened by dependency on subsistence farming, limited market access, and seasonal income fluctuations.

5.5 Physical Cultural Resources

Tangible Cultural Heritage. Cultural heritage plays a significant role in the communities, with numerous sacred sites, temples, *lhakhangs*, and *chortens* identified across the project area. These sites are integral to religious practices and community identity. The Kurichu River is associated with certain recreational and medicinal uses, such as hot stone baths, though its cultural significance varies by locality. A baseline assessment of cultural heritage in the Project area identified 45 tangible cultural heritage sites, including religious and cultural structures like temples (Lhakhangs), monasteries (Goenpas), and sacred *chortens*. Four sites are within 0.5 km, eight are 0.5–1 km away, nine are 1–2 km away, 21 are 2–5 km away, and four are over 5 km from the project area.

Intangible cultural heritage was also documented through community consultations, revealing elements integral to local identity, including:

- Religious practices such as festivals and rituals,
- Traditional arts and crafts (weaving, pottery, mask-making),
- Local dialects and languages, and
- The community's cultural connection with the river, notably for hot stone baths.

6 Potential Environmental and Social Impacts, Risks and Mitigation Measures

6.1 Summary of Overall Project Impacts and Risks

Overall E&S Impacts and Risks of the Project: According to the World Bank ESF, the DHPP's overall E&S risks can be categorized as 'high' due to the construction of large-scale activities in a highly sensitive biodiversity environment that will significantly impact these sensitive habitats. An assessment of these impacts and proposed mitigation measures are summarized in the following sections. A summary of major impacts and their significance before and after the mitigation measures are given in Table 1, along with targeted measures.

Mitigation Hierarchy: DGPC has conducted a comprehensive E&S assessment and applied the principles of ESF mitigation hierarchy in the project planning and design. The avoidance of E&S impacts is demonstrated in Chapter 4 on Analysis of Alternatives while selecting the project locations and designs. Additional avoidance measures incorporated into the project design include adaptation to geophysical and climate change risks and the integration of environmental issues, such as designing muck disposal sites, waste disposal facilities, and wastewater treatment facilities for sewage and construction wastewater. DGPC has developed several E&S instruments, including an ESMP, to minimize and reduce the project's E&S risks and a BMP to offset the significant residual impacts on biodiversity. The ESMP will be included in the bidding documents, and its implementation will be ensured.

Implementation Capacity: DGPC will establish dedicated E&S units within its PIU—including an environmental unit, a social unit, and an OHS unit—with adequate E&S staff (14 E&S staff are already in place). Similar units will be established in the Owner's Engineer's team and the Contractor's teams. Details of these units are provided in Chapter 9. These E&S units will be responsible for implementing all the management plans in the ESIA.

Environmental and Social Commitment Plan (ESCP). The DGPC has developed the ESCP and agreed with the Bank on the actions, measures, and timelines necessary to ensure compliance with the ESSs throughout the project lifecycle. The ESCP includes commitments such as conducting risk assessments, implementing mitigation measures, engaging stakeholders, building institutional capacity, and establishing monitoring frameworks. It also integrates ESS requirements into procurement processes and contracts, addresses grievance mechanisms, and outlines reporting obligations. By adhering to the agreed actions and timelines, the Borrower demonstrates continuous compliance with the ESSs, ensuring the project meets its environmental and social sustainability objectives.

Table 1. Summary of Project's major E&S Impacts and their significance and key mitigation measures

Major Impacts and Risks	Significance of Impact	Targeted Mitigation Measures	Residual Significance
E&S Impacts during Construction			
Labour/OHS			
Lack of proper employment contracts, wages and rest hours for about 6,400 project workers	High	Formal employment contracts and other measures as specified in LMP. Establish a Grievance Mechanism for Workers	Low
Child and Forced labour	Moderate	Minimum age of working is 18 years. No forced labour.	Low

Major Impacts and Risks	Significance of Impact	Targeted Mitigation Measures	Residual Significance
Potential health risks due to inadequate facilities at worksites.	High	Camps with adequate water, sanitation, recreation facilities and medical facilities.	Low
OHS risks arising from hazards associated with construction activities, including instream work, underground tunnelling, mountain slopes, blasting, drilling, working at heights, trenches, and cold weather conditions	High	Prepare and implement OHS plans by contractors. Dedicated OHS units with qualified staff (about 20) within PIU, Supervision/Owner Engineer and Contractors for regular site inspections. Strong managerial commitment by all these parties to manage OHS risks Continuous and ongoing training.	Moderate
Resource use			
15 MW of energy requirement for construction	High	The project will build a dedicated substation without affecting other energy users.	Low
476 cubic meters of water per day for construction and drinking purposes	High	The project will build a dedicated water supply system for the project works without affecting other water users.	Low
2.5 million cubic meters of aggregate material usage during construction	High	Construction material use is optimized by reusing the excavated material from the tunnels. Material will be sourced only from the two identified sites with stringent environmental controls.	Low
Pollution			
Erosion and sediment from earth works		Collection and storage of topsoil for future plantation and sediment control measures around the construction sites.	
Dust from earth works, crushing plants and vehicular traffic	High	Establish a water supply system with mobile lawn sprinklers for continuous watering at the dam and other major excavation sites. Conduct regular road water spraying using water bowsers. Implement wet drilling and dust collection measures for crushing plants.	Moderate
Air and noise pollution from construction activities	Substantial	Compliance with national standards on vehicle and machinery emissions. Implement air and noise pollution control measures with regular monitoring.	Low

Major Impacts and Risks	Significance of Impact	Targeted Mitigation Measures	Residual Significance
Generation of 175 cubic meters of sewage per day from workers' camps	High	Design and construct modular sewage treatment plants (Sequencing Batch Reactors) at each campsite, with provisions for reusing treated wastewater for gardening and transporting sludge to in-vessel composters.	Low
Wastewater from batching plants and tunnel discharges contains high sediment loads and pH.	High	Design and construct sedimentation ponds of adequate size and capacity to collect waste/discharge water, including provisions for pH adjustment treatment.	Moderate
Wastewater from crushing plants and construction yards	High	Design and construct sedimentation ponds equipped with oil-water separators.	Low
Waste			
Generation of about 7 million cubic meters of excess earth (musk/spoil) from excavation	High	Design and construct 12 identified muck disposal sites, ensuring efficient transport and disposal of spoils at these designated locations.	Low
Generation of about 3 to 4.2 tons of solid waste from camps	High	Install in-vessel composters at each campsite for organic waste treatment, with the compost utilized for plantation development. Use balers to compress recyclable waste and transport it to recycling facilities.	Moderate
Generation of construction waste, including hazardous waste	High	Non-hazardous waste will be disposed of at controlled landfill sites established under the project. Hazardous waste will be transported to designated treatment facilities, while medical waste will be sent to Mongar Hospital for incineration.	Moderate
Community Health and Safety			
Risk of landslides from earthworks and blasting on slopes	High	Conduct controlled blasting. Install rock fall protection measures. Identification and monitoring of landslide areas. Traffic control along the public roads during blasting.	Moderate
Community exposure to construction-hazards, including	High	Install barricades around worksites to prevent unauthorized access, conduct community awareness programs on	Moderate

Major Impacts and Risks	Significance of Impact	Targeted Mitigation Measures	Residual Significance
the risk of traffic accidents and pollution.		construction hazards, implement traffic management plans, and address grievances related to construction impacts with the highest priority.	
GBV and SEA/SH risks from labour influx	High	Implement the GBV and SEA/SH Action Plan developed for the project, including a code of conduct and awareness programs for workers, in collaboration with local organizations such as RENEW.	Low
Emergencies during construction, such as floods, wildfires and landslides	High	Implement the Emergency Response Plan prepared for the project by establishing dedicated staff and facilities.	Medium
Resettlement			
Acquisition of 918.31 acres of land permanently from 50 households and 2 institutions	High	Adequate compensation at replacement cost and other measures in Land Acquisition and Livelihood Restoration Plan	Moderate
Physical displacement of one household and economic impact on 53 households (inclusive of physical displaced) due to loss of private land which includes 6 households losing currently cultivated land and one land lease.	High	Same as above	Moderate
Cultural Heritage			
No direct impact on cultural heritage sites	Low	The Cultural Resources Management Plan and Chance Find Procedures have been developed and implemented	Low
Biodiversity			
Impact on 778 acres of natural habitat from land clearance, including impact on a critical flora species	High	Implement the BMP to achieve no net loss of biodiversity, incorporating additional conservation measures to achieve net gain. Establish a biodiversity unit within the PIU to oversee BMP implementation.	Low
The impact of construction activities on biodiversity, including the risks of vehicle-wildlife accidents and poaching	High	Implement pollution prevention measures and secure open trenches with barricades. Conduct code of conduct training and awareness programs for	Low

Major Impacts and Risks	Significance of Impact	Targeted Mitigation Measures	Residual Significance
		workers, emphasizing the protection of biodiversity.	
E&S Impacts during Operation			
OHS risks from plant operations and exposure to electric magnetic fields	Moderate	Development and implement an OHS plan for the operation phase. Monitoring and avoiding exposure to electromagnetic fields. Training of workers	Low
Changes in river flow from reservoir operations (upstream, in the diversion reach and downstream of the tailrace)	High	The release of an environmental flow of 6 m^3/s is needed to maintain water flow within the dewatered reach. Controlled ramping up and ramping down rate of 1 cm per minute	Moderate
Changes in water quality (dissolved oxygen and temperature)	Low	Monitoring of water quality	Low
Changes in sediment quality	High	Flushing of sediments during high flow season through low-level outlets	Moderate
Submergence of 3.72 km of public road and other farm roads from the future reservoir	High	Reconstruction of these roads at higher elevations as part of preparatory works in the project	Low
Drowning risks from sudden release of water from the tailrace and from the reservoir from peaking operations	Substantial	Establish warning signs and designate no-go areas, secured with fencing and continuous video surveillance and sirens. Conduct awareness campaigns.	Low
Impact on wildlife movement in Biodiversity Corridor #7 and on critical habitat species due to loss of connectivity and aquatic habitat alteration	Moderate	Downstream dewatered reach will improve the connectivity. Implement BMP with net gain measures.	Low
Reduced water flow causing impacts on aquatic natural habitat in the 16-km dewatered reach and 288 acres of riverine forest	High	Release of environmental flows Implement BMP with net gain measures	Moderate
Barrier to Fish Migration	High	Implement the catch-and-release protocol for migratory fish. A fish hatchery will be established to supplement the native fish population.	Moderate
Collision and electrocution risks to birds and primates	Substantial	Design and construct raptor-friendly towers with perch deterrents. Install bird flight diverters.	Low

6.2 E&S Impacts and Risks during the Construction

6.2.1 Potential Labour Impacts and Risks

Project Workers: The DHPP workforce includes 466 direct workers employed by the PIU, as well as 6,347 contracted workers engaged through contractors. Direct workers will consist of technical, administrative, and support staff within the PIU, who will be responsible for day-to-day project management. Contracted workers, including civil works contractors, are expected to fulfill the majority of construction roles, with a mix of skilled and semi-skilled labor, and a large proportion (about 90%) of international migrant male workers.

Potential Labour Risks: Key labor risks for DHPP include risks related to employment conditions. Potential issues include a lack of formal contracts, excessive working hours, delayed wages, and discrimination in recruitment and payment. The LMP provides guidelines to mitigate these risks. The Contractor, including its Subcontractors and Suppliers, shall not employ or engage in forced labor and a child under the age of 18. The Contractor shall provide the Contractor's Personnel information and documentation that are clear and understandable regarding their terms and conditions of employment, including their rights related to hours of work, wages, overtime, compensation and benefits, as well as a code of conduct and a grievance mechanism for workers.

Labor Influx: The influx of foreign labor poses risks to local communities, including increased competition for resources, the strain on public services, and potential public health concerns due to communicable diseases. The presence of migrant workers, especially in rural project areas, could disrupt local social dynamics and increase the risk of Sexual Exploitation and Abuse/ Sexual Harassment (SEA/SH) incidents. To address these concerns, DHPP will implement a Community Health and Safety Management Plan, health screenings for workers, and semi-closed camps to control interactions with local populations, supported by a mandatory worker Code of Conduct.

OHS Risks during Construction: Construction activities at DHPP entail multiple OHS hazards, such as risks from machinery operation, high-altitude work, electrical risks, falls, hazardous materials, and confined spaces. The PIU will enforce strict adherence to OHS standards, including regular training and toolbox meetings on health and safety, SEA/SH, and communicable diseases. Contractors will implement their own OHS Management Plans, overseen by the PIU, to ensure safe working conditions (through identification of potential hazards and of provision of preventive and protective measures to modify, substitute, and eliminate hazardous conditions) and enforce the use of personal protective equipment, permit system for high-risk activities to ensure workers are trained and accredited, training on OHS, processes for documenting and reporting of accidents, diseases and incidents, emergency readiness and response, and remedies for adverse impacts. Contractors will establish their own medical, ambulance and first aid facilities at the site and partner with medical services or Mongar Regional Referral Hospital.

6.2.2 Impact on Resources

Resource Efficiency Measures: The project's energy use during construction is estimated at 15 MW, and it will construct its own substation power supply. During construction, energy-efficient practices will include optimized machinery usage, strategic scheduling to reduce idle times, and the application of fuel conservation techniques. The project's water use during construction is estimated at 476 m3/day, and the water will be drawn from the existing tributaries by ensuring there are no significant adverse impacts on communities, other users, and the environment during the course of the construction. The Project will also reuse treated water from the sedimentation ponds and wastewater treatment plants. The project designs also include measures to

reduce resource use and waste generation by reusing the excavated material as aggregates and reducing the use of cement by incorporating fly ash, an industrial by-product, into concrete mixtures.

Effect on Local Springs: The construction of the tunnels and underground powerhouse may intersect with fault and fracture zones within the geology of the project area. The seepage from these constructions has the potential to lower the groundwater table, reducing or eliminating flow from overlying springs that are crucial for local water supplies. However, no impacts are expected on the headrace tunnel, which is largely downslope from the settlement, and the local community tapping water sources coming from upslope. Should any local springs be affected, the project will provide alternative water sources to the affected households. Where seepage is detected during excavation, grouting and installing reinforced concrete linings will be used to reduce or eliminate groundwater ingress into tunnels.

6.2.3 Soil, Water, Air and Noise Pollution

Erosion and Sediment Control: The construction activities will disturb large land areas, increasing risks of soil erosion, sediment deposition, and landslides due to exposed slopes and excavation activities. Key mitigation measures include constructing drainage channels and sedimentation basins before land disturbance to control runoff and sedimentation; stabilizing slopes using mechanical methods like retaining walls and bio-engineering techniques such as planting native grasses; installing temporary sediment control structures like silt fences around construction sites; conserving and protecting topsoil for reuse in rehabilitation; and properly disposing of spoil material with erosion control measures.

Dust and Air Pollution: The main sources of air pollution during construction will include (i) Dust emissions from excavation, blasting, and the movement of heavy vehicles on unpaved roads and (ii) Exhaust emissions from construction equipment and transport vehicles. Mitigation measures include dust suppression techniques, such as regular watering of exposed surfaces, covering construction materials, and ensuring proper maintenance of machinery to minimize emissions. A water supply system will be established, pumping from the Kurichhu River for storage and distribution to major construction sites such as dam excavation sites.

Noise and Vibration: Noise levels will increase significantly during construction due to activities such as blasting for tunnels and excavation, operation of heavy machinery (e.g., rock crushers, hydraulic hammers), and vehicle traffic, particularly along access roads. Vibration impacts may result from blasting and piling operations, potentially affecting nearby structures. The project will implement mitigation measures such as restricting noisy operations to daylight hours, regular equipment maintenance, and conducting noise monitoring at key locations.

Wastewater Management: During construction, runoff from disturbed areas, spoil disposal sites, and muck dumping could lead to sediment-laden water entering the Kurichhu River, increasing turbidity. The project will implement erosion control measures and construct sediment retention structures to reduce sediment flow into water bodies. Wastewater includes runoff from equipment cleaning, concrete mixing, and general site maintenance and shows high alkaline pH because of cement content, harmful if discharged into water bodies. The effluents from these facilities will be treated to neutralize pH before discharge or re-use. With up to 6,350 workers expected at peak construction, the project will establish wastewater treatment facilities at workers' camps to ensure that domestic effluent is treated to meet Bhutan's national standards before discharge.

6.2.4 Generation of Waste

During peak construction, is estimated to generate approximately 3 to 4.2 tons of solid waste per day during peak construction. This includes domestic waste such as putrescible materials, paper, cardboard, plastics, and construction debris. The project's waste management strategy is designed to address domestic, recyclable, construction and demolition, hazardous, and organic waste, following Bhutan's Waste Prevention and

Management Regulations and international best practices. A system of waste segregation at source will be implemented to separate various waste types. Organic waste, primarily from worker camps and food services, will be managed through composting. In-vessel composters will be set up at designated sites, where biodegradable waste will be processed into compost for landscaping or land reclamation purposes. Recyclable waste will be compressed through balers and transported to local recycling facilities or vendors. Concrete debris will be crushed on-site for reuse as aggregate in other construction activities. For unusable materials, designated disposal sites with appropriate containment measures will be established. The spoil will be deposited in engineered disposal sites, ensuring slope stability and erosion control. Non-recyclable, non-hazardous waste will be disposed of in controlled landfills specifically developed for the project. Hazardous waste will be stored in bunded areas to prevent leaks or spills and will be transported to specialized treatment facilities where available. If disposal facilities are not accessible, waste will be temporarily stored in a sealed facility designed to international standards until it is handed over to authorized vendors. Medical waste from the project's clinics will be disposed of through an agreement with the Mongar Regional Referral Hospital, following national protocols for the incineration of medical waste. The project will collaborate with the local district management to support the development of sanitary landfill sites, ensuring long-term waste management solutions for the region.

6.3 Community Health and Safety Impacts and Risks

Impact on Community Facilities: The Project will result in the direct submergence of about 3.72 km of public roads near Autsho. The reservoir will also flood about 0.41 km of farm road to Takhambi village. The project will reconstruct these facilities at higher elevations as part of preparatory works. -

Community Health and Safety Risks during Construction: The construction activities pose several community health and safety risks due to increased heavy machinery operation, elevated dust and noise levels, and possible accidents involving community members. Construction activities also raise the risk of water pollution and the spread of infectious diseases due to labor influx, impacting local health. The project's Community Health and Safety Management Plan includes measures to barricade the worksites, monitor health trends, control dust emissions, manage noise, and ensure sanitation standards, all in coordination with local health authorities to mitigate these risks.

Traffic Management: The construction will significantly increase traffic, impacting local travel times and road safety and potentially causing traffic congestion. The project's Traffic and Transport Management Plan includes specific measures to mitigate these impacts, such as designated travel routes for project vehicles, hiring licensed drivers and their training, and public awareness campaigns on traffic safety for local residents**.**

Gender-Based Violence (GBV) and SEA/SH Risks: The project acknowledges the increased risk of GBV and SEA/SH due to labor influx, especially with a predominantly male workforce. A GBV-SEA/SH Action Plan has been developed, focusing on strict enforcement of a Code of Conduct, mandatory awareness and prevention training, and collaboration with local organizations, like Respect, Education, Nurture and Empower Women (RENEW), to support survivors. The plan also includes a dedicated grievance mechanism to create a safe environment for reporting and addressing GBV and SEA/SH incidents.

Emergencies during Construction: The potential emergencies during the construction could include floods, wildfires, and landslides. Intense monsoon rains may cause floods that damage infrastructure and equipment, leading to delays. Wildfires during dry seasons threaten access roads and facilities, posing safety risks to workers and potentially halting progress. Frequent landslides and rockfalls in regions like Mongar and Lhuentse endanger vital infrastructure and on-site personnel due to their sudden occurrence. DGPC has prepared an Emergency Preparedness and Response Plan to mitigate these risks, including early warning systems,

engineering solutions like slope stabilization, wildfire prevention measures, worker training, and collaboration with local authorities to enhance response capabilities and ensure project continuity.

6.3.1 Land Acquisition and Resettlement

Land Acquisition:

The land required for the DHPP amounts to 918.31 acres. Most of this land, especially for access roads, quarry sites, and muck disposal areas, consists primarily of government land. These areas are already under public management and will be followed up with the relevant government bodies for necessary clearances and permissions. Regarding land acquisition, the Project requires about 18.89 acres of private land (including 0.658 acres belonging to institutions) from 58 plots that belong to 50 households (157 people) and two institutions.

- **Physical Displacement:** The project will physically displace one household, which will lose a traditional two-storied house and associated structures such as a poultry barn, huts, and water tanks. The relocation of this household will be required due to the reservoir's submergence.
- **Economic Displacement**: 53households (inclusive of 1 physically displaced, 2 institutions and one lease) will experience economic displacement, which will directly impact their private land and livelihoods. Due to submergence or land clearing for project infrastructure, around 342 fruit trees and 3.361 acres of currently cultivated agricultural land will be lost.
- **Community Infrastructure**: Several community assets, including portions of the Mongar-Lhuentse Highway, a footpath, an automatic water-level station, and an automobile workshop, will also be affected.
- **Social and Livelihood Impacts**: The project is expected to impact traditional livelihood activities such as subsistence farming, with approximately 6 households losing a substantial portion of their land. Some affected households rely solely on agriculture, and the loss of land could disrupt their income sources.

Mitigation Measures: The project has developed a comprehensive Land Acquisition and Livelihood Restoration Plan (LALRP) to mitigate these impacts. The plan includes compensation for lost land at replacement value or through substitute land, trees at replacement value, relocation assistance for the physically displaced household, livelihood restoration programs to help households maintain or improve their income levels, and preferential employment opportunities during construction. For permanent land loss, affected landowners can choose to substitute land or cash compensation, with priority for replacement land within the same locality. Temporary land loss will be compensated through rental payments, with the land restored after use. Structures will be compensated at current construction costs without depreciation, and owners may salvage materials. This approach aims to minimize the economic and social impacts on the affected communities while supporting their long-term recovery and stability.

6.3.2 Impact on Cultural Heritage

No known cultural site will be impacted by reservoir submergence or land-clearing requirements. There are 45 identified cultural heritage sites near the DHPP. Four of these are located within 500 meters of key infrastructure, such as the dam and powerhouse, while the rest are between 500 meters and five kilometres away. Although no direct impact on these sites is anticipated, they may be indirectly affected by increased vibrations and access due to road construction and human activity. One traditional hot stone bath (used for cultural and therapeutic purposes) located within the dewatered section of the river is likely to lose its value due to reduced water flow and access to the river, which is a significant aspect of the local community's interaction with the river. This indirect impact requires monitoring and potential alternative solutions. While the project

does not pose a direct threat to intangible heritage, concerns arise regarding the influx of foreign workers and how this may disrupt local traditions, festivities, customs, and cultural values.

To mitigate the impacts on cultural heritage, the following measures are proposed: (i) the Development of a Cultural Heritage Management Plan (CHMP), which includes a Chance Find Procedure to address any undiscovered cultural resources during construction, (ii) Ongoing community engagement to ensure that local cultural values are respected and protected during project development, (iii) Cultural sensitivity training for all project personnel to ensure they understand and respect local customs and heritage, and (iv) Efforts to preserve intangible cultural heritage, particularly by minimizing disruptions caused by the labor influx and respecting local cultural practices.

6.4 E&S Impacts and Risks during the Operational Stage of the Project

6.4.1 OHS Risks during Operation

The potential OHS risks associated with the O&M stage of hydropower plants are (i) exposure to higher levels of electric and magnetic fields (EMF) than the general public because of working in proximity to electric power generators, equipment, and connecting high-voltage transmission lines, and (ii) exposure to high noise levels from the turbines and generators. Workers of the transmission line may be exposed to occupational hazards from contact with live power lines during maintenance and operation activities. Occupational EMF exposure will be prevented or minimized by preparing and implementing an EMF safety program that includes (i) Identify potential exposure levels in the workplace, including surveys of exposure levels in new projects and the use of personal monitors during working activities, (ii) Train workers in the identification of occupational EMF levels and hazards, and (iii) Establish and identify safety zones to differentiate between work areas with expected elevated EMF levels compared to those acceptable for public exposure and limiting access to properly trained workers.

6.4.2 Impacts on River Flows and Quality during Operation

The peaking operation of DHPP will result in considerable variations in river flow between the dam and the powerhouse:

- **Upstream of the DHPP dam:** The project will not significantly alter the natural flow of the Kurichhu River upstream from the dam. However, peaking can create landslides and affect riparian ecology at the reservoir, as the level rapidly decreases during peak power production hours. The project will construct retaining walls in the potential landslide areas in the reservoir.
- **Diversion Reach:** The most significant impact will occur in the 16 km diversion reach downstream of the dam. Flows in this section will be reduced by over 90% during the dry season and significantly lower during the monsoon season. An environmental flow (e-flow) will be released to maintain the water flows in the diversion reach (details are given under ESS 6).
- **Downstream of the DHPP Powerhouse:** Downstream from the powerhouse, flows will fluctuate significantly during peak generation periods, especially during the dry season when the river is at its lowest. These flow changes could affect aquatic habitats and increase the risk of fish stranding, but they are not significant as the Kurichhu reservoir, located close to the tail race tunnels, acts as an ideal demodulation. To minimize these risks, a controlled ramping up and ramping down rate of 1 cm per minute will be applied to create a smooth transition is important to avoid negative impacts on biodiversity.

Water Quality During Operation: During operation, the reservoir's creation could result in changes to the water quality, including lower dissolved oxygen levels and fluctuations in water temperature. However, due to the relatively small size and rapid water turnover in the DHPP reservoir, the risk of stratification and eutrophication is considered low. Continuous water quality monitoring will be in place to track parameters such as temperature, dissolved oxygen, turbidity, and nutrient levels, ensuring that water quality remains within acceptable standards.

Sediment Management during Operation: The Kurichhu River carries a significant sediment load, particularly during the monsoon season. The project's dam and reservoir will alter natural sediment transport, trapping sediment upstream, which can reduce reservoir capacity over time and impact downstream ecosystems. Sediment transport models indicate that, while initial sediment deposition in the reservoir will be rapid, the system will reach equilibrium within three years, with an estimated 19% loss in storage volume due to sedimentation. The project will use low-level outlets (LLOs) to flush accumulated sediments from the reservoir, particularly during high-flow monsoon periods. This process will help maintain the reservoir's capacity and prevent excessive sediment buildup, ensuring continued efficient operation of the hydropower facilities.

Greenhouse gas emissions: The DHPP is projected to result in substantial greenhouse gas (GHG) emission reductions by displacing fossil fuel-generated electricity with clean, renewable hydropower. Annually, it is expected to reduce approximately 4,139,176 tonnes of CO_2 equivalent, aligning with Bhutan's climate goals and contributing positively to regional emission reduction targets.

6.4.3 Drowning Risks from Peaking Operation

The DHPP's peaking operations will involve controlled, periodic releases of water through the tailrace tunnels, resulting in sudden, high-volume water flows downstream. These fluctuations present a risk to community safety, especially for individuals engaged in activities near the river, such as fishing, religious rituals, and gravel collection. Sudden rises in water level and velocity could catch people unprepared, increasing the risk of drowning. To mitigate these hazards, the project includes the installation of warning systems (video surveillance, sirens, flashing lights) and the establishment of restricted access zones. Additionally, regular community awareness programs will educate local residents on water safety protocols during peaking periods.

6.5 Biodiversity Impacts and Risks During Construction and Operation

Impact of Construction on Terrestrial Biodiversity: Construction-related risks to biodiversity include: loss of natural habitat, noise and vibrations, blasting, dust emissions, contamination from chemical spills, loss of fauna from road kills, falling into trenches, killing due to perceived conflict with workers, and other impacts. An increase in human activity due to population influx associated with workforce demands could indirectly intensify natural resource depletion and poaching risks despite Bhutan's strong cultural and regulatory frameworks.

Loss of Terrestrial Natural Habitat: The project's infrastructure will directly affect approximately 778 acres of terrestrial natural habitat in the form of forests, shrublands, and riparian environments. The extent of natural habitat was established through landcover mapping, within the area encompassed by a 10 km radius of the affected Kurichhu River. Landcover units are classified into modified and natural habitats based on the definitions within ESS6.

Collision and Electrocution Risks to Birds and Primates: The transmission line component of the DHPP presents a collision and electrocution hazard for large bird species. There is also a risk that primates will climb transmission towers and be exposed to the live cables.

Impact to Protected Areas, specifically BC-7: The reservoir will extend across the southern arm of the BC-7, which will widen the natural barrier created by the Kurichuu River, and may impact the ecological connectivity for some species. It should be noted the downstream dewatered stretch of the river will improve connectivity.

Impacts to Critical Habitat Species: Bengal Tiger, Dhole, Red Panda, Capped Langur, Pallas's Fish Eagle, three range-restricted fish and one plant (*Hoya bhutanica*) are critical habitat species expected to be impacted by the Project. Impacts on these species will include loss of habitat connectivity, aquatic habitat alteration (transformation to a reservoir and downstream reduced water flow) and loss of terrestrial natural habitat.

Loss of Aquatic Natural Habitat: The construction and operation of the DHPP will fragment the Kurichuu River, transform a large stretch of river into a reservoir and reduce water flow in the 16-km dewatered reach. The Kurichuu River is in a near-pristine state and qualifies as an aquatic natural habitat, and these impacts will reduce the river's ecological integrity.

Impact on Fish Migration: The dam will create a physical barrier that disrupts fish migratory movements which are essential for their reproduction and survival. The creation of the reservoir and flow modifications, particularly during the dry season, could further impact the habitats of sensitive fish species. These impacts will significantly affect Snow Trout and three restricted-range catfish species described above as critical habitat features.

Mitigation to address project impacts on biodiversity: Mitigation measures provided within the BMP to address project impacts on biodiversity include: Biodiversity protection and a code of conduct will be incorporated into the DGPC Natural Resource Management Policy. Biodiversity protection requirements will be incorporated into tender documents. Awareness of biodiversity protection will be raised among staff, workers and local people. A Biodiversity Unit will be established within the PIU, comprising a Biodiversity manager, terrestrial and aquatic ecologists who will receive capacity building training. The Biodiversity Unit will introduce biodiversity friendly approaches to the Social Influx Management Plan. Many additional biodiversity protection measures will be applied to enhance contractor management plans required by the ESMP and special measures taken to avoid animal mortality during construction work. Trapped or injured animals will be safely removed from construction sites and the future reservoir and translocated. A preconstruction survey will assess the presence of nesting sites for important birds (such as vultures and Dark-rumped Swift). A separate preconstruction survey will search for *Hoya Bhutanica* plants growing within the construction footprint that will be translocated or used for propagation in a plant nursery. Invasive alien plant species will be controlled at sites where materials are sourced and in the construction site. Electrocution risks will be minimized by design through using raptor-friendly towers with perch deterrents, include necessary insulation and allow a spacing between vertical conductors that exceeds the wingspan of large birds. Bird flight diverters will be installed on wires to improve the visibility. Underground cabling will be used where possible and transmission line routing will avoid bird sensitive areas (wetlands and migratory paths) to the extent possible. These measures will reduce risks to primates, but in addition trees in the proximity will be pruned, anti-climbing devices such as baffles, collars of metal spikes and non-toxic slippery surfaces, will be installed on towers.

Mitigation to address Net Gain requirements for Key Biodiversity: Loss of terrestrial natural habitat, impacts to legally protected areas and impacts to critical habitat species could occur due to Project activities. The ESS6 stipulates specific mitigation requirements for such impacts, which include No Net Loss of biodiversity, additional programs to enhance the conservation aims and effective management of protected areas, and a mitigation strategy to achieve net gains for biodiversity features for which critical habitat is designated. These mitigation approaches must be proportional to the project impacts. The BMP is compiled

with these requirements specified as its objectives. Activities of the BMP to achieve these objectives are in preparation, and this summary will be updated upon completion of the BMP.

Mitigation for Aquatic Natural Habitats: The primary mitigation for protection of aquatic habitats will be achieved through the implementation of the EFlow Management Plan (EFMP) described below. Installation of a fish ladder is not feasible as dam height (at least 85m above the riverbed) is beyond the capacity of fish to climb. The operation of a fish ladder also requires a large volume of water to be diverted from power generation units. Instead, a catch-and-release protocol will be implemented to sustain migratory fish movement. A fish hatchery will be established to supplement the populations of dominant fish species that naturally occur in the Kurichhu River and to address the cumulative impacts of this Project and other hydropower schemes in the catchment.

Environmental Flow Assessment: An Environmental Flow (EFlow) Management Plan is compiled to achieve No Net Loss of the aquatic natural habitat and associated biodiversity. The EFlow Management Plan (EFMP) is based on a high-resolution EFlow Assessment to guide the release of water flow to protect aquatic habitats and associated biodiversity in the dewatered reach of the Kurichhu River.

- **EFlow Methodology**: The EFlow assessment was based on the Building Block Methodology (BBM) supported by Hydraulic modelling, using the HEC-RAS model, to estimate minimum flow requirements necessary to maintain aquatic ecological health in the river's dewatered reach, while balancing the hydraulic, ecological, and social needs. Habitat requirements for Snow Trout were used as a proxy for other aquatic species, based on the understanding that preserving this species would protect the broader ecosystem, and (iii) Tributary inflows into the dewatered reach were assumed to supplement the E-Flow, especially during the monsoon season.
- **Dewatered Reach Requirements**: The 16 km dewatered reach is the most impacted section. The Project will mitigate the reduction in flow by maintaining a year-round minimum EFlow of 6 m^3/s. During critical ecological periods, such as the early monsoon (April-May), short peaks in flow ("freshes") will be allowed to trigger biological responses like fish migration and spawning. These peaks will be proportional to natural flow variation and supplemented by tributary inflows.
- **Monthly Flow Requirements**: The monthly flow requirements are established to reflect natural seasonal variation while maintaining ecological balance. The EFlow values are consistent throughout the year, ensuring a steady minimum of 6 m^3/s, with fluctuations allowed during the monsoon season.

7 Cumulative Impacts

7.1 Scope and Valued Environmental Components

The Cumulative Impact Assessment (CIA) was conducted for the Kuri-Gongri Basin to evaluate the combined environmental and social impacts of multiple hydropower projects. This basin was chosen due to its strategic importance in Bhutan's hydropower development and its ecological significance. A previous CIA conducted in 2018 by SWECO, commissioned by the Department of Hydropower and Power Systems (DHPS), focused on the Kuri-Gongri Hydropower Project situated downstream of the Kurichhu Hydropower Dam (SWECO, Kuri-Gongri CIA Report, 2018). As part of the current project, an addendum to the 2018 CIA has been prepared to update and supplement the findings, ensuring the assessment reflects current conditions and planned developments.

Spatial Boundary: The Kuri-Gongri Basin spans a total area of 28,500 km², with 16,000 km² within Bhutan. It receives runoff from parts of India and China and is a vital part of Bhutan's hydrological system, supporting ecological and economic activities. The study area covers portions of 10 districts in Bhutan. The CIA aims to provide a comprehensive understanding of how hydropower development may cause cumulative effects on biodiversity, ecosystems, and local communities, ensuring better decision-making for sustainable development.

Temporal Boundary. A summary of the four hydropower development scenarios (0-3) used in the Kuri-Gongri CIA is given below, and the locations of these hydropower projects are given in Figure 3. The locations of other developments considered for the DHPP addendum study is given in Figure 4.

Scenario	Time-frame	Candidate projects (SWECO, 2018)	DHPP Addendum
Scenario 0	2025	Kurichhu (operational, 60 MW), Mangdechhu (under construction, 720 MW), Nikachhu/Tangsibji (under construction, 118 MW), Kholongchhu (under construction, 600 MW)	• Delay of Kori-Gongri construction. • Yungichhu HPP (3 MW) under construction. • Power evacuation from Dorjilung HPP. • Solar Power Projects. • Sand mines. • Gyalsuung Industrial Estate Development. • Gangola- Lhuentse Highway widening. • Development of Autsho town. • Gyalpozhing Town.
Scenario 1	2030	Scenario 0 projects plus: Kuri-Gongri (2,640 MW)	
Scenario 2	2040	Scenario 1 projects plus: Khomachhu (363 MW), Dorjilung (1,125 MW)	
Scenario 3	>2040	Scenario 2 projects plus: Krissachhu (32 MW), Borgongchhu I (69 MW), Borgongchhu II (70 MW), Chamkharchhu IV (364 MW), Chamkharchhu I (590 MW), Chamkharchhu II (770 MW), Gamri III (80 MW), Gamri/Yemkhari (81 MW), Gamri V (91 MW), Sherichhu (36 MW), Gongri (593 MW), Gobari (43 MW), Panbang (1,100 MW)	

Valued Environmental Components (VECs): The selection of VECs for the Cumulative Impact Assessment (CIA) followed a structured process, starting with a stakeholder workshop in March 2018. This workshop allowed stakeholders to provide feedback on the Basin Report and propose VECs. The final selection was based on inputs from the workshop, the DHPP's list of 12 proposed VECs, and several criteria: the VEC's

importance to stakeholders, its susceptibility to hydropower impacts, measurability, availability of baseline data, and legal or policy relevance. VECs were grouped into environmental, social, and economic categories, ensuring a balanced representation of potential impacts across these areas.

VECs used for analysis in the Kuri-Gongri CIA are given below.

Environmental VECs	Social VECs	Economic VECs
Forest Cover	Livelihood Opportunities	Economic Growth
Slope Stability	Community Quality of Life	Domestic Electricity Supply Security
Migratory Fish	Access to Markets and Services	
Scenery and Landscapes	Cultural Heritage	
Protected Areas	Downstream Public Safety	

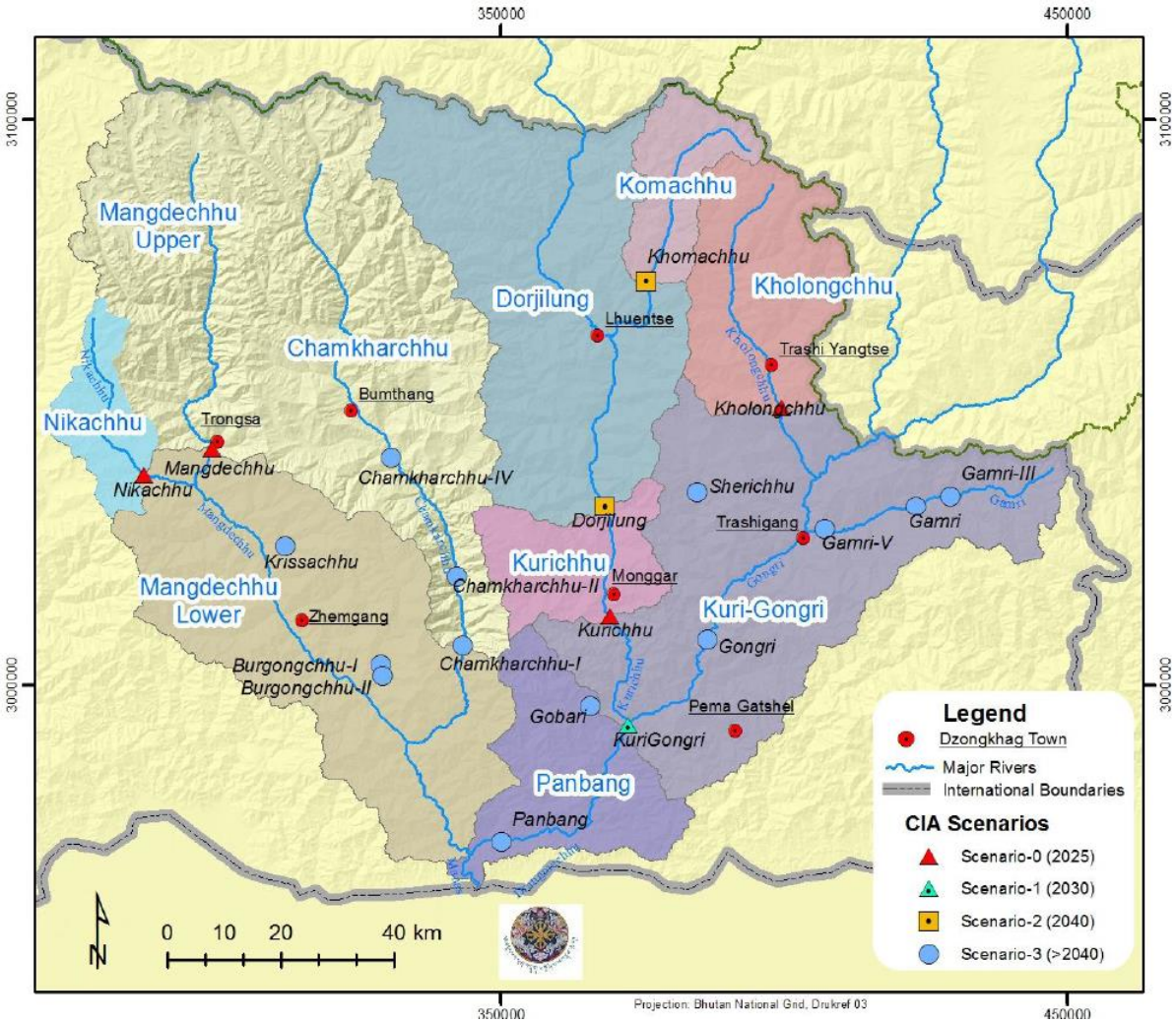


Figure 3: Existing and Proposed Hydropower Project in Kuri-Gongri Basin

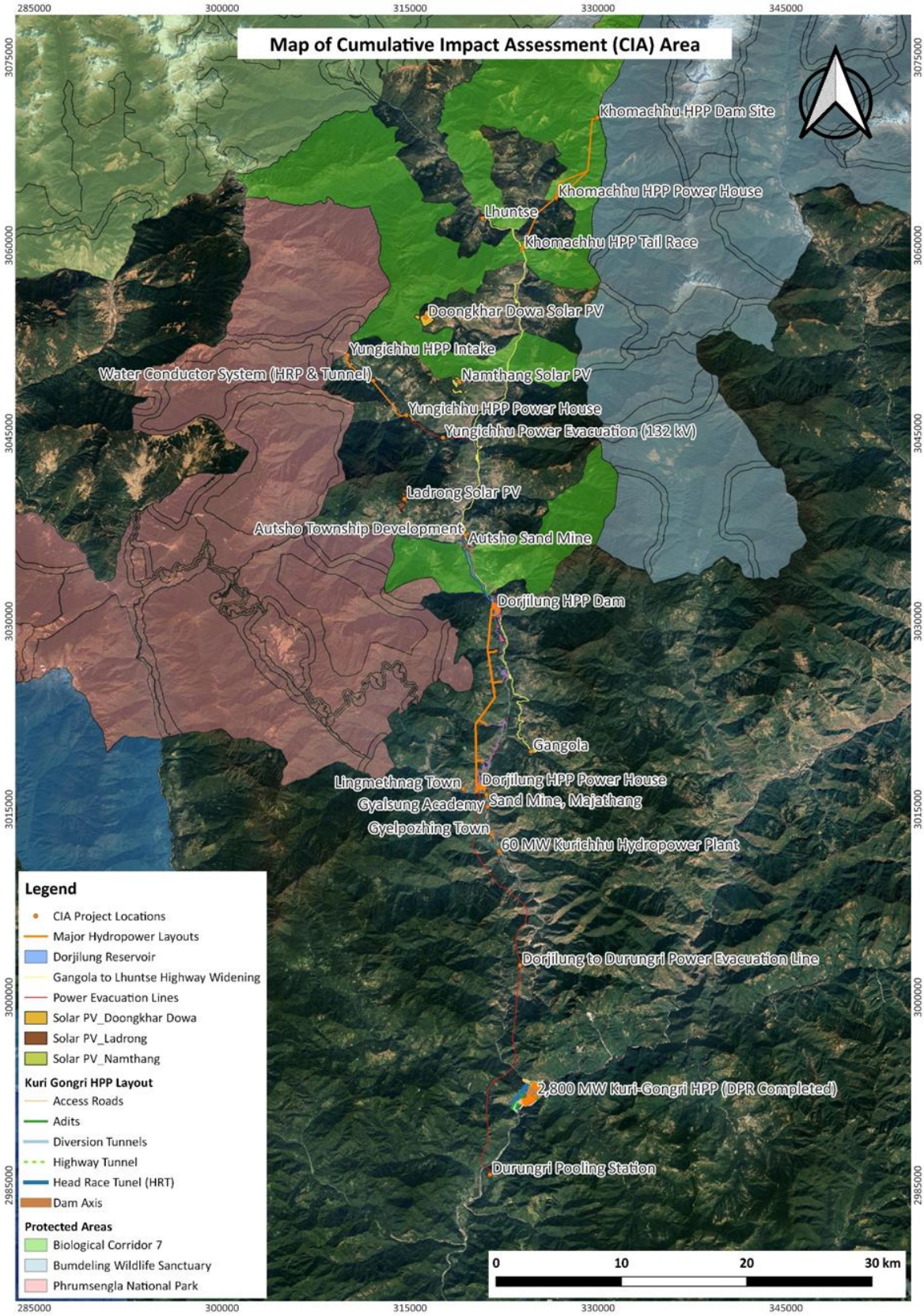


Figure 4: Existing and Proposed Developments in DHPP CIA Area

7.2 Cumulative impacts Assessment

7.2.1 VEC 1: Forest Cover

The Kuri-Gongri Basin covers approximately 1,164,955 hectares (ha) of forest, providing crucial biodiversity, ecosystem services, and livelihoods. The impacts of hydropower projects on forest cover according to the original CIA study and the addendum are:

Cumulative Impacts: The existing projects (under Scenario 1), such as Kurichhu and Mangdechhu, result in a forest loss of around 1,557 ha, or 0.13% of the total forest cover. These impacts are relatively minor due to the run-of-river design, which minimizes forest clearing. The overall development (under Scenarios 1 to 3) is expected to have a cumulative forest loss **of** 10,311 ha (0.89% of the total forest area in the basin), with the Gongri sub-basin experiencing the most severe impact. Nearly 7,000 ha of forest are expected to be lost due to projects like Panbang and Kuri-Gongri.

DHPP Addendum: The Dorjilung HPP will lead to the loss of approximately 758 acres of forest. Combined with other developments, including transmission line construction, solar projects, road widening, and urban expansion, this will result in significant and potentially irreversible forest loss, along with increased risks of habitat fragmentation.

Mitigation Measures: Compensatory afforestation, which mandates replanting twice the affected forest area, is a key mitigation strategy and 1,557 acres of reforestation will be implemented under the DHPP. The reforestation initiative will be supported by a long-term adaptive monitoring program to validate the implementation of planned actions and assess the effectiveness of natural habitat restoration. However, concerns remain about the biodiversity and ecological quality of replanted forests compared to natural forests. Effective monitoring, enhancing reforestation practices, and ensuring the quality of replanted areas are essential to mitigate long-term impacts on the basin's forest ecosystems.

7.2.2 VEC 2: Slope Stability

Slope stability in the Kuri-Gongri Basin varies across sub-basins, influenced by geological, seismic, and hydrological factors. Areas with steep terrain and high rainfall, such as the Gongri and Panbang sub-basins, are particularly prone to landslides. The risks increase significantly during hydropower construction as they involve large-scale excavation and result in water-level fluctuations, which exacerbate riverbank erosion and slope instability.

Cumulative Impacts: For the existing projects, moderate slope stability risks are present during the construction of projects like Mangdechhu and Kurichhu, but the impacts are generally manageable with proper controls. The cumulative impacts of multiple projects, under Scenarios 1 to 3, especially in the Chamkharchhu sub-basin, increase the likelihood of slope failures across several high-risk areas.

DHPP Addendum: The cumulative impact rating of slope stability indicates significant concerns, with major negative impacts due to geological vulnerabilities, faulting, and thrusting. Blasting during construction may exacerbate instability, increasing landslide risks. Although slope instability can be managed through conventional methods, the overall cumulative impact remains substantial despite minimized deforestation and reduced project footprint.

Mitigation Measures: To manage these risks, slope stabilization techniques, such as slope reinforcement, proper drainage, and engineering controls, are essential. Real-time monitoring during construction is critical to addressing emerging issues promptly. Additionally, proactive planning, including careful site selection and the use of reforestation to stabilize slopes, can further reduce landslide risks. Continuous monitoring and

maintenance are crucial to prevent landslides that could pose threats to communities and infrastructure, particularly during and after construction phases.

7.2.3 VEC 3: Migratory Fish

The Kuri-Gongri Basin is home to several migratory fish species of conservation concern, including the Golden Mahaseer (*Tor putitora*) and Chocolate Mahaseer (*Neolissochilus hexagonolepis*). The Golden Mahaseer, a widely distributed species, migrates up rivers such as the Kuri-Gongri and Mangdechhu, reaching elevations of up to 1,000 masl for spawning and other life-cycle events. Hydropower development poses significant risks to these migratory species.

Cumulative Impacts: Existing projects, such as Mangdechhu and Kurichhu, have already caused slight to moderate impacts on migratory fish by disrupting river connectivity and leading to localized population declines. The construction of additional dams under various scenarios is expected to further exacerbate these impacts, with the situation worsening significantly under Scenario 3. Across all major sub-basins, the situation deteriorates, with migratory fish, including the Golden Mahseer, facing potential extirpation from most, if not all, sub-basins. Fish migration routes are projected to be reduced by over 50%, and suitable habitats will become increasingly scarce.

DHPP Addendum: The Dorjilung HPP poses severe and irreversible risks to migratory fish due to disrupted river connectivity and habitat loss. While minimal impact on Golden Mahseer is expected, restricted-range species in upper tributaries face significant threats.

Mitigation Measures: Current fish passage designs are ineffective for species like the Mahaseer, which require long-distance, unimpeded migration. To mitigate these impacts, the analysis recommends preserving the Chamkharchhu sub-basin as a wild river and operating the Kuri-Gongri and Panbang projects in a run-of-river mode to reduce disruptions to river connectivity and migration patterns. These actions are essential to safeguarding the remaining migratory fish populations in the basin.

7.2.4 VEC 4: Scenery and Landscapes

The visual impacts of hydropower projects in the Kuri-Gongri Basin are a key concern, especially regarding tourism and cultural heritage. The scenic beauty of the region plays an important role in attracting visitors and preserving cultural identity.

Cumulative Impacts: Existing projects, such as Mangdechhu and Nikachhu, have already caused moderate visual impacts. These projects are located within 2 km of prominent tourist sites like Trongsa Dzong and Taa Dzong, and are partially visible from these viewpoints, altering the visual landscape of historically and culturally significant areas. The cumulative visual impacts become more significant with the introduction of projects like Gamri III, located within 3 km of the Sakteng Wildlife Sanctuary. More than 50% of the Gamri III project may be visible from key tourist viewpoints, potentially affecting both the natural landscape and the region's cultural value.

DHPP Addendum: The cumulative impact rating on scenery and landscapes across the sub-basins shows a mixture of moderate to major negative impacts due to visible transmission lines, increased urbanization and the construction of five hydropower projects, with all areas considered of some importance to national tourism.

Mitigation Measures: To reduce these impacts, strategies such as vegetation buffers, landscaping, and careful architectural design of hydropower infrastructure should be implemented. These measures help blend the projects into the natural environment and preserve key view fields that are essential for maintaining the aesthetic

and cultural value of the region. While some visual impacts are unavoidable, strategic planning can minimize these intrusions, helping to protect the scenic beauty that supports both the local economy and cultural heritage.

7.2.5 VEC 5: Protected Areas

The Kuri-Gongri Basin overlaps with several important protected areas, including the Royal Manas National Park (RMNP) and the Sakteng Wildlife Sanctuary, which account for 73.1% of the basin's total protected area. These areas are critical for conserving the Golden Langur, Bengal Tiger, and Asian Elephant.

Cumulative Impacts: Existing projects like Kurichhu and Mangdechhu have minimal impacts on protected areas, as they are located outside core conservation zones. The addition of projects like Panbang significantly exacerbates impacts, with around 1,000 hectares of forest expected to be lost in the Chamkharchhu sub-basin, leading to increased sediment disruption in RMNP and impacts on biodiversity. Transmission lines, such as the Chamkharchhu PH-Yangbari 400-kV line, will pass through 70 hectares of forest in the Mangdechhu and Gongri sub-basins, further fragmenting habitats and increasing human activity, which can lead to poaching and illegal resource extraction.

DHPP Addendum: The Dorjilung HPP and other developments will not directly impact Phrumsengla National Park or Bumdeling Wildlife Sanctuary but will inundate part of Biological Corridor #7, affecting Key Biodiversity Areas and Tiger Conservation Landscape territories. Increased access and social influx during construction may elevate pressure on nearby protected areas and multiple-use zones.

Mitigation Measures: To protect these ecologically sensitive areas, mitigation strategies include preserving undammed rivers such as the Chamkharchhu River, implementing strict conservation regulations, and enforcing anti-poaching measures. Additionally, hydropower projects, like Kuri-Gongri and Panbang, should operate in a run-of-river mode to reduce downstream impacts. Proper education and management of construction workers are also essential to prevent illegal activities such as poaching and timber harvesting. Continuous monitoring and enforcement are critical to maintaining the ecological integrity of these protected areas while balancing development needs.

7.2.6 VEC 6: Livelihood Opportunities

Hydropower development in the Kuri-Gongri Basin is expected to provide temporary social benefits primarily through wage employment during construction phases. The increase in employment opportunities is anticipated to grow with the addition of projects. Under Scenario 1, local employment could rise by approximately 2%, with further increases under Scenario 3, where the cumulative impacts could boost employment by up to 3%. However, without enhancement measures, these gains may remain moderate and temporary. Efforts to increase local hiring, such as providing skills training and ensuring Bhutanese participation, will maximize positive impacts. While temporary, these employment opportunities offer an important short-term economic boost to local communities, particularly in the early construction phases of projects like Dorjilung.

7.2.7 VEC 7: Community Quality of Life

Hydropower development impacts the quality of life in nearby communities through various direct and indirect effects. The number of villages and towns affected by the projects is a key indicator. In Scenario 0, ongoing projects in the Mangdechhu and Kholongchhu sub-basins already exert moderate negative impacts. By Scenario 3, major impacts are predicted in the Kurichhu Chamkharchhu and Gongri sub-basins if mitigation is not effectively applied. The impacts could range from increased community disruption due to construction.

7.2.8 VEC 8: Access to Markets and Services

Hydropower projects can improve access to markets and services by constructing new roads. All the proposed projects are expected to generate moderate positive impacts through improved road infrastructure, allowing better access to markets and services for local communities. The projects under Scenarios 1 and 2 are mostly situated near existing national and district roads, requiring minimal road construction, aside from minor realignments. In Scenarios 2 and 3, approximately 270 km of new roads will be developed. These improvements are essential for facilitating transportation, commerce, and access to healthcare and education.

7.2.9 VEC 9: Cultural Heritage

Hydropower development poses risks to cultural heritage sites, especially in terms of physical destruction or indirect impacts such as vibrations, dust, and traffic during construction. In the Kuri-Gongri Basin, there are no direct impacts on World Heritage candidate sites like Trongsa Dzong and Jago. However, the construction of ancillary infrastructure, such as transmission lines, may indirectly affect less significant religious structures and chortens. Mitigation strategies include realigning infrastructure to avoid culturally significant areas and ensuring vibration control measures to protect heritage sites from damage.

7.2.10 VEC 10: Downstream Public Safety

Hydropower operations can pose risks to downstream public safety, particularly due to fluctuating water levels and increased flow velocities. The most significant impacts are expected in the Panbang sub-basin, where the Kuri-Gongri project will exacerbate flooding risks. The total flood-wave arrival time from peak operations will increase, posing a significant risk to downstream communities. Proper flow management strategies are required to mitigate these impacts. In the Panbang sub-basin, the cumulative impacts of water-level changes may lead to a major negative impact without proper safety protocols.

7.2.11 VEC 11: Economic Growth

Hydropower projects are expected to contribute significantly to Bhutan's economic growth. The Dorjilung could generate an additional 3-4% GDP growth from increased power generation. As hydropower exports rise, revenues bolster the national budget, supporting infrastructure development, poverty alleviation, and long-term macroeconomic stability. The overall hydropower development in the basin will yield even greater economic benefits as Bhutan transitions to a major energy exporter, increasing national revenue and reducing energy import dependency during low-flow winter periods.

7.2.12 VEC 12: Domestic Electricity Supply Security

Bhutan's dependence on hydropower for 99% of its electricity means that domestic energy security is closely tied to the capacity of these projects. During winter months, the country faces energy shortages, leading to imports from India. The additional hydropower development is projected to secure a more stable domestic power supply, and to help meet the growing demand from industrial estates and support Bhutan’s economic development.

8 Environmental and Social Management Plan

8.1 Institutional Arrangements

Project Implementation Unit. The DHPP will be overseen by Druk Green Power Company (DGPC) as the Project Owner, with the responsibility for overall implementation. DGPC will establish a Project Implementation Unit (PIU) tasked with the day-to-day coordination and on-site implementation of DHP activities. The PIU will liaise closely with affected communities and collaborate with local authorities, reporting directly to the DGPC General Manager. PIU will oversee Environmental, Social, Health, and Safety (ESHS) management through a dedicated ESHS Section with three specialized units: Environment Unit, Social Unit, and Occupational Health and Safety (OHS) Unit.

- **The Environment Unit** within the PIU is dedicated to managing biodiversity and environmental compliance. It includes teams focusing on aquatic biodiversity, overseeing the impacts on riverine habitats and species, and terrestrial biodiversity, which is responsible for managing land-based ecosystems and ensuring alignment with conservation standards. 3 environmental officers and 1 biodiversity are already in place.
- **The Social Unit** addresses the project's social impacts and community engagement with several sub-units. Resettlement manages relocation and compensation for affected communities, while the Gender Unit addresses GBV and SEA/SH risks. The Communication sub-unit ensures effective communication with stakeholders, and the Local Community Liaison team engages directly with local communities to address concerns. GRM & SEP oversees the Grievance Redress Mechanism and Stakeholder Engagement Plan, and the Cultural Heritage team safeguards both tangible and intangible cultural heritage within the project's influence. 2 social development officers are already in place
- **The OHS Unit** oversees Occupational Health and Safety across different project components. This includes sections dedicated to Infrastructure Safety, Headworks safety, HRT safety, and Powerhouse safety, each focusing on maintaining robust safety protocols for specific project areas. One officer is already in place.

Owner's Engineer: To support the PIU, an Owner's Engineer (OE) will be appointed to supervise project design and construction, with the potential to be either an external consultancy or an internal unit within the PIU. The OE will establish an ESHS team within its engineering division to monitor ESHS performance and assist the PIU with environmental management, staff training, and environmental and social activities coordination. The OE's ESHS team consists of the ESHS Manager, two Environmental Specialists, two Social Specialists, four OHS Specialists, a Biodiversity Specialist, four social specialists and adequate environmental and OHS site inspectors.

Construction Contractor. The construction contractors (CC) appointed by DGPC will most likely be engineering, procurement, and construction (EPC) contractors responsible for delivering turn-key projects. The EPC Contractor will handle all subcontractors' bidding, selection, and management. The Contractors ESHS team will include the ESHS Manager, an Environmental Sanitation Engineer, two Environmental Specialists, **five** OHS Specialists, a Biodiversity Specialist, a Social and Communication Specialist, a Human Resources Manager, Gender/GBV/SEA/SH Specialist, two medical doctors and adequate environmental and OHS site supervisors.

8.2 ESMP Implementation by Contractors

8.2.1 E&S Conditions in the Bidding Documents

The DGPC will require that all contractors engaged in the project operate in a manner consistent with the requirements of the ESSs, including the specific requirements set out in the ESCP. The Borrower will manage all contractors in an effective manner, including (a) Assessing the environmental and social risks and impacts associated with such contracts; (b) Ascertaining that contractors engaged in connection with the project are legitimate and reliable enterprises and have knowledge and skills to perform their project tasks in accordance with their contractual commitments; (c)Incorporating all relevant aspects of the ESCP into tender documents; (d) Contractually requiring contractors to apply the relevant aspects of the ESCP and the relevant management tools, and including appropriate and effective non-compliance remedies; (e) Monitoring contractor compliance with their contractual commitments; and (f) In the case of subcontracting, requiring contractors to have equivalent arrangements with their subcontractors.

The DGPC will include the following E&S conditions, including cost implications, in the bidding documents: (a) Past performance of the contractor on E&S aspects, including SEA and GBV, (b) Requirement of E&S Performance Guarantee; (c) Required E&S staff with the contractor; (d) Inclusion of ESMP and ESMP implementation costs into the bidding documents; (e) Code of Conduct for the contractor's personnel; (f) Contractor's proposed management strategies and implementation plans to manage the E&S risks; (g) Requirement to prepare A C-ESMP with site-specific management plans, including an OHS plan; (h) Labor Management Procedures and (i) Penalties for non-compliances.

8.2.2 Contractor ESMP

The Contractor will submit a C-ESMP with a site-specific mitigation plan before the start of the construction works for approval from the PIU and OE and implement them during the construction. The C-ESMP will consist of the following site-specific plans. The OHS plan will be submitted as a standalone plan. The C-ESMP and OHS plans will be updated every six months.

- Engineering Designs and Drawings – on Muck Disposal Sites, Sedimentation and pH treatment systems for treatment of wastewater from batching plants and tunnel discharges, sewage treatment plants, in-vessel composters, and landfill site.
- Erosion and Sediment Control Plan - To manage and mitigate erosion and sedimentation risks during construction.
- Muck Disposal Planning and Management Plan - For effective disposal and management of muck generated from excavation activities.
- Waste Management Plan - To ensure proper handling, segregation, and disposal of waste.
- Hazardous Substances Management Plan - To safely manage and store hazardous materials.
- Explosive and Blasting Management Plan - For controlled use and storage of explosives, ensuring safety.
- Emergency Preparedness and Response Plan - To prepare for and respond to emergencies.
- Water Quality Monitoring Plan - To monitor and maintain water quality in compliance with environmental standards.
- Quarry Management Plan - To manage quarry operations, minimizing environmental impacts.
- Emissions, Dust, and Noise Management Plan - For controlling pollution, dust, and noise levels.

- Physical Cultural Resources Management Plan - To protect cultural heritage resources from construction impacts.
- Vegetation Clearing Plan - For controlled vegetation clearing, ensuring minimal ecological disruption.
- Landscaping and Re-vegetation Plan - For post-construction landscaping and re-vegetation to restore affected areas.
- Biodiversity Protection Plan - To protect biodiversity in and around the project site.
- ESHS Training for Construction Workers Plan - To train workers on environmental, social, health, and safety (ESHS) practices.
- Road Traffic Management Plan - For managing road and traffic impacts due to construction activities.
- Construction Sites Access and Security Plan - To secure construction sites and manage access.
- Management of Construction Worker Colonies (Camps) Plan - For the effective management of worker camps.
- Occupational Health and Safety Plan - To ensure workplace safety and health standards.
- Communities Health and Safety Management Plan - To address health and safety concerns of local communities.
- Site Cleaning and Rehabilitation Management Plan - For cleaning and rehabilitating construction sites post-project.
- Reservoir First Impoundment Management Plan - To manage the initial filling of the reservoir safely.
- Logistics Management Plan - For efficient management of logistical aspects of the construction phase

8.3 Monitoring

The proposed monitoring during the implementation of the ESMP and the key performance indicators are summarised below:

Worksite Inspections and Compliance Monitoring: Daily inspections by OE-ESHS Inspectors focus on adherence to the ESMP and impact minimization. Weekly inspections led by the OE-ESHS Manager address findings from daily checks, while monthly joint inspections involving OE, PIU, and CC ESHS Managers address major non-compliance, ensuring corrective actions with photographic documentation.

Indicators for ESHS Plans and Staffing: Key indicators include timely staffing and training of PIU-ESHS roles and contractor compliance with ESHS specifications. Stakeholder satisfaction is gauged through GRM, aiming for over 90% satisfaction among surveyed individuals.

Environmental Monitoring: Environmental quality monitoring targets compliance with water, air, and noise quality standards, dust, silica and hazardous gases inside tunnels, wastewater quality, sediment control, and erosion prevention.

Community Health and Safety Performance: Community and worker health indicators emphasize training in hygiene, STD prevention, GBV awareness and SEA/SH risks, with quarterly audits addressing health impacts. Public safety is monitored by tracking incidents such as drownings and evaluating adherence to safety protocols near project areas.

OHS Performance: OHS performance is tracked using metrics like Lost Time Injury Frequency Rate, Total Recordable Incident Rate and accident rates against industry benchmarks. Regular emergency preparedness drills and training ensure readiness, with annual emergency preparedness and response drills and bi-annual reporting on readiness, Lock-Out/Tag-Out procedures for electrical safety, and maintaining machinery through regular checks.

Penalties for non-compliance: For repeated instances of non-compliance with E&S requirements, the Owners Engineer will withhold three percent of the contractor's monthly payment. The withheld amount will only be released once the identified non-compliance issues have been satisfactorily addressed.

8.4 Reporting

The following reports will be prepared by PIU and contractors during the project implementation.

Incident and Non-Compliance Reporting: Any incidents or non-compliance related to environmental and social incidents will be documented and reported promptly. Incident reports are required to include a description of the incident, immediate corrective actions, and preventive measures to avoid recurrence. Major incidents or those with significant environmental or social impacts are reported immediately to the PIU and relevant stakeholders, including regulatory authorities, as necessary.

Monthly and Quarterly Reporting: Monthly reports on environmental and social performance are prepared by the Contractors' teams on-site. These reports are consolidated into quarterly reports by PIU that provide a comprehensive overview of the project's adherence to the ESMP. The quarterly reports serve as critical tools for the PIU to review the project's compliance status and decide on any additional interventions or modifications in the management plan.

Annual Environmental and Social Performance Report: An annual report by PIU compiles all relevant data and findings from the monthly and quarterly reports, providing a year-end summary of the project's overall environmental and social performance. This report includes an evaluation of the effectiveness of implemented mitigation measures and any need for adjustments to the C-ESMP.

8.5 Grievance Mechanism

The grievance mechanism (GM) for the DHPP is structured to ensure that complaints and concerns from individuals, groups, and local communities are handled systematically throughout the project lifecycle—from preparation through construction, operation, and decommissioning. Key elements of the mechanism are as follows:

- **Purpose and Objectives:** The GM aims to identify, assess, and resolve grievances early, providing a predictable, transparent, and credible process that ensures outcomes are seen as fair and effective. This mechanism seeks to address adverse community incidents before they escalate, thus supporting stable community relations.
- **Structure**: The GM is organized with two levels of committees—regional and local. Each grievance can be escalated to higher levels if the proposed resolution is unsatisfactory to the complainant. Criminal complaints, if any, are automatically referred to the judiciary or Royal Bhutan Police (RBP)
- **Submission Channels**: Grievances can be submitted through multiple channels: Short Message Service (SMS) to a project focal officer; Email to a designated address; In-person submissions at the DGPC Office or the project office in Mongar; Grievance boxes located at key project sites; and Online submission through a dedicated link on the project website.

- **Steps of the Process:**
  - **Grievance Uptake**: Complaints are categorized upon receipt based on type (e.g., environmental, social, or cultural) and logged in a grievance register.
  - **Acknowledgment and Follow-up**: An acknowledgment of receipt is sent to the complainant within two days.
  - **Verification and Investigation**: The Grievance Redress Committee (GRC) investigates the complaint within 10 days, aiming to propose an appropriate resolution .
- **Resolution and Feedback**: If the resolution is accepted by the complainant, the case is logged and closed. If rejected, the grievance may be escalated to a higher committee or resolved through the judiciary. Feedback is provided monthly, tracking the status of complaints and satisfaction with the resolution.

8.6 Capacity Building

The DGPC demonstrates foundational E&S management capabilities but has areas for improvement to meet the requirements of the DHPP. DGPC operates with a centralized E&S management system supported by ISO certifications (ISO 9001, 14001, and 45001), ensuring quality, environmental, and occupational health and safety standards. The DGPC's current E&S staff consists of 14 professionals, including three senior officers with over 13 years of experience, but the team is constrained by limited specialized roles and resources for high-capacity, large-scale projects like DHPP. The E&S unit, structured under the Geology, Environment, and Survey Unit, is responsible for compliance with Bhutan's environmental guidelines and is engaged in several environmental monitoring and compliance activities. However, DGPC lacks certain expertise areas crucial for DHPP, including social specialists, biodiversity experts, and specialists in gender and GBV/SEA/SH issues. Moreover, the DGPC's E&S unit does not have GIS resources, although some staff use QGIS for spatial planning, indicating a need for enhanced technical resources.

To bridge these gaps, the proposed capacity-building plan includes hiring additional personnel and delivering targeted training. Essential roles, such as an international ESHS consultant and specialists in biodiversity, social development, and community engagement, will be added. Training will focus on implementing World Bank standards, advanced monitoring techniques, GIS applications, and specific areas like environmental flow assessment and gender-sensitive planning. This strategic capacity-building initiative aims to strengthen DGPC's E&S risk management, aligning its operations with international standards to successfully implement and monitor DHPP's E&S commitments.

8.7 ESMP Budget

The total budget of US$ 34 million is allocated for the implementation of the ESMP, including US$ 16.6 million for the implementation of BMP. This budget covers comprehensive environmental and social measures, PIU's E&S staffing and consultants, environmental monitoring, biodiversity conservation and local area development.

9 Stakeholder Consultations and Disclosure

9.1 Identification of Stakeholders

Affected Stakeholders: Affected stakeholders of the Project include individual households facing impacts from land acquisition, resettlement, and land submergence, particularly in Tsengkhar, Tsamang, and Jarrey Gewogs. Local communities near project areas—such as those in Tsamang, Saleng, Chhaling, Tsakaling, and Tsenkhar Gewogs—are also affected due to anticipated disruptions from construction activities. Businesses and downstream communities potentially impacted by river flow changes are similarly categorized. Additionally, Community Forest Management Groups that depend on forest resources may experience restricted access, while workers and their families—both local and foreign—are directly affected by employment, labor standards, and health and safety conditions associated with the project.

Other interested stakeholders: These stakeholders consist of parties with professional, regulatory, or social interests in the DHPP, though they are not directly impacted by the project's physical operations. This group includes governmental and regulatory bodies such as the Ministry of Energy and Natural Resources (MoENR) and its departments, along with the DoFPS. Local government and community representatives, including Dzongkhag and Gewog authorities, are also involved in project oversight. Civil society organizations and NGOs, such as the Royal Society for Protection of Nature and the Tarayana Foundation, are engaged due to their advocacy roles. Academic and research institutions like the National Research and Development Centre for Riverine and Lake Fisheries contribute through environmental monitoring and research. Local businesses and service providers are economically interested as suppliers, while cultural and religious institutions overseeing cultural heritage sites are concerned with preserving nearby sacred areas.

9.2 Details of Stakeholder Consultations

A total of 67 consultation meetings were conducted, including both broad community sessions and targeted focus group discussions. Consultations were conducted in multiple phases, with key rounds in May 2023, April 2024 and November 2024. About 894 participants (482 male and 412 female) have participated in these meetings. These consultations involved the following groups.

- **Government and Local Officials:** Meetings were conducted with officials from Mongar and Lhuentse Dzongkhags, including Dasho Dzongdas, Dzongrabs, and sector heads. These sessions gathered high-level input on the project's impacts and potential mitigation strategies.
- **Communities:** Consultations were organized in affected gewogs, specifically Tsamang, Saleng, Mongar, Chaling, Tsakaling, Tsenkhar, and Jarey. Additional sessions were held for directly impacted communities, such as Autso, Tsamang, Tsakaling, Tokari and Drangmaling.

9.3 Feedback from Stakeholder Consultations

There is overwhelming support for the DHPP from the local communities, with strong enthusiasm for the potential economic and infrastructure benefits it promises. Key outcomes from the community are land compensation, environmental impacts, social welfare, and long-term community benefits. Stakeholders emphasized the need for clear communication regarding land acquisition and compensation, particularly for small landowners. Environmental concerns included air and dust pollution, waste management, and the potential impact on local water sources.

Social issues such as GBV, child protection, and community safety were highlighted, with recommendations for a gender action plan, community policing, and collaboration with the National Commission for Women and Children (NCWC). Local communities also expressed strong expectations for employment opportunities

and economic benefits from the project, with particular interest in renting housing to workers and engaging in business activities.

Requests were made for improvements in public infrastructure and services, including waste collection, fire engines, and power supply. Lastly, concerns about health and safety, especially regarding the impact of an influx of workers, led to calls for stronger health infrastructure and safety measures to protect children and local communities. Overall, the feedback emphasized transparency, environmental protection, and long-term benefits for the local population.

9.4 Disclosure

The project's E&S documents, including this executive summary, ESIA, and ESMP, will be disclosed on the DGPC and World Bank websites. The executive summary of the ESIA will be translated into Bhutanese language and disclosed on the DGPC website. It will also be made available to the local communities through public information centres. These centres will serve as a resource hub where community members can access project-related information and follow up on the implementation of the ESIA and associated management plans.