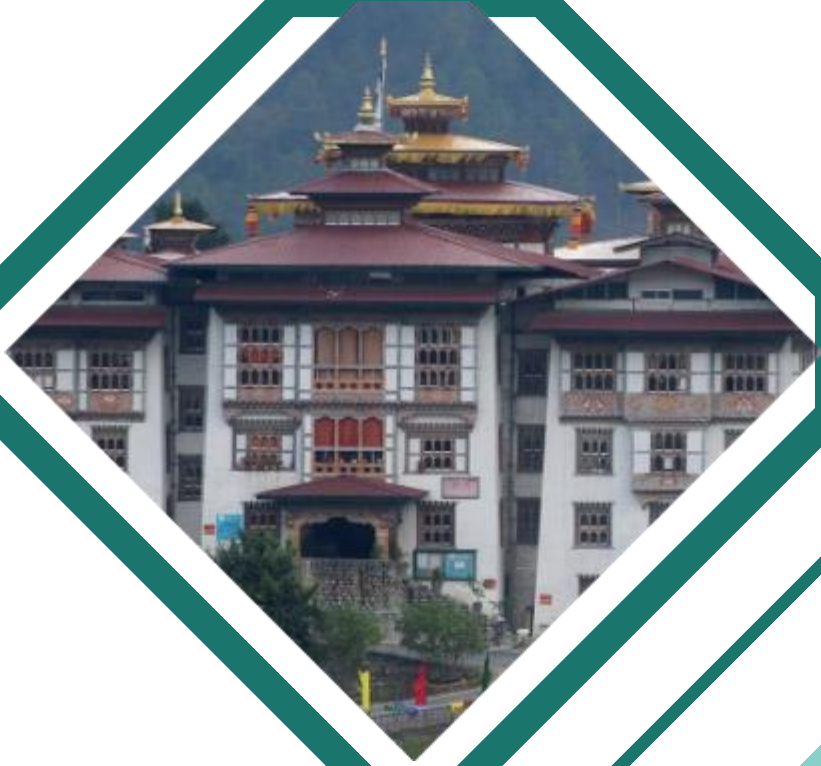
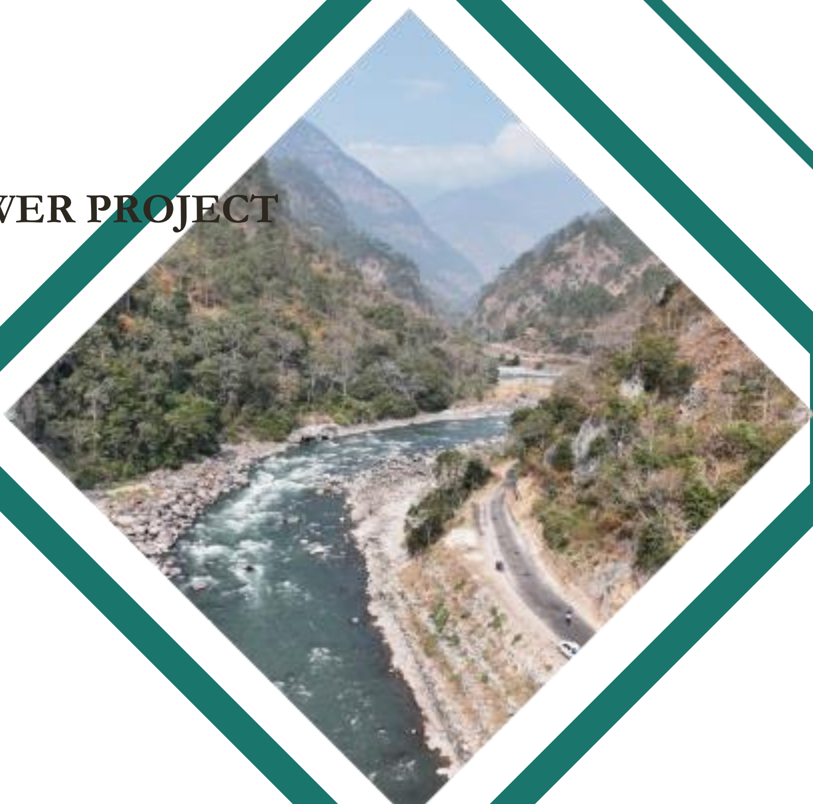


ENVIRONMENT & SOCIAL IMPACT ASSESSMENT (ESIA)

ADDENDUM TO CUMULATIVE IMPACT ASSESSMENT (CIA)

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)"

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LIST OF ABBREVIATIONS AND ACRONYMS

BMP	Biodiversity management plan
CIA	Cumulative Impact Assessment
DGPC	Druk Green Power Corporation
DPR	Detailed Project Report
Eflow	Environmental Flow
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
HPP	Hydropower Project
RgoB	Royal Government of Bhutan
VECs	Valued Ecosystem Components
WB	World Bank

GLOSSARY

Word / Term	Meaning
Note on units	For most of the ESIA, the metric system is being used. Surface is expressed in acres as this is the commonly used unit in Bhutan.

1. EXECUTIVE SUMMARY

The Cumulative Impact Assessment (CIA) for the Dorjilung Hydropower Project (HPP) has been prepared as an addendum to the original CIA for the Kuri-Gongri Basin (SWECO, 2018). It addresses the cumulative impacts associated with the Dorjilung project and other HPPs and associated human activities in the Kurichhu Basin, which were not comprehensively covered in the original SWECO CIA. The SWECO CIA provided a broad assessment of the cumulative impacts of multiple hydropower projects within the Kuri-Gongri Basin, but it lacked detailed, project-specific data on the Dorjilung HPP, other HPPs and activities. This addendum aims to bridge that gap by incorporating recent data and analysis for the environmental and impact assessment of Dorjilung HPP, ensuring a thorough evaluation of the Dorjilung HPP's potential cumulative impacts on the basin's environment and communities.

The Dorjilung HPP is a significant project within the Kurichhu Basin, and its cumulative impacts need specific attention. This addendum allows for a detailed examination of these impacts, particularly in relation to other hydropower projects and human activities in the basin. It provides a focused assessment on how the Dorjilung HPP interacts with existing and planned projects, which is essential for understanding the full scope of cumulative impacts across the basin.

The cumulative impact assessment assesses broader impacts, specifically examining the cumulative effects of the Dorjilung Project in combination with other hydropower initiatives within the Kurichhu Basin. It uses the same methodology used for the SWECO CIA and the selection of the same twelve valued environmental and social components (VECs). Three VECs have been identified as experiencing beneficial cumulative impacts, while eight VECs are assessed to face slight to significant cumulative impacts (see Table 1 below).

Table 1: Cumulative Impacts to Selected VECs

Selected VECs	Kuri-Gongri Scenario 1 Case	Dorjilung CIA Addendum Case
Forest Cover	Slight negative impact.	Significant negative impact
Slope Stability	Significant negative impact	Major negative impact
Migratory Fish	Major negative impact	Significant negative impact
Scenery and Landscapes	Moderate negative impact	Major negative impact
Protected Areas	Major negative impact	Moderate negative impact
Livelihood Opportunities	Slight positive impact	Significant positive impact
Community Quality of Life	Significant negative impact	Major negative impact
Access to Markets and Services	Positive impact	Positive impact
Cultural Heritage	Significant negative impact	Slight negative impact
Downstream Public Safety	Significant negative impact	Significant negative impact

Selected VECs	Kuri-Gongri Scenario 1 Case	Dorjilung CIA Addendum Case
Economic Growth	Significant positive impact	Major positive impact
Domestic Electricity Supply Security	Positive impact	

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

The following are key recommendation suggested to manage cumulative impacts in the Kurichhu Basin:

- **Develop and implement a cascade management plan** for the coordinated operation of Kurichhu, Dorjilung, Kuri-Gongri, Khomachhu and Yungichhu HPPs within the catchment (focusing on flood risks, sediment transport, and flushing strategies to maintain riverine health, and ensuring effective fish monitoring and ecological management to support biodiversity). DGPC is the sole developer and operator of the assets, greatly increasing the consistency and efficiency of the cascade management plan.
- **An aquatic and fish management plan** should be established, to address the conservation and monitoring of aquatic life across the Kurichhu basin, particularly focusing on migratory species.
- Create strategies to **maintain or enhance river connectivity**, which is critical for migratory species, to ensure they can complete their life cycles without significant disruption from hydropower operations.
- Prepare a **cumulative impact management plan** for the Kurichhu Basin.
- Develop a **downstream adaptive management plan** below the confluence of the Kuri and Gongri Rivers.
- Consider the implementation of a nation-wide strategy for the Hydropower Master Plan 2040 to **preserve one or more free-flowing rivers** without hydropower development on the river mainstem across watersheds in Bhutan. Options for hydropower development could be undertaken on tributaries in coordination with solar power development. This would provide further assurance of energy security while also promoting ecotourism and other economic development opportunities.
- **Work in collaboration with environmental agencies, non-governmental organizations, and local communities to** develop and implement these programs.

2. INTRODUCTION

2.1. BACKGROUND

This Cumulative Impact Assessment (CIA) for the Dorjilung Hydropower Project (HPP) has been prepared as an addendum to the original CIA for the Kuri-Gongri Basin (SWECO, 2018). It addresses the cumulative impacts of the Dorjilung HPP, which were not comprehensively covered in the original CIA. The SWECO CIA provided a broad assessment of the cumulative impacts of multiple hydropower projects within the Kuri-Gongri basin, but it lacked detailed, project-specific data for the Dorjilung HPP. This addendum aims to bridge that gap by incorporating recent data and analysis for the environmental and impact assessment of Dorjilung HPP, ensuring a thorough evaluation of the Dorjilung HPP's potential cumulative impacts on the basin's environment and communities.

The Dorjilung HPP is a significant project within the Kuri River Basin (Kurichhu) and its cumulative impacts require specific attention. This addendum allows for a detailed examination of these impacts, particularly in relation to other hydropower projects and other projects in the basin. It provides a focused assessment on how the Dorjilung HPP interacts with existing and planned projects in combination with other projects and associated human activities, which is essential for understanding the full scope of cumulative impacts on selected valued environmental and social components (VECs).

Importantly, this addendum does not alter the content and conclusions of the original CIA concerning other hydropower projects in the Kurichhu Basin. Instead, it complements the original assessment by adding depth and detail to the analysis of the Dorjilung HPP. This ensures that stakeholders have a clear and complete understanding of any additive potential cumulative impacts attributed to the Dorjilung HPP without changing the established findings related to other projects. It also adds other projects in the Kuri River basin which were not included in the SWECO CIA.

The addendum also responds to stakeholder concerns and requirements for more detailed information about the Dorjilung HPP. It aligns with IFC Good Practices for cumulative impact assessment, ensuring that all potential impacts are thoroughly evaluated and managed. This detailed approach supports informed decision-making and helps to mitigate any adverse effects on the environment and local communities within the Kurichhhu Basin.

2.2. SCOPE OF THE CIA

The SWECO CIA (2018) for the Kuri-Gongri Basin provided a comprehensive evaluation of the collective environmental and social impacts of multiple hydropower projects within the basin. However, since the original assessment, significant developments and additional data have emerged, necessitating an update to refine the cumulative impact analysis with a specific focus on the Dorjilung HPP and other potential projects. The CIA of the Dorjilung HPP aims to evaluate the collective impacts of various projects and activities, focusing on the same Valued Environmental and Social Components (VECs) within the Kurichhu Basin.

2.3. STUDY LIMITATIONS

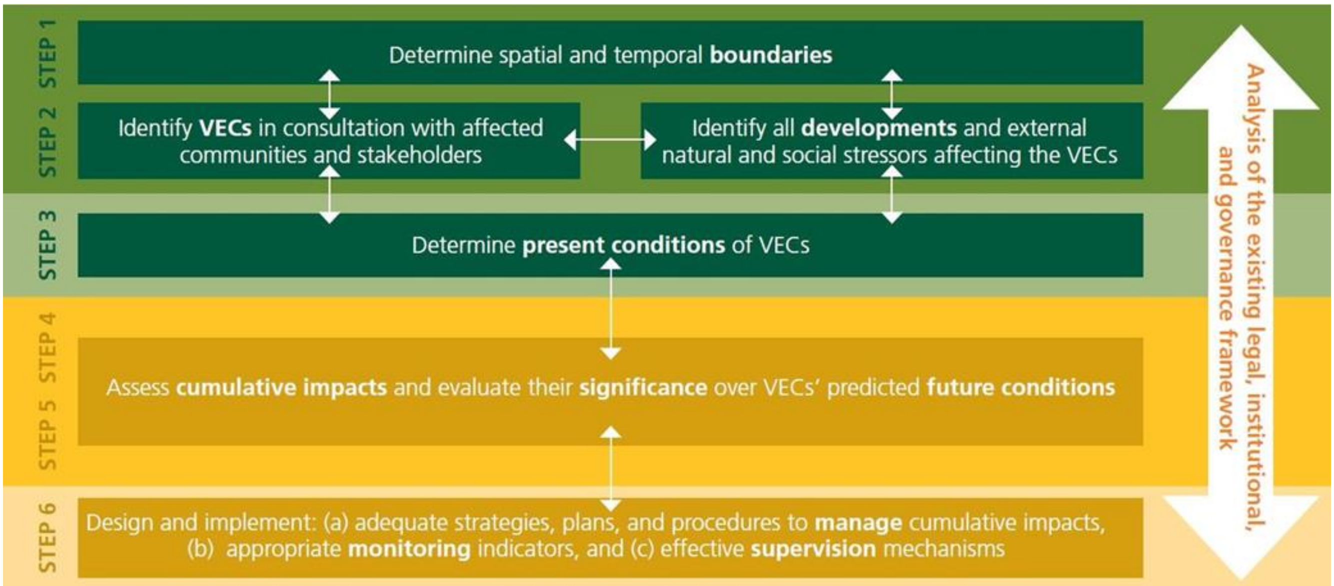
The Dorjilung HPP CIA addendum present some important limitations that may be improved in future studies including:

- The use of secondary, and sometimes outdated, baseline data, which may not fully reflect current conditions.
- The provision of unreliable elevation data, affecting key hydraulic and topographical analyses.
- Incomplete information on other activities, necessitating estimations and assumptions that introduce uncertainty.
- Lack of detailed public consultation regarding the various steps of the CIA process.
- The lack of detailed design information for many projects, leading to significant uncertainties in assessing the impacts on footprint dependent VECs.
- Uncertainties in the extent of spatial and temporal boundaries as a result of the above.

3. CIA METHODOLOGY

The CIA follows a structured six-step process based on the International Finance Corporation's (IFC) Good Practice Handbook on Cumulative Impact Assessment (IFC, 2013) as shown below in Figure 1.

Figure 1: CIA Methodology Steps from The IFC CIA Good Practice Handbook



These steps include:

- **Scoping Phase I:** Identifying VECs and establishing the spatial and temporal boundaries for the assessment. This step involves stakeholder consultation to understand concerns and define the scope of the study.

- **Scoping Phase II**: Identifying other activities and environmental drivers within the established spatial and temporal boundaries that could contribute to cumulative impacts. This involves compiling data on existing and planned projects and understanding their potential interactions with the VECs.

- **Baseline Status of VECs:** Establishing the current conditions of VECs, including their resilience and ability to recover from stress. This step requires comprehensive data collection on ecological, hydrological, and socio-economic aspects to form a robust baseline.

- **Cumulative Impact Assessment:** Identifying and assessing the potential cumulative impacts on the VECs. This involves evaluating the additive, countervailing, masking, and synergistic effects of multiple projects and activities on the VECs.

- **Significance Assessment:** Evaluating the significance of identified cumulative impacts on the VECs. This step assesses the magnitude, extent, and duration of impacts, considering thresholds and indicators relevant to each VEC.

- **Management of Impacts:** Proposing mitigation measures and monitoring programs to manage the identified cumulative impacts. This includes developing strategies to minimize adverse effects and enhance positive outcomes for the VECs.

A CIA focuses on VECs which are the receptors of impacts from various projects and activities. This approach contrasts with an Environmental and Social Impact Assessment (ESIA), which concentrates on a single project as a generator of effects on various environmental and social receptors. In a CIA, the emphasis is on understanding the cumulative impacts that multiple projects and activities have on key environmental and social components in time and space. A cumulative impact assessment therefore focuses on the VEC, while the ESIA focuses on the impacts of project activities.

3.1. DETERMINATION OF SPATIAL AND TEMPORAL BOUNDARIES

IFC (2013) recommends the following rules of thumb to determine the spatial boundary of a CIA:

- Include the area that will be directly affected by the project or activity which is known as the direct area of influence (Direct Area of Influence (DAI);
- List the important resources (VECs) within the DAI;
- Define if these VECs occupy a wider area beyond the DAI; and
- Consider the distance an effect can travel, and other impacts the VEC may be exposed to within its range.

The proposed basic rules of thumb to determine the temporal boundaries for the assessment are as follows:

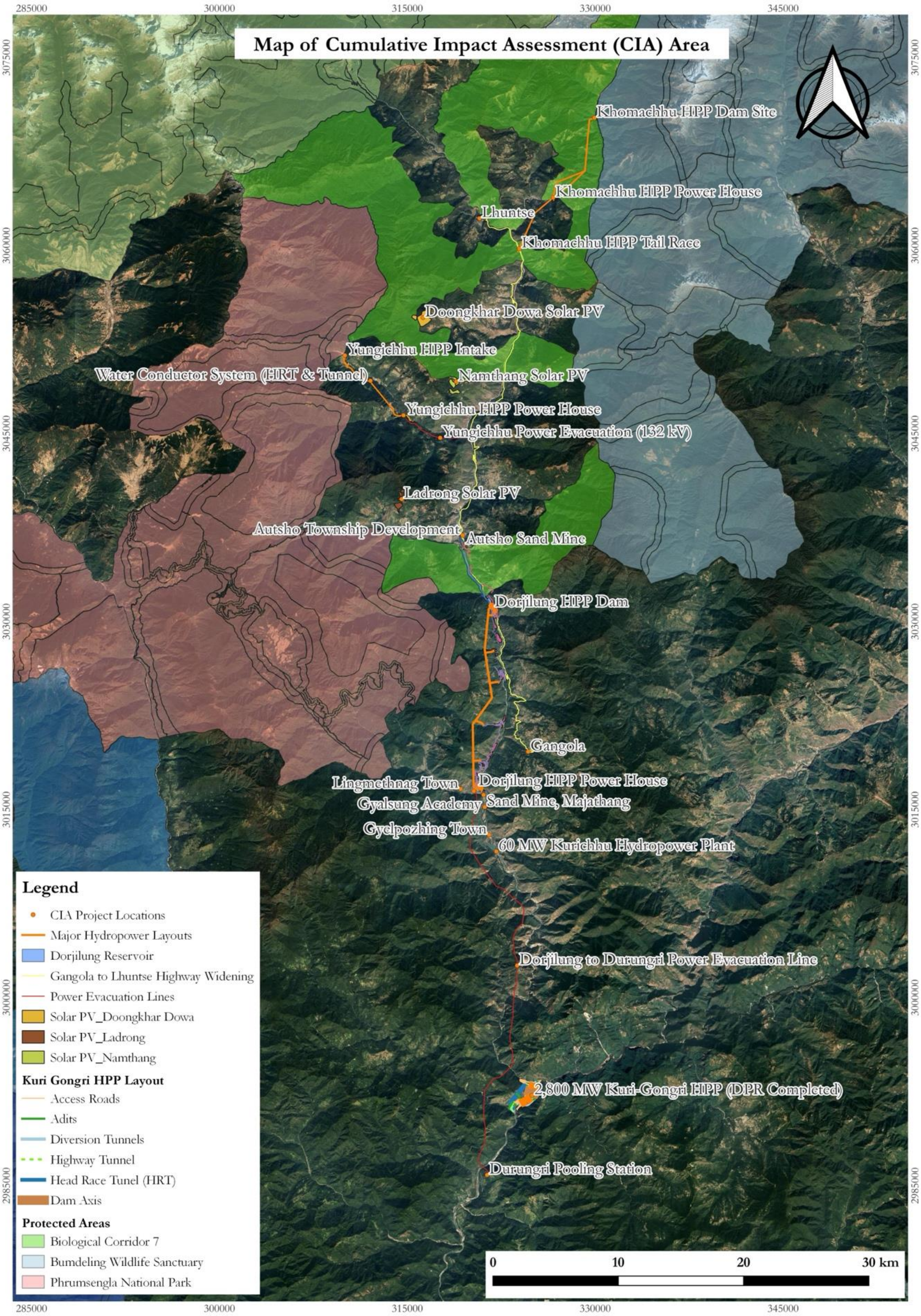
- Use the time frame expected for the complete life cycle of the proposed development
- Specify whether the expected time frame of the potential effects of proposed development can extend beyond the project life.
- Use the most conservative time frame between the above.
- Use of professional judgment to balance between overestimating and underestimating, and make sure to document the justification or rationale.
- Exclude future actions if (i) they are outside the geographical boundary, (ii) they do not affect VECs, or (iii) their inclusion cannot be supported by technical or scientific evidence.

The area that will be directly affected by the project or activity is referred to in three ways encompassing direct, indirect, and cumulative areas of influence.

- The **direct AoI** includes the specific geographic area where the project activities will have immediate and noticeable impacts. This area typically covers the construction site, operational facilities, and any locations where project activities directly alter the physical environment, such as land clearing, infrastructure development, and resource extraction.
- The **indirect AoI** extends beyond the direct AoI to include areas where project impacts are not immediate but occur as secondary effects. These could involve changes in local traffic patterns, socio-economic shifts due to increased employment opportunities, and alterations in local ecosystems due to upstream or downstream effects on water flow or quality.
- The **cumulative AoI** is broader and encompasses the overall geographic region affected by the combined impacts of the project and other existing, planned, or reasonably foreseeable projects. In

the case of the Dorjilung HPP, the cumulative AoI includes the Kuri-Gongri Hydropower Project (HPP) downstream and the Yungichhu HPP upstream. This extended area considers the aggregated effects on the environment, society, and economy from multiple projects within the same watershed or region.

Figure 2: Cumulative Impact Assessment Area



3.1.1. Extension of the CIA Boundary to the Bhutan/India Border

There have been concerns raised by the Government of India to the Government of Bhutan over flooding downstream in the Manas River and its effect in Assam Province. Therefore, consideration was given towards extending the border downstream of the proposed Kuri-Gongri Project to the Indian border. However, it was decided to maintain the most southerly border of the CIA to the confluence of the Kuri and Gongri River for the following reasons.

1. There are no downstream HPPs planned for the Drangmechhu River (Manas River). Panbang Pumped Storage Power Project was listed as one of the three identified sites for the pumped storage hydropower projects in the Bhutan Power System Master Plan (PSMP-2040), where there was a plan to construct a regulating reservoir and HPP - the 1,100 MW Panbang HPP. However, based on the reconnaissance study carried out in 2021, the project was not pursued further due to significant geological and seismic challenges, including fractured rocks, landslide sand active thrust zones, which required extensive feasibility studies. Furthermore, the financial viability of the project was questionable. As there are no HPPs planned downstream of the Kuri Gongri HPP, it was decided to keep the boundary of the CIA to the confluence of the Kuri Gongri Rivers. This is a primary reason for not extending the boundary of the CIA as there are no other hydropower projects to include in the CIA.

2. There are numerous references [2]in the media regarding downstream flooding in Assam that was attributed to the Kurichhu HPP and from HPP development in Bhutan. However, review of the evidence shows that both the size and nature of flushing volumes of the Kurichhu HPP would not be enough to cause downstream flooding in India. Downstream flooding and sedimentation in Assam were rather attributed more to heavy rainfall and flooding in Bhutan watersheds and not ascribed to HPP development.[3]

3. There are also two hydroelectric projects on the Mangdechhu River (also the Trongsa River) which is a tributary to the Drangmechhu River downstream of Kuri Gongri HPP. The first is the Mangdechhu HPP which is 720 MW run of river project (commissioned in 2019). There is also another 118 MW project on a tributary to the Mangedechhu River. As these are upstream and not in the mainstem of the Mangedechuu River, they are not included in the CIA.

[2] **References:**

i. *https://thebhutanese.bt/kurichu-project-wrongly-blamed-for-floods-in-some-districts-of-assam/*
ii. *https://dialogue.earth/en/climate/massive-flood-on-bhutan-india-border-triggers-blame-game/*
iii. *https://businessbhutan.bt/indian-media-reports-on-floods-baseless/*
iv. *https://www.deccanherald.com/india/bhutan-to-release-excess-water-from-kurichhu-dam-assam-on-high-alert-1236840.html*
v. *https://timesofindia.indiatimes.com/city/guwahati/water-from-bhutan-dams-flooding-assam/articleshow/101378448.cms*
vi. *https://economictimes.indiatimes.com/news/india/assam-cm-regulated-release-of-water-from-bhutans-kurichhu-dam-ensured-no-severe-flooding/articleshow/101786799.cms?from=mdr*
vii. *https://www.business-standard.com/world-news/incessant-rainfall-in-bhutan-linked-to-assam-floods-say-officials-123062000597_1.html*

3.2. PROJECTS, OTHER ACTIVITIES AND ENVIRONMENTAL DRIVERS

The identification of projects that could influence the VECs, or influence the Dorjilung HPP itself, was carried out as follows:

- **Inventory of Significant Projects:** A list of notable projects currently underway in the catchment area, observable in the field.
- **Direct Consultation with Developers:** Engaging directly with the developers of these projects when necessary to gather detailed information.
- **Bibliographic Review:** Reviewing documents from other funders and stakeholders about the study area to gain additional insights.
- **Consultation with Government Agencies and Dzongkhags:** Consulting with government agencies and local administrative bodies in Thimphu, Mongar, and Lhuentse to identify planned or ongoing development projects.

Key past, present, and future actions within the Kuri River Basin include hydropower, road infrastructure, industrial infrastructure, renewable energy (solar) developments, hospitals, agriculture, sand and gravel extraction, and mining, as well as other external stressors such as climate change and natural hazards. These activities help identify the sources of risks and impacts , including past developments with historical lingering impacts, current developments, anticipated future developments, and other relevant external social and environmental drivers. Table 2 below present a list of these projects.

Table 2: List of Updated Projects Included in the CIA

Project	Description	Location
Yungichhu HPP	Construction of a medium size HPP (32 MW) in the Lhuentse Dzongkhag. Construction has started and it is planned to be commissioned before the likely start of Dorjilung HP.	Yungichhu Stream, Kurichhu basin Maedtsho Gewog, Lhuentse Dzongkhag
Yungichhu HPP Power Evacuation Line	The construction has been completed. The power from Yungichhu HPP will be evacuated at 132 kV to Kilikhar substation and a 33 kV outgoing feeder (7 km till the point of termination) will be connected to Tangmachhu substation. The total 132 kV line distance up to the point of connection on the existing Kilikhar-Tangmachhu line from the project is about 7 km. The tower for the existing Kilikhar-Tangmachhu line starts at about 2 km away from the substation and up to which is connected with	Tshenkhar Gewog, Lhuntse Dzongkhag

Project	Description	Location
	overhead 33 kV poles. Two additional towers have to be erected in that stretch during the expansion of the bay.	
Khomachhu HPP	Large HPP (363 MW) Prefeasibility study completed. Feasibility study of the project is currently being undertaken by DGPC.	Located in the Lhuentse Dzongkhag, with its intake in Khomachhu, upstream of Khoma village
Dorjilung HPP	Large HPP (1125 MW) in planning phase.	Planned on Kurichhu river/basin in Lhuntse – 20 km upstream of Kurichhu HPP
Kurichhu HPP	60 MW HPP on Kurichhu River. Entered into service in 2001.	Located on the Kurichhu River in eastern Bhutan in Gyalpozhing, Mongar
Power evacuation from Dorjilung HPP	Construction of 2 400 kV transmission lines with 52 m ROW. Construction of 132/33 kV substation at Dorjilung HPP. Proposed, construction has not started.	35 km transmission line from Dorjilung HPP to Durungri PS
Solar Power Projects	Ladrong Solar PV (30 MW), Namthang Solar PV (60 MW) and Doongkar Dowa Solar PV (80 MW). Desktop studies undertaken. Field surveys and detailed feasibility studies yet to be initiated.	Jarey Gewog and Maenbi Gewog, Lhuentse
Sand mines	The NRDCL sand mining site in Autsho is very small, less than half an acre and very marginal as it only includes a small sand borrow area on the riverbank (no permanent equipment or sand pumping operations).	(Tsenkhar Gewog-Lhuentse Dzongkhag)
Gyalsuung Industrial Estate Development	Bhutan national service training center. The first training session is started in September 2024.	Lingmethang, Saling gewog
Gangola-Lhuentse Highway widening	DPR has been completed and the widening is scheduled to commence very soon during the current 13th Five Year Plan subject to budget availability.	Chhaling, Tsakaling, Tsenkhar gewogs
Development of Autsho town	Autsho has been designated as pilot town "Liveable City" for Lhuentse Dzongkhag.	Autsho Town, Tsenkhar gewog

Project	Description	Location
Kuri Gongri HPP	Detailed Project Report of Large (2,800 MW) HPP completed in 2024. Implementation schedule not known.	Planned on the Drangmechhu/Mongar River basin in Mongar Bhutan
Gyalpozhing Town	Gyelpozhing is a town in Mongar District in southeastern-central Bhutam. It is located to the west of Mongar and east of Limgmethang. The town's growth began in the mid-1990s following the commencement of Kurichhu Hydropower Corporation Limited (KHPCL) in 1992 (Kuensel, Aug 11, 2022).	Drepong Gewog, Mongar Dzongkhag

VALUED ENVIRONMENTAL AND SOCIAL COMPONENTS

Establishing the baseline involves defining the existing conditions of VECs, understanding their reaction to stress, resilience, and recovery time, and assessing trends. This includes detailed hydrological and socio-economic data collection. The Dorjilung HPP CIA Addendum therefore uses the same valued environmental and social components as the SWECO (2018) CIA.

Table 3: List of Selected VECs for the Dorjilung CIA Addendum

VEC	Description
Forest Cover	Bhutanese policies mandate a minimum of 60% forest cover in the country, highlighting the importance placed on preserving this ecosystem. Protecting habitats is recognized as crucial for preserving biodiversity. Forest cover serves as a measurable indicator in assessing the impacts of hydropower developments, particularly focusing on the area of forest affected by such projects. The development of transmission lines and roads associated with hydropower projects may also impact protected areas, underscoring the interconnectedness of various environmental factors within the region.
Slope Stability	Bhutan's susceptibility to natural disasters, particularly due to its steep landscape prone to landslides, underscoring the paramount importance of public safety. Potential impacts from hydropower developments include direct construction effects, indirect consequences from roadworks, and hydropower operations-induced slumps along reservoirs or downstream rivers due to fluctuating water levels.
Migratory Fish	Dams and associated infrastructure inherently alter the aquatic ecosystem, primarily through changes in the water flow regime and by creating barriers to fish passage. These changes can be particularly detrimental to migratory fish species, such as the Golden Mahseer*,* which is both culturally significant in Bhutan and known for its extensive migratory patterns. Given that the Golden Mahseer is an indicator species for the health of riverine systems, its vulnerability to the cumulative impacts underscores the need to consider fish and aquatic habitats as an important VEC in the assessment. However, the field surveys (2023) for this ESIA highlighted the absence of the Golden Mahseer upstream of the Kurichhu HPP as the species is strongly suspected of not crossing its fish ladder. The construction of the Dorjilung HPP will directly impact these species by altering their natural habitats and migration routes, not only through the presence of the dam itself but also due to the additional construction of roads and transmission lines. These activities increase human access to previously remote areas, which could lead to a rise in both legal and illegal fishing activities. The indirect threats also include habitat fragmentation, changes in sedimentation patterns, and potential pollution from construction activities. The project is also characterized by restricted range species for which little is known in term area distribution, matting, population dynamic, movement, and migration. In the project area 3 CHQ fish species (*Creteuchiloglanis bumdelingensis*, *Parachiloglanis bh*utanensis and *Parachiloglanis dan*gmechuensis are present and known to occur in the upper part of watershed and tributaries.
Protected Areas	The presence of Phrumsengla National Park within the project's area of influence is particularly noteworthy, as this park plays a vital role in conserving the central region's temperate ecosystems and is interconnected with four other protected areas, thereby forming a larger conservation network. The Bumdeling Wildlife Sanctuary and associated biological corridors in particular BC#7 are essential for ensuring safe migratory paths for various species, facilitating their movement between protected zones. This connectivity is crucial for the genetic diversity and resilience of wildlife

VEC	Description
	populations. In addition to national parks and protected areas, the CIA contain the KBA designated for the Pallas Fish Eagle and is inside the Tiger conservation landscape (WWF and Resolve) and the Eastern Himalaya endemic birds area (BirdLife). The integrity of natural forests is another critical consideration, having been included in the CIA due to the forested land's value to local communities, its contribution to biodiversity, and its role in sustaining ecological processes and ecosystem services. These areas are not just habitats for flora and fauna but also underpin community livelihoods and cultural values. Given these factors, the potential cumulative impact of the Dorjilung Project, particularly when considered alongside other planned developments, necessitates careful assessment and management to safeguard these vital ecological and socio-cultural resources.
Livelihood Opportunities	Construction phases provide employment and business opportunities, but operational phases offer limited local livelihood prospects. The effectiveness of mitigation measures strongly influences this VECs impact. It was decided to maintain it as a VEC and assess its practical implications through detailed analysis.
Community Quality of Life	Community Quality of Life highlighted concerns regarding the potential disruption of traditional village life by hydropower projects. Key concerns included local impacts such as increased road traffic, dust, and changes in land use, as well as issues like economic and physical displacement, community safety and loss of community cohesion.
Access to Markets and Services	This VEC centers on the many potential benefits brought to local communities by hydropower projects. These benefits typically include better road access, health centers, and markets. Given that there are almost no project details of this nature within the Kurichhu basin, there were concerns it could not be measurable. It was agreed to retain for the VEC analysis and see if an indicator could be derived relating to the road network and improved accessibility.
Cultural Heritage	Cultural heritage was deemed crucial to include as a VEC due to its significance to the national Bhutanese identity and its importance in local contexts. Discussions on quantifying it as a VEC centered around identifying cultural heritage sites and assessing their proximity to the projects.
Downstream Public Safety	This VEC was identified as vital and specifically focuses on in-river safety concerns downstream of the five hydropower projects. Key considerations include downstream dam-break modeling, which can be assessed utilizing the hydraulic modeling capabilities.
Economic Growth	Discussion of this VEC relates to Bhutan's interests in greater industrial development and income from electricity exports. It was considered that there were several potential ways to derive indicators for this.

VEC	Description
Domestic Electricity Supply Security	This VEC was quite consistently agreed as of high importance. It was proposed as Enhancement of Firm Power in the DHPS list. It was noted that the main period of concern is in winter with low flows, during which Bhutan must import electricity, and that storage hydropower is a critical aspect of ensuring supply security. Because there was insufficient data available in the revised update, this VEC was not considered in the CIA.

3.3. STAKEHOLDER ENGAGEMENT

The International Finance Corporation Stakeholder Engagement Guidelines outline principles to ensure effective and meaningful engagement with stakeholders in the context of projects (IFC, 2007).

The stakeholder engagement process respects the principles of **transparency and inclusivity** thereby ensuring that all relevant stakeholder groups, including marginalized and vulnerable communities, are identified, and involved in the engagement process. It requires respect of and adaptation to cultural contexts and practices of stakeholders to facilitate their participation. It includes **responsiveness** whereby stakeholder feedback influences project decisions and adaptive management and **mutual respect**. It is an **ongoing dialogue** with stakeholders throughout the project lifecycle, from planning through implementation and monitoring. The Stakeholder Engagement Plan (SEP) ensures that the effectiveness of stakeholder engagement activities is monitored and evaluated. The SEP provides accessible and effective mechanisms for stakeholders to raise concerns or complaints about the project and ensure that grievances are addressed in a timely, transparent, and fair manner.

DGPC ensured that stakeholder engagement was prioritized and integrated into the project's core operations and allocate sufficient resources to ensure effective engagement activities. The Stakeholder Engagement process started early in the Project's planning phase to ensure effective stakeholder engagement during the Project.

- Consultation was conducted as part of the ESIA preparation phase in 2015-2016 with a) affected households, b) local communities' people in the villages and urban settlements, c) local government at the gewog level in Mongar and Tsaenkhar in Lhuentse). The objective of the consultations was to inform the public about the project, project components, the activities, the size, labor and equipment that would be employed, the positive impacts that the project will bring to the local and national economy; possible negative impacts that the people have to accommodate with and to invite public opinion, issues and concerns in the ESIA and RP Report. Formal meetings were held with government agencies such as the National Environment Commission, National Library, National Referral Hospital, Ministry of Health, Forest Ranger, Gyelpozhing, and with the Dzongkhag Administration in Mongar and Lhuentse.

- The later ESIA phase engagement activities sought stakeholder opinions on impacts, mitigation, and enhancement measures and the draft ESIA findings. The process took the form of formal meetings with national and local government, agencies and departments, health and school facilities, community consultation, key informant interviews with NGOS/CSOs, private companies, religious leader, focus group discussion with specific groups including women, youth and vulnerable groups.

Particular emphasis for engagement was placed on the following:

- Present in detail the project details and discuss potential environmental and social aspects.
- Obtain local and traditional knowledge to inform the ESIA process.
- Identify issues of concern to stakeholders so these can be addressed appropriately within the ESIA process, while managing expectations and misconceptions regarding the project
- Establish the significance of environmental, social and health impacts identified.
- Provide engagement opportunities to ensure that the benefits of the project are maximized and that no major potential impacts have been overlooked.
- Provide an opportunity for those otherwise unrepresented to present their views and values, therefore allowing more sensitive consideration of mitigation measures and trade-offs.
- Reduce conflict through early identifications of any contentious issues and seeing acceptable solutions.
- Consult those households whose land is impacted during the land identification process as part of the process of the Land Acquisition and Livelihood Restoration Plan preparation process.
- Discussion livelihood options and other activities that the community may like to take up or be involved in.

Stakeholder consultation also complemented field surveys, data analysis and literature view in the selection of VECs. Feedback from various consultations have also been used to inform the SEP, the ESIA/ESMP and to develop the Gender, SEA/SH and Vulnerability Action Plan, the Cultural Heritage Management Plan, the LARAP and this CIA.

Details of consultation and reports of consultation are included in the Stakeholder Engagement Plan of the Dorjilung Project ESIA.

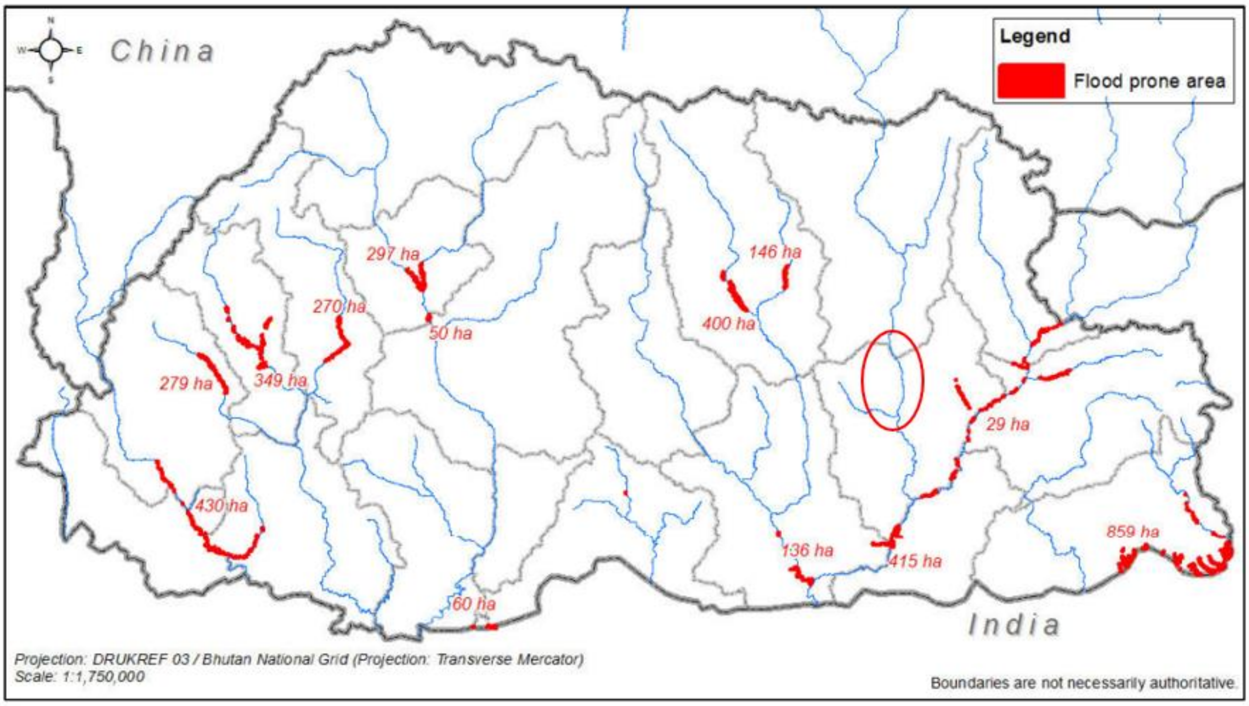
3.4. NATURAL HAZARD AND CLIMATE RISKS

3.4.1. Floods

The climate change-induced unpredictable rainfall patterns and sudden heavy monsoon rains in Bhutan have led to an increase in the occurrence of flash floods in some of the river catchments. Over the years, the southern region of Bhutan has witnessed frequent flash floods and landslides due to intense and sudden heavy rainfall. These extreme weather events have caused significant damage to properties, highways, agricultural lands, irrigation channels, and water supply schemes. The frequency of floods has been on the rise since 1999, with some of the most severe floods occurring in 2000, 2004, 2009, and 2016 (Namgyal 2022).

The impacts of climate change are expected to intensify the monsoon rainfall in the future, leading to an increased risk of floods in certain areas. The National Integrated Water Resources Management Plan (NIWRMP) has investigated areas prone to monsoon floods using Geographic Information System (GIS) technology. The results from the investigation, depicted in Figure 3, highlight the areas that are at higher risk of floods in terms of surface area in hectares. The Dorjilung HPP project site has been identified as being situated in an area isolated from zones prone to floods during the monsoon season and underscores the project's lower sensibility to significant flood-related risks.

Figure 3: Map of Areas Prone to Monsoon Flooding



Source: (Muhammad Atiq 2021) – Red oval show the project area.

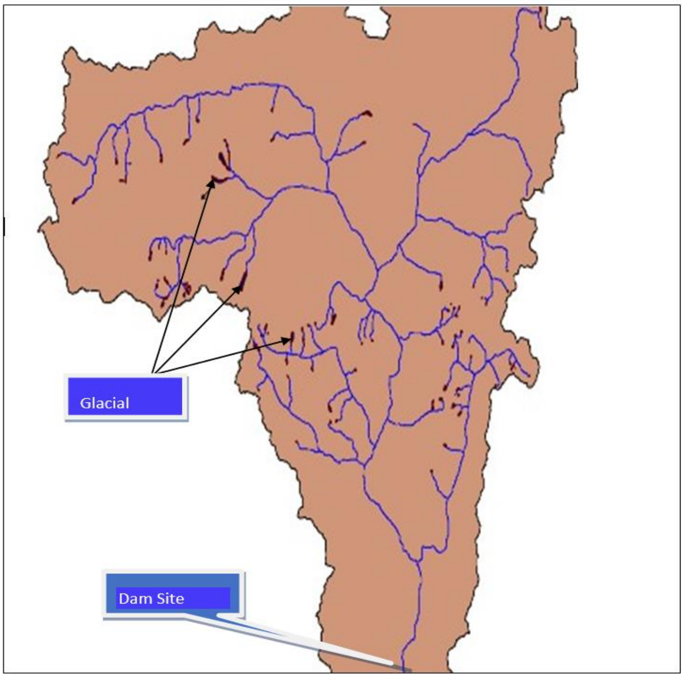
3.4.2. Glacial Lake Outburst Floods (GLOFs)

A GLOF study conducted by Energy Infratech Private Limited India for DGPC in 2016 revealed that the Kuri basin contains a total of 109 glacial lakes with a combined area of 20.30 km². Out of these, 17 lakes covering an area of 12.1 km² were identified as critical due to their size and geomorphologic characteristics. The study identified three types of glacial lakes in the region:

- Glacial Erosion Lakes,
- Glacial Cirque Lakes, and
- Moraine-Dammed Lakes.

Moraine dammed glacial lakes, which are still in contact or very near to the glaciers, are of concern. The Dorjilung HPP site has been deemed to be capable of withstanding potential GLOFs (Figure 4).

Figure 4: Dorjilung Catchment Model with Identified Glacial Lakes



Source: DPR, 2016

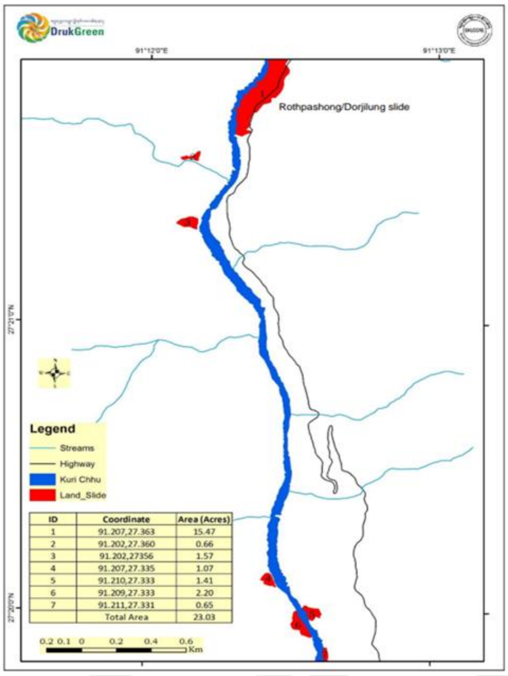
3.4.3. Landslides

Seven landslides have been identified within the project area, predominantly situated near the Kurichhu drainage. The two most significant landslides are the Dorjilung landslide, and another located on the right bank, approximately 1 km downstream of Dorjilung. Collectively, these seven landslides are estimated to cover about 23 acres. Figure 5 below illustrates the major landslide areas along with their location coordinates.

3.4.4. Earthquakes

Bhutan is situated in a highly seismically active region known for experiencing earthquakes of moderate to high intensity. Several significant earthquakes with magnitudes greater than 7, including the Shillong Earthquake (1897, magnitude 8.7) and the great Assam earthquake (1950, magnitude 8.5), have occurred in the nearby north-eastern region. Additionally, the area has experienced other earthquakes of substantial magnitude, such as the Srimangal earthquake (1918, magnitude 7.6), Dubri earthquake (1930, magnitude 7.1), and Bihar-Nepal border earthquake (1934, magnitude 8.3). No significant earthquakes have occurred to date in the project area (see Figure 6).

Figure 5: Areas Prone to Landslide



ID	Coordinate	Area (Acres)
1	91.207,27.363	15.47
2	91.202,27.360	0.66
3	91.202,27356	1.57
4	91.207,27.335	1.07
5	91.210,27.333	1.41
6	91.209,27.333	2.20
7	91.211,27.331	0.65
	Total Area	23.03

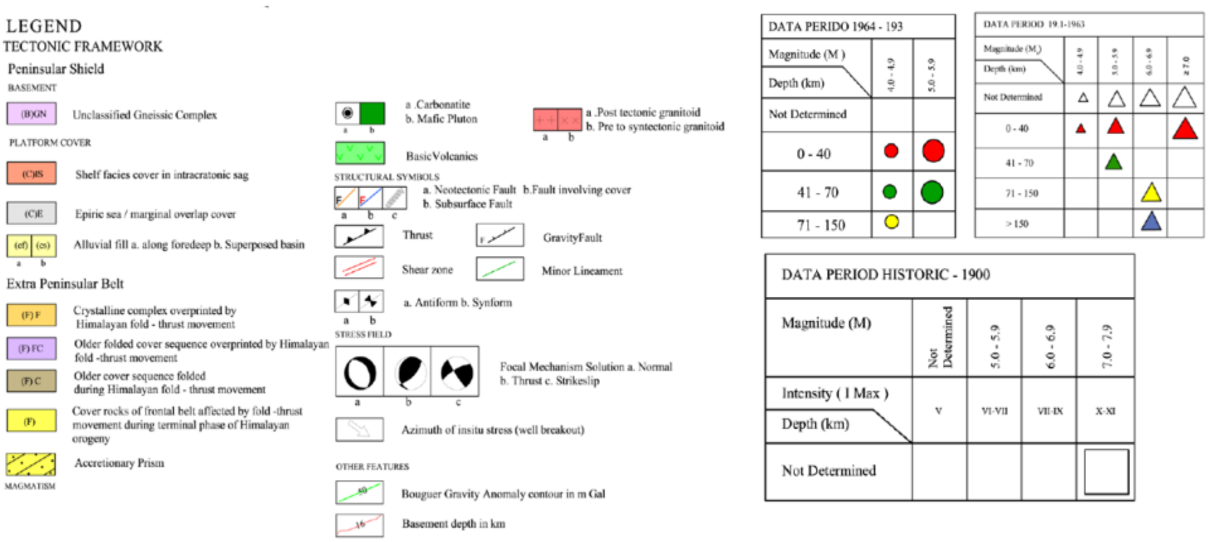
Source: DPR, 2016

3.4.5. Climate Change

The Climate Resilience Assessment for the Dorjilung HPP, prepared by Studio Pietrangeli, evaluates the impacts of climate change on the project area using the latest climate models and scenarios. The assessment predicts the following:

- Temperature and Precipitation: In the near future (2020-2039), temperature increases up to 1.5°C with precipitation varying between -10% and +10%. For the far future (2036-2065), temperatures could rise between 0.7°C and 4.5°C, with precipitation changes ranging from -10% to +30%.
- Streamflow: Dry season flow is expected to increase due to earlier snow and glacier melts, while wet season flow may decrease with rising temperatures.
- Energy Production: Energy production could vary between -7% and +18%, depending on changes in precipitation and temperature.
- PMF values vary significantly, with future estimates ranging from 3,665 m^3/s to 20,617 m^3/s.
- For most scenarios, the PMF is expected to increase modestly in the near and medium term but could see more significant increases (up to 20%) in the far future.
- The area of glacial lakes could increase significantly, with the most pessimistic scenarios predicting a 210% increase by 2100.

Figure 6: Seismotectonic Map of The Project Area (Reproduced From DPR, 2016)



3.5. CUMULATIVE IMPACT SIGNIFICANCE

The construction of hydropower projects, particularly the Dorjilung and Kurichhu HPPs, has identified significant existing cumulative impacts that may require additional mitigation measures. The most affected areas include: Hydrology, river sediment transport, floods, water quality, and fish and aquatic habitats These components are rated with the highest negative impacts across multiple projects.

Specific concerns include the habitats of the Golden Mahseer and species with restricted ranges:

- ***Golden Mahseer***: The natural distribution is limited downstream of the Dorjilung HPP by its occurrence area and the Kurichhu HPP, which appears to act as an impassable barrier for migratory fish. The fish passage effectiveness remains unproven; experts suggest it may be too high and have too many pools to facilitate effective fish passage.
- **Species with Restricted Range:** These are species which are specific to upstream heads of watersheds and steep-slope tributaries, are impacted by the major equipment of Kurichhu HPP and Dorjilung HPP. Smaller HPP projects in these tributaries also contribute significantly, as dewatered segments and poorly assessed environmental flows may disrupt lateral fish migration.

To address these high-impact areas, the Dorjilung HPP's Environmental and Social Impact Assessment (ESIA) has outlined several key mitigation initiatives, forming part of the Environmental and Social Management Plan (ESMP) and Biodiversity Management Plan (BAP). These measures are crucial to managing and mitigating the environmental impacts identified (see the accompanying ESIA for more details on these measures).

By implementing these mitigation strategies, the project aims to minimize the cumulative impacts on the selected VECs chosen for the CIA.

3.5.1. Significance of Cumulative Impacts

The same significance rating for cumulative impacts was used as per SWECO (2018). Assessment of cumulative impacts for each VEC used two main criteria groups as follows:

Group A Criteria: Consider the importance of the VEC and the magnitude of impact

- A1) The geographic scale of impact.
- A2) The magnitude of impact.

Group B Criteria: These criteria assess the permanence, reversibility and synergism with external stressors.

- B1) The permanence of impact.
- B2) The reversibility of impact.
- B3) The synergism with external stressors.

The significance of cumulative impacts is considered for each VEC – the significance is not evaluated in terms of the magnitude of change but in terms of VEC response and the impact on resulting condition and sustainability. Cumulative impact significance definitions used in this CIA are as follows:

- **No impact**: Conditions with no importance or change, maintaining the status quo, are scored as zero.
- **Slight negative impact**: Slight changes involve local importance with significant magnitude, permanence, and irreversibility
- **Moderate negative impact:** Moderate changes lie between slight and significant changes.
- **Major negative impact**: This is marked by conditions of major importance that extend beyond local boundaries but are temporary, reversible, and non-cumulative.
- **Significant negative impact**: Major changes are identified by conditions extending to regional/national boundaries with major magnitude, permanence, and irreversibility.
- **Positive impact:** Positive changes with considerable benefits to the VEC, extending beyond local boundaries.

The present CIA addendum offers a more comprehensive and detailed analysis of cumulative impacts, particularly with the inclusion of the Dorjilung HPP. Expanded data, and specific mitigation plans have led to more precise impact assessments and enhanced strategies for environmental, social, and economic management. The comparison between the 2018 CIA and the present addendum underscores significant advancements in understanding and mitigating the cumulative impacts of hydropower projects.

4. ASSESSMENT OF CUMULATIVE IMPACTS TO KEY VECS

The following is a discussion of cumulative impacts to each of the 12 identified VECs. A summary of cumulative impacts for each VEC, compared to the Kuri-Gongri CIA is presented in Section 4.13.

4.1. FOREST COVER

Table 4 below illustrates significant keys stressors and impacts to forest cover in the CIA Assessment Area.

Table 4: Keys Stressors and Impacts to Forest Cover.

Keys stressors	Impacts
Road developments (negative, increasing)	Conversion of forest land to construct new and expand existing roads and increased access to forests;
Transmission lines (negative, increasing)	Clearing of forest areas to install and maintain transmission lines, leading to habitat loss and fragmentation
Hydropower's (negative, increasing)	Conversion of forest land for construction of HEP components and associated facilities.
Climate change and natural hazards (negative, increasing)	Increased climate related disasters such as landslides and floods in the future.
Land clearance (negative, increasing)	Conversion of forest land to develop and expand upon existing agricultural land and settlements. Loss of forest cover will result in increased dependency on the remaining forests for e.g., NTFP, building materials and other ecosystem services.
Timber and firewood extraction (negative, increasing)	Overharvesting of timber and firewood, leading to deforestation, loss of biodiversity, and degradation of forest ecosystems.
Sand mining	Extraction of aggregates leads to increased erosion and sedimentation and affects to aquatic habitat quality.
Policy developments (positive, increasing	Implementation of policies that may either protect forests through conservation efforts or lead to deforestation due to economic development priorities.

The cumulative impact rating for Dorjilung HPP, shows a **significant negative impact** on forest cover due to construction of the Dorjilung and Kuri Gongri HPPs, which is considered important to national interests. However, the impact is seen as permanent and irreversible due to the loss of forest cover in the inundated reservoir area, however some mitigation could be realized through compensatory afforestation. The overall impact is additive, with other stressors increasing the total impact on the forest cover beyond just the hydropower development itself.

In the Kurichhu sub-basin, the Dorjilung Hydropower projects will likely impact 758 acres of forest. In addition to the project footprints, the dewatered section may have a significant impact on the forest cover with 280 acres of forest impacted. The construction of the transmission lines and access roads for these projects will also contribute to the loss of forest cover and could lead to habitat fragmentation, which in turn has the potential for secondary impacts on the ecosystem.

The construction of three solar projects will also lead to a loss of forest cover and added to by linear impacts of road and transmission line construction. In addition, the construction and widening of the Gankola - Lhuentse Highway will lead to some moderate loss of forest cover. The expansion of the Gyalsuung Industrial Estate and the Autsho and Gyelpozhing towns could lead to some significant loss of forest habitat, but this requires further verification.

Mitigation measures

To achieve the objective of no net loss of forest cover and in accordance with good practices and national regulations, a comprehensive reforestation program must be implemented. This program aims to offset the loss of natural habitat due to the Dorjilung Hydropower Project (HPP).

To mitigate the loss of natural habitat:

- **Forest and Shrub Loss**: The project will result in the loss of 701.7 acres of forest and shrubland due to project footprints (100% loss) and an additional 77.0 acres within the corridor of the construction power line, totaling a loss of 778.7 acres.
- **Replanting Ratio**: Using a replanting ratio of 2:1, the reforestation program will cover approximately 1,557 acres.

The reforestation program will be financed by the Dorjilung HPP and developed in collaboration with relevant authorities, specifically the Department of Forest and Park Services (DFPS) of the Ministry of Environment and Natural Resources (MoENR) and the National Biodiversity Centre (NBC). This program will align with Bhutan's forest restoration strategy and focus on the restoration of riverine broadleaf forests, broadleaf forests, and chir pine forests.

While feasible, this offsetting program will require a significant effort from the project owner. The reforestation efforts will be supported by a long-term adaptive monitoring program to validate the completion of the actions and the effectiveness of natural habitat restoration. This ongoing monitoring will ensure that the objectives of the reforestation program are met and maintained over time.

4.2. SLOPE STABILITY

Table 5 below illustrates significant keys stressors and impacts to slope stability in the CIA Assessment Area.

Table 5: Key Stressors and Impacts to Slope Stability

Keys stressors	Impact	Positive Effect	Negative Effect
Geology	Underlying geologic composition and structure exerts a strong influence on	Coherent, unweathered and unfractured strata have higherstability.	Weathered, fractured or stratawith high sheet silicate content are more susceptible

Keys stressors	Im pac t	Positive Effect	Negative Effect
	slope stability		to water infiltration and failure
Seismicity	Earthquakes and tectonic movements can destabilize banks through fracturing rock and increasing weathering andthrough destabilization during earthquakes.	Areas with low seismicity tendto be more stable	Areas with high seismicity tendto be less stable
Slope	Hill slopes are a major influenceon slope stability	Low-angle slopes tend to bemore stable	High-angle slopes have lowerstability
Rainfall	Rainfall is a major factor in slope stability, as increasing saturation of soils and rocks will. Reduce shear strength, and	Periods of low rainfall tend to have fewer landslips, however, extended droughts can decrease vegetation that can lead to greater slope instability.	The highest risk of slope failure coincides with the periods of highest rainfall and rainfall intensity in the Himalaya.

The cumulative impact rating of slope stability suggests significant concerns, with moderate risks of landslides and more permanent and less reversible impacts. Slope stability could be affected by intense rainfall.

The geological susceptibilities of the area, especially due to faulting and thrusting in the southern part of the site, which indicate a history of geological activity impacting the rock formations. The use of blasting during construction could potentially exacerbate these vulnerabilities, leading to localized instabilities and increasing the risk of adverse cumulative impacts on the environment.

The potential cumulative impact of the Dorjilung HPP is assessed as **major negative impact.** The basin presents limited issues of deforestation and the footprint of the Project has been reduced significantly through alternatives selection (further reducing land clearing and erosion impacts). While there are some impacts associated with increased slope instability and landslides, they can be actively managed by the Project through conventional and common methods. Potential cumulative impact are rated as **major negative impact.**

Mitigation measures

To address the cumulative impact on slope stability, several adaptation measures are proposed.

- Optimized blasting techniques will be employed to minimize vibrations and rock fragmentation, reducing the risk of dislodging large rock masses. A monitoring system will track ground vibrations and rock movement in real-time, allowing for immediate response to any adverse effects.

- Precise blasting patterns will be developed based on the geological characteristics of the site, determining optimal drilling angles, hole depths, and explosive quantities to minimize disturbance. Blasting operations will be carefully sequenced to prevent excessive loosening of rock material in concentrated areas.

- Additionally, rockfall protection measures, such as catch fences or barriers, will be installed in potential landslide zones to intercept falling rocks. Proper communication with local communities will ensure they are informed about blasting schedules through village Tsogpa or elected representatives.

- An Explosives and Blasting Management Plan and a Construction Emergency Management Plan will be prepared and implemented to enhance overall safety and stability.

- Finally, DGPC should consider the implementation of slope instability assessment in the reservoir to monitor the extent of slope failure through visual evaluation, satellite and drone imagery and geotechnical instrumentation.

4.3. MIGRATORY FISH

Table 6 below illustrates significant keys stressors and impacts to migratory fish in the CIA Assessment Area.

Table 6: Key Stressors and Impacts to Migratory Fish

Keys stressors	Impacts
Road developments	Road construction could result in soil erosion into rivers which could then likely result in a significant increase in total dissolved solid levels which degrades aquatic habitats.
Transmission lines	Clearing vegetation for transmission lines can lead to increased sedimentation and habitat fragmentation, impacting aquatic ecosystems.
Hydropower dam	could result in altered hydrological regimes, water quality degradation, loss of aquatic habitat from reservoir development and water diversion, and barrier effects.
Natural hazards	Could exacerbate the frequency and severity of floods and droughts, further stressing aquatic ecosystems and fish populations
Water quality	Degradation from agricultural runoff, industrial discharges, and urbanization can lead to eutrophication, hypoxia, and harmful algal blooms, severely impacting fish health and habitats.
Illegal harvesting	Overfishing and poaching can deplete fish populations, disrupt breeding cycles, and lead to genetic bottlenecks.
Tourism and sport fishing	Can lead to habitat disturbance, increased waste and pollution, and pressure on fish populations from catch-and-release practices.

Keys stressors	Impacts
Climate change	Could lead to changing patterns of rainfall (both higher and lower) within and between seasons, affecting river flow and temperature regimes, which are critical for fish migration and breeding.

The Dorjilung HPP cumulative impact ratings for the Migratory Fish VECs project poses a severe and irreversible risk to migratory fish, with substantial and permanent negative impacts on river connectivity and critical fish habitats. However, restricted range species that are critical habitat qualifying species are lateral moving species using upper part of the watershed. These species are found in small tributaries with steep slope. The Kurichhu River plays a role in the genetic diversity of these species. The project area is notable for hosting species with restricted ranges, where there is a significant lack of information regarding their geographical distribution, mating behaviours, population dynamics, and migratory patterns. Within this region, three CHQ fish species – *Creteuchiloglanis bumdelingensis, Parachiloglanis bhutanensis*, and *Parachiloglanis* dangmechuensis – are known to exist, predominantly in the upper reaches of the watershed and its smaller streams. The project's design and operation are expected to have long-term detrimental effects on migratory fish populations in the sub-basin, exacerbated by other external stressors for longitudinal migratory fish.

The impact of the Dorjilung HPP on migratory fish species, such as the Golden Mahseer, is considered minimal, as this species has not been recorded in the Project area. The fish ladder at the Kurichhu HPP may not be allowing upstream movement of fish and this requires further verification. Considering the cumulative impacts on migratory fish due to the Kurichhu HPPs, the Dorjilung project is not expected to have a significant additional cumulative impact on the flow, sediment transport, or the habitat of migratory fish species like the Golden Mahseer. Similarly other hydropower projects in more upper reaches such as Khomachhu and Yungichhu HPPs also will not likely create additional cumulative impact. Once constructed the Kuri-Gongri HPP in the lower reaches of the watershed will effectively limit any upstream movement of fish in the Kurichhu watershed. The overall cumulative impact in the Kurichhu watershed is therefore assessed as a **significant negative impact**.

A comprehensive fisheries mitigation and management plan for the entire watershed is therefore proposed.

Mitigation measures

Given the significant cumulative impact of the Dorjilung HPP on migratory fish, especially the three CHQ restricted range catfish species, several mitigation measures are proposed.

For the dewatered segment, an Environmental Flow (Eflow) will be implemented to maintain lateral connectivity with tributaries and ensure minimum flow in the Kurichhu River. This Eflow should maintain adequate water depth and velocity, preserve hydraulic continuity in rapid areas, and sustain the alternation of pools and rapids, with specific values considered for design. Peak flows during the monsoon will be preserved to support biological signals necessary for fish behaviors such as migration and mating.

Despite the implementation of Eflow, the residual impact on these critical species will range from substantial to moderate without adequate monitoring. Therefore, a long-term management plan dedicated to the three CHQ catfish species will be developed. This includes additional investigations to assess their distribution and validate their status, assessments to understand their lateral movements, and dedicated monitoring to ensure the population levels remain stable.

Considering the height of the Dorjilung HPP dam, a fish ladder is not feasible due to its ineffectiveness beyond 30 meters. While fish lifts have been experimented with in various countries, they have shown limited success due to constraints such as low biomass transport, species limitations, and high maintenance efforts. Options to offset this loss of fisheries in the watershed will involve establishing a fish hatchery in the watershed, possibly at the Gyalsuung Industrial Estate area. Another option would be to establish a catch and release process to capture fish at the base of the dam on the downstream side and transport them to the reservoir above. However, this will involve a significantly larger effort than a hatchery and catch and release programs have had limited success in other hydroelectric projects. Either of these options will require further investigation.

Furthermore, a national fish conservation action plan will be established, focusing on these and other restricted range species. This plan will include inventories and mapping of restricted range species in similar tributaries and setting up a national fish conservation strategy. This could involve keeping one or more key watersheds free of hydroelectric projects and designating additional upper watersheds for protection. Long-term management of these protected watershed areas will be crucial to ensure the conservation of fish species important to Bhutan.

If residual impacts remain moderate or major, additional adaptive management measures will be implemented, potentially involving more ambitious conservation programs to achieve net biodiversity gain.

4.4. SCENERY AND LANDSCAPES

Table 7 below illustrates significant keys stressors and impacts to scenery and landscapes fish in the CIA Assessment Area.

Table 7: Keys Stressors and Impacts to Migratory Fish

Keys stressors	Impacts
Road developments	Creation of new roads can disrupt natural landscapes, leading to habitat fragmentation, loss of vegetation, and altered visual aesthetics. Road construction may also result in soil erosion and increased sedimentation in water bodies.
Transmission lines	Installation of transmission lines can disrupt scenic views and natural landscapes, particularly in pristine areas. Clearing vegetation for these lines may also lead to habitat fragmentation and visual clutter.
Hydropower dam	Construction of hydropower dams can alter landscapes significantly, including changes in river flow, creation of reservoirs, and the presence of associated infrastructure such as access roads and transmission lines.
Protected area (positive stable)	Designation of protected areas can preserve natural landscapes, ensuring their stability and protection from development. These areas contribute positively to the scenic beauty and biodiversity of the region.
Industrial parks	Establishment of industrial parks may lead to habitat destruction, pollution, and altered landscapes, negatively impacting scenic beauty and natural environments.
Urbanization	Urbanization can lead to the loss of natural habitats, fragmentation of landscapes, and increased pollution, detracting from scenic beauty and altering the character of the environment.
Tourism and sport fishing	Increased tourism and sport fishing activities can lead to habitat disturbance, littering, and infrastructure development, potentially altering scenic landscapes and impacting natural habitats.
Policy developments	Implementation of policies may either protect landscapes through conservation efforts or lead to landscape alterations due to economic development priorities. The effectiveness of policies determines their impact on scenery and landscapes.
Landslides	Landslides, whether natural or triggered by human activities such as construction, can significantly alter landscapes, causing erosion, habitat loss, and visual disturbances.

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. The potential impacts are generally seen as permanent and irreversible for the life of the HPPs.

The analysis of the potential cumulative Impact, on scenery and landscapes as outlined in the previous CIA, has increased the rating from a **Moderate negative impact** to a **significant negative impact** due to the presence of five HPPs in the Kurichhu basin with two transmission lines and associated roads.

Mitigation measures

To mitigate view field impacts from hydropower projects within tourist stop areas, it is recommended to implement avoidance, minimization, and mitigation measures wherever possible. These measures may include:

- Constructing visual barriers such as fencing or planting trees strategically to block the view of unsightly features from tourist viewpoints.
- Siting and designing projects to minimize the presence of unsightly features within the visible area, ensuring quarries and spoil dumps are located out of sight.
- Choosing colors and textures for built structures that blend seamlessly with the surrounding scenery, reducing their visual prominence.
- Implementing progressive rehabilitation of disturbed sites throughout the construction period, allowing for rapid recontouring, and replanting to lessen the duration of visual impact.
- Designing projects to incorporate visual interest, such as through architectural choices for permanent structures and the addition of decorative and aesthetic features.

By employing these diverse measures, the visual impact of hydropower projects on tourist view fields can be reduced, but visual impacts in the basin will result due to the conversion of free flowing rivers to dammed reservoirs.

4.5. PROTECTED AREAS

Table 8 below illustrates significant keys stressors and impacts to protected areas in the CIA Assessment Area.

Table 8: Key Stressors and Impacts to Protected Areas

Keys stressors	Impacts
Road developments	Construction of roads can lead to habitat fragmentation, increased access to remote areas, and disturbance to wildlife, potentially impacting the integrity and biodiversity of protected areas.
Transmission lines (negative increasing)	Installation of transmission lines can disrupt wildlife habitats, alter landscapes, and negatively impact scenic beauty, thereby affecting the ecological and aesthetic value of protected areas.
Hydropower dam (negative increasing)	Construction of hydropower dams can result in habitat destruction, alteration of flow regimes, and fragmentation

Keys stressors	Impacts
	of habitats, leading to loss of biodiversity, impaired wildlife movements and ecological disruption in protected areas.
Erosion and sedimentation (negative increasing)	Increased erosion and sedimentation can degrade water quality, destroy aquatic habitats, and impact riparian ecosystems, affecting the overall health and biodiversity of protected areas.
Forest extraction (negative increasing)	Unsustainable forest extraction practices can lead to habitat loss, biodiversity decline, and disruption of ecosystem services, posing significant threats to the integrity and resilience of protected areas.
Illegal fish, wildlife and NTFP harvesting (negative increasing)	Illegal harvesting of fish, wildlife, and non-timber forest products can deplete populations, disrupt ecological balance, and undermine conservation efforts, jeopardizing the conservation status of protected areas. This can also be affected by social influx of workers during HPP construction.
Improvement Park management (positive increasing)	Enhanced Park management can lead to improved conservation outcomes, biodiversity protection, and ecosystem resilience, bolstering the effectiveness and sustainability of protected areas.
Climate change (negative increasing)	Climate change can exacerbate existing threats, including habitat loss, altered precipitation patterns, and increased frequency of extreme weather events, further challenging the resilience of protected areas.

The Dorjilung HPP is in close proximity to Phrumsengla National Park (also KBA). There is no direct impact on the PNP but the headrace tunnels on the right bank will pass through the multiple use area. A portion of Biological Corridor #7 that enables safe passage between Phrumsengla National Park and the Bumdeling Windllife Sanctuary will be flooded. This includes Key Biodiversity Areas (KBAs) identified for the conservation of the Pallas's Fish Eagle and territories within the Tiger Conservation Landscape noted by Birdlife International for their unique avian population endemic to the Eastern Himalayas.

Similarly, construction of roads and the headrace tunnels for the Khomachhu HPP will cross Biological Corridor #7. The water intake and headrace structures of the Yungichhu HPP is sited in the multiple use of Phrumsemgla NP.

The Bumdeling Wildlife Sanctuary will not be directly affected by any HPP either through inundation or construction of headrace tunnels or associated roads. The existing Kurichhu HPP does not affect any protected areas and construction of the Kuri-Gongri HPP will also not affect any protected areas.

Despite limited direct impacts to protected areas, social influx during construction and increased access may increase the pressure on these protected areas and associated multiple use zones.

Based on the above, the overall cumulative impact to multiple-use zones of protected areas and biological corridors in the Kurichhu watershed is a **moderate negative impact** and requires the implementation of appropriate mitigation strategies**.**

Mitigation measures

Mitigation measures for mitigating cumulative impacts on protected areas in the Kurichhu basin include:

- Implementing a management plan to manage social influx, incorporating avoidance and reduction measures to minimize social disturbances in the vicinity of key areas such as Phrumsengla National Park (PNP), Corridor#7, and the Pallas's Fish-eagle Key Biodiversity Area.
- Potentially extending Corridor #7 downstream by 5 kilometers from the dam site to enhance connectivity between eastern and western sections, thus facilitating movement of wildlife and preserving terrestrial habitats.
- Implementing Environmental Flow (Eflow) measures to maintain adequate water levels and prey availability in dry segments, crucial for sustaining the Pallas Fish-eagle population.
- Installing nest boxes suitable for Pallas Fish-eagles near the reservoir area two years post-commissioning to provide additional nesting sites and support population growth.
- Forming partnerships with Phrumsengla National Park and Corridor #7 authorities to support habitat preservation programs within these protected areas and conduct mammal monitoring in Corridor#7.
- Collaborating with relevant authorities to contribute to the preservation of the Pallas Fish-eagle KBA, ensuring the long-term protection of this critical habitat. These mitigation measures and conservation efforts aim to mitigate the negative impacts of hydropower development on protected areas, ensuring the conservation of biodiversity and ecological integrity in the basin.

4.6. LIVELIHOOD OPPORTUNITIES

Table 9 below illustrates significant keys stressors and impacts to livelihood opportunities in the CIA Assessment Area.

Table 9: Key Stressors and Impacts To Livelihood Opportunities

Keys stressors	Impacts
Other private investments (positive impact)	Investment from the private sector stimulates economic growth, creates job opportunities, and enhances income generation, thereby positively impacting livelihood opportunities in the region.
Transmission lines (positive impact)	Development of transmission lines improves connectivity, facilitates access to markets, and enhances infrastructure, contributing to economic development and creating employment opportunities.

Hydropower's (positive impact)	Hydropower projects generate employment, attract investments, and stimulate economic activities, leading to increased livelihood opportunities through job creation, income generation, and economic growth.
Other increased demands on labor, products, and services (positive increasing)	Increased demands for labor, products, and services result in job creation, income generation, and economic growth, thereby positively impacting livelihood opportunities in the region.
Other Public investment (positive impact)	Public investments in infrastructure, social services, and community development initiatives contribute to economic development, job creation, and income generation, positively impacting livelihood opportunities.
Road development (Positive negative)	Road development can have both positive and negative impacts on livelihood opportunities. While it improves accessibility and facilitates trade, it may also lead to environmental degradation and displacement of communities.
Climate change and natural hazard (negative increasing)	Climate change and natural hazards pose threats to livelihoods through impacts such as crop failure, loss of livestock, and damage to infrastructure, thereby negatively affecting livelihood opportunities in the region.

The cumulative impact assessment for livelihood opportunities suggests that the Dorjilung HPP will bring both short and long-term benefits. While it is expected to moderately contribute to national and local employment, with a majority of workers being foreigners during the construction period, it will also create opportunities for locals to develop income-generating activities and businesses through increased procurement and employment.

However, some economic activity sites, such as the NRDCL sand mining site in Autsho and an automobile workshop, will be submerged. Additionally, approximately 12 households will be impacted by the loss of trees, and around 388 fruit trees will be lost due to the project. Cultivated land covering about 19.37 acres will also be directly affected. However, it is important to note that these impacts are not permanent, and efforts may be required to sustain economic growth post-construction. While the jobs created may not ensure long-term employment security, they will still serve as a significant economic boost. Overall, these opportunities are expected to have a positive effect on the local economy, further enhancing the livelihoods of surrounding communities. It should also be recognized that the majority of jobs will occur during the construction phase and that the operational phase will involve a decrease in economic opportunities for local businesses which must be planned for.

The Initial assessment from the CIA indicated **positive impact** with enhancement measures suggests a significant and potentially irreversible positive impact on livelihood opportunities in the Kuri-Gongri Basin. However, these impacts were seen as not permanent, and the reports indicated that efforts would be needed to sustain economic growth post-construction. The incorporation of the Dorjilung ESIA does not change this initial assessment and suggests a **positive impact** on livelihood opportunities in the Kurichhu watershed.

Mitigation measures

The following measures are proposed to address the impact:

- Design and construction of a poles and line by Bhutan Power Corporation: This measure involves the implementation of infrastructure designed to mitigate the impact on livelihoods, particularly those affected by the project. By constructing poles and lines, the Bhutan Power Corporation aims to address any disruptions caused by the project and ensure the continued provision of essential services.
- Land Acquisition and Livelihood Restoration Plan: This plan focuses on acquiring land necessary for the project while also ensuring that affected livelihoods are restored or compensated for. It involves comprehensive planning to minimize disruptions to communities and provide support for those impacted, ensuring that their livelihoods are adequately restored or compensated for any losses incurred.
- Development of a Local Content strategy: DGPC should look at opportunities for provision of local service opportunities and employment in communities adjacent to the Dorjilung HPP.

4.7. COMMUNITY QUALITY OF LIFE

Table 10 below illustrates significant keys stressors and impacts to community quality of life in the CIA Assessment Area.

Table 10: Key Stressors and Impacts to Community Quality of Life

Keys stressors	Impacts
Relative decline of traditional livelihoods (negative impact)	This refers to the reduction in traditional ways of life and income-generating activities. As communities transition away from traditional livelihoods (such as subsistence agriculture, handicrafts, etc.), there can be economic hardships due to loss of income sources that were culturally and economically significant. Younger generations often move away from villages for better opportunities, leaving behind incomplete families and disrupting traditional social structures.
Exposure to unhealthy lifestyles (negative impact)	Exposure to non-traditional lifestyles can lead to deteriorating health conditions. As communities adopt new dietary habits, sedentary lifestyles, and face increased environmental pollution (such as noise, dust, and waste from development), there is a risk of rising health issues like obesity, respiratory problems, and stress-related illnesses.
Exposure to non-traditional ways of life (negative impact)	This relates to the erosion of traditional cultural practices and values. As communities are exposed to new ways of life brought about by development projects like hydropower and infrastructure investments, there can be a gradual loss of indigenous knowledge, languages, ceremonies, and architectural styles. This impacts cultural identity and social cohesion.

Keys stressors	Impacts
Hydropower (negative impact)	Hydropower development accelerates social transformation by bringing in new infrastructure, employment opportunities (often temporary and involving a high percentage of non-local workers) and altering the local environment.
Other Public investment (negative impact)	While public investments in infrastructure, social services, and community development initiatives contribute positively to economic growth, job creation, and income generation, they can also disrupt traditional ways of life. The influx of outside influences and resources may lead to cultural changes and social tensions within communities.
Efforts to maintain traditions and cohesion (negative impact)	Efforts to preserve traditional practices and social cohesion are essential for maintaining cultural identity and community resilience. Initiatives that support traditional arts, education in local languages, and community-based conservation efforts can mitigate some of the negative impacts of modernization and development.
Decline in environmental quality (negative impact)	The reduction in environmental health and aesthetics due to development activities like hydropower projects, roads, and urbanization leads to degraded landscapes, polluted waterways, loss of biodiversity, and increased exposure to environmental hazards. This negatively affects the overall quality of life for communities dependent on natural resources.

The ESIA of the Dorjilung Project highlights that the large Influx of foreign workers and in general the influx of population can have significant impacts on general security, community safety and wellbeing and social links and gender related impacts.

The Dorjilung HPP will have a **major negative impact** on a substantial number of villages, albeit with the potential for these impacts to be mitigated and reversed. However, these impacts were expected to be exacerbated by other social changes occurring in the region, leading to a greater overall effect on the Community Quality of Life.

Mitigation measures

Table 11 below specifies mitigation measures to avoid and reduce cumulative impacts to community quality of life.

Table 11: Mitigation Options for Community Quality of Life

Type of Displacement	Mitigation Options
Physical Displacement (relocation, loss of residential land or loss of shelter)	Avoidance and minimization: Through careful project siting, design, and operations to minimize physical displacement. Resettlement: Affected households involved in decisions, options for self-relocation after satisfactory transition support. Compensation: Monetary compensation at replacement cost or PAVA rates. Community Integration: Assistance with living standards improvement, leisure, social life, and environmental quality. Monitoring: Continuous monitoring and follow-up to ensure effectiveness over time. Temporary Accommodation: Equivalent temporary accommodation during construction. Host Community Support: Ensuring host community agreement and support to eliminate additional burdens and potential conflicts.
Economic Displacement (loss of land, natural resources, assets, or access to assets, leading to loss of income sources or other means of livelihood, and decline in nutritional status)	Avoidance and minimization: Through strategic project siting, design, and operational considerations. Livelihood Restoration: Discussions with affected households on participating in livelihood restoration programs or accepting monetary compensation. Compensation: In-kind (land-for-land, shop-for-shop) or cash at replacement cost or PAVA rates. Livelihood Support: Assistance for maintaining and improving livelihoods through resources, equipment, permits, credit, training, and preparatory actions. Planning for economic transition: Incorporation of measures to transition local communities from the construction to operation phase.

4.8. ACCESS TO MARKETS AND SERVICES

Table 12 below illustrates significant keys stressors and impacts to Access to markets and services in the CIA Assessment Area.

Table 12: Key Stressors and Impacts to Access to Markets and Services.

Keys stressors	Impacts

Expansion of Road Access	Improved connectivity to remote areas, facilitating easier access to markets and services. Increased traffic and potential for road accidents. Environmental impact due to road construction and maintenance.
Increased Availability of Public Transport	Enhanced mobility for individuals, especially in areas without private vehicle ownership. Reduced dependency on private vehicles, potentially lowering traffic congestion. Improved access to services and markets for communities relying on public transport.
Increased Ownership of Vehicles	Greater personal mobility and flexibility. Increased traffic congestion in urban areas. Potential for improved access to remote markets not served by public transport.
Household Usage of Public Transport	Varied usage patterns affecting local economies and accessibility. Potential reduction in private vehicle usage, easing traffic congestion. Challenges in rural areas with limited or irregular public transport services.

The Dorjilung project is expected to contribute to the development of local roads and local development. The influx of population will at the same time benefit local services e.g., Increase the number of school children in underused facilities and put additional pressure on others (e.g.: health, goods/ inflations, essential services).

SWECO (2018) concluded that the cumulative impact to access to markets and services would be **positive**. The. Addendum to the CIA also concludes a **positive impact** as the impacts are local and irreversible.

These measures aim to capitalize on the positive impacts of the Dorjilung project on local infrastructure and socio-economic development while minimizing potential negative effects. By focusing on infrastructure development, community services, and sustainable management practices, the project can contribute effectively to enhancing access to markets and services in the Kurichhu basin.

4.9. CULTURAL HERITAGE

Table 13 below illustrates significant keys stressors and impacts to cultural heritage in the CIA Assessment Area.

Table 13: Keys Stressors and Impacts to Cultural Heritage

Keys stressors	Impacts
Other construction (negative increasing)	Potential damage to heritage structures from construction activities.
Policy developments and Funding (positive, increasing)	Enhanced preservation efforts and sustainable management of cultural heritage.
Earthquakes and other natural Disasters (negative, stable)	Risk of damage or destruction of heritage structures due to seismic events.
Inadequate repairs and modernization (Negative, stable)	Alteration of original character of heritage structures from improper maintenance.
Vandalism, theft, and neglect (Negative, stable)	Deterioration or loss of heritage assets from vandalism, theft, or neglect.
Natural wear and tear (Negative, stable)	Gradual deterioration of heritage structures due to environmental exposure.
Hydropower (Negative, increasing)	Acceleration of impact on cultural heritage due to project footprint and construction.
Transmission lines and roads (Negative, increasing)	Indirect impacts on heritage sites from infrastructure development.

While the Dorjilung HPP will not directly affect any cultural sites (tangible heritage), it still can affect their settings or access to the site. However, there may also be some impacts to intangible heritage as a result of major influx of foreign workers.

The SWECO CIA (2018) classified the impact to cultural heritage as **a significant negative impact** under Scenario 1. The Dorjilung CIA addendum is revised as lower impacts on both tangible and intangible heritage than anticipated to a **slight negative impact.** A targeted surveys of heritage sites and a dedicated analysis of both tangible and intangible heritage did not highlight major issues or significant impacts. Project design measures have been incorporated to avoid impact to cultural heritage.

Mitigation measures

To address these challenges, comprehensive mitigation measures to protect tangible and intangible cultural heritage are essential. These measures should include strict monitoring of construction activities, implementation of vibration control measures, and proactive community engagement to safeguard cultural heritage sites. By integrating these measures into project planning and execution, it is possible to mitigate adverse impacts on Bhutan's rich cultural heritage and ensure sustainable development practices are upheld.

The following management plan should be implemented:

- Develop and implement a Cultural Heritage Management Plan including preconstruction surveys and Chance Find Procedures during construction.
- Develop and implement a Stakeholder Engagement Plan.
- Develop and implement a Grievance Mechanism.

4.10. DOWNSTREAM PUBLIC SAFETY

Table 14 below illustrates significant keys stressors and impacts to cultural heritage in the CIA Assessment Area.

Table 14: Significant Keys Stressors and Impacts to Downstream Public Safety

Keys stressors	Impacts
Urbanization	Concentration of population in flood-prone areas raises the vulnerability of communities to flood-related hazards.
Climate change	Warmer climate accelerates glacial melting, increasing the risk of Glacial Lake Outburst Floods (GLOFs).
GLOF	GLOFs pose the risk of sudden, large-scale flooding downstream, endangering lives and property.
Steep natural terrain	Natural terrain lacks the capacity to attenuate floodwaters, exacerbating downstream flood risks. Steep terrain limits the natural ability to slow down floodwaters, leading to rapid downstream flows.
Flow regime changes (Negative, stable)	Changes in flow patterns disrupt the natural balance, impacting downstream safety and infrastructure.
Dam breach (Negative, increasing)	Climate change and other factors contribute to more frequent and severe flooding events downstream. This is exacerbated by the presence of five cascade HPPs in the Kurichhu watershed.

Flood (Negative, increasing)	Development of response plans strengthens preparedness and enables effective management of flood situations.
Warming systems (positive increasing)	Implementation of warning systems enables early detection and alerts for potential flood events.
Emergency response plans (positive, increasing	Development of response plans strengthens preparedness and enables effective management of flood situations.

The cumulative impact assessment for the downstream public safety indicates significant importance to local interests, particularly within a 5 km radius of the project site. This importance is underscored by the magnitude rating, suggesting high predicted changes to the flow regime, including substantial water-level increases and rapid velocity changes. These impacts are deemed permanent, posing ongoing safety risks during the operational phase of the project. The risk to downstream public safety is further compounded by the presence of five HPPs in the watershed which will require a cascade management plan.

In the event of a spillway failure or dam breach, rapid and severe flooding downstream poses substantial risks to communities, infrastructure, and natural habitats. Such flooding can result in significant economic losses, displacement of residents, and potential loss of life. Moreover, a Glacial Lake Outburst Flood (GLOF) could damage critical components of the hydropower plant, disrupt operations, and lead to financial losses.

Furthermore, landslides near the hydropower plant could trigger waves and overtopping of reservoirs, exacerbating the risk of dam failure and massive floods downstream. These hazards could result in loss of life, injuries, property damage, and physical displacement of communities.

Despite the potential risks, the synergism rating indicates that there are no significant exacerbating effects from other stressors. This suggests that the predicted impact, while substantial, may not be further intensified by external factors, potentially mitigating some of the adverse effects of hydropower development.

The potential cumulative impact result show that in the Kurichhu watershed, the predicted impact increases in severity due to the inclusion of the of the Dorjilung project to the level of **a significant negative impact**. In the Dorjilung sub-basin, project is predicted to cause a negative impact, primarily due to fast changes in flow velocities. However, the demodulation provided by the Kurichhu HPP reservoir will greatly limit the downstream extent of these impacts are will not result in cumulative impacts with other HPPs. However, it warrants developing and implementing a cascade management plan of the various HPPs.

Mitigation measures

- Develop and implement an Operational – Emergency Management Plan
- Implement a Stakeholder Engagement Plan to inform communities of risks to downstream public safety

4.11. ECONOMIC GROWTH

Table 15 below illustrates significant keys stressors and impacts to economic growth in the CIA Assessment Area.

Table 15: Key Stressors and Impacts to Economic Growth

Keys stressors	Impacts
Demographic Change (uncertain)	Demographic changes, such as shifts in age structure and population dynamics, can influence economic growth. An aging population might strain social welfare systems and reduce workforce participation rates, potentially impacting productivity, and economic output. Conversely, changes in the youth demographic could affect education and skill development, influencing future labor supply and economic opportunities.
Institutional Capacity (positive, increasing)	Strengthening institutional capacity enhances Bhutan's ability to formulate and implement effective economic policies, regulatory frameworks, and governance structures. This fosters a conducive environment for investment, entrepreneurship, and sustainable development, thereby supporting overall economic growth and stability.
Hydropower investments (positive, increasing)	Investments in hydropower infrastructure contribute significantly to Bhutan's economic growth. They stimulate employment, boost infrastructure development, and generate revenue through energy exports. Hydropower projects also enhance energy security and sustainability, supporting industrial development and economic diversification.
Economic growth	Sustainable economic growth leads to improved living standards, job creation, poverty reduction, and enhanced economic opportunities for Bhutanese citizens. It fosters a stable macroeconomic environment conducive to investment, stimulates consumer spending, and supports social development initiatives, thereby contributing to overall prosperity.
Hydropower revenues (positive, increasing)	Increasing revenues from hydropower exports bolster Bhutan's fiscal capacity, enabling investment in social infrastructure, education, healthcare, and poverty alleviation programs. These revenues also support national development priorities and contribute to long-term economic stability and resilience.
Resource constraints (negative, increasing)	Bhutan faces challenges related to resource constraints, including land scarcity, environmental degradation, and sustainable water management. These constraints can limit agricultural productivity, constrain industrial growth, and pose risks to biodiversity and

Keys stressors	Impacts
	ecosystem services. Effective resource management strategies are essential to mitigate these impacts and ensure sustainable economic development.
Technological change (positive, increasing)	Advances in technology drive productivity gains, innovation, and competitiveness across sectors in Bhutan. Technological advancements in hydropower, agriculture, manufacturing, and services improve efficiency, reduce costs, and enhance product quality. Embracing technological change fosters economic diversification and supports sustainable development goals.
Political stability (positive, stable)	Political stability provides a conducive environment for sustained economic growth and development in Bhutan. It fosters investor confidence, supports policy continuity, and enhances governance effectiveness. Stable political conditions promote long-term planning, attract foreign direct investment, and enable effective implementation of economic reforms and infrastructure projects.

The cumulative impact rating for economic growth in the Dorjilung HPP CIA Assessment Area, indicates a high level of importance, a significant positive magnitude of change, permanent impacts, full realization of economic benefits through enhancement, and additional positive synergistic effects. Given the extent of development opportunities provided by the construction of five HPPs in the Kurichhu watershed, the potential cumulative impact for Dorjilung has a **major positive impact** on economic growth.

4.12. DOMESTIC ELECTRICITY-SUPPLY SECURITY

This VEC was not assessed due to the lack of information available.

4.13. SUMMARY OF CUMULATIVE IMPACTS TO SELECTED VECS

For the Dorjilung Project, three VECs have been identified as experiencing beneficial cumulative impacts, while eight VECs assessed face a range of slight to significant negative cumulative impacts. Mitigation measures are required at the project and regional level to effectively reduce the extent of cumulative impacts of hydropower development in the Kurichhu watershed. Table 16 summarizes the significance of cumulative impacts for each of the VEC and compares the Kuri Gongri Scenario 1 case to the Dorjilung Addendum case.

Table 16: Cumulative Impacts to Selected VECS

Selected VECs	Kuri-Gongri Scenario 1 Case	Dorjilung CIA Addendum Case
Forest Cover	Slight negative impact.	Significant negative impact
Slope Stability	Significant negative impact	Major negative impact

Selected VECs	Kuri-Gongri Scenario 1 Case	Dorjilung CIA Addendum Case
Migratory Fish	Major negative impact	Significant negative impact
Scenery and Landscapes	Moderate negative impact	Major negative impact
Protected Areas	Major negative impact	Moderate negative impact
Livelihood Opportunities	Slight positive impact	Significant positive impact
Community Quality of Life	Significant negative impact	Major negative impact
Access to Markets and Services	Positive impact	Positive impact
Cultural Heritage	Significant negative impact	Slight negative impact
Downstream Public Safety	Significant negative impact	Significant negative impact
Economic Growth	Significant positive impact	Major positive impact
Domestic Electricity Supply Security	Positive impact	Not assessed

5. MANAGEMENT OF CUMULATIVE IMPACTS – DESIGN AND IMPLEMENTATION

The 2018 Kuri-Gongri CIA evaluated mitigation strategies like avoidance, minimization, mitigation, and enhancement to address the impacts across the entire Kuri-Gongri Basin. For the Dorjilung HPP specifically, the ESMP and the BMP has introduced specific mitigation measures to tackle project related environmental, biological, and social impacts. The project has developed various management plans designed to modify the extent of its cumulative impacts.

This includes the following:

- Stakeholder Engagement Plans and related Community GRM, the Labor Management Plan and related Code of Conduct and demobilization plan, as well as the Gender Based Violence/ SEA-SH and Vulnerability Action Plan, the community Health, and Safety Plan. These initiatives are designed to mitigate the project's adverse effects on community quality of life.

- The GSVAP and Local Development to enhance local economic opportunities and local economic development with mid- and long-term vision, integrated with local development projections.

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

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

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

- A **Downstream Adaptive Management Plan** below the confluence of the Kuri and Gongri Rivers to the Assam border should be completed. This should also include an assessment on the cumulative impacts to potential future ecotourism activities. It will be necessary however to consider downstream impacts in the Drangemechhu River to Manas National Park and the border of Assam. This should include the following:

    a. Continued notification of sediment flushing releases from the Kurichhu HPP.

    b. Downstream sediment and water quality monitoring.

    c. An assessment of cumulative impacts to downstream potential future ecotourism activities of sport fishing and white-water rafting.

d. Potential transboundary impacts to India.

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

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

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

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

- Finally, the Hydropower Master Plan 2040 should also address options for the **Preservation of One Or More Free-Flowing Rivers** without hydropower development on the river mainstem. Options for hydropower development on tributaries in coordination with solar power development could provide further assurance of energy security while also promoting ecotourism and other opportunities.

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

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