Accelerating Transport and Trade Connectivity in Eastern South Asia (ACCESS) Project, Bhutan

Gelephu-Tareythang Road

Department of Surface Transport (DoST), Ministry of Infrastructure and Transport, Royal Government of Bhutan (RGoB)

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[Image on front page shows the Mau River in the project area]

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B METHODOLOGY AND SCOPING

This chapter provides an overview of the methodology applied for the ESIA. The main objective of the ESIA is to comprehensively evaluate all direct, indirect, and cumulative environmental and social risks and impacts throughout the Project's life cycle. It aims to predict potential impacts of the proposed Project and to outline measures to avoid, minimize, or mitigate these impacts according to the mitigation hierarchy.

The direct, indirect, and cumulative impacts are defined as follows in the *World Bank Environmental and Social Framework 2017*:

- A direct impact is an impact which is caused by the Project, and occurs contemporaneously in the location of the Project;
- An indirect impact is an impact which is caused by the Project and is later in time or farther removed in distance than a direct impact, but is still reasonably foreseeable, and will not include induced impacts; and
- The cumulative impact of the Project is the incremental impact of the Project when added to impacts from other relevant past, present and reasonably foreseeable developments as well as unplanned but predictable activities enabled by the Project that may occur later or at a different location.

B.1 IMPACT ASSESSMENT PROCESS

ERM employs a comprehensive framework to direct the ESIA process as depicted in ***Figure B-1***. This framework encompasses specific techniques, models, and assessment criteria tailored to each environmental and social aspect. These methods adhere to globally recognized best practices, such as the WBG ESF. By addressing the unique concerns linked to Project development and associated infrastructure, this framework provides a customized impact identification and evaluation mechanism. As a result, it enables a more targeted and precise assessment of the Project's impact. ***Table B***.1 breakdowns the approach to each step and provides a reference to the respective section in the ESIA.

FIGURE B-1 ERM'S ESIA PROCESS DIAGRAM

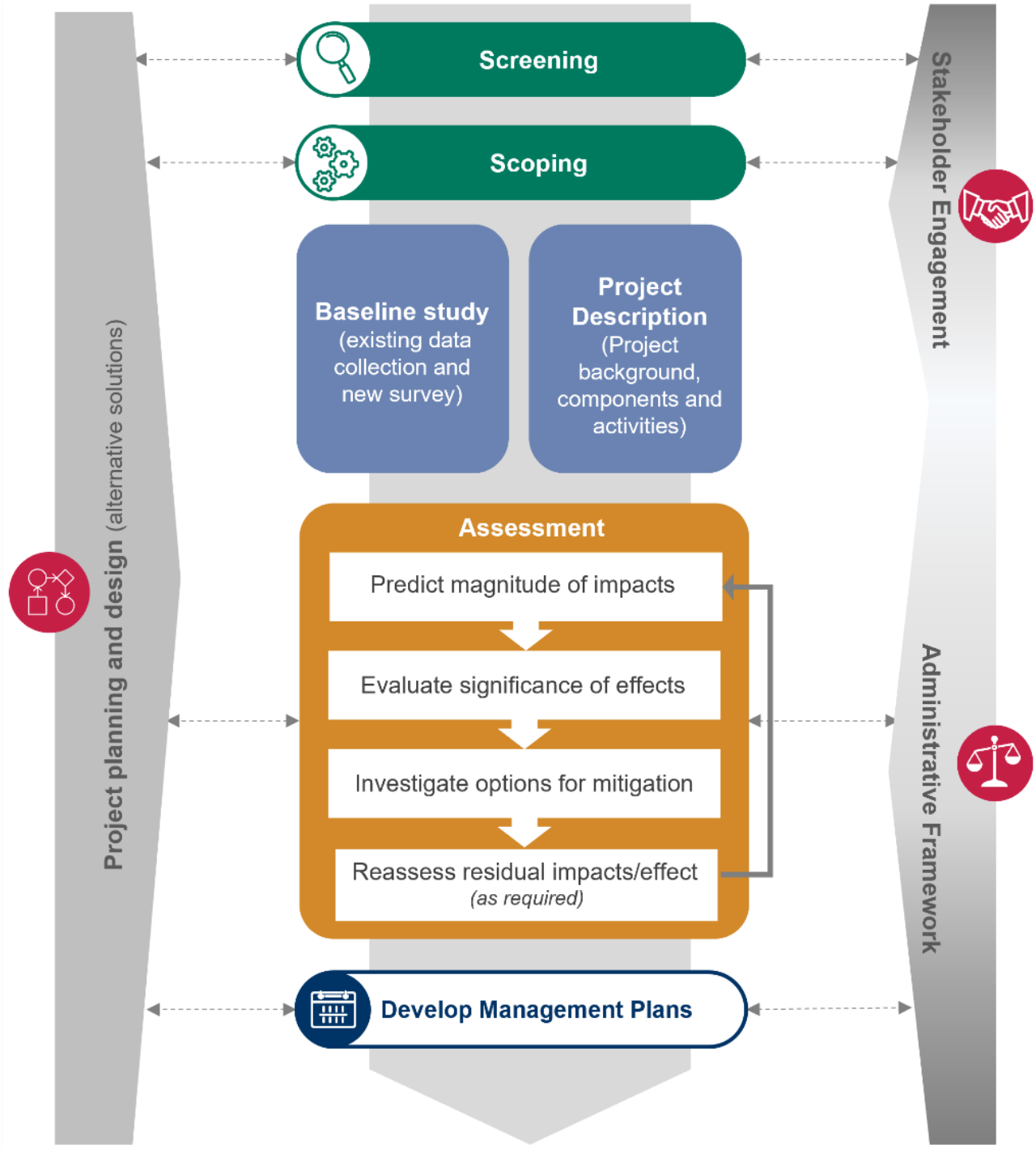


TABLE B.1 ESIA PROCESS DESCRIPTION

ESIA Step	Description
Review Administrative Framework	National regulatory requirements, applicable international treaties and conventions, and internal guidelines and standards voluntarily committed to by the Project Proponent.
Interaction with Project Planning and Design	Detailed information on the Project components, activities, planning, and design is crucial for all stages of ESIA, including screening, scoping, impact assessment, mitigation measures, monitoring, and auditing. Alternatives analysis is a critical step in this process, providing inputs for the scoping and impact assessment stages of ESIA. ERM worked with the project engineers during the initial options study to compare the alternatives for the road layout, road construction and bridge options.
Stakeholder Engagement	**Stakeholder engagement** is a vital part of the ESIA process, and it follows WB ESS10 to ensure the views, interests, and concerns of stakeholders are considered. The ESIA stakeholder engagement involved various approaches to socio-economic analysis, such as interviews and focus group discussions. A separate Stakeholder Engagement Plan (SEP) and Grievance Mechanism has been prepared as a standalone document.
Screening and Scoping	The **screening** process aims to identify potential social and environmental risks of a Project and determine the necessary requirements for further analysis. It involves reviewing relevant standards and guidelines, Project type, location, scale, duration, and potential Impact Areas for the Project. Sources used in screening include the initial options study, the ongoing feasibility study information, published literature, Integrated Biodiversity Assessment Tool (IBAT), satellite images, and client meetings. The **scoping** determines which impacts are likely to be significant and should become the focus of the ESIA. The potential interactions between the Project activities and key receptors in the Impact Areas for the Project (and thus the appropriate Study Area) are identified. A site visit is performed in this stage to solidify the Impact Areas, and confirm the key landmarks, features, locations for baseline sampling, scopes of the baseline survey, modeling, and other requirements. During the scoping study, the potential interactions between the Project and environmental and social resources/receptors that *likely* cause impacts of significant concern are identified (*scope-in*). The scoping exercise also identifies the areas *unlikely* to be significantly affected by the development activities, requiring little further consideration or associated data gathering (*scope-out*). The scoping phase also identifies data availability and gaps, the appropriate spatial and temporal scopes for the assessment, and the suitable survey and research methodologies required to meet WB requirements.

ESIA Step	Description
Baseline Studies	The Project's impacts must be assessed within the context of existing physical, biological, socio-economic, and cultural conditions. To establish this context, **baseline studies** were conducted based on literature review and field baseline surveys to comprehensively understand the current conditions of all potential receptors. Baseline data is also used to predict and model impacts and to evaluate the sensitivity, vulnerability, and importance of resources and receptors.
Impact and Risk Assessment	The **impact assessment** for planned activities was conducted through a systematic process that involves the identification, prediction, and evaluation of the positive and negative impacts that the Project may have on the physical, biological, socio-economic, and cultural environment. This process also entails the identification of appropriate mitigation measures that the Project Owner must take to avoid, reduce, mitigate, offset, or compensate for any adverse impacts and to enhance positive impacts where practicable. The **risk assessment** for unplanned and non-routine activities follows a similar approach, with an additional step in the evaluation process that considers the likelihood of the occurrence of such events. The stages of the impact and risk assessment process are thoroughly described below. The stages of the impact and risk assessment process are described in more detail in ***Section B.2*** below.
Management Plan	The final stage in the ESIA Process is the determination of management and monitoring programs and auditing requirements to ensure the potential impacts are reduced and appropriately managed. The monitoring programs should be designed to detect impacts, confirm modeling results, quantify indicators to meet regulatory mitigation measures and ensure that emissions/discharges remain within international standards. An ESMP is then compiled, which summarizes all actions that the Project Owner and their Engineering, Procurement, and Construction (EPC) Contractor will commit to executing with respect to environmental/social/community health performance for the Project. The ESMP will document the proposed set of management, mitigation, and monitoring measures and specific actions to be taken at all stages of the Project development to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels.

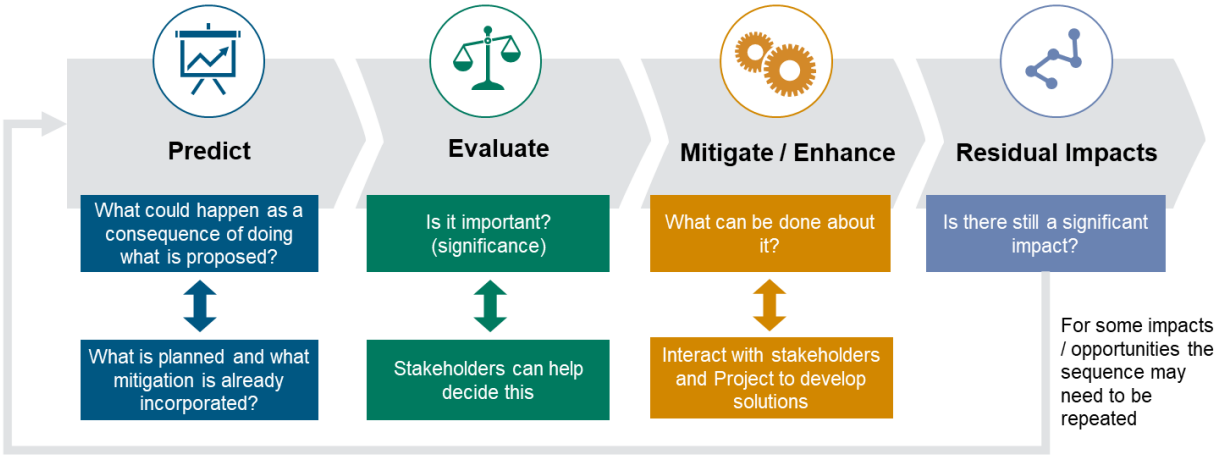
B.2 IMPACT ASSESSMENT METHODOLOGY

Impact identification and assessment starts with scoping and continues through the remainder of the impact assessment process, as demonstrated in ***Figure B-2***. The principal steps are:

1. Impact prediction: to determine what could potentially happen to resources/receptors because of the Project and its associated activities.

2. Impact evaluation: to evaluate the significance of the predicted impacts by considering their magnitude and likelihood of occurrence and the sensitivity, value and/or importance of the affected resource/receptor.
3. Mitigation and enhancement: to identify appropriate and justified measures to mitigate negative impacts and enhance positive impacts; and
4. Residual impact and risk evaluation: to evaluate the significance of impacts and risks assuming effective implementation of mitigation and enhancement measures.

FIGURE B-2 ESIA IMPACT AND RISK ASSESSMENT PROCESS



B.2.1 PREDICTION OF IMPACTS

The first step in the impact evaluation process involved predicting and quantifying, to the extent possible, the nature, type, magnitude, extent, and duration of the identified impacts on receptors. These terms are identified in ***Table B***.2.

TABLE B.2 DEFINITION OF IMPACT CRITERIA

Criteria	Definition
Nature of impacts on Environment/Community	**Beneficial** - impacts that result in net benefits **Adverse** - impacts that result in net detriments
Type of impact	**Direct** - impacts resulting directly from changes caused by the Project **Indirect** - secondary impacts caused by the Project
Magnitude—the level of impact, takes into consideration importance of the receptor, sensitivity of the receptor to change, likelihood of the impact occurring, and the predicted degree of impact	**Low** - a small, but measurable, change from the baseline conditions, typically that would not result in an exceedance of any applicable national and international standards. **Medium** - a noticeable and readily measurable change from the baseline conditions that may result in an exceedance of any applicable national and international standards. **High** - a substantial change from the baseline conditions that would result in an exceedance of any applicable national and international standards.

Criteria	Definition
Extent—the areal "reach" of the impact	**Site-specific** - impacts confined to within the RoW or ancillary facilities (e.g., laydown areas) **Local** - impacts extend beyond the Project footprint area to affect resources within Impact Areas of the Project **Regional** - impacts observed within 5 km away from the Project.
Duration	**Short-term** - less than two years or during construction phase **Medium-term** - more than two years and less than 10 years **Long-term** - 10 years or more

B.2.2 EVALUATE IMPACT SIGNIFICANCE

The second step of the impact evaluation process involved determining the significance of each identified impact. The magnitude, extent, and duration criteria each are assigned relatively to be in different level, which are then combined in a risk matrix to characterize the overall impact significance ***(Table B***.3***)***. ***Table B***.4 provides a decision tree illustrating how the various rating criteria combine to determine the impact significance. ***Table B***.5 defines each of the levels of impact significance.

TABLE B.3 ENVIRONMENTAL AND SOCIAL IMPACT RATING CRITERIA

Magnitude	Extent	Duration
Low	Site-specific	Short-term
Medium	Local	Medium-term
High	Regional	Long-term

TABLE B.4 ENVIRONMENTAL AND SOCIAL IMPACT SIGNIFICANCE RATING

Magnitude	Extent	Duration	Significance
Low	Site-specific	Short-term	Low
Low	Site-specific	Medium-term	Low
Low	Local	Short-term	Low
Medium	Site-specific	Short-term	Low
Low	Site-specific	Long-term	Low
Low	Local	Medium-term	Low
Medium	Site-specific	Medium-term	Low
Medium	Local	Short-term	Moderate
Low	Local	Long-term	Moderate
Medium	Site-specific	Long-term	Moderate

Magnitude	Extent	Duration	Significance
Medium	Local	Medium-term	Moderate
Medium	Local	Long-term	Substantial
Low	Regional	Short-term	Substantial
High	Site-specific	Short-term	Substantial
Low	Regional	Medium-term	Substantial
High	Site-specific	Medium-term	Substantial
Medium	Regional	Short-term	Substantial
High	Local	Short-term	Substantial
Low	Regional	Long-term	High
Medium	Regional	Medium-term	High
High	Site-specific	Long-term	High
High	Local	Medium-term	High
Medium	Regional	Long-term	High
High	Local	Long-term	High
High	Regional	Short-term	High
High	Regional	Medium-term	High
High	Regional	Long-term	High

TABLE B.5 IMPACT SIGNIFICANCE RATING DEFINITIONS

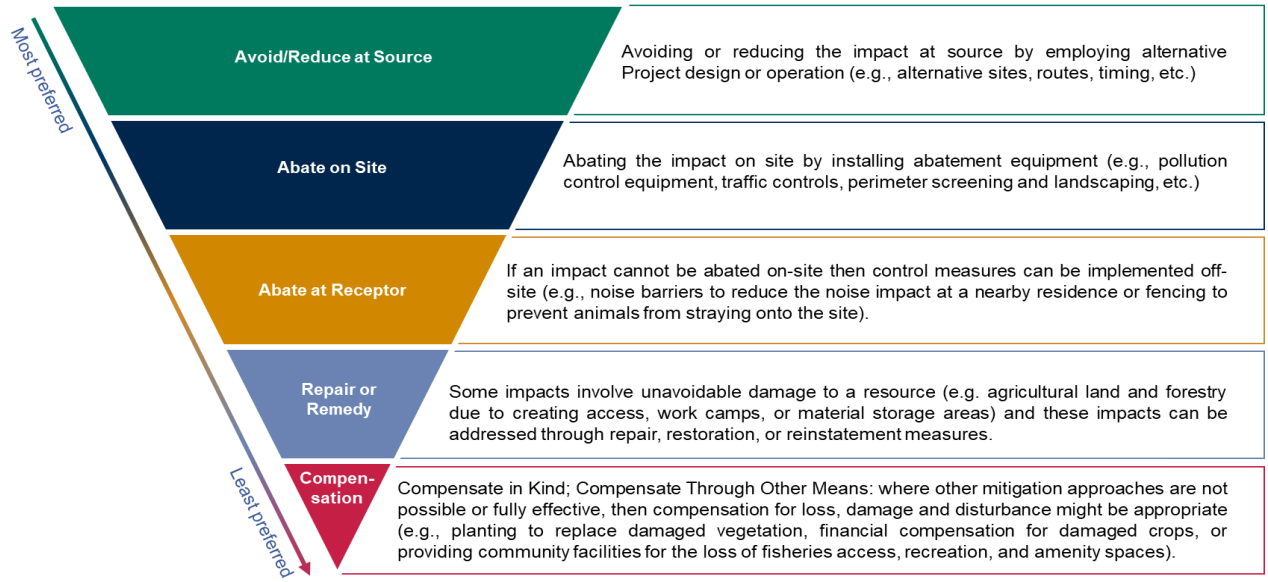
Impact Rating	Rating Definition
High	The resource/receptor would likely experience a large magnitude impact that would endure for a long time, extend over a large area, exceed national/international standards, endangers public health and safety, threatens a species or habitat of national or international significance, and/or exceeds a community's resilience and ability to adapt to change. The Project may have difficulty in complying with the applicable ESF requirement, and significant mitigation would likely be required.
Substantial	The resource/receptor would experience a clearly evident change from baseline conditions and would approach but not exceed applicable standards. The Project would comply with the applicable ESF requirement, but mitigation would be required.
Moderate	The resource/receptor would experience a noticeable effect, but the magnitude of the impact is sufficiently small (with or without mitigation) that the overall effect would remain well within applicable standards. The Project would comply with the applicable ESF requirement, but mitigation may be required.

Impact Rating	Rating Definition
Low	The resource/receptor would either not be affected or the likely effect would be imperceptible or indistinguishable from natural background variation. The Project would comply with the applicable ESF requirement and mitigation would typically not be required.

B.2.3 MITIGATION IMPACTS

The next step in the process was the identification of measures that could be taken to mitigate, as far as reasonably practicable, the identified potential impacts of the Project in accordance with the requirements of the WB ESS-1. The development of mitigation measures followed the mitigation hierarchy of avoidance, minimization, mitigation to the extent feasible, and compensation or offsetting if necessary. Mitigation measures were developed to address the potential impacts identified in the ESIA process and reviewed with affected communities. These are outlined in **Figure *B-3***.

FIGURE B-3 HIERARCHY OF MITIGATION OPTIONS



B.2.4 DETERMINE RESIDUAL IMPACTS

The final step in the impact evaluation process was the assessment of residual impacts and risks. Residual impacts and risks are those that would remain after all relevant avoidance, minimization, and mitigation measures have been taken into consideration. In cases where a residual impact significance rating is **High** or **Substantial**, emphasis is applied to reduce the impact/risk to a level that is as low as reasonably practicable. This is typically done by revisiting Steps 1 and 2 in the process (Predict Impacts and Evaluate Impacts, respectively) to identify ways of reducing impact magnitude or by considering implementation of new or additional avoidance or minimization measures aimed at reducing impact significance.

Several other factors must also be taken into consideration that influence the overall Project risk and residual significance rating and affect the feasibility of successful implementation of proposed mitigation measures:

- The Project Proponent and most local construction contractors have limited experience in developing Projects of this magnitude to international standards.
- Normative context of Bhutan – specifically, the presence of prevailing norms that may complicate the implementation of mitigation measures (e.g. lack of a stringent health and safety culture, elevated threats of natural disasters, low access to basic services like waste management, safely managed water and sanitation, etc.).
- Organizational capacity – the organizational capacity of the Project Proponent and most local construction contractors in implementing proposed mitigation measures and successfully delivering a large, complicated Project to international standards in the event that the proposed mitigation measures are particularly arduous/demanding.
- Institutional capacity - the institutional capacity of the RGoB and its applicable ministries to provide construction monitoring and enforce its regulations and Project approval conditions.

To address these considerations, the residual significance rating for certain impacts can be adjusted where it is determined that the implementation of mitigation measures is particularly complex and/or track record of poor implementation in Bhutan. The areas in which this has been done will be clearly indicated and the reason for the final adjustment rating explicitly noted. Where this occurs, the residual significance rating will be increased to a high significance/risk rating.

Although a standard goal of an impact assessment is to eliminate all significant residual impacts, for some resources/receptors there may be residual **High** or **Substantial** impacts/risks, even after all practicable mitigation options have been exhausted. In these situations, and especially where contextual and institutional/organizational risks apply, the ESIA may additionally recommend the specific measures such as requirement of third-party monitoring and auditing, institutional strengthening or organization capacity building.

B.2.5 CUMULATIVE IMPACT ASSESSMENT (CIA) PROCESS

As part of the impact assessment process, a CIA was conducted to determine the effect of the Project, in combination with other existing, planned, or proposed Projects and any external drivers, and provide an assessment of the likely significance of any cumulative impacts as detailed in ***Chapter 12***.

B.3 BASELINE DATA COLLECTION

A critical early step in the ESIA process involves collecting and assembling information to understand and characterize baseline condition of physical, biological, and social conditions within the project impact area. This information is gathered from a review of the available literature and secondary sources, as well as primary data collection through field surveys.

B3.1 LITERATURE REVIEW

A review of the publicly available secondary data online and secondary data collected from the site during the scoping site visit in July 2024 was used as the information for the baseline condition to understand and characterize condition of physical, biological, and social conditions within the Project impact area.

The objective was to understand the baseline condition of physical environment, biodiversity and social-economic conditions. For the purpose of the desk-based assessment, the following documents have been reviewed:

- First Biennial Update Report to the UNFCC, 2022. National Environment Commission, Royal Government of Bhutan (2022);
- Third National communication to the UNFCC. Royal Government of Bhutan (2020);
- Chapter 5 of the Project for the Formulation of Southern Central Regional Plan (Ministry of Works and Human Settlement Bhutan and Japan International Cooperation Agency, 2021);
- Gelephu Flood Protection Project: ESIA Report (Invest International, 2023). CDR;
- Final Report: Social Assessment for Assessment of Flooding Hazards and Development of Climate-Resilient Flood Mitigation Measures in Shetekheri and Aiepoly (Big and Small) Streams (World Bank, 2018);
- Integrated Biodiversity Assessment Tool (IBAT) for Business;
- International Union for Conservation of Nature (IUCN) Red List for Threatened Species online version;
- Birdlife Data Zone;
- Global Biodiversity Information Facility (GBIF) and iNaturalist;
- World Database on Protected Areas;
- UNESCO World Heritage Site;
- Ramsar Convention on Wetlands;
- Biodiversity Monitoring and Social Surveying Protocol of Bhutan, 2020, Department of Forests and Park Services, Ministry of Agriculture and Forests, Thimphu, Bhutan;
- Assessment of fish diversity in Bhutan: A systematic approach, 2018, Journal of Bhutan Studies;
- IFC Guidance Note (2019) of PS6 (2012). International Finance Corporation’s Guidance Note 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- Royal Government of Bhutan. Forest and Nature Conservation Act 1995, Ministry of Agriculture and Forests, Royal Government of Bhutan;
- Bhutan Biodiversity User List, 2021, National Environment Commission, Royal Government of Bhutan;

- 2017 Population & Housing Census of Bhutan: Sarpang Dzongkhag (National Statistics Bureau and Royal Government of Bhutan, 2018);
- Statistical Yearbook of Bhutan 2022. (National Statistics Bureau, 2022);
- Bhutan Living Standard Survey (BLSS), 2022;
- National Land Use Zoning, A Baseline Report, 2023, Royal Government of Bhutan;
- Bhutan Vulnerability Baseline Assessment, 2016, Gross National Happiness Commission Secretariat, Bhutan;
- Labor Force Survey Quarterly Report, Second Quarter, 2024, National Statistical Bureau; and
- Articles and information available in the public domain on aspects such as irrigation, drinking water supply, livelihood patterns, land, local governance, and active NGOs in the area and government development plans for the study area.

B3.2 FIELD BASELINE STUDIES

In addition to the literature review, primary data collection was conducted via field surveys to collect Project-specific data and fill data gaps from the literature. ***Table B***.6 summarized the field baseline studies. The detail baseline methodology is described in ***Appendix C.***

TABLE B.6 FIELD BASELINE STUDIES SUMMARY

Impact	General Location	Sampling Studies	Date	Completed by
Surface Water	• Downstream, midstream and upstream of Mau River • Jengkhurung River • Taklai River	10 grab water samples were collected at 5 locations and tested for various physical and chemical parameters.	20-21 August 2024	Mitra S K Laboratory
Groundwater	• Gelephu Workshop • Gyalsung Site Tareythang	5 grab water samples were collected at 2 locations and tested for various physical and chemical parameters.	20-21 August 2024	Mitra S K Laboratory
Soil	• Land next to National Center for Aquaculture • In the river channel of Mau River • Land next to Bhutan – India border checkpoint	7 soil samples were collected to determine the heavy metal content and pesticide levels.	20 August 2024	Mitra S K Laboratory

Impact	General Location	Sampling Studies	Date	Completed by
	• Land in Gelephu Airport • Land in agriculture field in Umling Gewog • Land in agriculture field in Tareythang Gewog • Land in agriculture field in Tareythang Gewog			
Ambient Air Quality	• Gelephu Workshop • Gelephu Airport Runway • Tareythang Weather Station • Gelephu Town Park • Residence close to road alignments in Umling • Tareythang Gewog Center • Residence close to road alignments in Tareythang Gewog	Baseline ambient air quality monitoring was conducted at 7 locations for parameters including PM2.5, PM10, SO_2, NO_x and NO_2.	24-25 August 2024 for SO_2, NO_x and NO_2 14 August - 20 September 2024 for PM2.5 and PM10.	Department of Energy and Climate Change Gradko International Ltd
Ambient Noise		Baseline noise sampling was conducted at 7 locations to measure ambient noise levels using sound level meters over a period of 48 hours.	14 - 20 September 2024	Department of Energy and Climate Change
Terrestrial Biodiversity	Bhutan is divided into 2424 grids of 4x4 km, called Biodiversity Monitoring Grids (BMG). The survey area includes the road alignment and its buffer of 750m towards both sides of the road.	• Flora • Bird • Herpetofauna • Large and Medium size mammals • Mammals	12 July - 29 August 2024	Department of Forestry and Park Services
Aquatic Biodiversity	• Upstream Mau River • Along Taklai River • Upstream Taklai River	• Fish • Macroinvertebrate • Water Quality	05 - 08 August 2024	College of Natural Resources

B.4 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLANS

An overarching ESMP was prepared that includes all the mitigation measures included in the ESIA and the procedures for the short and long-term environmental management of the Project. The ESMP identifies the phase of the Project when the mitigation will be applied, the entity responsible for implementing the mitigation measure, and monitoring requirements.

B.5 SCOPING

A preliminary Scoping Report was prepared based on ERM's professional judgement, as there was limited information provided at the time of writing. Since the report was submitted, ERM has revisited and updated the impacts that are likely to result in significant impacts as additional information has been gathered.

Potential impacts are identified through a systematic process whereby the features and activities (both planned and unplanned) associated with the pre-construction, construction, operation and decommissioning of the Project have been considered with respect to their potential to interact with resources/receptors.

A scoping matrix is used as the tool for identifying the various Project features and activities within the Impact Areas that could reasonably act as a source of potentially significant impact. Each resulting cell on the scoping matrix thus represents a potential interaction between a Project activity and an E&S resource/receptor.

The Project activities presented in ***Chapter 2***, have been listed down the vertical axis of the matrix. The resources/receptors relevant to the baseline environment are listed across the horizontal axis of the matrix. The emergency events against the risks and impacts to the resources/receptors are also included in the scoping matrix. The 'scoped in' or 'scoped out' of risks and impacts are classified in the matrix with color coding described in ***Table B***.7.

TABLE B.7 SCOPING MATRIX DEFINITIONS

	Key
	Scoped in - Potentially significant impact requiring further assessment
	Scoped out - Potential interaction unlikely to be significant
	Positive impacts - An interaction with positive impact expected
	An interaction is not reasonably expected

The completed scoping matrix is presented in ***Table B***.8. A summary of the interactions that were assessed to be possibly significantly are **scoped in** and shall are assessed at the ESIA stage.

Interactions that were assessed to have possibly insignificant impacts on the environmental and social receptors that are **scoped out** and shall not be further assessed

at the ESIA stage as existing control measures were considered sufficient to deem the impacts insignificant. The scoped-out rationale are included in ***Table B***.11.

TABLE B.8 SCOPING MATRIX

No.	Activity	Environmental and Social Resource/Receptor																				
		Physical								Biodiversity			Social									
		Air Quality	Waste	Noise/Vibration	Greenhouse Gas Emission	Surface Water and Quality Hydrology	Ground Water	Sediment/Soil	Traffic	Protected Areas	Aquatic Flora and Fauna	Terrestrial Flora and Fauna	Land Use and Livelihoods	Visual and Landscape	Cultural Heritage	Community Health, Safety and Security	Labour and Working Conditions	Indigenous Peoples	Vulnerable groups	Community Service / Infrastructure	Employment and Local Economy	Community Forests
1	**Pre-Construction Phase**																					
1.1	Land acquisition for right-of-Way (RoW)												■		■			■	■			■
2	**Construction Phase**																					
2.1	Construction of temporary ancillary facilities	■	■	■	■	■	■	■	■		■	■	■	■		■	■		■			■
2.2	Worker mobilization/influx		■	■	■				■	■		■				■			■	■	■	■
2.3	Procurement of material and operation of borrow pits	■	■	■	■	■			■		■	■				■	■					
2.4	Site preparation/Land clearing	■	■	■	■	■	■	■	■		■	■		■	■	■	■		■			■
2.5	Earthworks (Cutting and Filling)	■	■	■	■	■	■	■	■		■	■		■	■	■	■		■			
2.6	Road construction & retaining walls	■	■	■	■		■	■	■			■		■	■	■	■		■			
2.7	Construction of river training works	■	■	■	■	■	■	■	■		■	■				■	■					
2.8	Construction of bridges, including foundations, piers / abutments, and superstructures	■	■	■	■	■	■	■	■		■	■		■	■	■	■		■			
2.9	Construction of culverts / drainage and water management structures	■	■	■	■	■	■	■	■		■	■		■	■	■	■					
3	**Operation and Maintenance Phase**																					
3.1	Road Operation and Maintenance	■		■	■				■			■		■		■	■			■	■	■

B.5.1 KEY ENVIRONMENTAL AND SOCIAL IMPACTS SUMMARY

The key impacts that will be included in the ESIA are summarized in ***Table B***.9 below.

TABLE B.9 KEY IMPACTS TO BE INCLUDED IN ESIA

ESS	Key Environmental Impacts	Key Social Impacts
ESS-1 Assessment and Management of Environmental and Social Risks and Impacts	Air Quality Noise and Vibration Surface Water, Groundwater and Hydrology Soil Quality and land use Physical environment including terrain / Topography, geology, seismicity and climate Waste management Cultural Heritage	Community Health and Safety Socioeconomic Conditions Community Engagement and Stakeholder Consultation Land Acquisition and Resettlement Cultural and Social Dynamics Access to Services and Resources Gender Impacts
ESS-2 Labor and Working Conditions	NA	Labor influx Potential health risks and risks related to gender-based violence (GBV) Occupational Health and Safety (OHS) Risk
ESS-3 Resource Efficiency and Pollution Prevention and Management	Erosion and Sedimentation Riverbed Erosion Wastewater Discharges management Air and Noise Pollution control Greenhouse Gas (GHG) Emissions Spoils Generation Construction Waste management Downstream Water Flows	NA
ESS-4 Community Health and Safety	Landslide Risks Safety Hazards from construction Human-Wildlife Conflicts	Public heath and safety impacts
ESS-5 Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	Land Acquisition and Resettlement Impact on Community Forests	Involuntary Resettlement Loss of Livelihoods Cultural Disruption Inadequate Compensation Impacts on vulnerable Groups
ESS-6 Biodiversity Conservation and Sustainable	Critical Habitat Assessment Impact on Aquatic Habitats Impact on Royal Manas National Park	NA

ESS	Key Environmental Impacts	Key Social Impacts
Management of Living Natural Resources	Elephant Movements Forest Clearing and Terrestrial Habitat Loss	
ESS-7 Indigenous Peoples	NA	NA
ESS-8 Cultural Heritage	NA	Protection of Cultural Heritage Community engagement
ESS-9 Financial Intermediaries	NA	NA
ESS-10 Stakeholder Engagement and Information Disclosure	NA	NA

B.5.2 CLIMATE RISK INTERACTIONS

The ESIA will address the potential exposure of the Project's infrastructure to floods and landslides, risks that are expected to intensify due to climate change. The engineering team has proactively incorporated design considerations to enhance the resilience of the infrastructure against future climate scenarios. This section of the ESIA will detail the specific design choices made to reduce the vulnerability of the infrastructure. Additionally, a comprehensive physical risk review will be conducted, focusing on the impact of extreme weather events on the asset.

B.5.3 UNPLANNED EVENTS INTERACTIONS

The scoping process for unplanned events includes identifying the most likely unplanned events leading to environmental, social and/or community health impacts including accidental leaks, road accidents and fire and explosion as detailed in ***Table B***.10.

TABLE B.10 SCOPING REVIEW OF UNPLANNED EVENT INTERACTIONS

Risks	Receptors	Description	Scoping
Accidental leaks and spills in construction phase	Surface water, soil, and groundwater Community health and safety	Oil, lubricants, bitumen, paints or other hazardous material spills and chemical leak to unpaved areas could potentially seep into the soil or make its way to nearby surface water. However, as the infrastructure construction will be phased, the amount of hazardous materials present at any time on site is expected only to generate a negligible, temporary localized impacts that can be promptly remediated through standard hazardous materials	In

Risks	Receptors	Description	Scoping
		handling practices. Therefore, this unplanned event is scoped out from the ESIA	
Hazardous / Chemical waste released to environment	Surface water, soil, and groundwater Community health and safety Terrestrial Flora and Fauna	Improper hazardous / Chemical waste disposal may result in contamination of water and possibly result in disruption of ecosystem. It may contaminate drinking water and may cause air quality issues.	In
Road accidents in construction and operation phases	Surface water, seawater, soil, and groundwater Terrestrial Fauna Community Health and Safety	The rise in road traffic volume during construction and operation amplifies the potential risk of traffic accidents, leading to the risk of mortality of terrestrial fauna and community health and safety. This impact will be discussed in detail in the ESIA.	In
Fire and explosion	Community health and safety Terrestrial Flora and Fauna	The storage of fuel for machinery and bitumen for road pavement may elevate the risk of accidental fire. However, given that the construction sites and storage areas will be dispersed along the length of the road, it is unlikely that fuel will be stored in quantities large enough to pose a significant explosion hazard. Adhering to good international industry practices for fire prevention and response will effectively reduce the fire risk to a negligible level. As a result, this potential impact is scoped out from the ESIA.	Out
Fall and slips in construction site	Community health and safety	Constructing elevated bridges involves working at heights, which carries a risk of falls. Additionally, construction debris on the ground can increase the likelihood of slipping accidents.	In
Struck by moving machinery in construction site	Community health and safety Terrestrial Fauna	Large and movable construction machinery will be used throughout construction period, this will potentially lead to being struck by moving machinery.	In

B.5.4 SCOPED-OUT RISKS AND IMPACTS

All the issues that are marked as "white" in ***Table B***.8 (i.e. an interaction is not reasonably expected) will be all scoped-out from the impact assessment and will not be further assessed during the subsequent ESIA and ESMP. These interactions that were assessed to have possibly insignificant impacts on the environmental and social receptors are presented in ***Table B***.11***.***

Furthermore, this section provides rationale for scoping out of the potential E&S issues that were marked "grey" (where an interaction is reasonably possible but is unlikely to be significant), where issues are proposed to be scoped out as the likelihood of the interactions leading to significant effects is considered low. Such E&S issues will also not be assessed during the

subsequent ESIA. The rationale for such scoping out is provided broadly against the E&S receptor/ resource.

TABLE B.11 SCOPED-OUT RATIONALE

No.	Receptor/ Resource	Project Activity	Rationale to Scope Out
1.	**Physical Environment**		
1.1	Air Quality	**Construction Phase** • Construction of river training works • Construction of culverts / drainage and water management structures	The dust emissions generated during river training work and the construction of culverts are expected to be negligible. This is due to the relatively wet environment and the coarse granularity of riverbed sediments and soil on the riverbanks, which are less prone to suspension by wind.
1.2	Waste	**Construction Phase** • Construction of temporary ancillary facilities • Road construction & retaining walls • Construction of river training works • Construction of bridges, including foundations, piers / abutments, and superstructures • Construction of culverts / drainage and water management structures	These construction activities are not likely to generate significant waste because materials are expected to be procured locally from the riverbed. Additionally, the use of prefabricated components in bridge and culvert construction further minimizes excess material. Temporary structures like formwork are commonly reusable or recyclable, contributing to overall waste reduction.
1.3	Noise/Vibration	**Construction Phase** • Worker mobilization/influx	Generation of noise from presence of workers is expected to be negligible in comparison to the machineries used in the construction phase. Potential nuisance from the presence of workers and in the vicinity of their accommodation will be discussed in the Community Health, Safety and Security section of the ESIA.
1.4	Greenhouse Gas Emission	**Construction Phase** • Worker mobilization/influx	Presence of workers is expected to have a negligible impact on greenhouse gas emissions as associated mainly to the generation of energy at their accommodation.

1.5	Surface Water Quality and Flow	**Construction Phase** • Construction of temporary ancillary facilities	Temporary facilities are expected to have a small footprint compared to the rest of the infrastructure and will have limited interaction with surface water.
1.6	Hydrology and Ground Water	**Construction Phase** • Construction of temporary ancillary facilities • Site preparation/Land clearing • Earthworks (Cutting and Filling) • Road construction & retaining walls	Those mostly terrestrial operations are unlikely to have any significant interaction with the area's hydrology. The right of way is negligible compared to the effects that the construction of the bridges will have on the rivers. Temporary facilities are expected to have a small footprint compared to the rest of the infrastructure. Given the depth of the groundwater table, it is unlikely that any of these activities will affect this receptor.
1.7	Sediment/soil	**Construction Phase** • Construction of temporary ancillary facilities	Temporary facilities are expected to have a small footprint compared to the rest of the infrastructure and the areas occupied will be rehabilitated upon completion of construction.
1.8	Traffic	**Construction Phase** • Construction of temporary ancillary facilities	The construction of such facilities will be very short and unlikely to affect the traffic on the existing road network.
2.	Biodiversity		
2.1	Protected Areas	**Construction Phase** • Worker mobilization/influx	The presence of workers on the construction site could increase the risk of poaching wild fauna and collecting flora in the forest. However, the road alignment does not intersect with any Protected Areas. Although the section of the road near Tareythang is relatively close to the Royal Manas National Park, access for workers will be restricted by the Tareythang Center, which is equipped with a permanently guarded post.
2.2	Aquatic Flora and Fauna	**Construction Phase** • Construction of temporary ancillary facilities	It is expected that temporary facilities will be installed outside the riverbed and have limited interaction with the aquatic habitat.

2.3	Terrestrial Flora and Fauna	**Construction Phase** • Worker mobilization/influx • Construction of river training works	The potential for poaching due to the presence of workers on site is expected to have a negligible impact on local flora and fauna, as the Project predominantly traverses agricultural land and plantations (i.e., Modified Habitats) where human activity already significantly influences the ecosystem. Works conducted mainly on the riverbed is unlikely to generate a significant impact on the terrestrial flora and fauna.
3.	Social		
3.1	Land Use and Livelihoods	NA	NA
3.2	Visual and Landscape	**Construction Phase** • Construction of temporary ancillary facilities Site preparation/Land clearing • Earthworks (Cutting and Filling) • Road construction & retaining walls • Construction of bridges, including foundations, piers / abutments, and superstructures • Construction of culverts / drainage and water management structures **Operation and Maintenance Phase** • Road Operation and Maintenance	All construction activities will be temporary and are expected to have a negligible effect on the landscape and visual amenity. The road will largely be concealed by existing vegetation and will traverse rural areas with low population density. No major tourist attractions or significant landscape features are anticipated to be impacted by the road. The visual impact of the bridge is also expected to be minimal. The main crossing over the Mau River is being carefully designed by both the engineering and architectural teams to blend with the landscape and traditional architectural elements of Bhutan to potentially become a landmark for Gelephu. As there are limited receptors the visual impact assessment is not included in the scope of work.
3.3	Cultural Heritage	**Construction Phase** • Construction of bridges, including foundations, piers / abutments, and superstructures	The riverbed is subject to strong flow during the wet season and high sediment flow. In such harsh condition, it is unlikely that the riverbed may host significant findings of cultural heritage significance.

3.4	Indigenous People	NA	NA
3.5	Vulnerable groups	**Construction Phase** • Construction of temporary ancillary facilities • Worker mobilization/influx • Site preparation/Land clearing • Earthworks (Cutting and Filling) • Road construction & retaining walls • Construction of bridges, including foundations, piers / abutments, and superstructures	The construction of the road and bridges may affect vulnerable populations. However, the specific individuals and groups at risk will be identified during the Pre-Construction Phase, particularly during land acquisition for the road's Right-of-Way. Prior to the commencement of construction, impacts and mitigation measures, including the preparation and implementation of a Resettlement Action Plan, will be established to address and manage these effects.
3.6	Community Service Infrastructure / Social Infrastructure	NA	NA
3.7	Employment and Local Economy	NA	NA
3.8	Community Forests	**Construction Phase** • Construction of temporary ancillary facilities • Site preparation/Land clearing	Temporary ancillary facilities will be located outside community forests. Land clearing in community forests is expected to be negligible and managed during the Land acquisition for Right-of-Way activity.

APPENDIX C ENVIRONMENTAL BASELINE METHODOLOGY

C ENVIRONMENTAL BASELINE METHODOLOGY

C.1 PHYSICAL ENVIRONMENT

C.1.1 TOPOGRAPHY OF BHUTAN

Bhutan is a landlocked country situated in the eastern Himalayas and the border is defined by rugged terrain including high mountains, valleys and rivers. The country shares boundaries with China to the north and India to the south, east, and west.

Bhutan's topography shaped by its location in the eastern Himalayas that ranges from deep valleys to towering mountains. The country's mountain systems are part of the greater Himalayan range, which extends across Nepal, India, and Bhutan, and are divided into several distinct ranges.

The Northern Bhutan is dominated by the Greater Himalayas, which lies along the Tibetan border, with several notable high peaks such as Gangkhar Peunsum and Jomolhari, ranged from 7,000 meters and above. The glaciers from the northern side of Bhutan feed Bhutan's river systems.

The Black Mountains at central Bhutan divides the eastern and western Bhutan with peaks ranged from 1,500 to 5,000 meters with dense forest area with rich biodiversity.

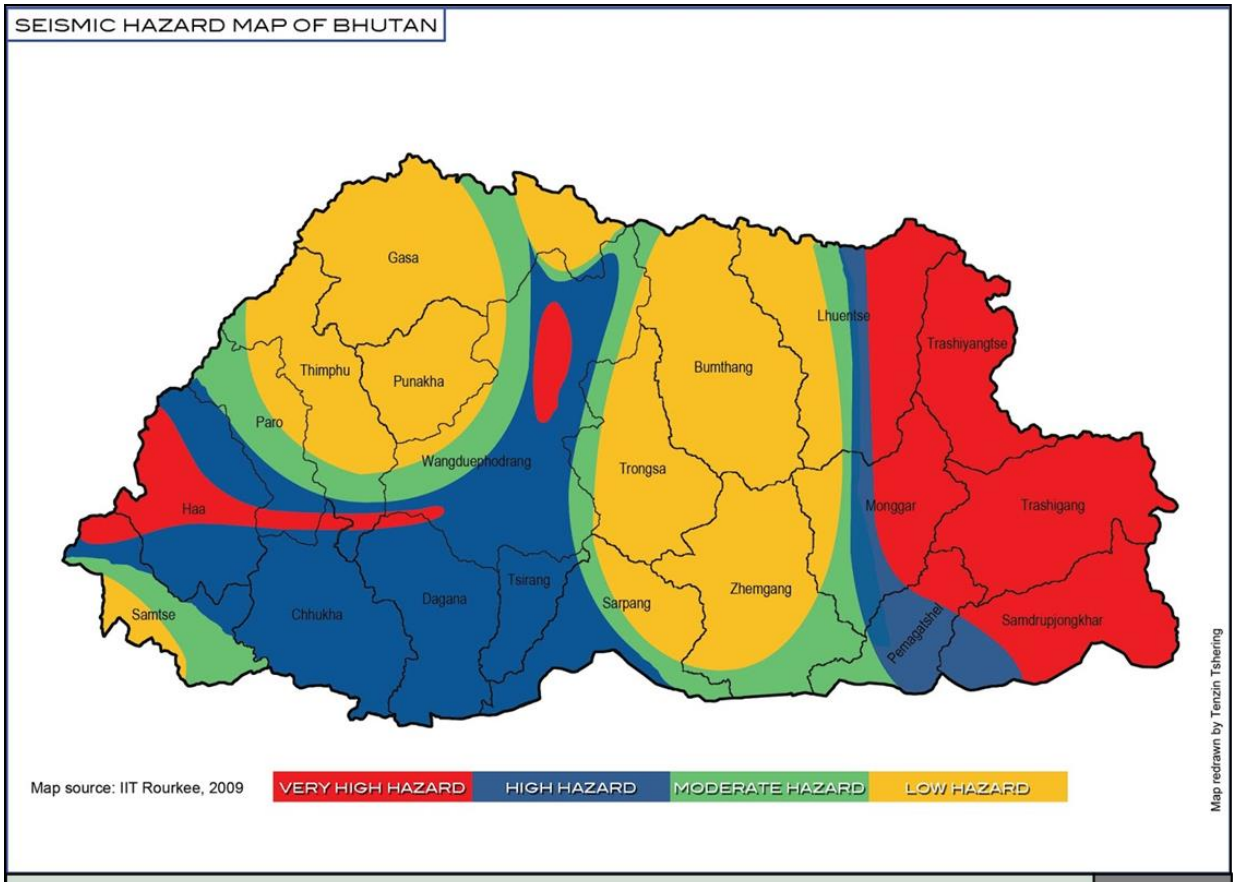
C.1.1 SEISMICITY OF BHUTAN

According to the Indian Regional Seismo-tectonic Zonation Map, Bhutan falls within Zone V, indicating a very high seismic risk. As shown in Figure C-1, the Rourkee Map classifies the west portion of Sarpang as having a high seismic hazard, including part of Gelephu.[1] The estimated seismic hazard levels for northeast India and Bhutan are fell into zone VI based on 1964 MSK Intensity Scale for earthquake ground shaking. The latest map shows Bhutan lies in Seismic Zone VI, which has a PGA of 0.50g and 0.75g for a return periods of 475 and 2,475 years respectively.[2]

[1] IIT Rourkee. (2009). State of Bhutan's hydropower projects.
https://yesheydorji.blogspot.com/2017/06/state-of-bhutans-hydropower-projects.html

[2] Draft Indian Standard Criteria for Earthquake Resistant Design of Structures Part 1 General Provisions [Seventh Revision of IS 1893 (Part 1)] (ICS No. 91.120.25).
https://www.services.bis.gov.in/tmp/WCCED21022343_26042023_2.pdf

FIGURE C-1 SEISMIC HAZARD RISK MAP OF BHUTAN



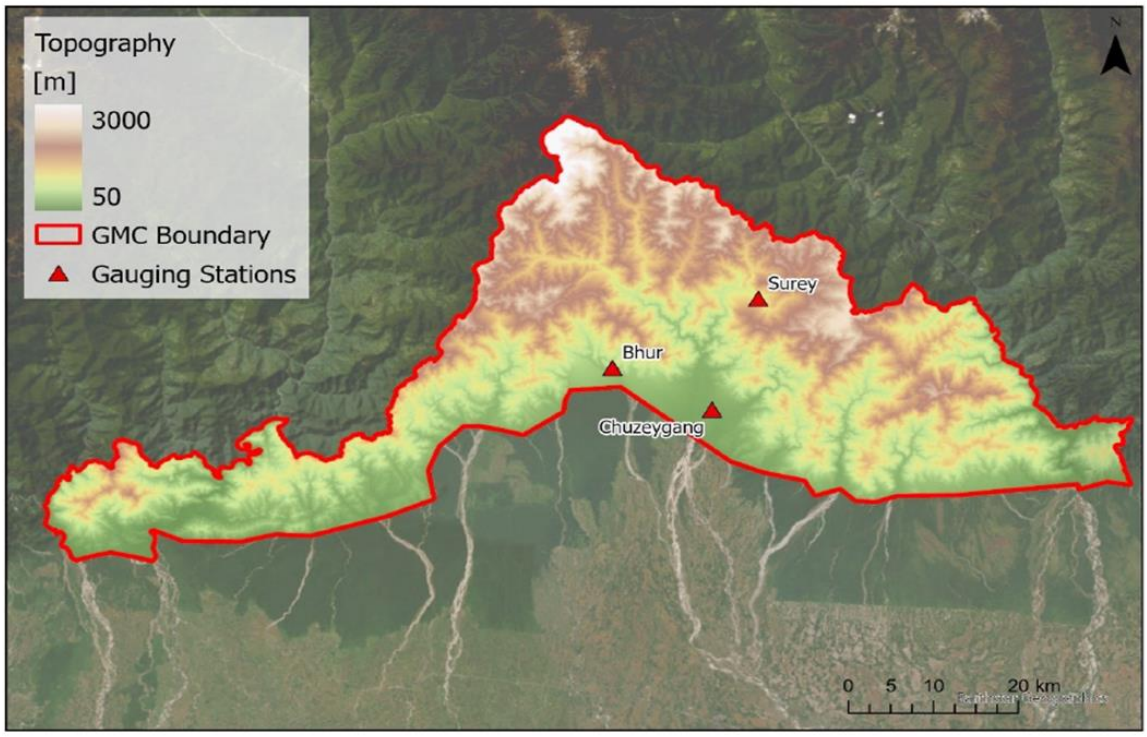
Seismic Hazard Risk Map of Bhutan		
0750493 Gelephu-Tareythang Road Project		ERM
Figure Source: IIT Rourkee (2009)	Date: September 2024	

C.1.2 CLIMATE

The climate of Bhutan varies significantly according to latitude and altitude. The country has three distinct climatic zones: subtropical, alpine and temperate, which encompass numerous micro-climates due to dramatic variations in elevation and topography.[3] Two main factors causing climatic variation of mean temperature and precipitation are the vast differences in altitude in the country and the influence of the North Indian monsoons. The rain gauging stations location is indicated in ***Figure C-2***.

[3] National Center for Hydrology and Meteorology. (2019). Analysis of Historical Climate and Climate Projection for Bhutan

FIGURE C-2 ELEVATION MAP INDICATING THE DIFFERENT RAIN GAUGING STATIONS



Elevation Map Indicating the Different Rain Gauging Stations		
0750493 Gelephu-Tareythang Road Project		ERM
Figure Source: CDR (2024)	Date: October 2024	

C.2 WATER RESOURCES AND HYDROLOGY

Most major rivers in Bhutan originate from glaciers and are replenished by watershed sources. The river system is characterized by main rivers flowing north to south from the Himalayas, with tributaries moving in an east-west direction. They typically feature steep gradients and narrow, steep-sided valleys that occasionally widen to create small, flat areas suitable for cultivation. Short rain-fed tributaries descend steeply from the east or west to join the major rivers.

The distinct rainy and dry seasons in Bhutan cause significant seasonal variations in river flows. During the monsoon season, rivers carry large volumes of water and often high sediment loads. Conversely, flow levels are relatively low during the dry season due to reduced rainfall and the limited presence of major groundwater reservoirs.

Bhutan has four major river systems: the Drangme Chhu (or Manas River System), the Punatsang Chhu (Sankosh River System), the Wang Chhu (Raidak River System), and the Amo Chhu (Torsa River System).

C.3 WATER QUALITY

C3.1 SURFACE WATER QUALITY

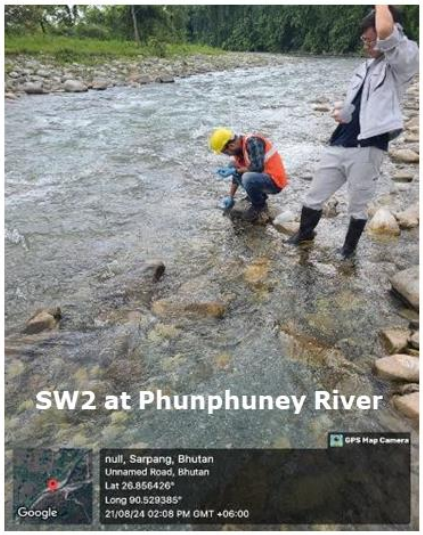
The baseline data for surface water quality assessment was done based on the parameters given in Baseline sampling plan. Five Surface water (n=10) sampling sites have been chosen for the investigation based on the physiographical condition. The selection of sites was done considering the location of different Project components, junction of streams course, spots of high-water velocity and some of the stagnated pools along with the areas having human interference. Both sites were targeted based on availability of human activities.

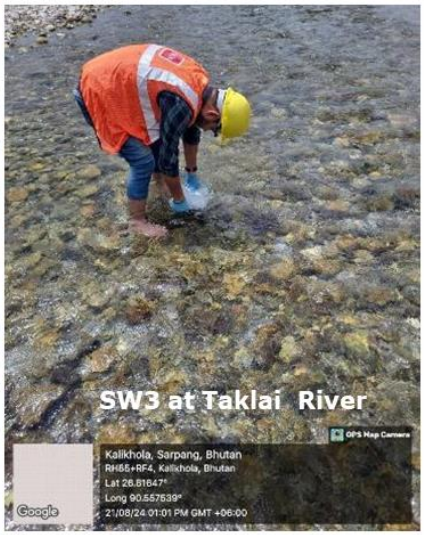
Surface water sampling was conducted on 20-21 August 2024 at five (05) sites, conducted by Mitra S K Laboratory (***Figure C-3***). A total of ten (10) grab water samples were collected and tested for various physical and chemical parameters, as well as microbiological, and radioactivity. The sampling water was analyzed by an accredited laboratory (Mitra S K Laboratory) and the results were compared to the Ambient Water Quality Criteria, Environmental Standards, 2020[4] and Guidelines for Drinking-Water Quality 4th edition[5].

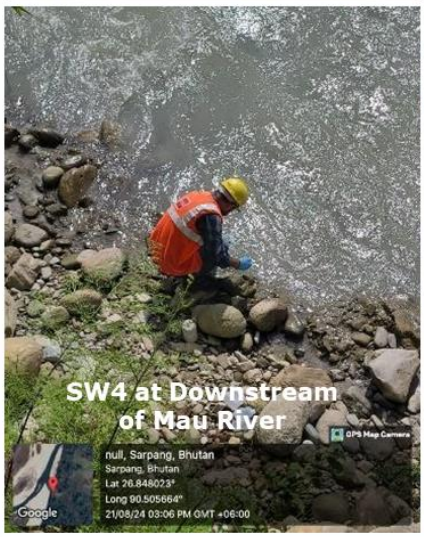
For carrying out the Compliance Monitoring and assessing its conformance to the regulation the standard for the Environmental Commodity following specified national and international standard used in this study which are the Indian Standard Specifications for Surface Water Quality Standards (as per IS:2296) for Surface water.

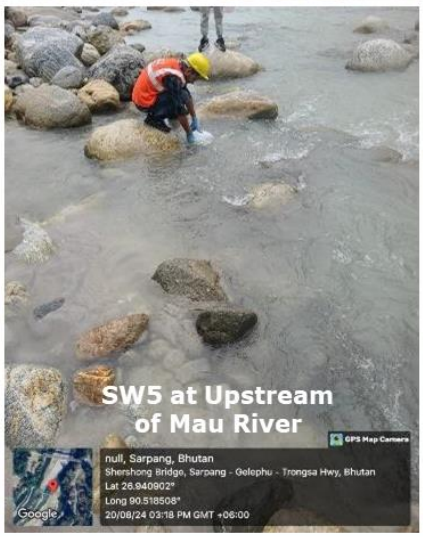
[4] National Environment Commission Royal Government of Bhutan, June 2020.
[5] World Health Organization, 2022.

FIGURE C-3 DOCUMENTATION OF SURFACE WATER SAMPLING









Photos of Surface Water Quality Monitoring		
0750493 Gelephu-Tareythang Road Project		ERM
Photo Credit: Mitra S K Laboratory	Date: September 2024	

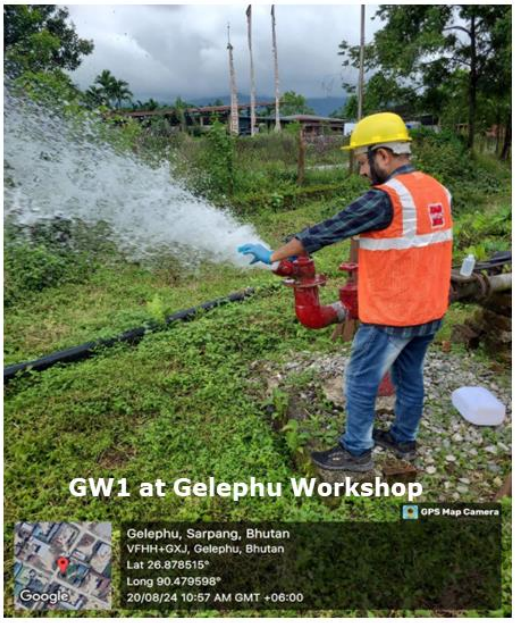
C3.2 GROUNDWATER QUALITY

The baseline data for groundwater quality assessment was done based on the parameters given in Baseline sampling plan. Six (n=4) groundwater sampling sites have been chosen for the investigation based on the physiographical condition.

Groundwater sampling was conducted on 20-21 August 2024 at two (02) sites, conducted by Mitra S K Laboratory (***Figure C-4***). A total of four (04) grab water samples were collected and tested for various physical and chemical parameters, as well as microbiological, and radioactivity. The sampling water was analyzed by an accredited laboratory (Mitra S K Laboratory) and the results were compared to the Ambient Water Quality Criteria, National Environment Commission Royal Government of Bhutan, June 2020 and Guidelines for Drinking-Water Quality 4th edition.

For carrying out the Compliance Monitoring and assessing its conformance to the regulation the standard for the Environmental Commodity following specified national and international standard used in this study which are the Indian Standard Specifications for Drinking Water. IS: 10500, regulation 2012 for essential characteristics of drinking water.

FIGURE C-4 DOCUMENTATION OF GROUNDWATER SAMPLING



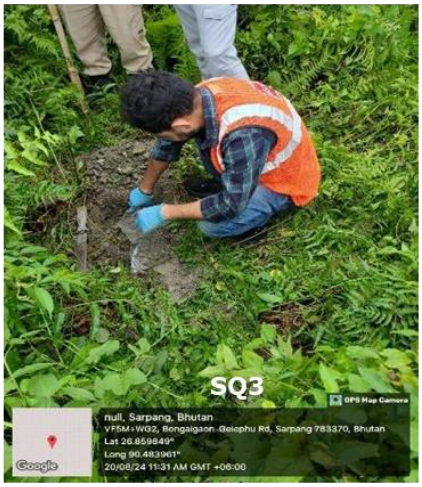
Photos of Groundwater Quality Monitoring		
0750493 Gelephu-Tareythang Road Project		ERM
Photo Credit: Mitra S K Laboratory	Date: September 2024	

C.4 SOIL QUALITY

The monitoring of the soil quality was carried out to understand the impacts on the soil, especially on the fertian soil sample was collected at 10-15 cm depth from surface (***Figure C-5***).

As there are not national standard for soil quality, therefore the United States Environmental Protection Agency (USEPA) and *Dutch Standard: Dutch Target and Intervention Values (2000)* has been used for this study. USEPA has developed various soil standards and guidelines depending on the type of contamination, land use, and risk level. Ecological Soil Screening Levels (Eco-SSLs) for mammals are utilized as reference, which is designed to protect ecological receptors (plants, animals) from the effects of contaminants in soil.

FIGURE C-5 DOCUMENTATION OF SOIL SAMPLING



Photos of Soil Quality Monitoring		
0750493 Gelephu-Tareythang Road Project		ERM
Photo Credit: Mitra S K Laboratory	Date: September 2024	

C.5 AMBIENT AIR QUALITY

The distribution of pollutants in the atmosphere is influenced by several factors, such as the location of emission sources, both natural and anthropogenic, relief and meteorological phenomena that are felt, namely wind, atmospheric stability conditions, inversions thermal, humidity, temperature, among others. Baseline air quality typically varies across any particular area. In essence, the baseline can be considered in the following components:

- ***Natural Baseline*** *– this represents the pollution concentrations that are ubiquitous in the region due to sources other than human activity. This primarily influences PM_{10} / $PM_{2.5}$ concentrations. Naturally occurring NO_x and NO_2 are typically minimal.*
- ***Regional Sources*** *– this represents the pollution concentrations that arise from large point or non-point sources that will affect substantial areas.*
- ***Local Sources*** *– this represents pollutant concentrations that vary on a small spatial scale but may be substantially elevated on a local level. An example of such sources includes road traffic and in the middle of towns where there are vehicles, industry and multiple small-scale sources. These sources can lead to elevated pollutant concentrations on a localised scale, for the pollutants of interest.*

The baseline environmental conditions in Gelephu are characterized by a combination of urban, rural, and semi-industrial elements. This creates a mix of natural and anthropogenic influences The air quality in Gelephu is generally influenced by local traffic, household emissions (including wood and biomass burning), and cross-border pollution from India. While Bhutan's air quality is typically better compared to heavily industrialized countries, rapid urbanization and increased vehicle traffic may lead to localized degradation of air quality. Emissions of PM_{10} and $PM_{2.5}$, NO_x, and CO are expected to be the primary pollutants in ambient air.

The key rationale for baseline study is to determine the current state of the airshed in the Project area. The approach to the baseline monitoring was informed by the WBG EHS Guidelines: Environmental: Air Emissions and Ambient Air Quality (2007) and ERM professional judgement and experience However, the framework does not contain any prescriptive methodologies and therefore reference has been made to other international guidelines.

The baseline study encompassed ambient monitoring of NO_2, NO_x, SO_2, PM_{10} and $PM_{2.5}$. The pollutants of interest are based on a review of the proposed activities against the relevant international guidance, namely increased traffic (exhausts from vehicle engines), and equipment such as trucks, and excavators and emissions from construction-related activities.

Monitoring air quality across different seasons helps identify trends and patterns in pollutant levels. This is essential for understanding the typical air quality conditions and detecting any deviations that might indicate emerging issues or changes in pollution sources. At the time of writing, only the wet season data has been collected and analysed. Monitoring of the dry season will be undertaken and will be incorporated into the ongoing assessment of air quality once available.

C5.1 PM_{10} AND $PM_{2.5}$

PM monitoring was undertaken for two months in the wet ad dry seasons (at the time of writin, only the wet season data is available). The monitor used was an Aeroqual AQS air monitor. The location was chosen based on the following factors: Accessibility, security, power supply,

proximity to the Project area and sensitive receptors. Data from the Aeroqual was downloaded after 23 days; the periods of missing data are attributed to power cuts in the area.

The locations for air quality monitoring were selected based on the proximity to sensitive receptors, which include areas with populations likely to be impacted by the project's activities. Of note is that the baseline survey was undertaken prior to confirmation of the exact road route. These locations are prioritized for monitoring to ensure that any potential air quality impacts from the project are accurately assessed and mitigated, thereby protecting public health and safety.

C5.2 NO_X, NO_2 AND SO_2

Monitoring was undertaken for the following pollutants, NO_x, NO_2 and SO_2 using Palmes-type diffusion tubes (see ***Figure C-6***), provided and analysed by Gradko Laboratories and deployed for approximately 30 days per sampling round. The diffusion tubes were sent for laboratory analysis to determine the period mean concentration.

FIGURE C-6 DIFFUSION TUBE (AQ1)

C.6 AMBIENT NOISE CONDITION

To assess background noise levels at each sampling location, all acoustic instrumentation used throughout the monitoring program can meet the requirements of IEC 61672 "Class 1 or 2 Sound Level Meter" with an A-weighting response curve. Noise logger shall be programmed to continuously record the following noise level indices in 10-minute intervals: L_{Aeq}, L_{Amax} and L_{A90}, L_{A10} and L_{Amin}.

Baseline noise sampling was conducted at seven (07) locations across the Project impact area to measure ambient noise levels using sound level meters over a period of 48 hours. The noise sampling was conducted by Department of Energy and Climate Change (DECC).

C.7 TRAFFIC AND TRANSPORT

C7.1 RELEVANT Standards AND GUIDELINES

C7.1.1 BHUTAN STANDARDS

The **Road Act (2013)** establishes the roles of governmental bodies to build, maintain, fund, and administer the road network. The Road Act requires that the Bhutan Department of Roads

prepare a national roads master plan and 5-year implementation plans; develop road and bridge design standards, manuals, and technical guides; implement road design and construction standards; pursue the planning, construction, and maintenance of national roads; and enforce safety standards in road design. The Road Act requires that local governments submit road plans for their jurisdictions to be incorporated into the national road master plan and pursue the planning, construction, and maintenance of local roads, pedestrian ways and bicycle tracks. The Department of Roads operates within the Ministry of Works and Human Settlement.

The **Road Rules and Regulations (2016)** establish administrative authority and procedures for the Department of Roads and local governments to administer the Roads Act. The document provides dispute resolution procedures; requires a Traffic Management Plan for road construction or maintenance activities that would affect road users, a Traffic Management Plan is required, to be prepared in consultation with the Traffic Division of the Royal Bhutan Police and the Road Safety and Transport Authority of the local jurisdiction. The Rules also provide that entities working on a road open to traffic must take all reasonable measures to prevent accidents or injury to construction workers and road users, or damage to assets.

The **Road Safety and Transport Act (1999)** and the **Road Safety and Transport Regulations (2021**) establish requirements for driver licensing, motor vehicle registration, driving under the influence of alcohol or drugs, speed limits, traffic regulations, motor vehicle insurance, and commercial passenger vehicles. The regulations are administered by regional offices of the Road Safety and Transport Authority, under the Bhutan Ministry of Information and Communications. The Traffic Division of the Royal Bhutan Police provides traffic enforcement.

The **Road Classification System in Bhutan (2017)** was published by the Ministry of Works and Human Settlement to provide a clear understanding of definition and technical standards of various road categories.[6] The standards address right-of-way width, standard cross sections, design speed, horizontal and vertical alignment, and other road design elements.

C7.1.2 INTERNATIONAL STANDARDS

C.7.1.1.1 World Bank Group Environmental and Social Standards

The World Bank Group's Environmental and Social Standards for Community Health and Safety address traffic and road safety in paragraphs 10 through 13:[7]

> 10. The Borrower will identify, evaluate and monitor the potential traffic and road safety risks to workers, affected communities and road users throughout the Project life-cycle and, where appropriate, will develop measures and plans to address them. The Borrower

[6] Ministry of Works and Human Settlement, Department of Roads. 2017. *Road Classification System in Bhutan.* Available from: https://www.moit.gov.bt/wp-content/uploads/2014/03/Road-Classification-System-in-Bhutan-Final.pdf.

[7] World Bank Group (WBG) 2017. *Environmental and Social Framework.* Available at: https://pubdocs.worldbank.org/en/837721522762050108/Environmental-and-Social-Framework.pdf#page=59&zoom=80. Accessed October 2024.

will incorporate technically and financially feasible road safety measures into the Project design to prevent and mitigate potential road safety risks to road users and affected communities.

11. Where appropriate, the Borrower will undertake a road safety assessment for each phase of the Project, and will monitor incidents and accidents, and prepare regular reports of such monitoring. The Borrower will use the reports to identify negative safety issues, and establish and implement measures to resolve them.

12. For vehicles or fleets of vehicles for the purposes of the Project (owned or leased), the Borrower will put in place appropriate processes, including driver training, to improve driver and vehicle safety, as well as systems for monitoring and enforcement. The Borrower will consider the safety record or rating of vehicles in purchase or leasing decisions and require regular maintenance of all Project vehicles.

13. For Projects that operate construction and other equipment on public roads or where the use of Project equipment could have an impact on public roads or other public infrastructure, the Borrower will take appropriate safety measures to avoid the occurrence of incidents and injuries to members of the public associated with the operation of such equipment.

C.7.1.1.2IFC Environmental, Health and Safety Guidelines, 2007

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). Performance measures in the Guidelines are normally acceptable to the World Bank Group and are generally considered to be achievable in new facilities at reasonable costs.[8] The following Guidelines have applicability to road construction, design, and operation.

IFC Environmental, Health, and Safety General Guidelines

Section 3.4 of the IFC EHS General Guidelines addresses traffic safety, emphasizing the "adoption of safety measures that are protective of Project workers and road users, including those who are most vulnerable to road traffic accidents." The guidelines for traffic safety, listed below, are applicable to Project construction practices:[9]

- Adoption of best transport safety practices across all aspects of Project operations with the goal of preventing traffic accidents and minimizing injuries suffered by Project personnel and the public. Measures should include:
  - Emphasizing safety aspects among drivers;
  - Improving driving skills and requiring licensing of drivers;
  - Adopting limits for trip duration and arranging driver rosters to avoid overtiredness;
  - Avoiding dangerous routes and times of day to reduce the risk of accidents;
  - Use of speed control devices (governors) on trucks, and remote monitoring of driver actions.

[8] IFC (International Finance Corporation). 2007. *Environmental, Health, and Safety (EHS) Guidelines.* April 30, 2007. Available at: https://www.ifc.org/content/dam/ifc/doc/2000/2007-general-ehs-guidelines-en.pdf. Accessed October 2024.

[9] IFC 2007a

- Regular maintenance of vehicles and use of manufacturer approved parts to minimize potentially serious accidents caused by equipment malfunction or premature failure;
- Where the Project may contribute to a significant increase in traffic along existing roads, or where road transport is a significant component of a Project, additional measures include:
  - Minimizing pedestrian interaction with construction vehicles;
  - Collaboration with local communities and responsible authorities to improve signage, visibility and overall safety of roads, particularly along stretches located near schools or other locations where children may be present. Collaborating with local communities on education about traffic and pedestrian safety (e.g. school education campaigns);
  - Coordination with emergency responders to ensure that appropriate first aid is provided in the event of accidents;
  - Using locally sourced materials, whenever possible, to minimize transport distances. Locating associated facilities such as worker camps close to Project sites and arranging worker bus transport to minimizing external traffic;
  - Employing safe traffic control measures, including road signs and flag persons to warn of dangerous conditions.

IFC Environmental, Health, and Safety Guidelines for Toll Roads

The 2007 EHS Guidelines include Industry Sector Guidelines. The Industry Sector Guidelines for Toll Roads include measures relevant to construction, operation and maintenance of large road projects including associated bridges.[10] Transportation-related guidelines within this document address pedestrian and traffic safety, including the following strategies:

Pedestrian Safety:

- Provision of safe corridors along the road alignment and construction areas, including tunnels and bridges (e.g. paths separated from the roadway), and safe crossings (preferably over or under the roadway) for pedestrians and bicyclists during construction and operation;
  - Installation of barriers (e.g. fencing, plantings) to deter pedestrian access to the roadway except at designated crossing points;
  - Installation and maintenance of speed control and traffic calming devices at pedestrian crossing areas; and
  - Installation and maintenance of all signs, signals, markings, and other devices used to regulate traffic, specifically those related to pedestrian facilities or bikeways.

Traffic Safety:

- Installation and maintenance of all signs, signals, markings, and other devices used to regulate traffic, including posted speed limits, warnings of sharp turns, or other special road conditions;
- Setting of speed limits appropriate to the road and traffic conditions;
- Design of roadways to accommodate anticipated traffic volume and flow;
- Maintenance of the road to prevent mechanical failure of vehicles due to road conditions;

[10] IFC (International Finance Corporation. 2007b. *Environmental, Health, and Safety Guidelines for Toll Roads. April 30, 2007.* Available at: https://www.ifc.org/content/dam/ifc/doc/2000/2007-toll-roads-ehs-guidelines-en.pdf. Accessed October 2024.

- Construction of roadside rest areas at strategic locations to minimize driver fatigue; and
- Installation of measures to reduce collisions between animals and vehicles.

C7.2 METHOD OF ASSESSMENT

The Project's effects on traffic and transportation are identified by anticipating the type and amount of Project-generated traffic during construction, and the change in traffic patterns resulting from the proposed new road. Direct and indirect impacts arising from the Project, both positive and negative, are considered and the likely significant effects described. Mitigation measures to reduce likely significant effects are described. The residual significant effects, both positive and negative, are then reported.

The magnitude of the road traffic impacts is defined as described in Appendix B of the ESIA. ***Table B-C***.1 defines the magnitude of impacts specific to transportation, while ***Table B-C***.2 defines the significance of those impacts specific to transportation. Road system users include drivers, passengers, public transit users, pedestrians, and bicyclists.

TABLE B-C.1 MAGNITUDE OF TRANSPORTATION IMPACTS

Magnitude	Description
Low	Project traffic impacts are limited to the area immediately surrounding the Project site. Minimal travel delays or increases in traffic safety risks are expected due to Project traffic and Project traffic has no discernible effect on road infrastructure conditions.
Medium	Project traffic impacts affect the road network close to the Project site. Project traffic would result in moderate delays, noticeable increases in transportation safety risk, and/or noticeable effects on road infrastructure condition that necessitates increased maintenance.
High	Project traffic impacts an extensive portion of the road network. Traffic volumes would result in extensive delays and/or substantial impacts on road infrastructure conditions that necessitates substantial maintenance, including emergency repairs.

TABLE B-C.2 TRANSPORTATION IMPACT SIGNIFICANCE

Impact Rating	Rating Definition
Low	Current and future road system users will not be affected by a particular activity, or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.
Moderate	Current and future road system users will experience a noticeable effect, but the impact magnitude is small (with or without mitigation) and/or the receptor is of low sensitivity/ vulnerability. In either case, the magnitude should be well within applicable standards.
Substantial	Current and future road system users will experience a noticeable effect in travel patterns or road conditions that may alter user ability to achieve necessary travel or result in travel hazards.

Impact Rating	Rating Definition
High	An accepted road system limit or standard may be exceeded, or large magnitude impacts occur to sensitive road system users.

APPENDIX D CLIMATE CHANGE RISK ASSESSMENT

D CLIMATE CHANGE RISK ASSESSMENT

D.1 INTRODUCTION

The primary objective of this chapter is to follow a methodical process to identify and analyze hazards directly linked to climate change within the specific context of the Project.

Subsequently, an evaluation of Project-specific vulnerabilities and exposure related to the hazard will be conducted.

The risk assessment will be provided based on understanding of the potential impact considering vulnerability, hazard, and exposure. Climate hazard trends in combination with Project-specific exposure and vulnerability are assessed to identify climate risks and their materiality to the Project.

Finally, a series of mitigation measures are proposed to reduce the risk level to the Project.

D.2 CLIMATE CHANGE ASSESSMENT METHODOLOGY

The key objective of this assessment is to understand the potential high-level physical risks to the Project from climate change. The methodology constituted of three (3) major steps as given below:

1. Step 1: Desktop Review of the baseline natural hazards

For the first step, a desktop-based review of prominent natural hazards was undertaken at the Project locations offshore as well as onshore. The natural hazards are then evaluated and categorized based on potential to cause damage to the natural environment due to intensity / severity and frequency.

2. Step 2: Evaluation of climate change projections

This second step involved evaluation projections for various climate variables such as temperature, sea level and precipitation. The climate change projections data involved multi-model mean climate change projections published under Coupled Model Intercomparison Project 6 (CMIP-6)[11], which is a recognized standard by the Intergovernmental Panel on Climate Change (IPCC). The climate change scenarios for which the data was evaluated involved RCP 8.5 over timelines of 2030 and 2050.

3. Step 3: Qualitative estimation of future hazards and physical risks

[11] Under the World Climate Research Programme (WCRP) the Working Group on Coupled Modelling (WGCM) established the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs). CMIP provides a community-based infrastructure in support of climate model diagnosis, validation, intercomparison, documentation and data access. This framework enables a diverse community of scientists to analyze GCMs in a systematic fashion, a process which serves to facilitate model improvement. CMIP6 is the latest phase of the project, and it involves a large number of modeling groups from around the world. It involves more modeling groups, uses advanced emissions scenarios considering socioeconomics, and features more sophisticated climate models. CMIP6 offers a wider range of experiments for a deeper look at climate change.

The third step involved use of the future projections on natural hazards to evaluate the potential risks in future. Qualitative estimation of future natural hazards was also conducted based on changes in indicator climate variables which are likely to affect a particular natural hazard, and baseline natural hazards in cases where future hazard level was not readily available. Hazard level in combination with exposure and vulnerability levels are used to estimate the physical risk to the Project.

It should be noted that this is a high-level review of publicly available information, and no detailed site-specific analysis or modelling has been undertaken. Hence, further investigation may be warranted to quantify the risks in more detail for consideration of adaptation measures.

Further, the qualitative evaluation of the impacts of climate change on natural hazards is an exercise of educated speculation and professional judgement. The likely changes in natural hazards presented here are based on the possible relation between the natural hazards and climatic parameters.

What are the Representative Concentration Pathways (RCP)?

RCPs usually refer to the portion of the concentration pathway extending up to the year 2100, for which Integrated Assessment Models produced corresponding emission scenarios. Each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term "pathway" emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome.

Four (4) RCPs produced from Integrated Assessment Models were selected from the published literature and are used in the Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment as a basis for the climate predictions and projections are as follows:

RCP2.6 One pathway where radiative forcing peaks at approximately 3 W m^{-2} before 2100 and then declines (the corresponding ECP assuming constant emissions after 2100);

RCP4.5 and RCP6.0 Two intermediate stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W m^{-2} and 6.0 W m^{-2} after 2100 (the corresponding ECPs assuming constant concentrations after 2150);

RCP8.5 One high pathway for which radiative forcing reaches greater than 8.5 W m^{-2} by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250).

D.3 HAZARD CATEGORIZATION

Hazard is defined by the IPCC AR6[12] as:

The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Open access databases have been reviewed to assess the hazard level at the Project site. As different sources present different classifications, ERM has reorganized those into three levels: low, medium, and high.

The table below presents the classification of the hazard level used in this report.

TABLE D.1 CATEGORIZATION OF NATURAL HAZARDS

Hazard (Criteria for Categorization)	**Report Categorization**
Water Availability	
Water Stress Source: WRI-Aqueduct Water Risk Atlas 4.0 *Based on the ratio of total water demand to available renewable water resources (surface and groundwater)*	Low: <20% Medium: 20-40% High: >40%
Inter Annual Variability Source: WRI-Aqueduct Water Risk Atlas *(Based on coefficient of variability (CV) as ratio of standard deviation of the available water and the mean available water during the period of 1979-2019 on monthly and annual basis)*	Low: <0.25 Medium: 0.25-0.5 High: >0.5
Seasonal Variability Source: WRI-Aqueduct Water Risk Atlas *(Based on coefficient of variability (CV) as ratio of standard deviation of the annual available water and the annual mean available water during the period of 1979-2019)*	Low: <0.33 Medium: 0.33-0.66 High: >0.66

[12] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

Hazard (Criteria for Categorization)	Report Categorization
Water Depletion Source: WRI-Aqueduct Water Risk Atlas *(Based on ratio of total water consumption to available renewable water resources (surface and groundwater))*	Low: <5%-25% Medium: 25-50% High: >50%
Floods Inland and Coastal	
Riverine Flood Risk Source: WRI-Aqueduct Water Risk Atlas *(Based on population exposed to floods per 1,000 people)*	Low: 0-2/ 1,000 Medium: 2-6/ 1,000 High: > 6/ 1,000
Coastal Flood Risk Source: WRI-Aqueduct Water Risk Atlas *(Based on population exposed to floods per 1,000,000 people)*	Low: 0-9/ 1,000,000 Medium: 9-300/ 1,000,000 High: >300/ 1,000,000
Flood Hazard Map Source: WRI-Aqueduct Flood Tool *(Based on depth of inundation in meters)*	Low: ≤0.5m Medium: 0.5-1.5m High: > 1.5m
Flood Hazard Map Source: FM Global *(Based on probability of flood occurring each year for a given flood return period)*	Medium High
Landslides	
Landslides Susceptibility Source: Think Hazard[13] *(The classify hazards based on probabilistic data in Think Hazard)*	Low Medium High
Landslides Hazard	Low

[13] GIS processing International Centre for Geohazards /NGI. Preprocessing for ThinkHazard! conducted by GFDRR

Hazard (Criteria for Categorization)	Report Categorization
Source: Think Hazard[14] *(The classify hazards based on probabilistic data in Think Hazard)*	Medium
	High
Extreme Heat Source: Think Hazard *(Based on widely accepted heat stress indicator, the Wet Bulb Globe Temperature (°C))*	Low: under 28°C
	Medium: between 28 and 32°C
	High: above 32°C
Cyclone and Hurricane Intensity Source: UNEP global Risk Data Platform *(Cyclone categories based on damage potential as classified by Saffir-Simpson Scale)*	Low: 119-153 km/h
	Medium: 154-177 km/h
	High: above 178 km/h
Wind Speed Source: Global Wind Atlas *(Based on damage potential of wind speed (m/s) with reference to the Beaufort's scale)*	Low: ≤ 11 m/s
	Medium: 11-21 m/s
	High: ≥ 21 m/s
Sea Level Rise	Low: 1-50cm

[14] GIS processing International Centre for Geohazards /NGI. Preprocessing for ThinkHazard! conducted by GFDRR

Hazard (Criteria for Categorization)	Report Categorization
Source: CLIMsystems, Sea Level Rise for Cities *(Combined processes of local (absolute) sea level rise and local vertical land movement expressed in centimetres)*	Medium: 51-150cm High: 151-200cm
Lightning Source: Lighting Imaging Sensor (LIS) on TRMM Science Data *(Lightning Density average between 1998 and 2013 expressed as Flashes per km^2)*	Low:1-20 Medium: 21-60 High: >61

D.3.1 EXPOSURE AND VULNERABILITY CATEGORIZATION

Exposure and vulnerability of the Project are necessary to determine the risk level.

Vulnerability is defined by the IPCC AR6[15] as:

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Exposure is defined as:

The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Details of the Project location, design of components, buildings and infrastructures, activities of Project personnel are used to determine the exposure of the Project to the hazards. Vulnerability can then be assessed in more detail, drawing on Project design information and standards together with any other factors which may provide resilience, e.g., pre-existing flood prevention measures.

The combination of exposure and vulnerability is categorized in three levels: low, medium, high.

D.3.2 RISK CATEGORIZATION

Risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Such interaction is complex and subject to uncertainty, therefore, ERM has performed a qualitative evaluation based on professional judgement.

The relation between hazard, vulnerability and exposure is presented in the table below.

TABLE D.2 CLIMATE CHANGE RISK LEVEL

		Hazard		
Exposure x Vulnerability		**Low**	**Medium**	**High**
	Low	**Low**	**Low**	**Low**
	Medium	**Low**	**Medium**	**Medium**
	High	**Medium**	**High**	**High**

[15] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

D.4 WATER AVAILABILITY

Availability of water in the airport boundary was assessed based on data from the online water risk assessment tool WRI-Aqueduct Water Risk Atlas for Water Stress, Seasonal Variability, and Inter-annual Variability. The description of the parameters assessed is provided in the table below.

TABLE D.3 LIST OF PARAMETERS FOR EVALUATION OF BASELINE WATER AVAILABILITY

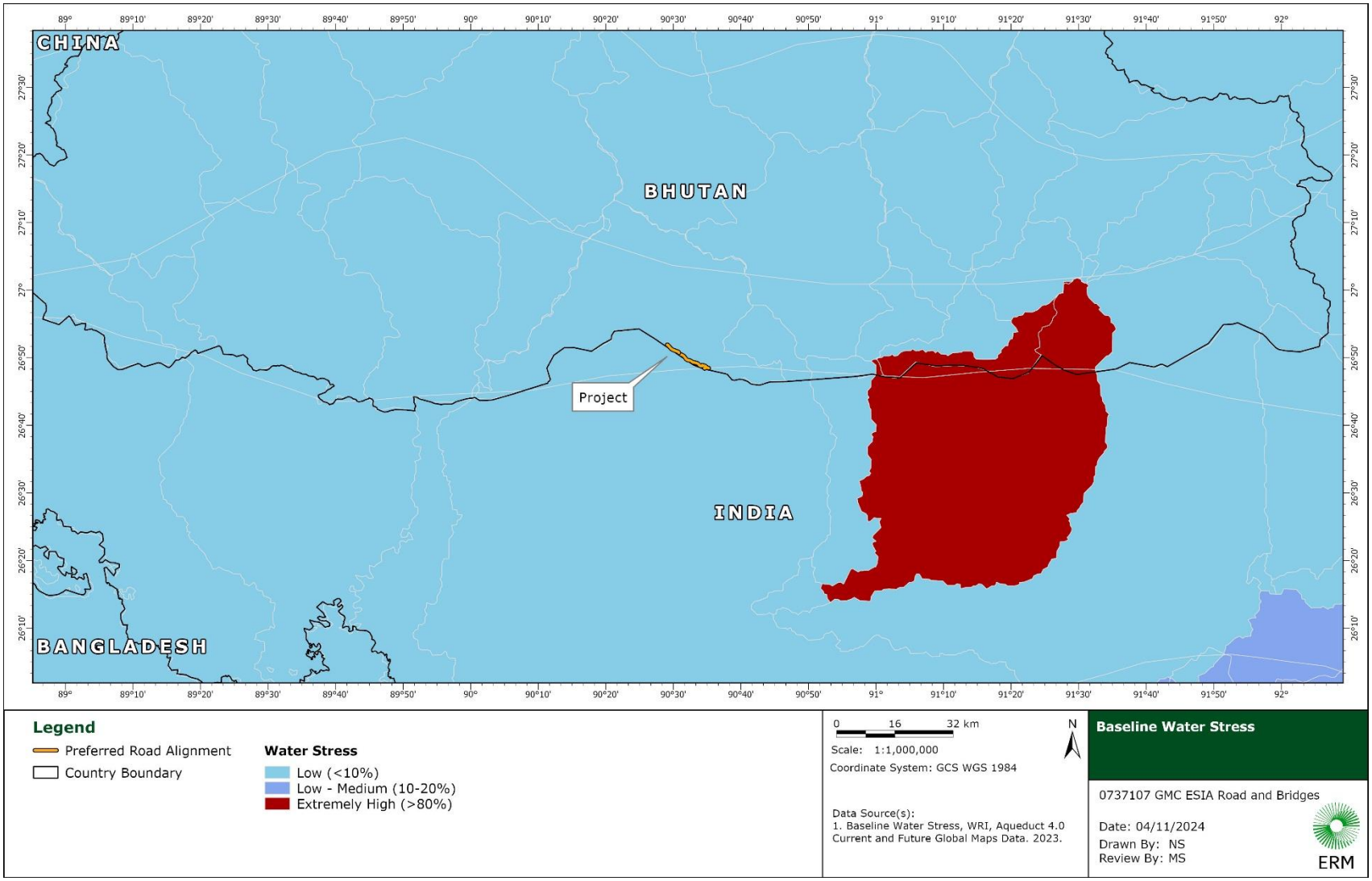
No.	Parameter	Definition
1	Baseline Water Stress	Baseline water stress is defined as the ratio of the total annual water withdrawals to the total available annual water renewable supply, accounting for upstream consumptive use. Higher values indicate more competition among users.
2	Seasonal Variability	Seasonal variability measures the average within-year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations of available supply within a year.
3	Inter Annual Variability	Inter-annual variability measures the average between year variability of available water supply, including both renewable surface and groundwater supplies. Higher values indicate wider variations in available supply from year to year.

D.4.1 BASELINE HAZARD

D.4.1.1 WATER STRESS

The baseline water stress map is presented in ***Figure D-1***. According to the WRI information, the specific location of the Project is Ganges - Bramaputra basin. The water stress shows 'Low' indicating that the ratio of total water demand to the available renewable surface and groundwater supplies is relatively small. This indicates there is less competition among users (domestic, industrial, irrigation, and livestock) for the available water resources. Hence, considering the hazard categorization due to water stress is categorized to be "Low".

FIGURE D-1 BASELINE WATER STRESS



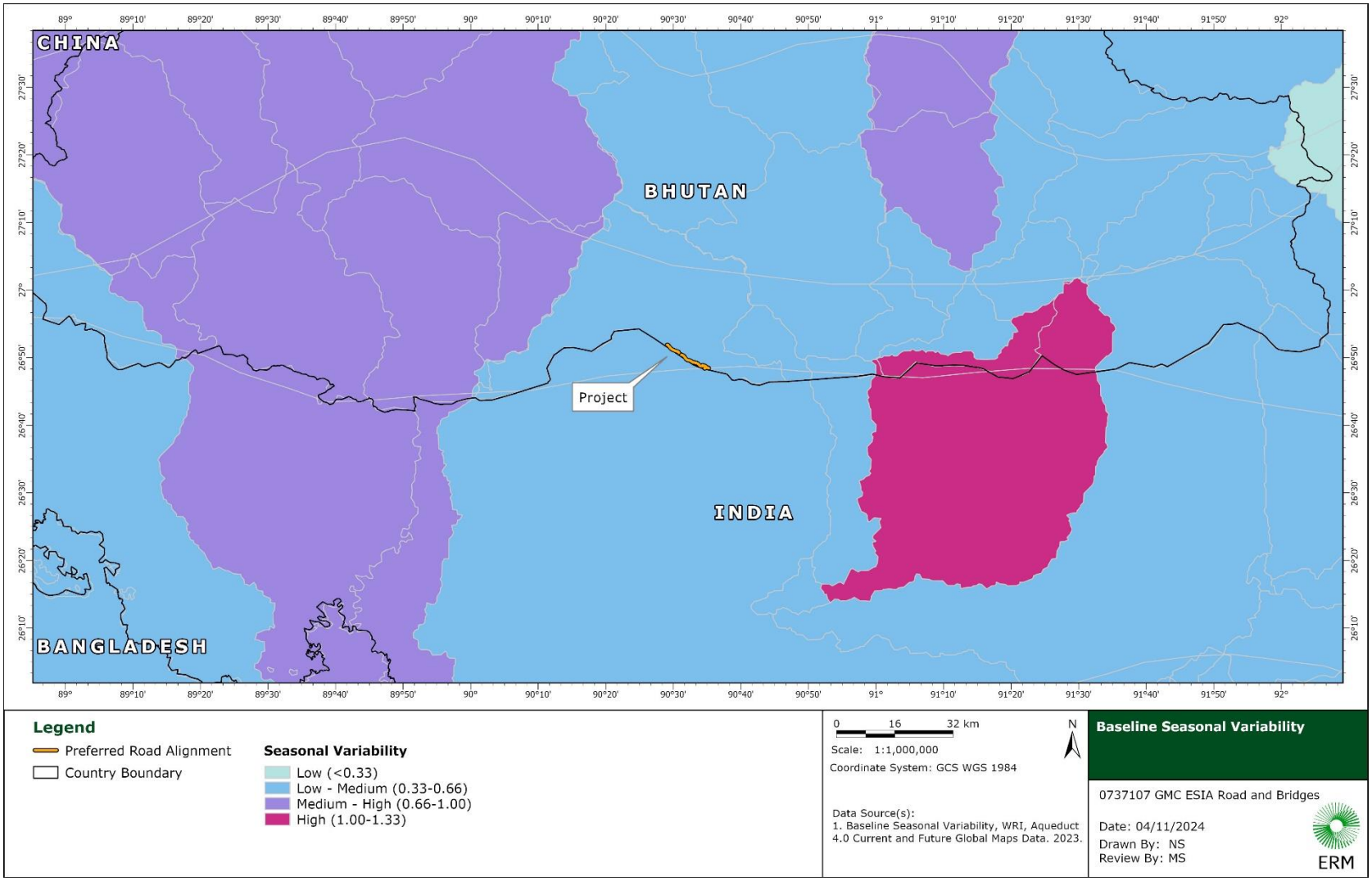
Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

D.4.1.2 SEASONAL VARIABILITY

Seasonal Variability map presented in ***Figure D-2*** indicates the likelihood of variations in water availability over different months within a year as 'Low to Medium'. This indicates that the supply of water over different months does not vary significantly. Considering the baseline hazard due to seasonal variability the hazard level is categorized to be **"Medium".**

During stakeholder consultations conducted in 2024, it was noted that residents experience shortage of water during dry season. However, such scarcity is understood to be related to insufficient infrastructure rather than lack of water resources.

FIGURE D-2 BASELINE SEASONAL VARIABILITY

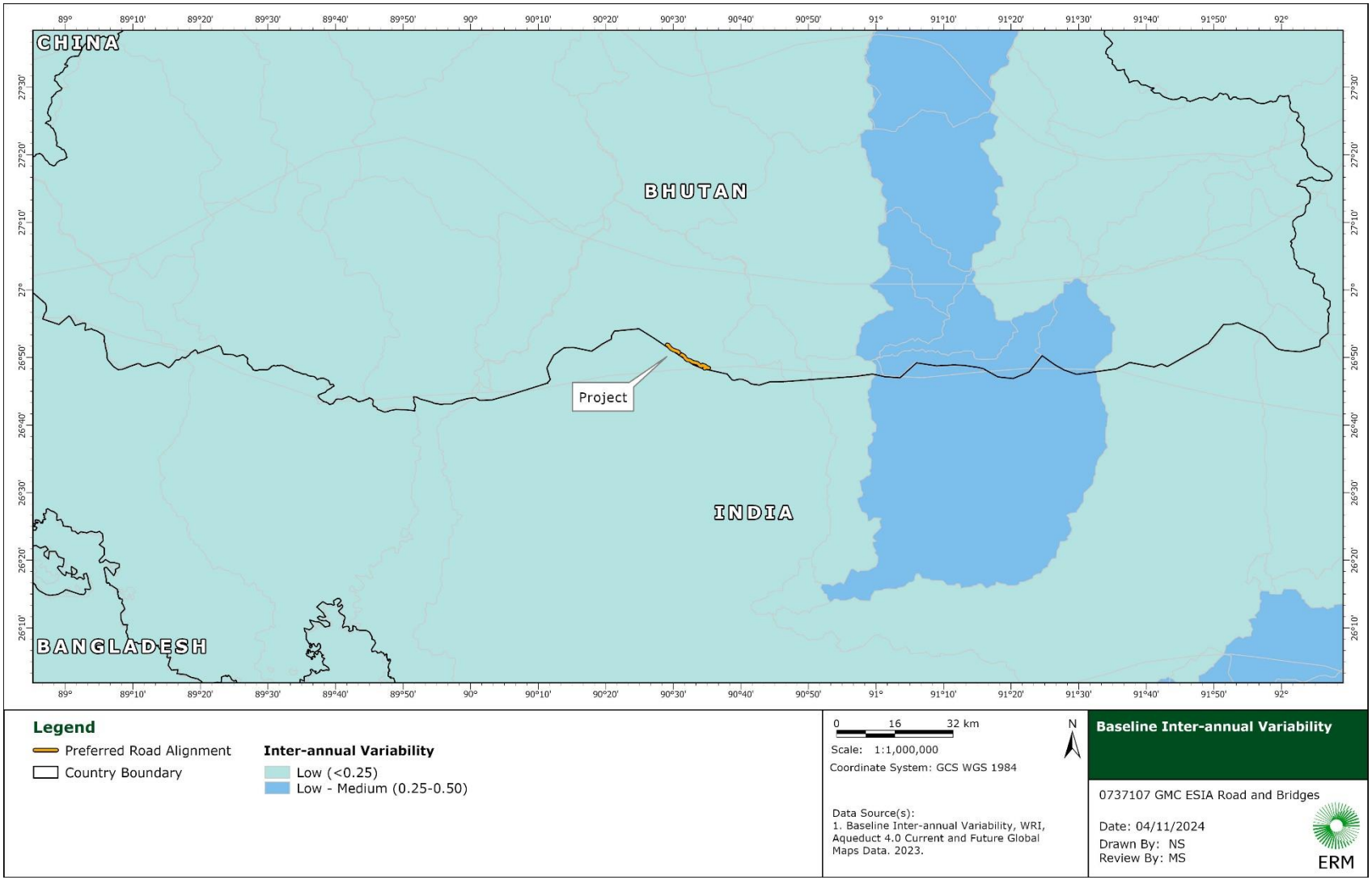


Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

D.4.1.3 INTER-ANNUAL VARIABILITY

Inter-Annual Variability map presented in ***Figure D-3*** indicates the variations in water availability over different years is 'Low'. This indicates that the supply of water over different years is likely to be similar to seasonal variation. The baseline hazard due to inter-annual variability is categorized as "**Low**".

FIGURE D-3 BASELINE INTER-ANNUAL VARIABILITY



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

D.4.1.4 HAZARD OF BASELINE WATER AVAILABILITY

Based on the baseline water stress, seasonal variability, and inter-annual variability, identify a region characterized by a consistently reliable water source. There is a sufficient amount of water that meets the majority of requirements, and the differences in water levels from season to season or year to year are not significant.

In conclusion, based on the evaluation of baseline water stress, seasonal variability, and inter-annual variability, the hazard due to availability of water is considered to be "**Medium**" on a conservative basis based on the medium hazard level associated to seasonal variability.

D.4.2 CLIMATE CHANGE PROJECTION

Water availability was assessed based on the evaluation of projections for water depletion, water stress, and seasonal variability under climate change scenario. The water availability will be assessed by using the "pessimistic" scenario (SSP5 RCP8.5) for both near-term and long-term periods (i.e. 2030 and 2050). The data were obtained from the WRI-Aqueduct Water Risk Atlas.

Water depletion measures the level of how humans consume water from accessible sources of fresh water. A higher depletion number indicates an increased demand for water supplies. The projection shows 'Low' in both 2030 and 2050, meaning the current pace of water consumption is not significantly impact the overall supply of freshwater resources until 2050.

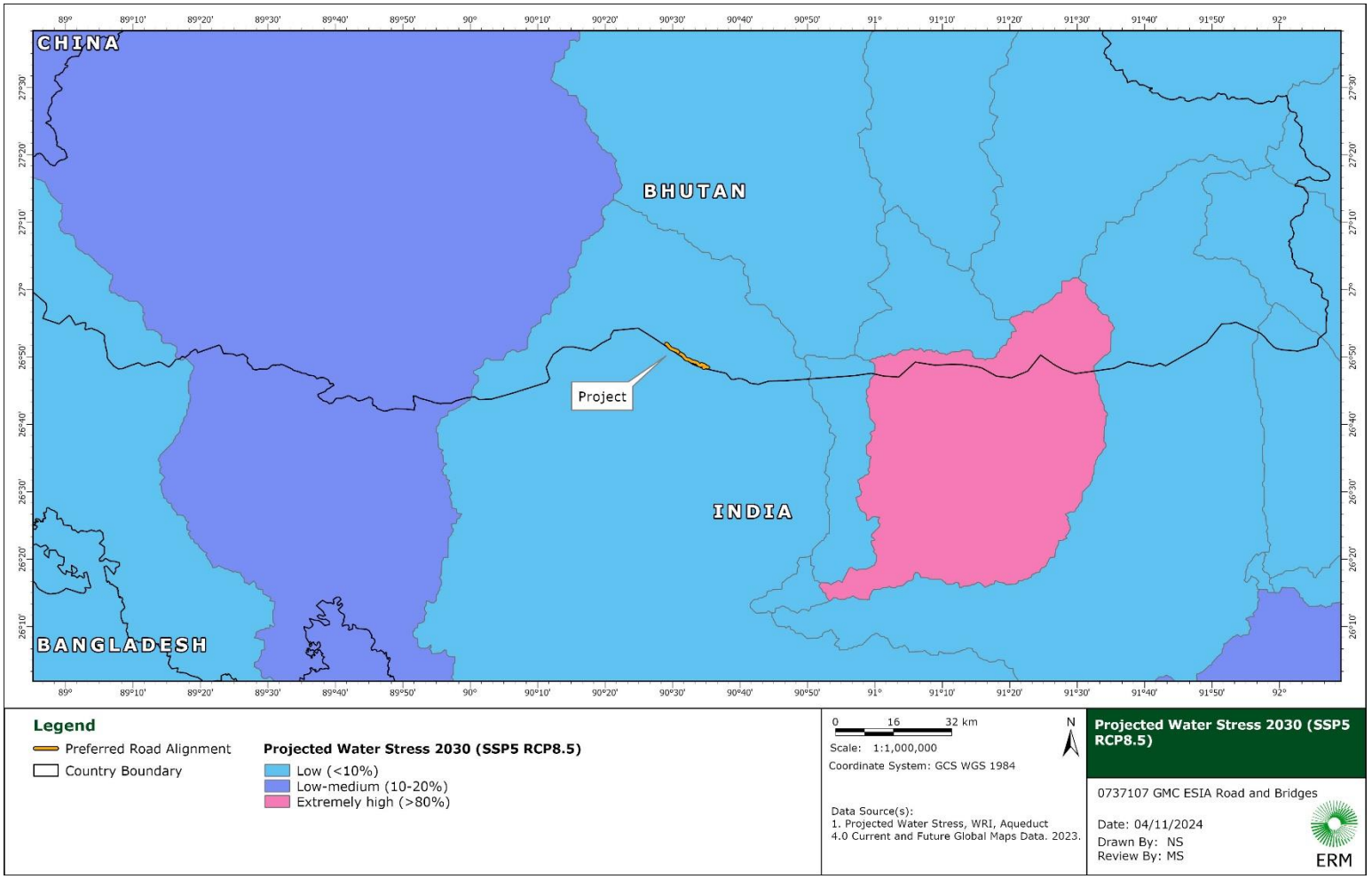
Further, water stress is projected to be 'Low' under all climate change scenarios as presented in ***Figure D-4*** and ***Figure D-5***. Seasonal variability is projected to be 'Low to Medium' for all climate change scenarios as presented in ***Figure D-6*** and ***Figure D-7*** indicates a similar seasonal variability in the future.

Consider the hazard categorization the water depletion and water stress will be classified as 'Low', and the water seasonal variability remain 'Medium'.

Based on the information for the three (3) indicators, an imbalance between supply and demand could occur leading to a water shortage. Hence, the hazard of water availability in the future remains **"Medium"**.

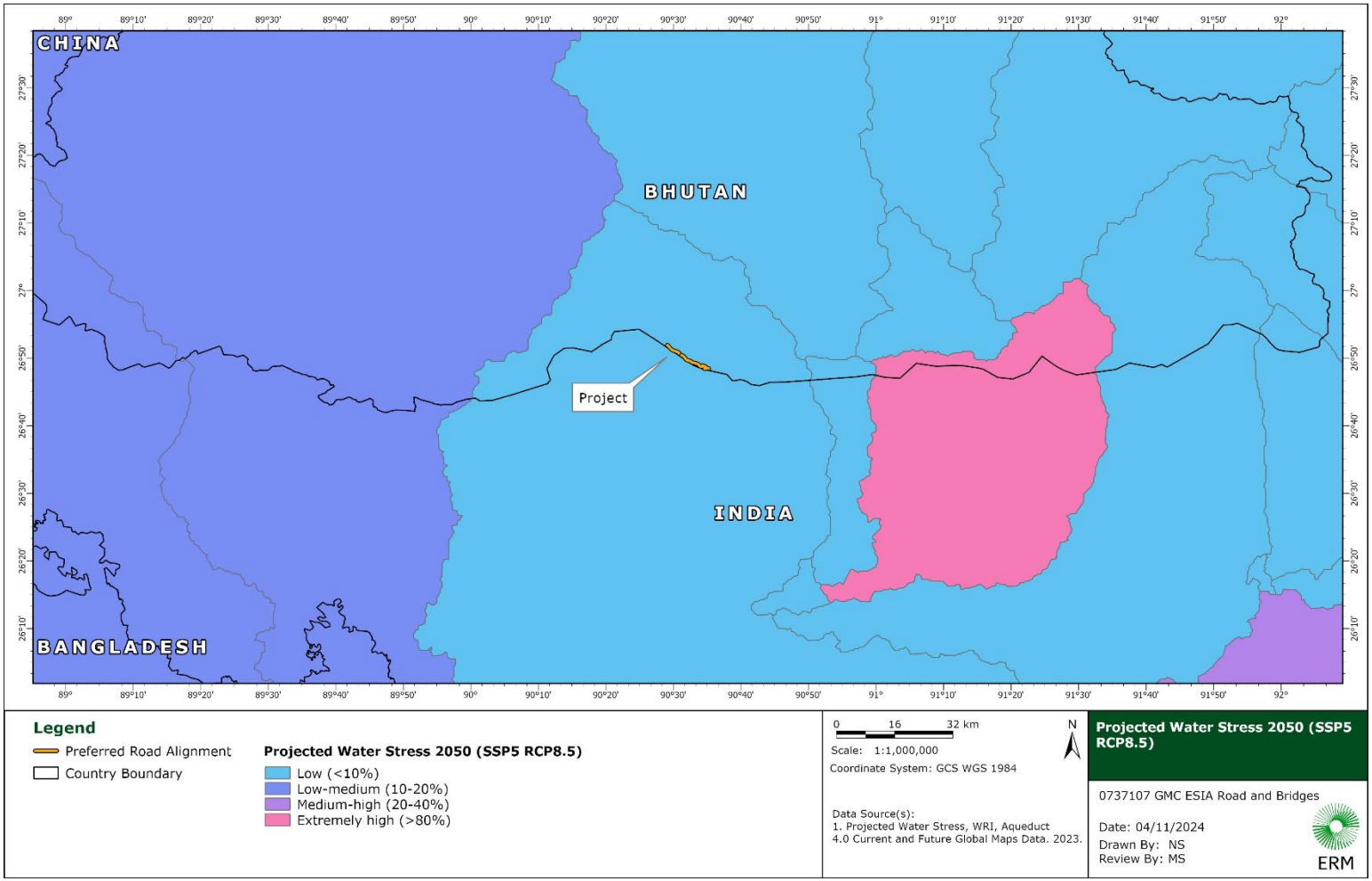
D.4.2.1 PROJECTIONS OF WATER STRESS

FIGURE D-4 PROJECTIONS OF WATER STRESS DURING 2030 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

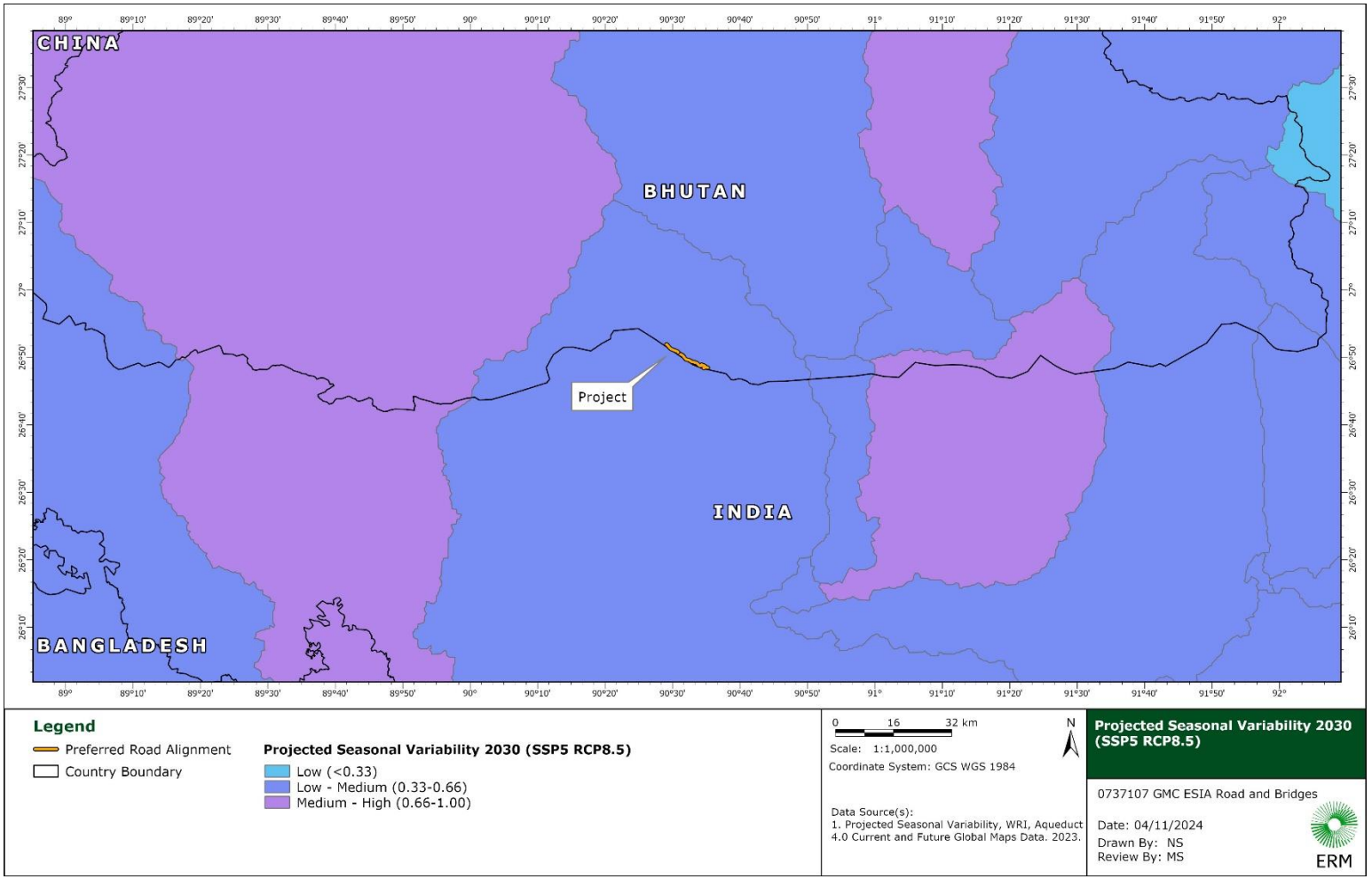
FIGURE D-5 PROJECTIONS OF WATER STRESS DURING 2050 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

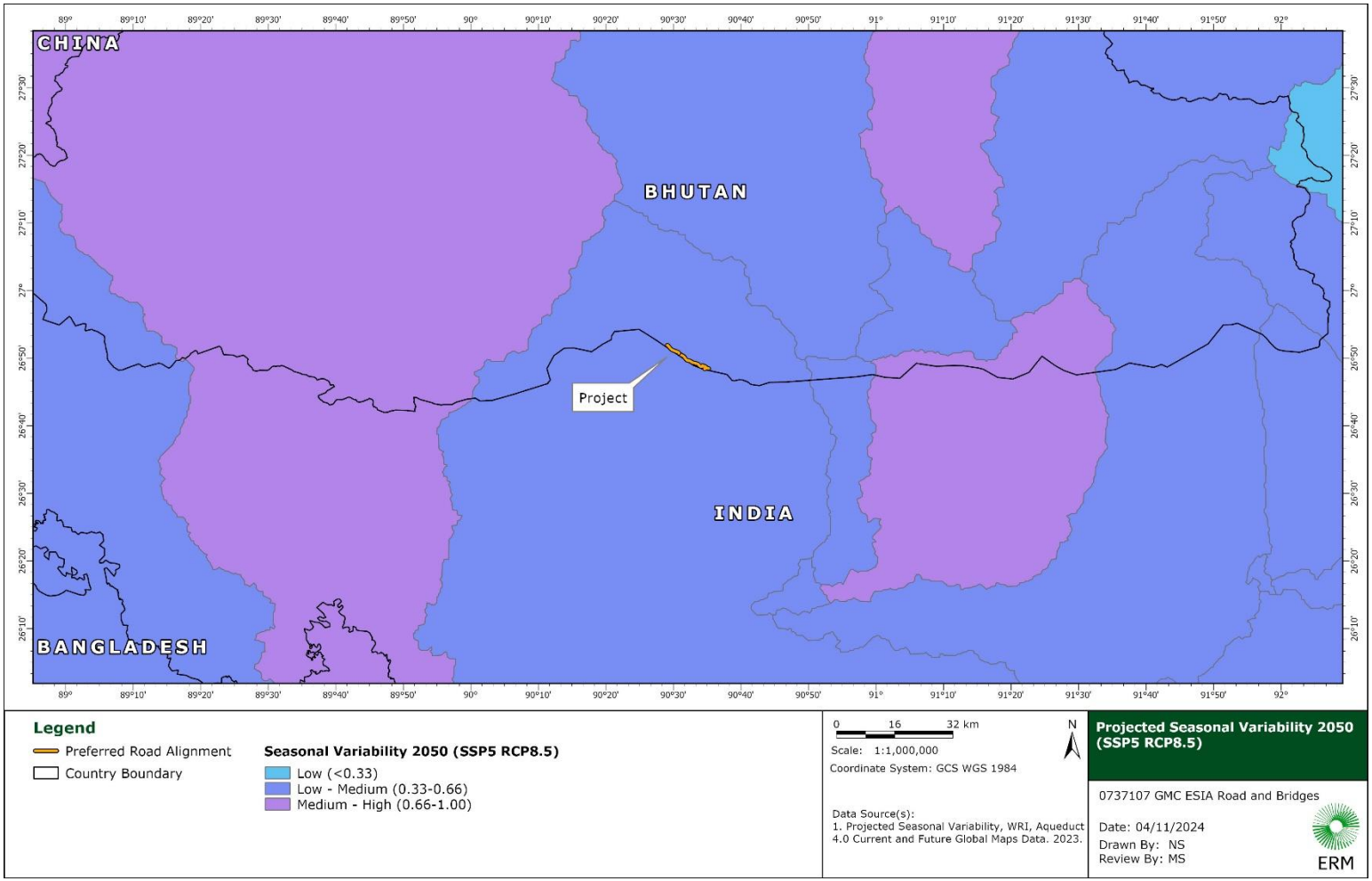
D.4.2.2 PROJECTIONS OF SEASONAL VARIABILITY

FIGURE D-6 PROJECTIONS OF SEASONAL VARIABILITY DURING 2030 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

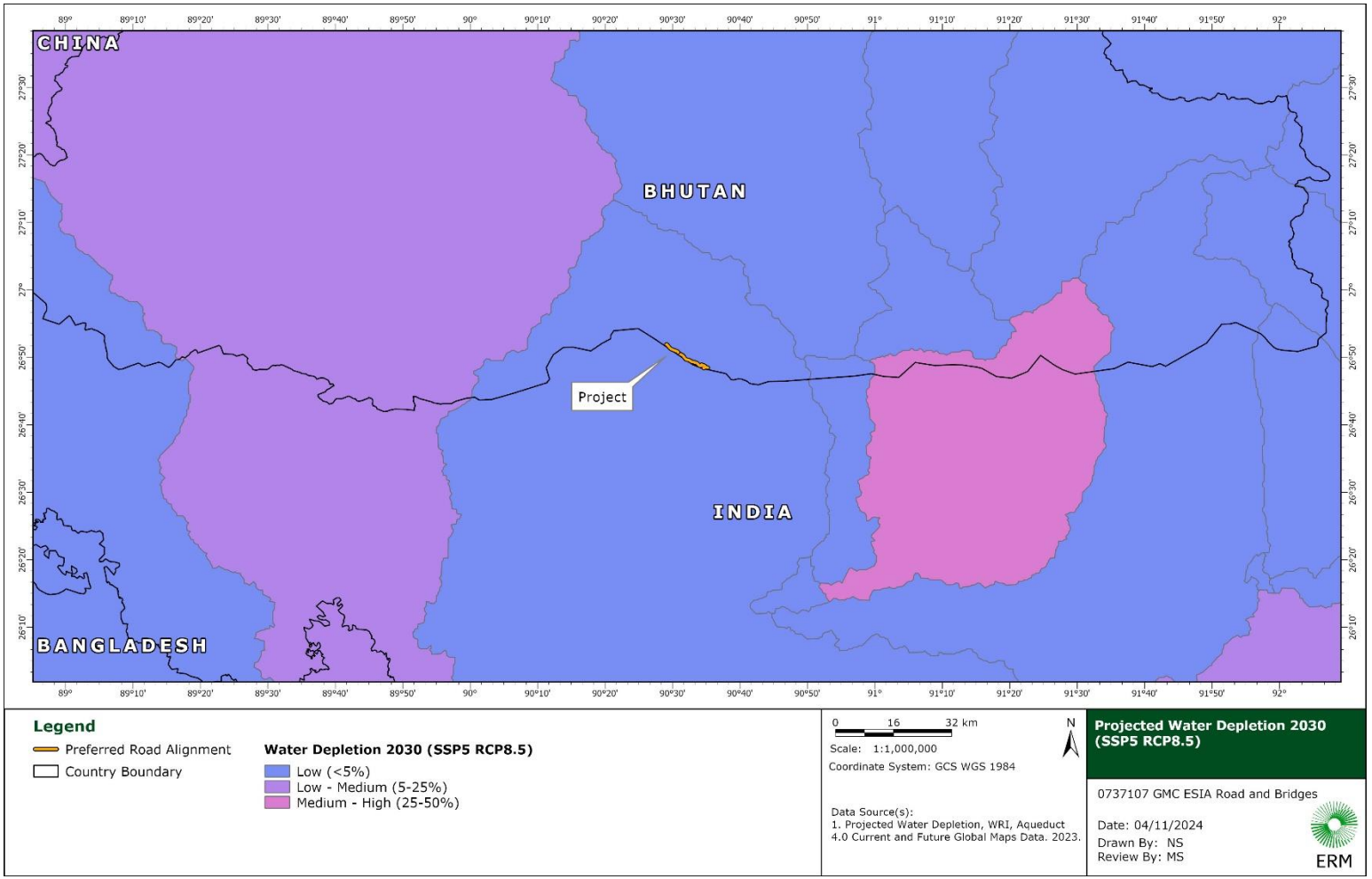
FIGURE D-7 PROJECTIONS OF SEASONAL VARIABILITY DURING 2050 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

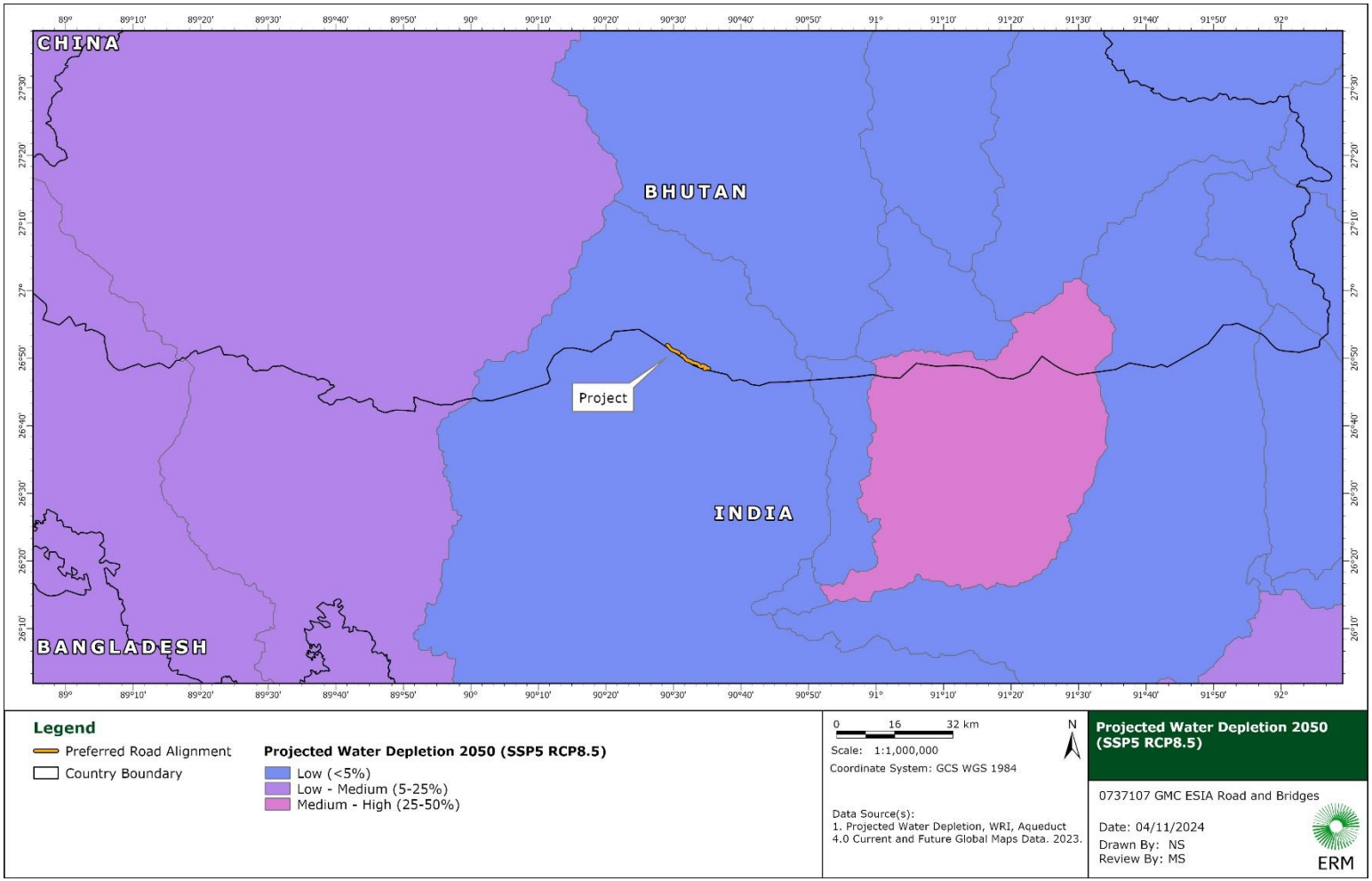
D.4.2.3 PROJECTIONS OF WATER DEPLETION

FIGURE D-8 PROJECTIONS OF WATER DEPLETION DURING 2030 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

FIGURE D-9 PROJECTIONS OF WATER DEPLETION DURING 2050 FOR RCP 8.5



Source: WRI- Aqueduct Water Risk Atlas. Available at https://www.wri.org/applications/aqueduct/water-risk-atlas/

C8.2.3 EXPOSURE AND VULNERABILITY

The project's exposure to water availability issues will primarily occur during the construction phase, as water is essential for activities like dust control and material mixing. Therefore, as the construction phase will last only for 3.5 years, the climate change related risks are unlikely to occur. During operation the water use is limited to potential cleaning during the dry season and watering of the roadside greenery (likely to be limited to the Mau River Bridge) both likely to require a negligible amount of water.

Based on the information provided above, the Project's exposure and vulnerability will be considered as **"Low"**.

C8.2.4 WATER AVAILABILITY RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.4 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR WATER AVAILABILITY

	Baseline	**RCP 8.5 - 2030**	**RCP 8.5 - 2050**
Hazard Level	**Low**	**Low**	**Low**
Exposure x Vulnerability Level	**Low**	**Low**	**Low**
Risk Level	**Low**	**Low**	**Low**
Implications for the Project	• Potential competition on water-use during the operation phase		
Key Potential Impacts	• No significant impacts identified		
Implemented Mitigations	• If possible, recycle water used for road cleaning to water the roadside greenery.		

D.5 FLOOD

Floods can be defined as the overflow of water resulting in the submergence of dry lands. Floods can be categorized as inland and coastal in nature. Inland flooding may be caused due to heavy rainfall, resulting in high run-off leading to water accumulation in low lying areas, or overtopping of water bodies such as rivers, streams, lakes, ponds, and tanks. Coastal flooding is a result of the ingress of the ocean or sea water via the coastal and/or estuarine systems onto open land. This could be a standalone of the combined effect of tides, surges, and increases in the sea surface elevation.

Floods are likely to result in widespread local as well as regional level destruction. This can be caused due to submergence, washing away, and damage to infrastructure, buildings, structures, sewerage systems, damage to power transmission and power generation, loss of agricultural land and crops, contamination of freshwater sources, propagation of waterborne diseases, and loss of life.

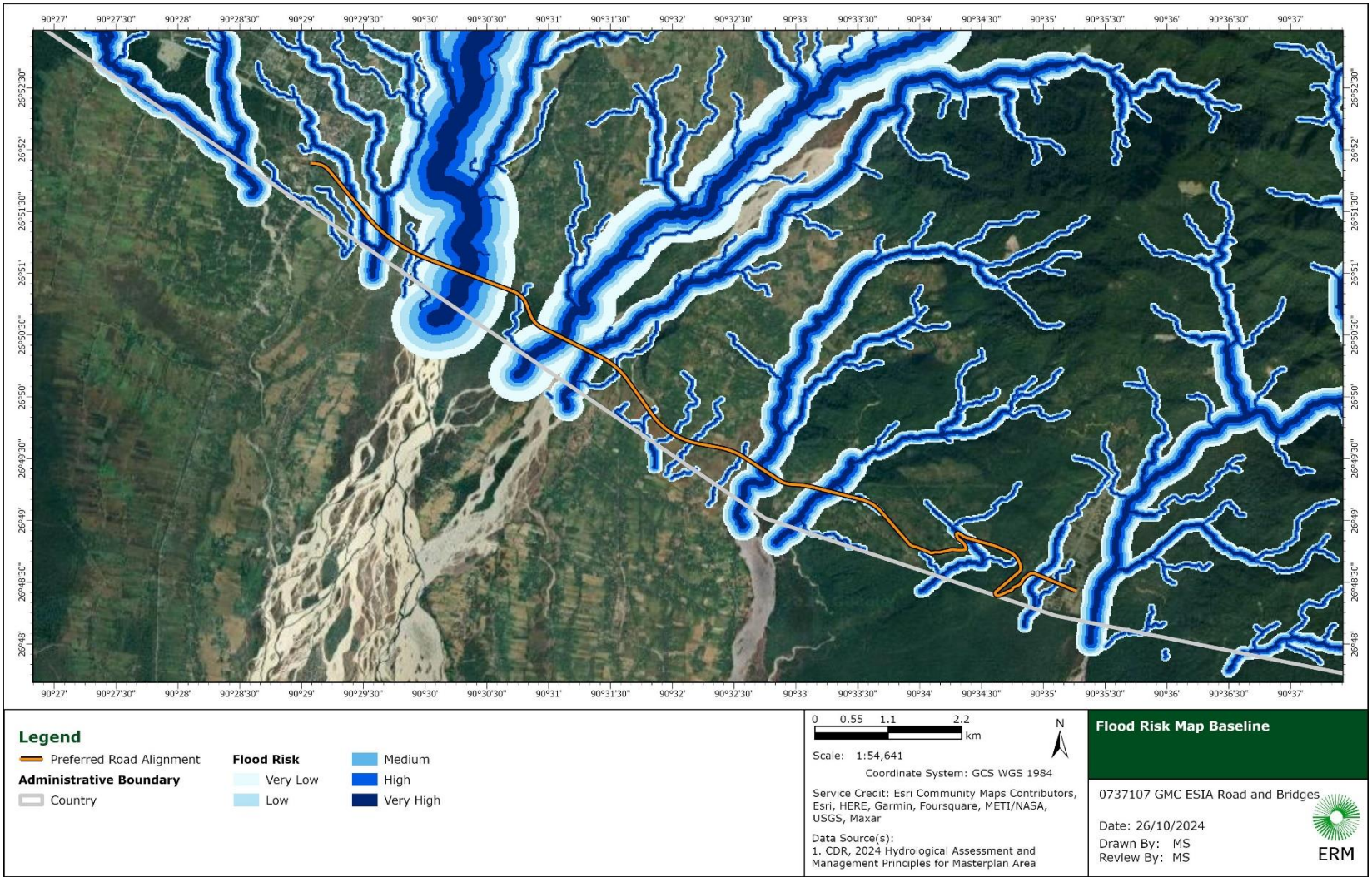
D.5.1 BASELINE HAZARD

CDR International conducted a comprehensive study on the hydrologic and river systems for the Gelephu Mindfulness City Project.[16] A detailed hydraulic assessment was performed using various models and historical rainfall data, which were extrapolated into Intensity-Duration-Frequency (IDF) curves that included a climate change factor. Rainfall time series derived from these curves were used as inputs for hydrological and flood models. The hydrological model simulated watershed processes, generating discharge time series for perennial rivers, while the flood model evaluated compound scenarios involving riverine and pluvial floods, estimating flood depths, extents, and velocities.

The model shows that the Project is crossing areas with high risk of flooding. Therefore, it is conservatively considered a "**high**" hazard for the Project.

[16] CDR, 2024. Hydrological Development of the Gelephu Mindfulness City Project, Bhutan. Hydrological Assessment and Management Principles for Masterplan Area. Pp. 62

FIGURE D-10 FLOOD RISK MAP BASELINE

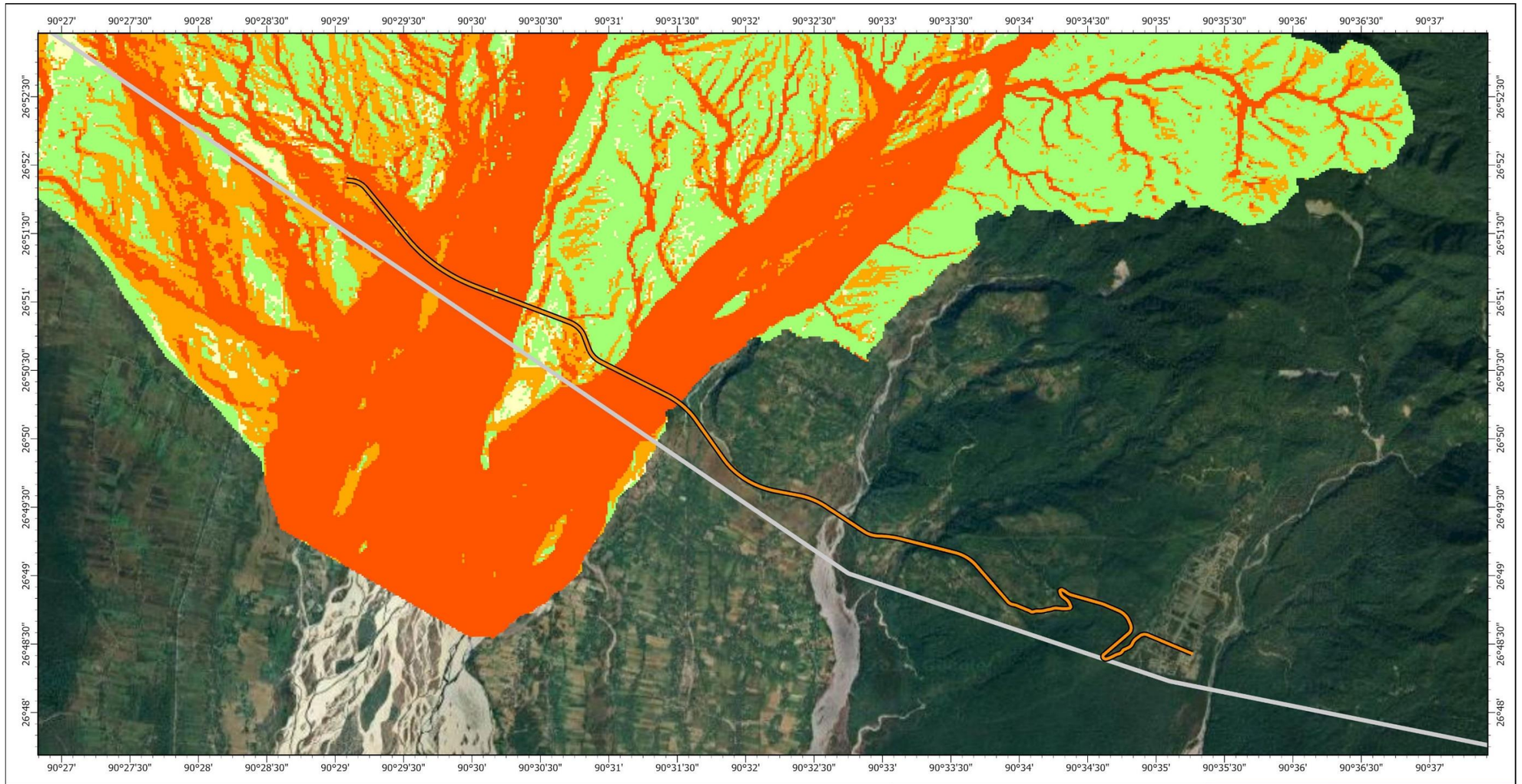


D.5.2 CLIMATE CHANGE PROJECTIONS

CDR International modeled the risk of flooding with a return period of 100 years. The model took into account future climate change scenario to provide comprehensive results. However, at the time of writing this CCRA, the modelling only included the Mau River and Taklai River. The modeling is currently being expanded to cover the entire length of the Gelephu Tareythang road, but the results are not included in this assessment.

The model identifies areas of high risk in the lowland on the western portion of the road and on the riverbanks of the Mau and Taklai Rivers. Therefore, the hazard of climate change associated with flooding is considered "**high**".

FIGURE D-11 FLOOD RISK MAP RETURN PERIOD 100 YEARS



Legend

- Preferred Road Alignment

Administrative Boundary

- Country

Hazard Risk (100 Years)

- Acceptable
- Low risk
- High risk
- Very high risk

0 0.55 1.1 2.2 km

N

Scale: 1:54,641

Coordinate System: GCS WGS 1984

Service Credit: Esri Community Maps Contributors, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Maxar

Data Source(s):
1. CDR, 2024 Hydrological Assessment and Management Principles for Masterplan Area

Flood Risk Map Return Period 100 Years

0737107 GMC ESIA Road and Bridges

Date: 26/10/2024

Drawn By: MS

Review By: MS

ERM

D.5.2.1 EXPOSURE AND VULNERABILITY

The road and bridges will be located in areas prone to flooding. The bridges will be particularly exposed to the high flow of the rivers during the wet season.

Floodwaters can erode bridge supports by washing away protective soil and destabilizing pylons, leading to weakened structural integrity and potential collapse.

For roadways, intense flooding can penetrate and undermine foundations, causing asphalt and concrete layers to crack, buckle, or wash away entirely, rendering the surfaces impassable and dangerous. Additionally, fast-moving floodwaters can strip away protective embankments and side slopes, creating further erosion along the road's edges and destabilizing adjacent land.

Considering the information provided, the Project exposure and vulnerability level is categorized as **"High".**

C8.3.4 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.5 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR FLOOD

	Baseline	**RCP 8.5 - 2030**	**RCP 8.5 - 2050**
Hazard Level	**High**	**High**	**High**
Exposure x Vulnerability Level	**High**	**High**	**High**
Risk Level	**High**	**High**	**High**
Implications for the Project	• Floodwaters can erode bridge supports, weaken road foundations, and wash away pavement, creating hazardous conditions for the users and requiring additional budget for maintenance operations		
Key Potential Impacts	• Structural damage for both road and bridges weakening structural integrity and, in the worst case, resulting in the collapse of the bridge structure • Surface erosion generating cracks in the pavement of the road • Floods can erode embankments, slopes, and shoulders, making roads vulnerable to further collapse and reducing road stability • Isolation of communities • Economic losses associated to reparation cost and disruption on local supply chain		

	Baseline	RCP 8.5 - 2030	RCP 8.5 - 2050
Implemented Mitigations	• Complete the flood modelling for the entire length of the Gelephu Tareythang road • Coordinate with the design of upstream infrastructure associated to the Gelephu Mindfulness City to integrate water retention structures that would reduce the flow and risk of flooding along the road • Integrate the results on the full model to the detailed engineering design of the road and bridges and include at least the risk associated with a 100 year return period, taking into consideration the effects of climate change • Design facilities and infrastructure (e.g., bridges, accommodation) to withstand flooding, including but not limited to the following measures: o Avoid placement of any vulnerable infrastructure (e.g. electrical installations) within natural drainage channels and floodplains and ensure that the finished floor levels of buildings are above modelled flood zones; o Debris protection will be provided at the base of the piers in the river crossings to protect the piers from impacts. Scour protection will also be provided in the form of boulders surrounding the base of the foundation; o To control erosion on the riverbanks and limit the extent of flooding, gabion basket walls are proposed upstream and downstream of the highway at the bridges crossing the Mau River, Jengkhurung and Taklai Rivers, and the Langer River; and o Box culverts will be introduced perpendicular to the highway at regular intervals along the embankment section to allow potential flood water to flow underneath the highway preventing flooding of the highway. • Prepare an Emergency Preparedness and Response Plan describing in detail the procedures the Contractor will put in place in the event of a flood. This plan, which will be prepared by the Contractor, will describe emergency procedures and communication protocols for alerting local villages and construction workers of any emergency conditions.		

D.6 LANDSLIDES

As per the United States Geological Survey (USGS), a landslide is defined as the movement of a mass of rock, debris, or earth down a slope. Several factors are responsible for occurrence of landslides. Some of these are poor mechanical stability, heavy rainfall events, geological formation, earthquake, vibration (mechanical) and slope, and could be influenced largely by human activities at a local level. Some of the human activities which are likely to cause or aggravate landslides are deforestation, cultivation, construction, vibration from heavy machinery and traffic, blasting and mining activities, and large and unstable earthwork/ excavation.

Landslides can cause wide stream damage such as disruption of infrastructure in form of roads and highways, damage to structures/buildings, power transmission lines and burial or damage of settlements resulting in loss of life.

D.6.1 BASELINE HAZARD

CDR International conducted a comprehensive study on the hydrologic and river systems for the Gelephu Mindfulness City Project.[17] Such study included a preliminary estimate of the landslide hazard in Sarpang region.

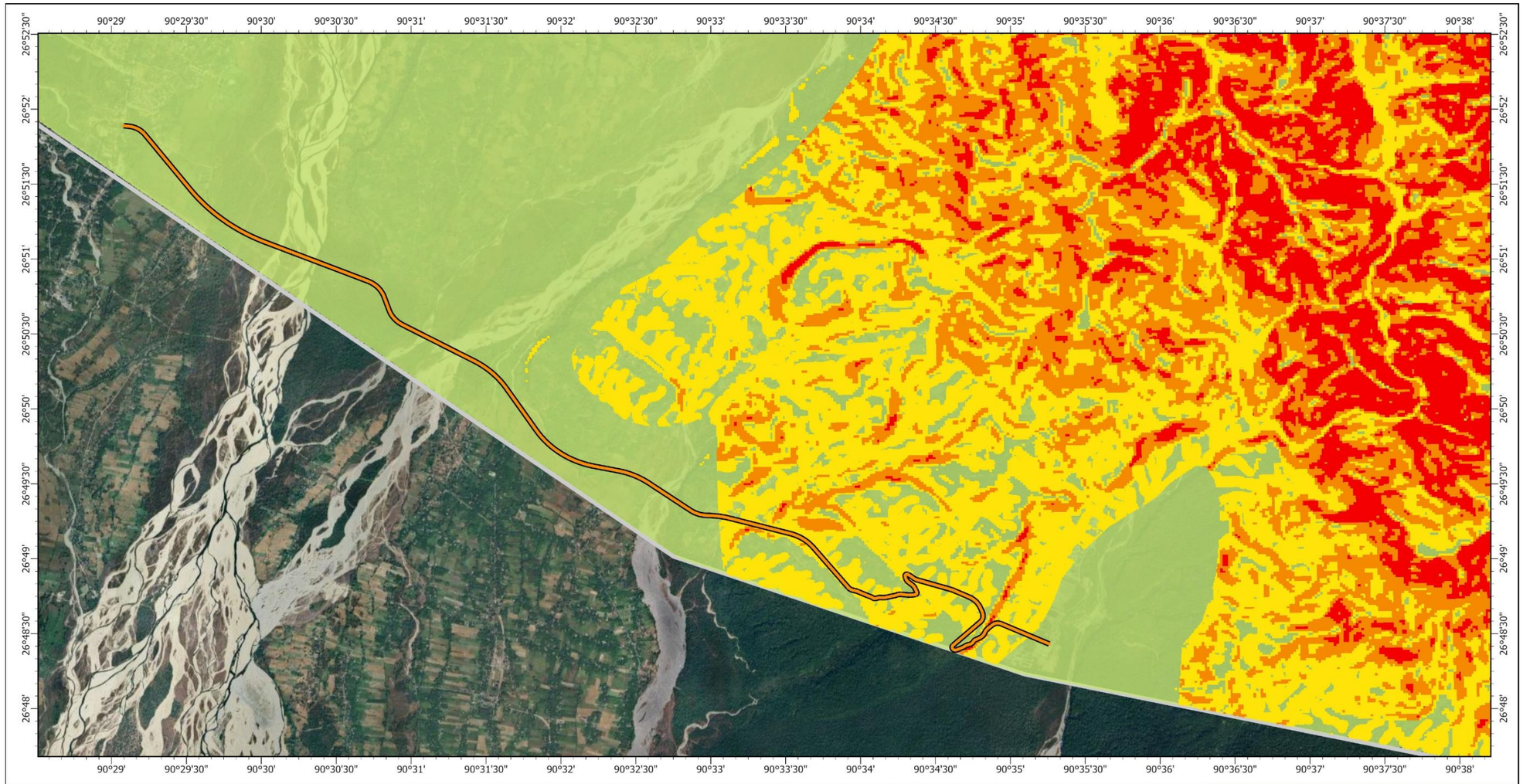
Although Gelephu town is situated on a relatively flat alluvial plain, the section of the road extending toward Tareythang traverses a more undulating and sloped terrain. This variation in topography introduces differing environmental conditions along the route, potentially increasing susceptibility to erosion, landslides, and drainage challenges in the sloped areas.

Almost the entire area overlapping with the proposed road alignment is classified as very low to low risk, with the exception of the last 500 m of the road that is descending to Tareythang, which is classified as medium to high.

The overall risk is conservatively assumed as “Medium” with particular reference to the 500 m of road close to Tareythang.

[17] CDR, 2024. Hydrological Development of the Gelephu Mindfulness City Project, Bhutan. Hydrological Assessment and Management Principles for Masterplan Area. Pp. 62

FIGURE D-12 BASELINE LANDSLIDE HAZARD



Legend

- Preferred Road Alignment

Administrative Boundary

- Country Boundary

Debris Flow Susceptibility

- Very Low
- Low
- Medium
- High

0 0.5 1 2 km

N

Scale: 1:50,000

Coordinate System: GCS WGS 1984

Service Credit: Esri Community Maps Contributors, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Maxar

Data Source(s):
1. CDR, 2024 Hydrological Assessment and Management Principles for Masterplan Area

Landslide Hazard

0737107 GMC ESIA Road and Bridges

Date: 25/11/2024
Drawn By: MS
Review By: MS

ERM

D.6.2 CLIMATE CHANGE PROJECTIONS

The likelihood of landslides can be monitored by tracking rainfall patterns. Heavier rainfall events can increase the risk of landslides.

Considering the results of the CDR International study[18], the future climate scenario show potential increase of high rainfall intensity events, leading to higher risk of precipitation-induced landslides.

However, the morphology of the majority of the area crossed by the road is a relatively flat alluvial plain.

Similarly for the baseline risk evaluation, the overall risk is conservatively assumed as "**Medium**" with particular reference to the 500 m of road close to Tareythang.

D.6.2.1 EXPOSURE AND VULNERABILITY

The Project is potentially susceptible to landslides, which could lead to impacts, including interruptions to traffic flow and accessibility along the route. In more extreme instances, landslides could inflict structural damage on the road infrastructure, requiring repairs and potentially compromising the safety and functionality of the corridor.

However, due to the area's topography, only the 500-meter segment of road near Tareythang is at risk.

Considering the factors mentioned above, the level of exposure and vulnerability is assigned as **"Low"**.

D.6.2.2 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.6 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR LANDSLIDES

	Baseline	**RCP 8.5 - 2030**	**RCP 8.5 - 2050**
Hazard Level	**Medium**	**Medium**	**Medium**
Exposure x Vulnerab. Level	**Low**	**Low**	**Low**
Risk Level	**Low**	**Low**	**Low**
Implications for the Project	• Potential interruptions to traffic flow and accessibility along the route. In more extreme instances, landslides could inflict structural damage on the road infrastructure, requiring repairs and potentially compromising the safety and functionality of the corridor.		
Key Potential Impacts	• Pavement damage or, in extreme cases, structural damage for road • Isolation of communities • Economic losses associated to reparation cost and disruption on local supply chain		

[18] CDR, 2024. Hydrological Development of the Gelephu Mindfulness City Project, Bhutan. Hydrological Assessment and Management Principles for Masterplan Area. Pp. 62

	Baseline	RCP 8.5 - 2030	RCP 8.5 - 2050
Implemented Mitigations	• Integrate slope stabilization structures (e.g. retaining walls, gravity walls, etc.) in the detailed design of the road • Reduce soil erosion by maintaining existing vegetation or revegetating ground movement areas through geotextiles or similar techniques along the 500 m road segment near Tareythang • Ensure correct drainage of rain and groundwater to avoid building up pressure on soil structure • Stabilize the slope by including supporting structures (e.g. retaining walls, gravity walls, etc.) or by stabilizing the soil structure • Regular inspection to identify potential structure failure (e.g. cracking, soil movements, water breaks from ground surface, etc.)The Project Contractor and Operator will develop and implement an Emergency Preparedness and Response Plan, which will include measures specifically for landslides. This plan will include at a minimum the following key mitigation measures: ○ Closely monitor slope stability, especially those slopes most susceptible to landslides and where construction activity is occurring directly above a settlement or populated area. The construction contractor will include a slope stability monitoring strategy as part of the Response Plan to detect movement of overburden material, which could serve as an early warning of a potential landslide; ○ Avoidance of landslide prone areas in siting and design; and ○ Minimize disturbance of steep slopes by careful selection and siting of the Project.		

D.7 EXTREME HEAT

Extreme heat is defined based on the maximum extreme heat hazard level for the selected area. Hazard level reflects expected frequency of extreme heat conditions, using simulations of long-term variations in temperature and expert guidance. Extreme heat is assessed using a widely accepted heat stress indicator, the Wet Bulb Globe Temperature (°C)[19]. The WetBulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account: temperature, humidity, wind speed, sun angle and cloud cover (solar radiation). It differs from the heat index, which takes into consideration temperature and humidity and is calculated for shaded areas. The WBGT has an obvious relevance for human health, but it is relevant in all kinds of Projects and sectors, including infrastructure related, as heat stress affects personnel and stakeholders, and therefore the design of buildings and infrastructure. In general, the WBGT is a relevant enough proxy to quantify the strain on physical infrastructure (energy, water, transport), such as increased demands for water and electricity, which may also affect decisions related to infrastructure.

D.7.1 BASELINE HAZARD

The hazard of extreme heat was assessed regionally using the Global extreme heat hazard 20 Year Return Period from Global Facility for Disaster Reduction and Recovery (GFDRR). Extreme Heat hazard is classified based on the daily maximum Wet Bulb Globe Temperature (WBGT, °C). The ***Figure D-13*** is showing daily maximum WGBT ranging between 32°C to 34°C at the Project.

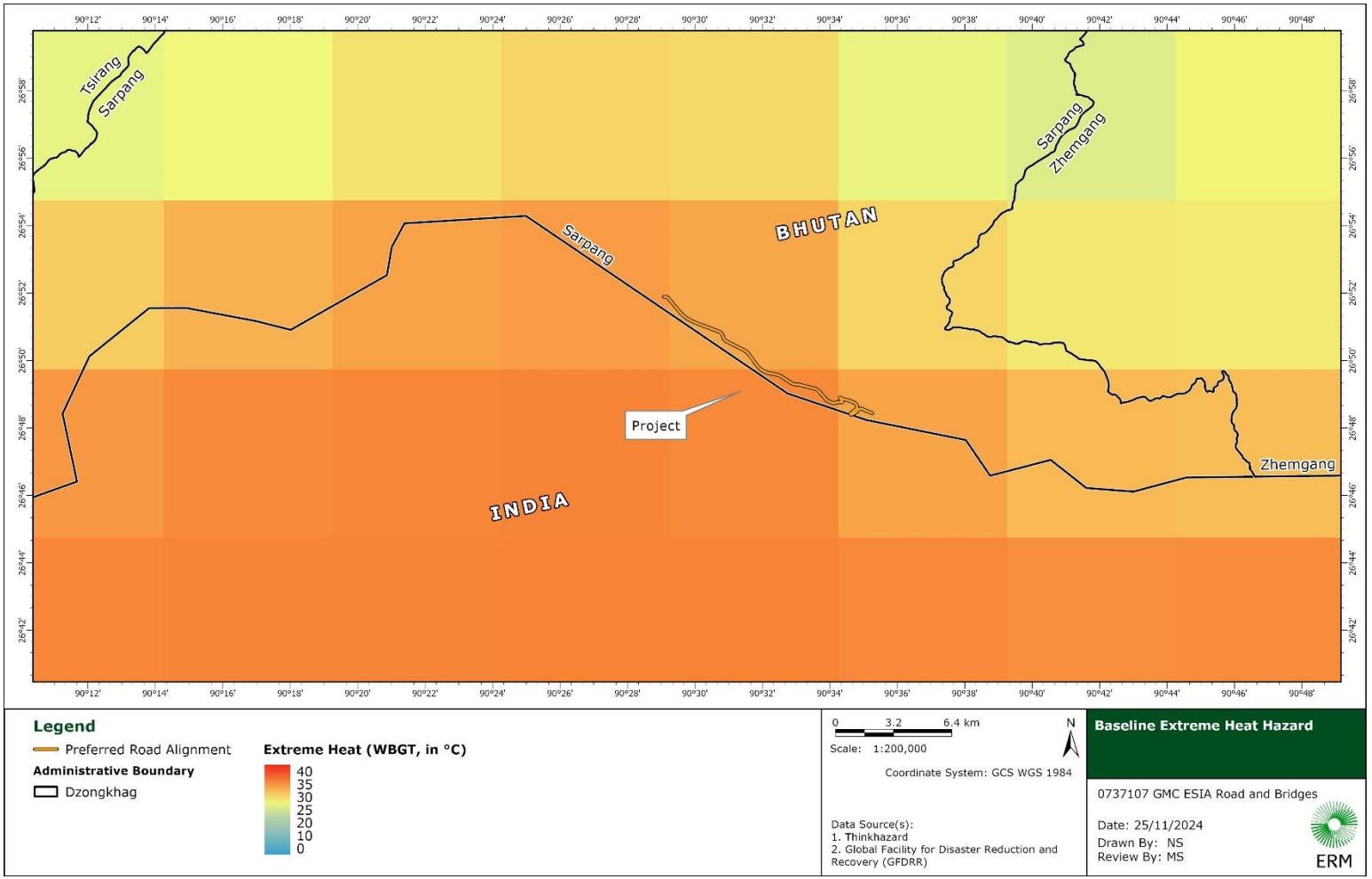
[19] ThinkHazard. 2020. Sumba Timur: https://thinkhazard.org/en/report/18158-indonesia-nusatenggara-timur-sumba-timur/EH

Furthermore, data collected from the Gelephu airport, Sarpang, and Chhuzanggang meteorological stations between 1996 and 2024 indicate that the highest temperatures occur in summer. The average maximum temperature for both Sarpang and Chhuzanggang stations is reported to be 32°C during this period[20].

The classification is based on hazard categorization, the extreme heat hazard is categorized as **"High"**.

[20] Basis of Design of Bhutan Gelephu Airport, NACO. 2024.

FIGURE D-13 AVERAGE MAXIMUM SURFACE AIR TEMPERATURE 1991-2020



Source: Climate Change Knowledge Portal. Available at https://climateknowledgeportal.worldbank.org/country/bhutan/climate-data-historical. Accessed on 09 October 2024

D.7.1.1 CLIMATE CHANGE PROJECTIONS

Climate change projections indicate an increase in maximum temperature and warm spell duration. The temperature projection was obtained from the IPCC WGI Interactive Atlas that provide the climate change data from the IPCC's Sixth Assessment Report (AR6). These reports detail anticipated alterations in climate impact drivers (CIDs), including temperature, snow melt, and wind patterns, which are attributable to future GHG emissions.

Based on the CMIP6 model, using baseline data during 1995 – 2014, the maximum of maximum temperatures changes in degree Celsius was evaluated for Ganges-Brahmaputra River basin.

TABLE D.7 CMIP6 - MAXIMUM OF MAXIMUM TEMPERATURES (TXX) CHANGE DEG C - NEAR TERM (2021-2040) SSP5-8.5 (REL. TO 1850-1900) - GANGES-BRAHMAPUTRA

Period	Scenario	Median	P25	P75	P10	P90	P5	P95
Near Term (2021-2040)	SSP5-8.5	1.2	0.7	1.7	0.1	2.2	0	2.4
Medium Term (2041-2060)	SSP5-8.5	2.2	1.6	2.9	1.3	3.4	1.1	3.8
Long Term (2081-2100)	SSP5-8.5	5.1	4.2	6.3	3.4	7.1	3.3	7.5

Source: IPCC WGI Interactive Atlas

Table D.7 shows the projected global average temperature increase under a high greenhouse gas emissions scenario (SSP5-8.5) for different time periods. In the near-term outlook (2021~2040), the median temperature increase is projected to be 1.2°C, with a 50% chance that it will be between 0.7°C and 1.7°C. There is a 95% chance that the increase will be between 0°C and 2.4°C.

For the medium-term outlook (2041~2060), the median temperature increase is projected to be 2.2°C, with a 50% chance that it will be between 1.6°C and 2.9°C. There is a 95% chance that the increase will be between 1.1°C and 3.8°C.

Based on the information above and considering the baseline extreme heat temperature and the projected temperature increase the extreme heat is considered to be **"High"** under future climate change scenarios.

D.7.1.2 EXPOSURE AND VULNERABILITY

Roads take in a large amount of solar heat throughout the day, causing their surface temperatures to rise significantly. Based on the information found, asphalt may begin to soften when the temperature surpasses 48 degrees Celsius[21].

[21] Texas Roads Could Melt as Potentially Record-Breaking Heat Wave Hits. May 03, 2024. Access via https://www.newsweek.com/texas-roads-could-melt-potentially-record-breaking-heat-wave-1897050

Hence, roads are vulnerable to heat because thermal expansion can lead to cracks, potholes, or uneven surfaces, which reduces their lifespan and increases maintenance costs.

Considering the information provided, the Project's exposure and vulnerability level is categorized as **"Medium".**

D.7.1.3 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.8 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR EXTREME HEAT

	Baseline	**RCP 8.5 - 2030**	**RCP 8.5 - 2050**
Hazard Level	**High**	**High**	**High**
Exposure x Vulnerability Level	**Medium**	**Medium**	**Medium**
Risk Level	**Medium**	**Medium**	**Medium**
Implications for the Project	Thermal expansion leads to the formation of cracks and potholes, while the deterioration of materials shortens the lifespan of the road and raises maintenance expenses. Heat-resistant materials or asphalt mixes can help roads withstand higher temperatures and prevent premature damage.		
Key Potential Impacts	• Reduces the overall lifespan of roads • High temperatures cause cracks and potholes or uneven surfaces • Workers are at risk of heat exhaustion during maintenance.		
Implemented Mitigations	• Schedule heavy labor work during cooler parts of the day • Set up cooling areas and provide heat protection for worker.		

D.8 CYCLONE AND HURRICANE

As per the American Meteorological Society, a cyclone or hurricane is a large-scale air mass that rotates around a strong centre of low atmospheric pressure. Tropical cyclones are formed over oceans due to conducive and coinciding conditions such as warm sea surface temperatures, atmospheric instability, high humidity in the lower and middle levels of troposphere, Coriolis force to develop low pressure centre and low vertical wind shear. Cyclones bring high wind speeds and heavy downpour with them, which are likely to cause disruption to infrastructure, structures, flooding and other damage to buildings and natural environment.

For this assessment, cyclone hazard at the airport boundary was evaluated based on cyclone intensity United Nations Environment Programme (UNEP) Global Data Platform, cyclone frequency data from Socioeconomic Data and Applications Center (SEDAC), and historical hurricane tracks data from National Oceanic and Atmospheric Administration (NOAA).

D.8.1 BASELINE HAZARD

The cyclonic storms are generally classified into five (5) categories based on Saffir-Simpson categorization of hurricanes as summarized in ***Table D***.9.

Figure D-14 presents the historical hurricane track maps within 100 km radius from the project. A review of historical tracks captured by NOAA since 1842 indicates 1 tropical depression have passed within 100 km radial distance with the maximum wind speed of 55.56 km/h (30 knots) as presented in ***Figure D-15***.

Moreover, historical cyclone data from National Center for Hydrology and Meteorology of Royal Government of Bhutan reports that Bhutan was affected from cyclone Remal in 2024[22]. However, by the time the storm approached Bhutan, it had weakened to a tropical depression which caused only heavy rainfall.

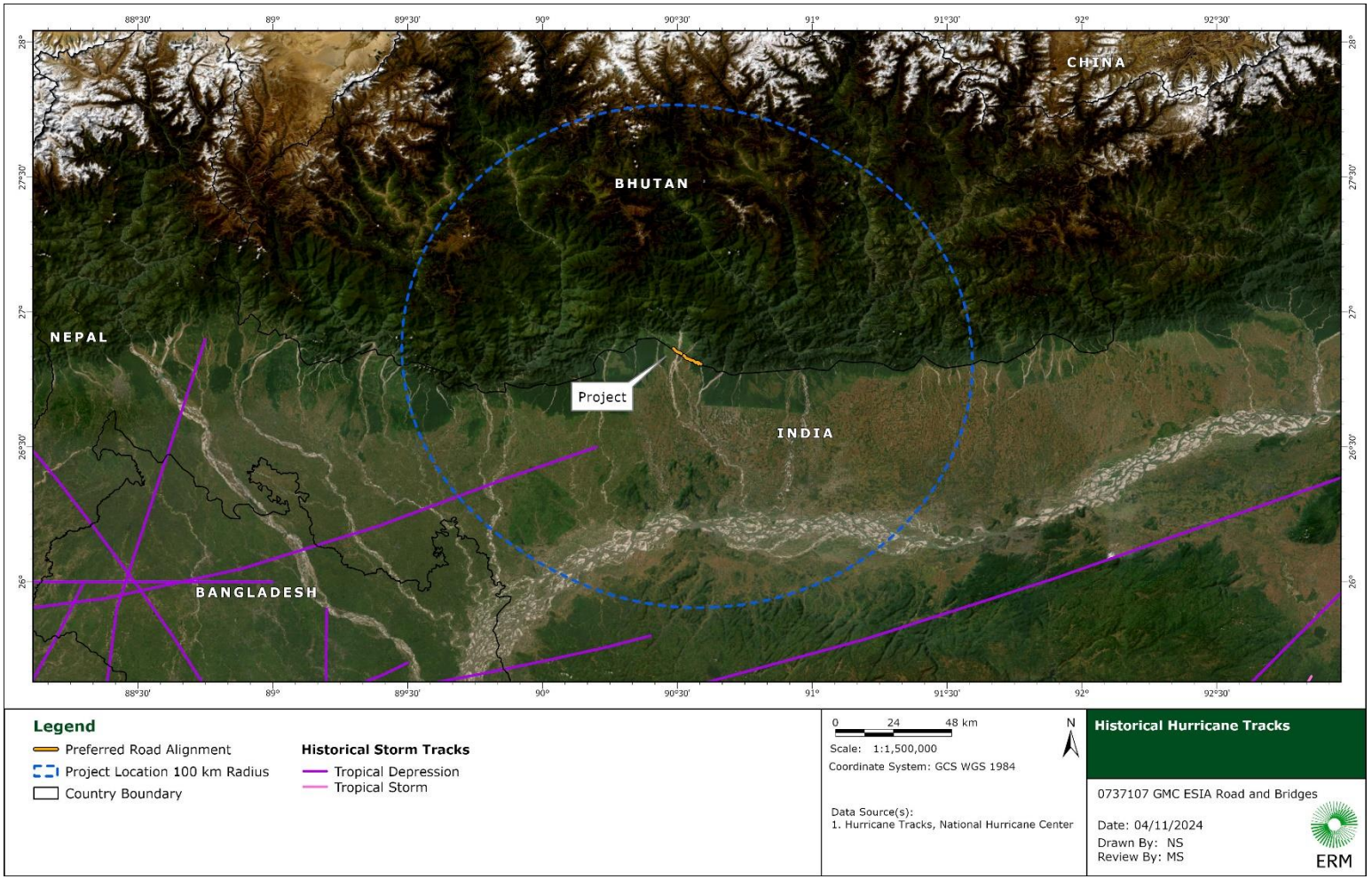
Based on these maps, cyclone hazard was evaluated as **"Low"**.

TABLE D.9 SAFFIR-SIMPSON CATEGORIZATION OF CYCLONE/HURRICANE

Hurricane Category	Wind Speed Criteria (km/h)
Tropical Storm	<119
Category 1	119-153
Category 2	154-177
Category 3	178-208
Category 4	209-251
Category 5	>251

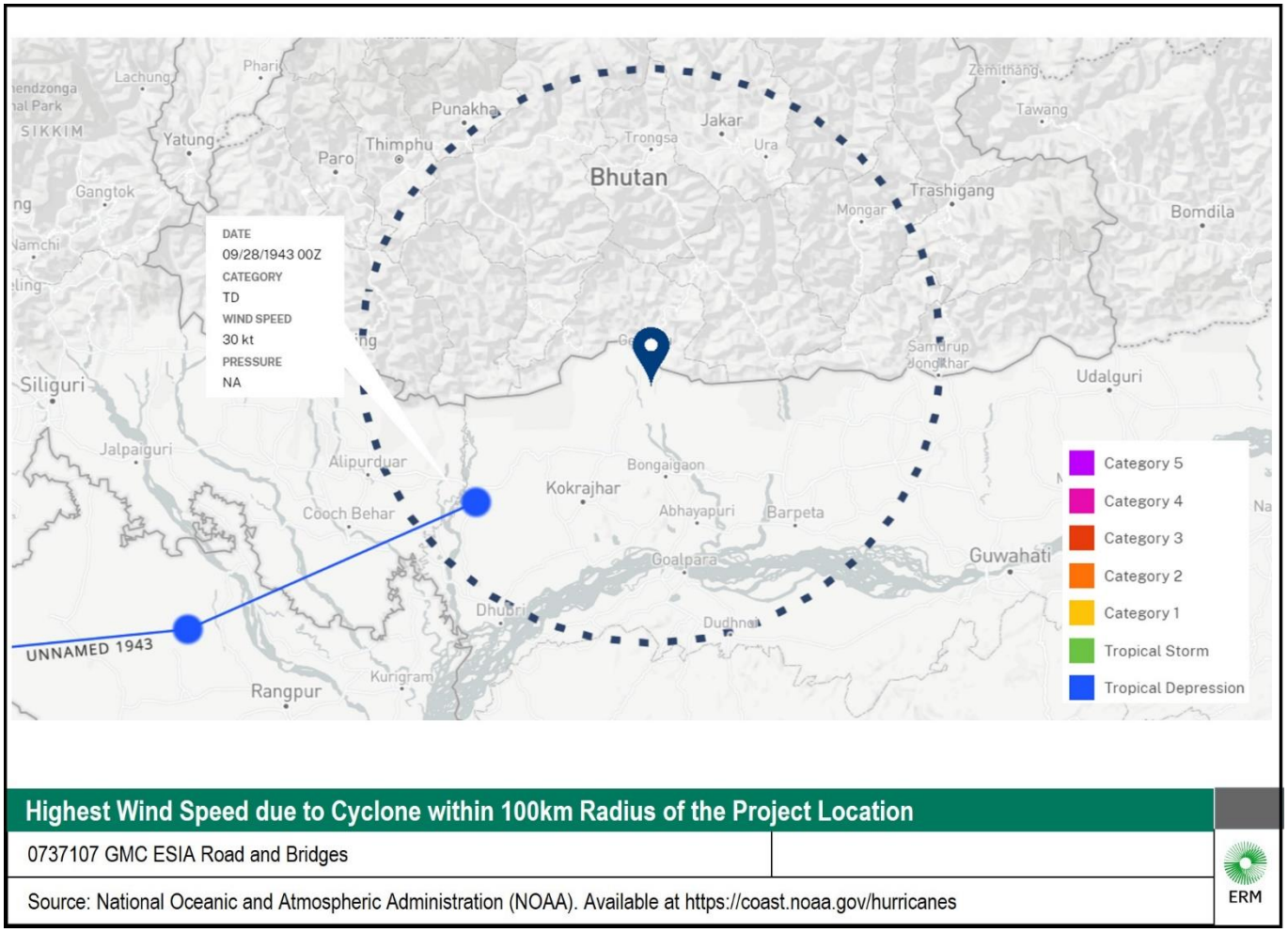
[22] Weather Advisory on Heavy Rainfall from Hydrology and Meteorology of Royal Government of Bhutan 7 July 2024. Via https://www.nchm.gov.bt/home/homeview/1

FIGURE D-14 HISTORICAL HURRICANE TRACKS MAP



Source: International Best Track Archive for Climate Stewardship (IBTrACS) from NOAA. Available at: Index of /data/international-best-track-archive-for-climate-stewardship-ibtracs/v04r00/access/shapefile (noaa.gov)

FIGURE D-15 HIGHEST WIND SPEED DUE TO CYCLONE WITHIN 100KM RADIUS OF THE PROJECT LOCATION



Source: Source: National Oceanic and Atmospheric Administration (NOAA). Available at https://coast.noaa.gov/hurricanes

D.8.1.1 CLIMATE CHANGE PROJECTIONS

Tropical cyclones or Typhoons occur in most of the tropical oceans and present significant threat to coastal communities and infrastructure. Every year about 90 cyclones or Typhoons are reported to occur globally. Further, this number is reported to remained pretty constant since the period of geostationary satellites (1970s). However, changes in inter-annual and multi-decadal frequency within individual ocean basin are reported to be substantial.

Literature review indicated the detection of trends in cyclone or typhoons occurrences (frequency and intensity) is a challenge due to: i) Changes in observation technology, ii) variations in protocol for identification of cyclones or Typhoons in different ocean basins, iii) limited availability of homogeneous data (30-40 years).

Global reanalysis of tropical cyclone or typhoons intensity using homogenous satellite data indicated increasing trend in intensity of cyclones, with a suggestive link between cyclone or typhoons intensity and climate change. However, these observations based on 30 years' period are reported to be insufficient to conclusively provide the evidence for long term trend.

Climate change studies suggested likely increase in peak wind intensity and near storm precipitation in future tropical cyclones and decrease in overall frequency of cyclones.

Furthermore, a review of literature on the Bay of Bengal's tropical cyclones found that while the overall number and intensity of Bay of Bengal cyclones may decrease in the coming decades (2020–49), post-monsoon cyclones in the northern part of the bay could potentially become more intense[23].

Based on the fact that due to the Bhutan's location, the country is not directly in the path of cyclones, it is assessed that the future hazard level is **"Low"** for all future climate scenarios.

D.8.1.2 EXPOSURE AND VULNERABILITY

The project is located in Sarpang, Bhutan, a landlocked region in the Himalayas that is generally not directly affected by cyclones or hurricanes.

Considering the information provided, the Project's exposure level is categorized as **"Low".**

D.8.1.3 RISK ASSESSMENT

The table below shows the summary of risk assessment.

[23] Fahad, Abdullah A., Oreste Reale, Andrea Molod, Tahmidul Azom Sany, Md Tashin Ahammad, and Dimitris Menemenlis. "The Role of Tropical Easterly Jet on the Bay of Bengal's Tropical Cyclones: Observed Climatology and Future Projection." Journal of Climate 36, no. 17 (2023): 5825-5840. https://doi.org/10.1175/JCLI-D-22-0804.1. Via https://journals.ametsoc.org/view/journals/clim/36/17/JCLI-D-22-0804.1.xml

TABLE D.10 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR CYCLONE AND HURRICANE

	Baseline	RCP 8.5 - 2030	RCP 8.5 - 2050
Hazard Level	**Low**	**Low**	**Low**
Exposure x Vulnerab. Level	**Low**	**Low**	**Low**
Risk Level	**Low**	**Low**	**Low**
Implications for the Project	The implication for the project is minimal in terms of storm-related risks since the project is not locate in the prone area of cyclone and hurricane.		
Key Potential Impacts	• Safety of the worker during maintenance operations.		
Implemented Mitigations	• Implement safety procedures during severe weather. • Monitor real-time weather conditions to be prepared for potential severe weather events.		

D.8.2 WIND SPEED

Winds are defined as large scale movement of gases in the earth's atmosphere. These are typically caused by differences in atmospheric pressure on earth surface and atmosphere. Depending upon the pressure gradient, winds of various speeds are propagated. Although winds are felt at a local scale, these are largely influenced by complex process at a regional and global scale.

Winds of high speed are likely to cause damage to natural and built environment, the extent of which depends upon magnitude of their velocity and pressure differential. High winds can cause damage to high rise structures, swaying of bridges or other structures, also leading to collapse, uprooting of trees, propagation of dust, migration of air borne contamination, spreading of wildfires, etc.

For the purpose of this assessment, average wind speed data from Global Wind Atlas 2.0, a free, web-based application developed, owned and operated by the Technical University of Denmark (DTU) in partnership with the World Bank Group, was utilized. Additionally, wind speed study in the EIA conducted by E&A (November 2020) will be reviewed. The basic wind speed corresponds to maximum wind speed on a 100-year return period[24].

D.8.2.1 BASELINE HAZARD

However, the average wind speed at the project was reported less than 2.8 m/s at 10 m height as presented in ***Figure D-16.*** Based on average and hourly wind speed data, the baseline hazard due to average wind speed for the area is considered to be 'Low'.

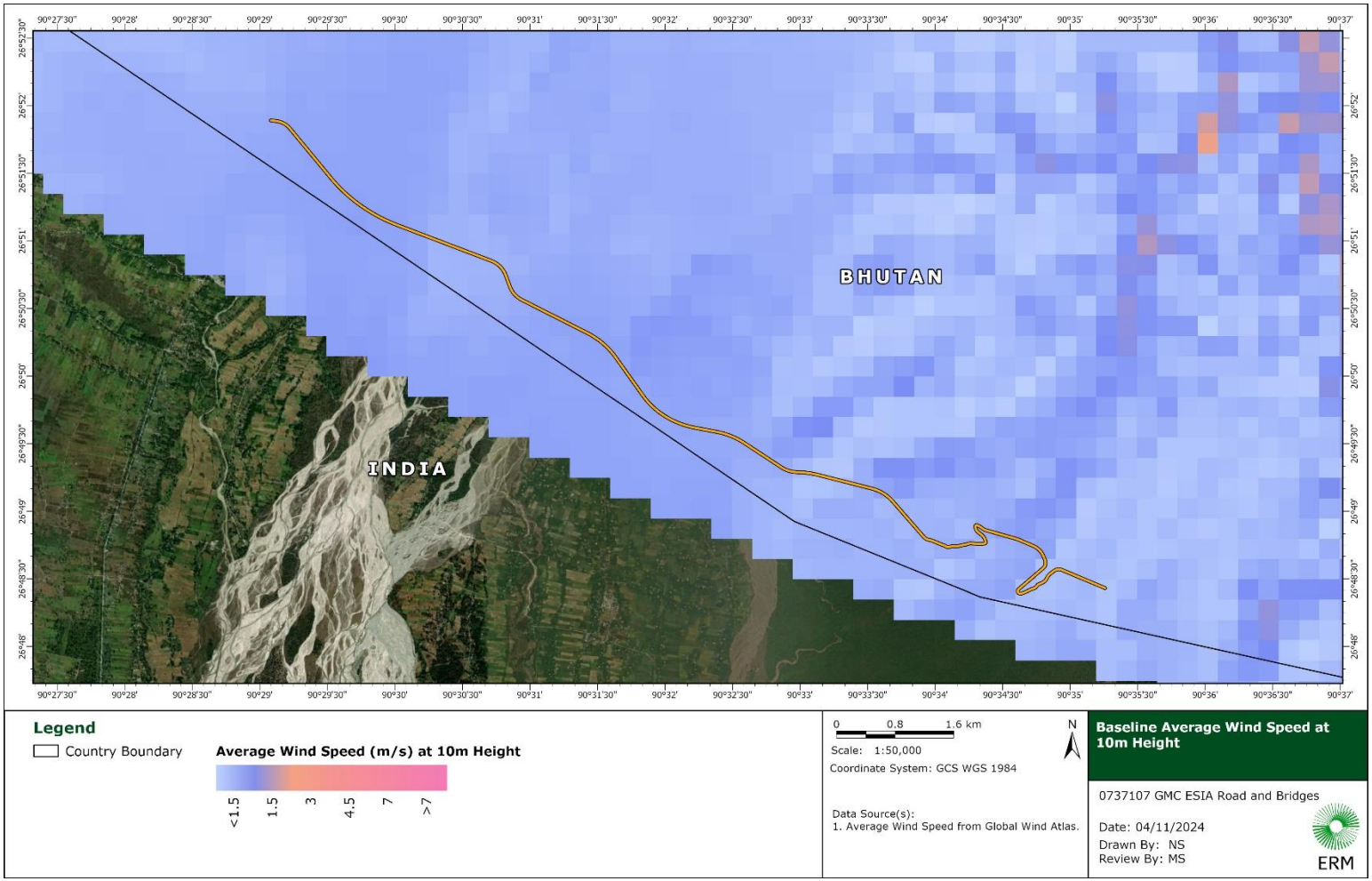
Based on the report of Basis of Design of Bhutan Gelephu Airport by NACO, wind speed data was collected from the meteorological station including Chhuzanggang station which

[24] Hahm, J.H., Jeong, H.Y, Kwak, K.H., 2019. Estimation of Strong Wind Distribution on the Korean Peninsula for Various Recurrence Periods: Significance of Nontyphoon Conditions. Advances in Meteorology, Article ID 8063169 https://doi.org/10.1155/2019/8063169

away from the project approximately 2 kilometers. The study report that the wind speed does not exceed 10 knots for all the measurements.

Therefore, the risk associated with the maximum wind speed is considered **"Low"**.

FIGURE D-16 BASELINE AVERAGE WIND SPEED MAP



Source: Global Wind Atlas. Available at https://globalwindatlas.info/en

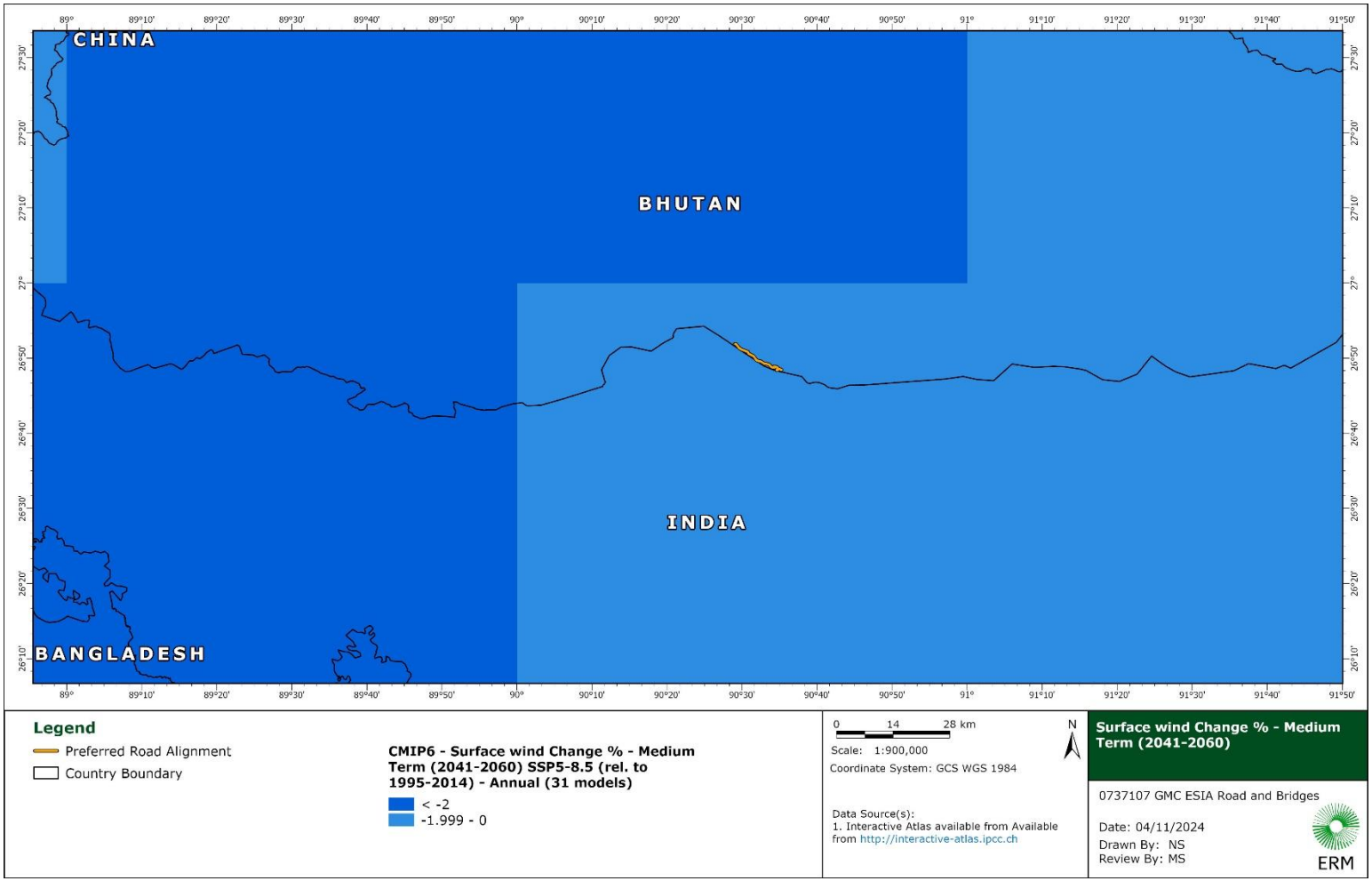
D.8.2.2 CLIMATE CHANGE PROJECTIONS

The climate models for wind speed indicate a high degree of uncertainty with models projecting increase, decrease, or no change in the future. However, a recent study from the IPCC has modeled the future projection of surface wind across the globe[25]. According to the IPCC interactive atlas, the Ganges-Brahmaputra basin may be subject to a decrease of surface wind speed approximately -1.75% as shown in ***Figure D-17***. This dedicates that the surface wind speed remains almost the same in the future.

Considering the limited information available, the wind hazard under a climate change scenario is considered to be **"Low"**.

[25] Gutiérrez, J.M., R.G. Jones, G.T. Narisma, L.M. Alves, M. Amjad, I.V. Gorodetskaya, M. Grose, N.A.B. Klutse, S. Krakovska, J. Li, D. Martínez-Castro, L.O. Mearns, S.H. Mernild, T. Ngo-Duc, B. van den Hurk, and J.-H. Yoon, 2021: Atlas. In Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L.Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K.Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press. Interactive Atlas available from Available from http://interactive-atlas.ipcc.ch/

FIGURE D-17 SURFACE WIND CHANGE % - MEDIUM TERM (2041-2060)



Source: IPCC WGI Interactive Atlas. Available at: https://interactive-atlas.ipcc.ch/

D.8.2.3 EXPOSURE AND VULNERABILITY

Generally, road projects are not highly exposed or vulnerable to wind speed. However, extreme wind events can impact construction activities, increasing risks for workers and equipment, and potentially delaying progress.

However, considering that the Project is located in a low risk of extreme wind hazard, the Project's exposure level is categorized as **"Low"** based on the given information above.

D.8.2.4 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.11 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR WIND HAZARD

	Baseline	**RCP 8.5 - 2030**	**RCP 8.5 - 2050**
Hazard Level Average Wind Speed	**Low**	**Low**	**Low**
Hazard Level Maximum Wind Speed	**Low**	**Low**	**Low**
Exposure x Vulnerability Level	**Low**	**Low**	**Low**
Risk Level	**Low**	**Low**	**Low**
Implications for the Project	The construction of roads typically takes place in open or elevated areas. The risks to workers and equipment can be caused by high wind speeds, which can affect construction activities. Due to low extreme wind speed risk, the project is not expected to be at risk.		
Key Potential Impacts	• Not applicable.		
Implemented Mitigations	• Not required		

D.8.3 SEA LEVEL RISE

Sea level rise is the phenomenon of increasing or rise in the sea surface elevation. The two (2) main reasons attributed to this phenomenon are 1) the added water from melting ice sheets and glaciers and 2) the thermal expansion of seawater as it warms-up. This is primarily due to global warming, resulting in accelerated melting of glaciers and snow. Impacts of sea level rise may further intensify or reduce due to vertical land movement. Current and future sea level rise is set to have a number of impacts, particularly on coastal systems. Such impacts include increased coastal erosion, higher storm-surge flooding, inhibition of primary production processes, more extensive coastal inundation, changes in surface water quality and groundwater characteristics, increased loss of land/property and coastal habitats, increased flood risk and potential loss of life/ property, loss of nonmonetary cultural resources and values, impacts on agriculture and aquaculture through decline in soil and water quality, and loss of tourism, recreation, and transportation functions. Some of the most vulnerable entities to sea level rise are habitations along the coastal regions, island nations/states and coastal ecosystems.

D.8.3.1 BASELINE HAZARD

No baseline hazard due to sea level (rise) was considered as it is a phenomenon driven by climate change. Therefore, hazard due to sea level rise was only evaluated under climate change scenario.

D.8.3.2 CLIMATE CHANGE PROJECTIONS

No implications as located far from areas susceptible to sea level rise. Hence, no change is considered for the sea level rise.

D.8.3.3 EXPOSURE AND VULNERABILITY

The project is located in the Sarpang, Bhutan which it is a landlocked area situated high in the Himalayan mountains. With no coastal areas, it is geographically isolated from the direct impacts of rising sea levels, meaning it has **No** vulnerability and exposure from sea level rise.

D.8.3.4 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.12 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR SEA LEVEL RISE

	Baseline	RCP 8.5 - 2030	RCP 8.5 - 2050
Hazard Level	**Not Applicable**	**Not Applicable**	**Not Applicable**
Exposure x Vulnerability Level	**Not Applicable**	**Not Applicable**	**Not Applicable**
Risk Level	**Not Applicable**	**Not Applicable**	**Not Applicable**

	Baseline	RCP 8.5 - 2030	RCP 8.5 - 2050
Implications for the Project	No implications as located far from areas susceptible to sea level rise.		
Key Potential Impacts	• None identified		
Implemented Mitigations	• Not required		

D.9 LIGHTNING

Lightning is an electrical discharge caused by imbalances between storm clouds and the ground, or within the clouds themselves. Most lightning occurs within the clouds.

During a storm, colliding particles of rain, ice, or snow inside storm clouds increase the imbalance between storm clouds and the ground, and often negatively charge the lower reaches of storm clouds.

Objects on the ground, like steeples, trees, and the Earth itself, become positively charged creating an imbalance that nature seeks to remedy by passing current between the two charges.

Lightning is extremely hot. A flash can heat the air around it to temperatures five times hotter than the sun's surface. This heat causes surrounding air to rapidly expand and vibrate, which creates the pealing thunder that is heard a short time after seeing a lightning flash.

Lightning can cause both destruction of infrastructure and lives. About 2,000 people are killed worldwide by lightning each year. Hundreds more survive strikes but suffer from a variety of lasting symptoms, including memory loss, dizziness, weakness, numbness, and other life-altering ailments[26].

For this assessment, data from the Tropical Rainfall Measuring Mission (TRMM) lightning Imaging Sensor (LIS) was used. TRMM LIS was a space-based lightning sensor aboard the Tropical Rainfall Measuring Mission satellite.

The TRMM LIS instrument recorded the time of occurrence of a lightning event, measured the radiant energy and estimated the location during both day and night conditions with high detection efficiency.

D.9.1 BASELINE HAZARD

Vaisala's Interactive Global Lightning Density Map is a space-based lightning detection system using Global Lighting Dataset GLD360 which is real-time data from the industry's most accurate global detection network.

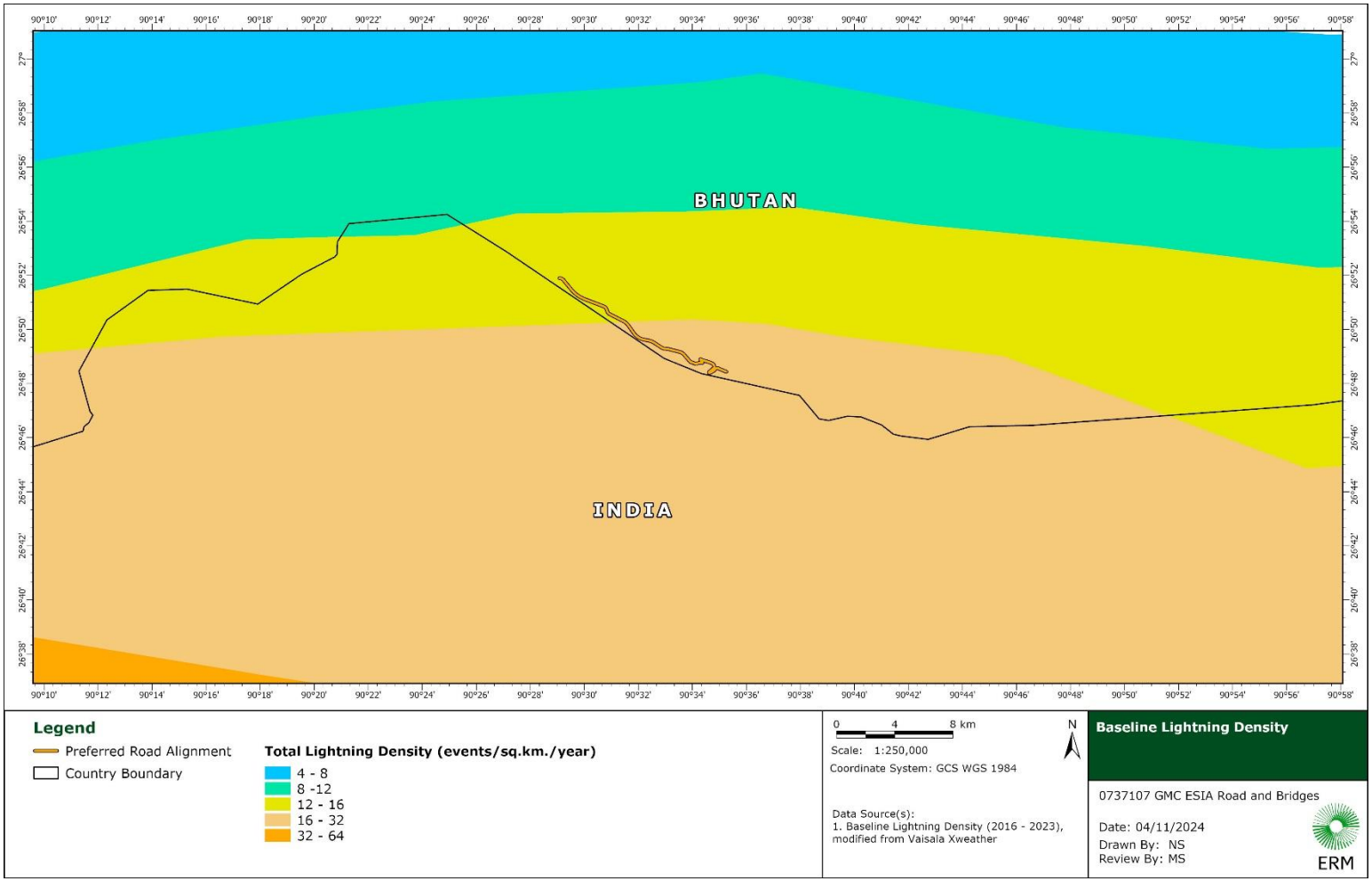
The lightning flash density map presented in ***Figure D-18*** indicates the density of lightning flashes to be 12 - 16 events km-2 year-1 during the period 2016 - 2023 along the road

[26] National Geographic, N.D. https://www.nationalgeographic.com/environment/natural-disasters/lightning/

alignment. Very limited information is available in the public domain regarding the hazard classification of lightning.

However, considering the hazard categorization the hazard in the airport boundary can be assumed as **"Low"**.

FIGURE D-18 BASELINE LIGHTNING DENSITY MAP



Source: Vaisala's Interactive Global Lightning Density Map. Available at: https://interactive-lightning-map.vaisala.com/?_ga=2.13283636.2075757537.1656405986-847756934.1656405986

D.9.1.1 CLIMATE CHANGE PROJECTIONS

There are no direct projections available for lightning. However, as lightning usually occurs during thunderstorms, any changes in occurrences of thunderstorm are considered as measure for changes in lightning in future.

Literature review indicates that predicting changes in thunderstorm directly is difficult task, and hence generally changes in large scale environmental conditions conducive to thunderstorms are used as an indirect measure. One such factor is convective available potential energy (CAPE), which is a measure of maximum kinetic energy obtainable by an air parcel lifted adiabatically from near surface. CAPE is also reported to be important large-scale indicator for the potential lightning.

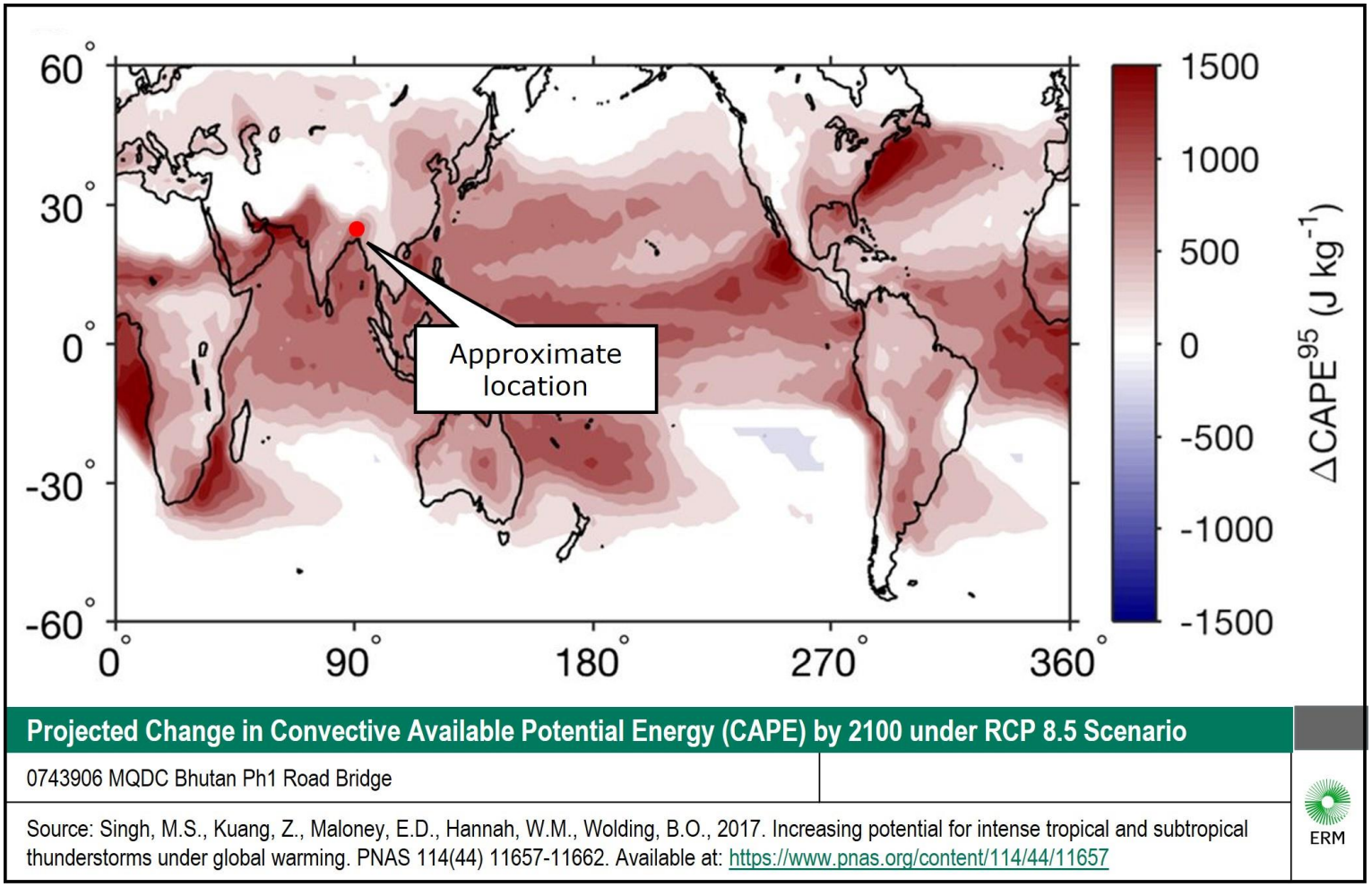
Literature review indicates tropical and subtropical CAPE extremes increasing sharply with warming across ensembles of GCMs participating in CMIP6. In general, the studies indicate an increase in potential for intense thunderstorms in warming atmosphere.

CAPE at Project site is likely to increase by 500 - 1000 J/kg by 2100 for RCP 8.5 scenario as presented in ***Figure D-19***. In general, the studies indicate an increase in potential for intense thunderstorms in a warming atmosphere. ***Figure D-20*** presents the likely increase in a number of days per year with conditions favorable for severe thunderstorm by end of the century. Accordingly, the projected increase in number of days with conditions favorable for formations of thunderstorms is reported to be between 30-40/year by 2100 under RCP 8.5 scenario. Hence, an increase in lightning activity/frequency may be experienced in the future.

It is possible that the probability of lightning events may increase to 42 - 56 events/year, based on the projected increase of thunderstorm day in ***Figure D-20.*** This indicates that the projection risk of lightning hazards is 'Low'.

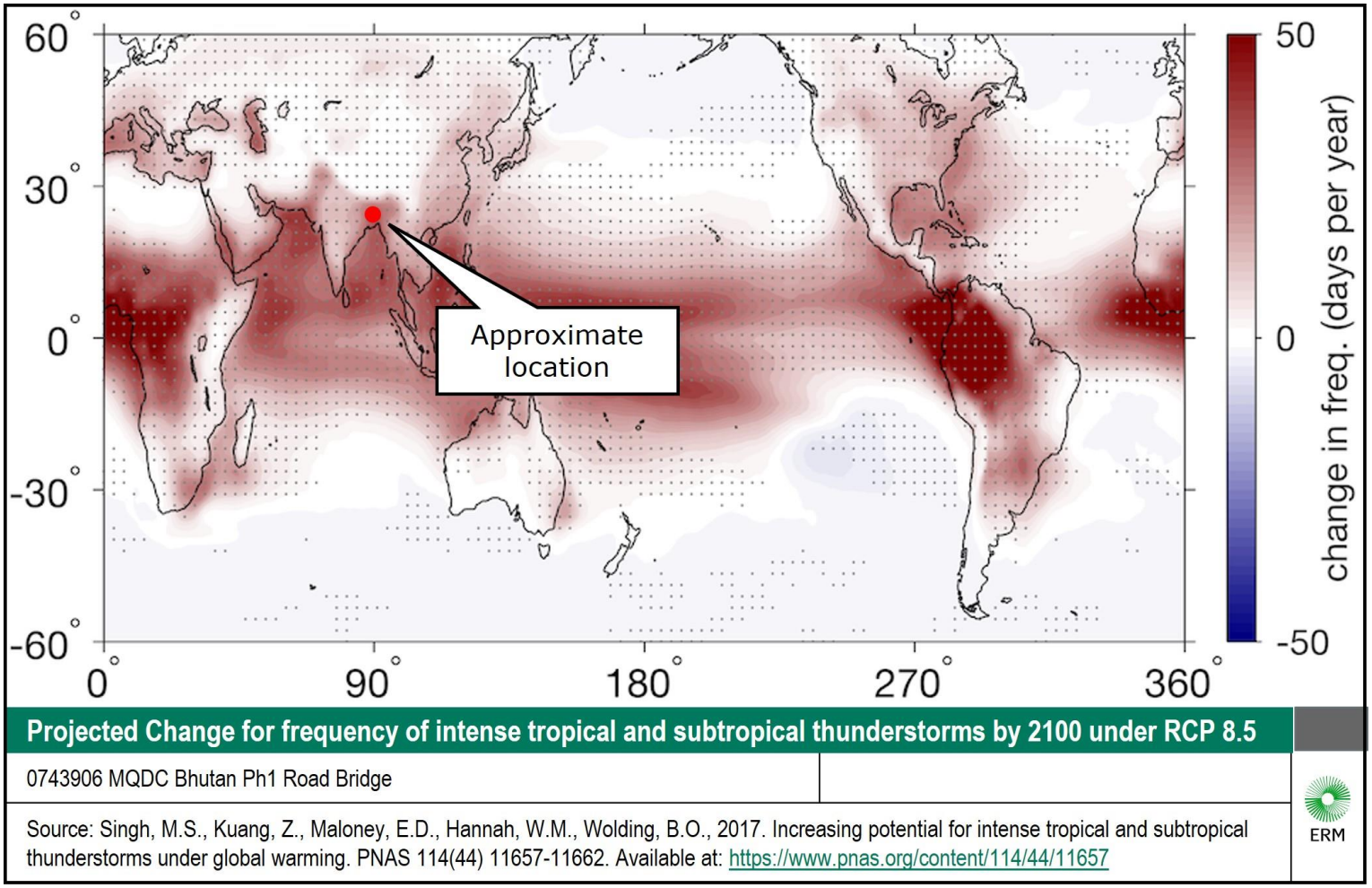
Considered the worst-case scenario, it is assessed a future risk of lightning to be a **"Low"** hazard level at the Project location.

FIGURE D-19 PROJECTED CHANGE IN CONVECTIVE AVAILABLE POTENTIAL ENERGY (CAPE) BY 2100 UNDER RCP 8.5 SCENARIO



Source: Singh, M.S., Kuang, Z., Maloney, E.D., Hannah, W.M., Wolding, B.O., 2017. Increasing potential for intense tropical and subtropical thunderstorms under global warming. PNAS 114(44) 11657-11662. Available at: https://www.pnas.org/content/114/44/11657

FIGURE D-20 PROJECTED CHANGE FOR FREQUENCY OF INTENSE TROPICAL AND SUBTROPICAL THUNDERSTORMS BY 2100 UNDER RCP 8.5 SCENARIO



Source: Singh, M.S., Kuang, Z., Maloney, E.D., Hannah, W.M., Wolding, B.O., 2017. Increasing potential for intense tropical and subtropical thunderstorms under global warming. PNAS 114(44) 11657-11662. Available at: https://www.pnas.org/content/114/44/11657

D.9.1.2 EXPOSURE AND VULNERABILITY

The road and bridge structures have limited exposure to lightning, as strikes are more likely to discharge onto taller structures, such as trees and utility poles.

In the unlikely event of a lightning strike directly on the road surface, only minor surface damage is expected. Thunderstorms, however, could pose safety risks to personnel conducting maintenance activities. Fortunately, maintenance operations for this project are infrequent and generally scheduled during dry weather conditions, further minimizing risk exposure to lightning-related hazards.

Hence, the exposure and vulnerability of the Project are considered to be **"Low"**.

D.9.1.3 RISK ASSESSMENT

The table below shows the summary of risk assessment.

TABLE D.13 QUALITATIVE RISK LEVEL AND PROJECT IMPLICATIONS FOR LIGHTNING

	Baseline	**RCP 8.5 – 2030**	**RCP 8.5 – 2050**
Hazard Level	**Low**	**Low**	**Low**
Exposure x Vulnerability Level	**Low**	**Low**	**Low**
Risk Level	**Low**	**Low**	**Low**
Implications for the Project	In the unlikely event of a lightning strike directly on the road surface, only minor surface damage is expected.		
Key Potential Impacts	• None identified		
Implemented Mitigations	• Not required		

D.10 CONCLUSION

The below table summarizes the risk level and mitigation measures identified for the Project.

TABLE D.14 SUMMARY OF RISK LEVEL FOR THE PROJECT

Hazard	Risk Level			Mitigation Measures	Residual Risk Level
	Baseline	RCP 8.5			
		2030	2050		
Water Availability	Low	Low	Low	• If possible, recycle water used for road cleaning to water the roadside greenery.	Low
Flood	High	High	High	• DoST to complete the flood modelling for the entire length of the Gelephu Tareythang road through collaboration with the engineering team • DoST to maintain coordination with the parties responsible for the design of upstream infrastructure associated to the Gelephu Mindfulness City. The coordination will ensure that the water retention structures that are installed within the Gelephy Mindfulness City will reduce the water/debris flow and risk of flooding along the road • Integrate the results on the full model to the detailed engineering design of the road and bridges and include at least the risk associated with a 100 year return period	Low
Landslides	Low	Low	Low	• Integrate slope stabilization structures (e.g. retaining walls, gravity walls, etc.) in the detailed design of the road • Reduce soil erosion by maintaining existing vegetation or revegetating ground movement areas through geotextiles or similar techniques along the 500 m road segment near Tareythang • Ensure correct drainage of rain and groundwater to avoid building up pressure on soil structure • Stabilize the slope by including supporting structures (e.g. retaining walls, gravity walls, etc.) or by stabilizing the soil structure • Regular inspection to identify potential structure failure (e.g. cracking, soil movements, water breaks from ground surface, etc.)	Low
Extreme Heat	Medium	Medium	Medium	• Schedule heavy labor work during cooler parts of the day • Set up cooling areas and provide heat protection for worker.	Low
Cyclone and Hurricane	Low	Low	Low	• Implement safety procedures during severe weather. • Monitor real-time weather conditions to be prepared for potential severe weather events.	Low

Hazard	Risk Level			Mitigation Measures	Residual Risk Level
	Baseline	RCP 8.5			
		2030	2050		
Wind Speed	Low	Low	Low	• Not required	Low
Sea Level Rise	Not Applicable	Not Applicable	Not Applicable	• Not required	Low
Lightning	Low	Low	Low	• Not required	Low

APPENDIX E GHG EMISSION ASSESSMENT

E GHG EMISSION ASSESSMENT

This section will summarize the greenhouse gas emissions during the construction and operation phases of the project. It includes direct emissions, also known as Scope 1, from sources under operational control, as well as indirect emissions from Scope 2 and Scope 3. Scope 2 refers to emissions resulting from the generation of purchased electricity by the project developer, while Scope 3 covers emissions from other sources.

The greenhouse gas emission assessment results will help project owners better understand the project's impacts and sources of emissions. This provides an opportunity to set a clear direction and reduce emissions early in the design phase, while also considering emissions from alternative options.

The general approach used to evaluate the potential GHG emission effects of the Project was to estimate the GHG emissions from the Project for the phase of activity (i.e., construction and operation) determined to have the highest (i.e. bounding) quantity of GHG emissions. The calculated GHG emissions reported herein are based on **conservative estimates** and may overestimate the actual emissions. GHG reporting requirements should be assessed based on actual annual emission totals and not those reported in this document.

E.1 SCOPE OF ASSESSMENT

The GHG Protocol establishes an international standard for accounting and reporting GHG emissions. According to the GHG Protocol, GHG emissions are divided into three categories, or scopes:

- Scope 1 emissions: Direct GHG emissions occur from sources that are owned or controlled by the reporting entity.
- Scope 2 emissions: Indirect emissions that accounts for GHG emissions from the generation of purchased energy products (principally electricity, steam/heat) by the reporting entity. For the Project, this includes energy purchased for day-to-day operations at the facility including machinery and equipment.
- Scope 3 emissions: Indirect emissions that are a consequence of the activities of the reporting entity but occurs from sources not owned or controlled by the reporting entity. Examples of Scope 3 activities include extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

In this Project, the calculation of greenhouse gas emissions will focus specifically on the construction and operation phases. During the construction phase, only Scope 1 and Scope 2 emissions will be considered, covering emissions from fuel consumption and electricity use during construction. The Scope 3 emissions during the construction phase are not included in this GHG assessment. However, calculating Scope 3 emissions for the construction phase is something we will consider studying in the future, as it would provide a more accurate and comprehensive picture of the overall greenhouse gas emissions. For the operation phase, only Scope 3 emissions will be calculated, which include other types of greenhouse gas emissions, such as those from vehicle use on roads during the operational phase.

E.2 ASSESSMENT BOUNDARY

The assessment will cover greenhouse gas emissions during the construction and operation phases of the Gelephu-Tareythang Road project on the Southern East-West Highway in Sarpang,

Bhutan. This includes the construction of the road and bridges between Gelephu and Tareythang. Emissions will result from fuel combustion used to power construction activities, and indirect emissions from electricity consumption during the construction phase. Additionally, the greenhouse gas assessment will account for other emissions during the project's operational phase, such as those from vehicles using the newly constructed road.

The greenhouse gas emissions resulting from deforestation for road construction will not be included in the emission assessment. This is because emissions from tree removal fall under Scope 3, and for this project, only Scope 1 and Scope 2 emissions will be assessed during the construction phase. Therefore, emissions from deforestation will not be considered in the evaluation.

E.3 RELEVANT STANDARD AND GUIDELINES

This section provides a detailed overview of the comprehensive legislative framework governing greenhouse gas (GHG) emissions at the national level. It covers essential national laws, policies, and regulations, as well as relevant international agreements and guidelines that play a significant role in GHG emissions management. These legislative measures are designed to ensure compliance with environmental standards and promote sustainable practices across various sectors. For more information about the relevant standards and guidelines, please refer to ***Chapter 3***.

E.4 LIMITATIONS OF THE ASSESSMENT

The following limitations have been identified for this assessment.

Scope Limitations:

- The greenhouse gas assessment will only evaluate the construction phase and operation phase.
- The greenhouse gas emissions assessment during the construction phase does not include Scope 3, which means it will not cover raw material production and emissions from deforestation for road construction.
- During the Operation phase, the greenhouse gas emissions assessment will only cover Scope 3.
- This greenhouse gas emissions assessment is high-level, and therefore, minor emissions may not be included in the evaluation.

Data Availability and Accuracy:

- The IPCC guidelines use "tiers" (from 1 to 3) to rate the reliability and methodological complexity of emission factors and activity data. It is good practice to report tiers for all emission sources included in the inventory. Tier 1 is the basic method, frequently utilizing IPCC-recommended country-level defaults, whereas Tier 2 involves country-specific data while Tier 3 involves Project-specific data. The higher the tier rank, the higher the quality of data is needed for assessment. This report primarily targets Tier 3 data use, but data constraints may necessitate the use of the Tier 1 and Tier 2 methodology.
- The accuracy of the GHG assessment depends on the availability and reliability of data sources used for emission calculations, which are mainly based on the data available in the Initial Options Study.

- Limitations may arise due to incomplete or insufficient data on energy consumption, emission factors, or other relevant parameters.
- Missing or incomplete information regarding the source population and activity data.
- Poor understanding of temporal and seasonal variations in the sources.
- The results from the GHG assessment in this report may not reflect the true quantity of emissions of the Project, as some GHG sources that might be significant are screened out due to the lack of information at the time writing this report.

Assumptions and Simplifications:

- The assessment may involve certain assumptions or simplifications due to limited data availability or complexity of certain processes.
- Simplifications may include using average emission factors or default values for certain emission sources or activities.
- Assuming similar vehicle growth rates and vehicle types reflects a realistic scenario, as these factors are likely to be influenced by broader economic and policy trends that affect both routes similarly.
- Having control variables—i.e., vehicle types, fuel usage, and growth rates, in both scenarios—helps in focusing on the differences in emissions due to the route characteristics alone.

Boundary Definitions:

- The geographical boundary of the assessment is defined based on the project site and its immediate surroundings. For this project, the boundary encompasses the area of road construction between Gelephu and Tareythang.
- Greenhouse gas emissions beyond the defined boundary, such as emissions from the production of construction materials and deforestation, are not considered.

Future Uncertainties:

- Should there be significant changes in factors such as assumptions made in Project description, engineering design, or agreed assessment criteria, the elements of this assessment and associated management, mitigation, and monitoring measures may need to be updated to reflect those changes.
- The assessment is based on current data and assumptions and does not account for potential future changes in technology, regulations, or operational practices.
- Future uncertainties, such as changes in energy sources, emission standards, or project expansion plans, are not considered in the assessment.

E.5 REFERENCE GUIDELINES AND STANDARD

The basic methodologies used to estimate the GHG emissions in this report will apply the following guidelines:

- **Scope 1**: This assessment will use GHG Protocol guidelines for mobile combustion, which GHG Protocol calculation tool was develop by IPCC Guidelines. Therefore, GHG Scope 1 assessment will deploy the IPCC approach.
- **Scope 2**: The assessment of Scope 2 emissions will be based on the GHG Protocol Scope 2 guidance. However, the Scope 2 emissions considered will only cover the electricity used by

construction equipment during the construction phase. Additionally, since Bhutan generates its own electricity, primarily from hydro sources, we will use the Emission Factor calculated by the International Renewable Energy Agency (IRENA) for our calculations.

- **Scope 3**: The assessment of Scope 3 emissions will follow the GHG Protocol Scope 3 guidance[27]. Scope 3 will cover the operation phase, including the greenhouse gas emissions from burning fuel in vehicles using the road. These emissions fall under Scope 3 category 11, "Use of Sold Products", and are considered indirect emissions.

E.6 NATIONAL POLICY AND REGULATION

The national policies and regulations for Bhutan include a comprehensive framework designed to promote sustainable development, environmental conservation, and social well-being. Central to these policies is the commitment to reducing GHG emissions, aligning with global efforts to combat climate change. The following sections outline Bhutan's commitments and national policy frameworks:

Bhutan's Commitment to GHG Emission Reduction

Bhutan is a signatory to three significant international conventions on Climate change, including:

1. The United Nations Framework Convention on Climate Change (UNFCCC) of 1992, ratified in 1994
2. The Kyoto Protocol of 1998, ratified in 2002, and
3. The Paris Agreement of 2016, ratified in the same year.

Policy Framework Supporting Implementation of GHG Reduction Targets

Bhutan has issued and adopted mitigation-related policies, legal documents, and strategies as well as programs, plans, and schemes to support the implementation of GHG reduction targets. Some of the key documents are listed below:

1. *Forest and Nature Conservation Act of Bhutan (1995):* Ensures the protection and sustainable utilization of flora, fauna, and other natural resources of Bhutan to benefit present and future generations incorporating the concepts of sustainable development.
2. *The National Environment Protection Act (NEPA) (2007)*: An umbrella legislation on environment conservation and protection and outlines principles and a legal framework that has implications for all spheres of development in Bhutan.
3. *Bhutan Sustainable Hydropower Policy (2008):* Aims to mobilize fund and attract investments for accelerated hydropower development, enhance the revenue contribution to the Royal Government, and contribute towards the development of clean energy to mitigate problems related to global warming and climate change.
4. *National Strategy and Action Plan for Low Carbon Development (2012):* Ensures that national emissions of greenhouse gasses (GHG) remain less than the national sequestration capacity.

[27] Technical guidance for Calculation Scope 3 Emission, available in;
https://ghgprotocol.org/sites/default/files/2023-03/Scope3_Calculation_Guidance_0%5B1%5D.pdf

5. *Climate Change Policy of Kingdom of Bhutan (2020):* Aims to remain carbon neutral, ensure coordinated stakeholder participation, and integrate climate change challenges and opportunities into relevant plans and policies.
6. *2nd Nationally Determined Contributions (2021):* Maintains the commitment to remain carbon-neutral where the mission of greenhouse gases will not exceed carbon sequestration by its forests and sinks as first pledged in 2009 and reaffirmed in the first NDC.
7. *Low Emission Development Strategy (LEDS) for Surface Transport (2021):* Includes various targeted interventions to control emissions, such as promoting low-carbon vehicles, improving fuel efficiency, and enhancing public transportation systems. By addressing the transport sector, which is a significant source of GHG emissions in Bhutan, the plan plays a crucial role in the country's overall low emission development efforts.

Bhutan is a country with low greenhouse gas emissions, and its landscape is filled with forests, making it a net carbon sink according to its GHG inventories. Therefore, Bhutan does not have a target to reduce greenhouse gas emissions but aims to maintain its carbon neutral status instead.

International Standards and Guidelines

The international standards and guidelines applicable for Bhutan include a range of frameworks designed to ensure sustainable development, environmental protection, and social responsibility. Key among these are the standards set by the Intergovernmental Panel on Climate Change (IPCC) and the Greenhouse Gas Protocol as detailed below:

Intergovernmental Panel on Climate Change (IPCC)

IPCC is a panel established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to provide independent scientific advice on climate change.

The IPCC has developed a variety of guidance documents and recommended methodologies for GHG emissions inventories, including:

- The 2006 IPCC Guidelines for National GHG Inventories (IPCC, 2006).
- The 2019 IPCC Guidelines for National Greenhouse Gas Inventories, Refinement to the 2006.
- IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019).
- The Physical Science Basis, the Contribution of Working Group I to the Sixth Assessment Report of the intergovernmental Panel on Climate Change (IPCC, 2021).

The Greenhouse Gas Protocol Standard

The 'Greenhouse Gas Protocol - A Corporate Accounting and Reporting Standard' was designed by the World Resources Institute (WRI) to develop internationally accepted GHG accounting and reporting standards for businesses.

The standard and guidance were designed to support the businesses prepare a GHG inventory that represents a true and fair account of their emissions, through the use of standardized approaches and principles. The GHG protocol has been adopted by the International Organization for Standardization, endorsed by GHG initiatives (such as Carbon Disclosure Project) and is compatible with existing GHG trading schemes. For this assessment, we will use the

'Construction CO_2-e Measurement Protocol' as a guide for reporting in accordance with the Greenhouse Gas Protocol for construction companies. The Greenhouse Gas Protocol uses the methodologies and emission factors from the 2006 IPCC Guidelines as its basis.

E.7 ASSUMPTIONS

Assumptions made for the GHG assessment:

1) **Vehicle Types and Ratio:** The types of vehicles will be based on the vehicles running along the old road in 2024 (Traffic Count Venue: Aie Bridge, Gelephu) and linked to ARUP's model projections. However, due to Bhutan's diverse fuel usage, the proportion of vehicles using each type of fuel will also be calculated, referencing research from the Vehicle Emission Control Strategy Bhutan from ADB Vehicle Emission Control Strategy for Bhutan [28]. However, this calculation does not include two-wheeled vehicles.
2) **Fuel Usage:** Assuming Heavy vehicles and Medium use only diesel, while light vehicles includes both diesel and gasoline-powered for conservative estimates, with no transition to electric vehicles (EVs) included.
3) **Vehicle Growth Rate:** Based on the statistical numbers of vehicles running along the old road in 2024 (Traffic Count Venue: Aie Bridge, Gelephu), with a gradual increase to ARUP's model projections, using the growth rate of vehicle from 2035 and 2053.
4) **Operational Period:** Covering a period of 25 years. The calculation of GHG emissions during the operation phase will begin in 2029 and end in 2053.

This approach ensures consistency and allows for a more accurate comparison of the emissions attributable to the different routes, or the two scenarios. The rationales are delineated below:

- **Consistency**: Using similar parameters for vehicle types, fuel usage, and growth rates ensures that the comparison is based on consistent data, making it easier to isolate the impact of the route differences on GHG emissions.
- **Control Variables**: By keeping these factors constant, variables that could otherwise skew the results are under controlled condition. This helps in focusing on the differences in emissions due to the route characteristics alone.
- **Realistic Projections**: Assuming similar growth rates and vehicle types reflects a realistic scenario, as these factors are likely to be influenced by broader economic and policy trends that affect both routes similarly.

E.8 EMISSION FACTOR

The tables below provide emission factors for fuel used in mobile combustion sources. Fuel use data are most accurate for calculating CO_2 emissions, while distance-traveled data are most accurate for calculating CH_4 and N_2O emissions. For transport emission sources, the recommended approach is to collect both fuel use and distance data. Where one type of data is unavailable, vehicle fuel economy information (e.g., MPG) can be used to convert between these data types. For non-U.S. or U.K. countries, if more specific emission factors are not available, the 'Other' region can be considered. Emission factors from "Other" region are based on LHV (or NCV). Reporting organizations should consistently use the same calorific value within an inventory.

[28] Vehicle Emission Control Strategy Bhutan, Available in; vehicle emission control strategy bhutan (adb.org)

TABLE E.1 GHG EMISSIONS FACTOR

CO_2 Emission factors by fuel				
Region	Fuel	Fossil CO_2 EF	Biogenic CO_2 EF	EF Unit
Other[1]	Jet Kerosene	2.57		kg/L
Other[1]	Aviation Gasoline	2.18		kg/L
Other[1]	Motor Gasoline/Petrol	2.29		kg/L
Other[1]	On-Road Diesel Fuel	2.91		kg/L
Other[1]	Residual Fuel Oil	3.01		kg/L
Other[1]	Liquefied Petroleum Gases (LPG)	1.47		kg/L
Other[1]	Compressed Natural Gas (CNG)	1.88		kg/m^3
US	Kerosene - Type Jet Fuel	9.75		kg/US Gallon
US	Aviation Gasoline	8.31		kg/US Gallon
US	Motor Gasoline	8.78		kg/US Gallon
US	Diesel Fuel	10.21		kg/US Gallon
US	Residual Fuel Oil[2]	11.27		kg/US Gallon
US	Liquefied Petroleum Gases (LPG)	5.68		kg/US Gallon
US	Compressed Natural Gas (CNG)	0.054		kg/scf
US	Liquefied Natural Gas (LNG)	4.50		kg/US Gallon
US	Ethanol (100%)		5.75	kg/US Gallon
US	Biodiesel (100%)		9.45	kg/US Gallon
US	E85 Ethanol/Gasoline*	1.32	4.89	kg/US Gallon
US	B20 Biodiesel/Diesel*	8.17	1.89	kg/US Gallon
UK	Aviation spirit (Aviation Gasoline)	2.283		kg/L
UK	Aviation turbine fuel (Jet Fuel)	2.520		kg/L
UK	Diesel (100% mineral diesel)	2.626		kg/L
UK	Fuel oil (Residual Fuel Oil)	3.163		kg/L
UK	Petrol (100% mineral petrol) (Motor Gasoline)	2.331		kg/L
UK	Processed fuel oils - residual oil	3.163		kg/L
UK	Compressed Natural Gas (CNG)	0.448		kg/L
UK	Liquefied Natural Gas (LNG)	1.166		kg/L
UK	Liquefied Petroleum Gases (LPG)	1.555		kg/L
UK	Natural gas (100% mineral blend)	2.050		kg/m^3
UK	Bioethanol[3]		1.52	kg/L
UK	Biodiesel ME[3]		2.39	kg/L
UK	E85 Ethanol/Gasoline*	0.350	1.292	kg/L
UK	B20 Biodiesel/Diesel*	2.101	0.478	kg/L

1 'Other' region EFs are from the Stationary Combustion worksheet (values from liquid basis and gas basis columns).
2 This value corresponds to Residual Fuel Oil No. 6.
3 UK DEFRA only presented values in CO2e, using GWP-100 from the IPCC's Fifth Assessment Report (AR5). CH4 and N2O values presented in this table were reverse calculated using the same GWP values in order to be provided per individual GHG.
*Note: EFs for biofuel blends (E85 Ethanol/Gasoline and B20 Biodiesel/Diesel) were calculated with corresponding EFs of pure fuels and percentage composition within the blend (e.g., 85% Ethanol EF and 15% Motor Gasoline EF). Commonly used alternative fuel names are provided in parenthesis.

TABLE E.2 CH_4 AND N_2O EMISSION FACTORS BY FUEL AND VEHICLE TYPE

CH_4 and N_2O Emission Factors by Fuel and Vehicle Type							
Region	Fuel	Transport Type	Vehicle/Engine Type	CH_4 EF		N_2O EF	
				EF	EF Unit	EF	EF Unit Numerator
Other	Sub-bituminous Coal	Rail		2	kg/TJ	1.5	kg/TJ
Other	Diesel	Rail		4.15	kg/TJ	28.6	kg/TJ
Other	Diesel	Agriculture Equipment		4.15	kg/TJ	28.6	kg/TJ
Other	Diesel	Forestry Equipment		4.15	kg/TJ	28.6	kg/TJ
Other	Diesel	Industry Equipment		4.15	kg/TJ	28.6	kg/TJ
Other	Diesel	Household Equipment		4.15	kg/TJ	28.6	kg/TJ
Other	Motor Gasoline	Agriculture Equipment	4 stroke	80	kg/TJ	2	kg/TJ
Other	Motor Gasoline	Industry Equipment	4 stroke	50	kg/TJ	2	kg/TJ
Other	Motor Gasoline	Household Equipment	4 stroke	120	kg/TJ	2	kg/TJ
Other	Motor Gasoline	Agriculture Equipment	2 stroke	140	kg/TJ	0.4	kg/TJ
Other	Motor Gasoline	Forestry Equipment	2 stroke	170	kg/TJ	0.4	kg/TJ
Other	Motor Gasoline	Industry Equipment	2 stroke	130	kg/TJ	0.4	kg/TJ
Other	Motor Gasoline	Household Equipment	2 stroke	180	kg/TJ	0.4	kg/TJ
US	Residual Fuel Oil	Ship and Boat		1.1	g/US Gallon	0.31	g/US Gallon
US	Motor Gasoline	Ship and Boat	2 stroke	4.64	g/US Gallon	0.08	g/US Gallon
US	Motor Gasoline	Ship and Boat	4 stroke	2.26	g/US Gallon	0.01	g/US Gallon
US	Diesel Fuel	Ship and Boat		6.41	g/US Gallon	0.17	g/US Gallon
US	Diesel Fuel	Locomotives		0.8	g/US Gallon	0.26	g/US Gallon
US	Jet Fuel	Aircraft		0	g/US Gallon	0.3	g/US Gallon
US	Aviation Gasoline	Aircraft		7.06	g/US Gallon	0.11	g/US Gallon
US	Motor Gasoline	Agricultural Equipment[1]	2 stroke	6.92	g/US Gallon	0.47	g/US Gallon
US	Motor Gasoline	Agricultural Equipment[1]	4 stroke	1.94	g/US Gallon	1.21	g/US Gallon
US	Motor Gasoline	Agricultural Equipment[1]	Off-Road Trucks	1.94	g/US Gallon	1.2	g/US Gallon
US	Diesel Fuel	Agricultural Equipment[1]		1.27	g/US Gallon	1.07	g/US Gallon
US	Diesel Fuel	Agricultural Equipment[1]	Off-Road Trucks	0.91	g/US Gallon	0.56	g/US Gallon
US	LPG	Agricultural Equipment[1]		0.33	g/US Gallon	0.95	g/US Gallon
US	Motor Gasoline	Construction Equipment[2]	2 stroke	7.98	g/US Gallon	0.12	g/US Gallon
US	Motor Gasoline	Construction Equipment[2]	4 stroke	2.85	g/US Gallon	1.47	g/US Gallon
US	Motor Gasoline	Construction Equipment[2]	Off-Road Trucks	2.85	g/US Gallon	1.47	g/US Gallon
US	Diesel Fuel	Construction Equipment[2]		1.01	g/US Gallon	0.94	g/US Gallon
US	Diesel Fuel	Construction Equipment[2]	Off-Road Trucks	0.91	g/US Gallon	0.56	g/US Gallon
US	LPG	Construction Equipment[2]		0.59	g/US Gallon	0.5	g/US Gallon
US	Motor Gasoline	Lawn and Garden Equipment	2 stroke	7.29	g/US Gallon	0.31	g/US Gallon
US	Motor Gasoline	Lawn and Garden Equipment	4 stroke	3.00	g/US Gallon	1.49	g/US Gallon
US	Diesel Fuel	Lawn and Garden Equipment		0.66	g/US Gallon	0.49	g/US Gallon
US	LPG	Lawn and Garden Equipment		0.41	g/US Gallon	0.63	g/US Gallon
US	Motor Gasoline	Airport Equipment		1.02	g/US Gallon	1.07	g/US Gallon
US	Diesel	Airport Equipment		1.89	g/US Gallon	1.16	g/US Gallon
US	LPG	Airport Equipment		0.35	g/US Gallon	0.89	g/US Gallon
US	Motor Gasoline	Industrial/Commercial Equipment	2 stroke	7.13	g/US Gallon	0.5	g/US Gallon
US	Motor Gasoline	Industrial/Commercial Equipment	4 stroke	2.74	g/US Gallon	1.54	g/US Gallon
US	Diesel	Industrial/Commercial Equipment		0.42	g/US Gallon	0.6	g/US Gallon
US	LPG	Industrial/Commercial Equipment		0.44	g/US Gallon	0.64	g/US Gallon

CH_4 and N_2O Emission Factors by Fuel and Vehicle Type							
Region	Fuel	Transport Type	Vehicle/Engine Type	CH_4 EF		N_2O EF	
				EF	EF Unit	EF	EF Unit Numerator
US	Motor Gasoline	Logging Equipment	2 stroke	9.68	g/US Gallon	0	g/US Gallon
US	Motor Gasoline	Logging Equipment	4 stroke	3.24	g/US Gallon	2.06	g/US Gallon
US	Diesel	Logging Equipment		0.49	g/US Gallon	1.27	g/US Gallon
US	Motor Gasoline	Railroad Equipment		3.24	g/US Gallon	1.81	g/US Gallon
US	Diesel	Railroad Equipment		0.4	g/US Gallon	0.95	g/US Gallon
US	LPG	Railroad Equipment		2.00	g/US Gallon	0.01	g/US Gallon
US	Motor Gasoline	Recreational Equipment	2 stroke	9.8	g/US Gallon	0.11	g/US Gallon
US	Motor Gasoline	Recreational Equipment	4 stroke	2.72	g/US Gallon	1.48	g/US Gallon
US	Diesel	Recreational Equipment		0.73	g/US Gallon	0.66	g/US Gallon
US	LPG	Recreational Equipment		0.43	g/US Gallon	0.61	g/US Gallon

[1]Includes equipment, such as tractors and combines, as well as fuel consumption from trucks that are used off-road in agriculture.
[2]Includes equipment, such as cranes, dumpers, and excavators, as well as fuel consumption from trucks that are used off-road in construction.
Note: Energy-basis EFs (kg/TJ) are LHV (NCV).

E.9 GHG EMISSION CALCULATION

GHG emission calculation of construction phase, the calculation based on used of construction equipment and fuel consumption of each equipment. The GHG emission calculation result is show in table below.

TABLE E.3 GHG EMISSIONS CALCULATION IN CONSTRUCTION PHASE

Activity	Equipment		GHG emission					
	Type	Amount	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Scope 1 (ton CO_2-e)	Scope 2 (ton CO_2-e)	Total (ton CO_2-e)
Road Construction								
Site Clearance	Crane, mobile	1	159.28	0.44	3.71	163.42		163.42
	Excavator/loader, wheeled/tracked	1	142.81	0.39	3.33	146.53		146.53
	Lorry	1	71.28	0.19	1.66	73.13		73.13
Roadworks, Pavement, Drainage and Utilities	Air compressor, air flow > 10 m^3/min and <= 30 m^3/min	2	445.40	1.22	10.38	456.99		456.99
	Asphalt paver	2	1,187.97	3.25	27.68	1,218.90		1,218.90
	Crane, mobile	2	796.38	2.18	18.55	817.11		817.11
	Dump truck	2	761.18	2.08	17.73	781.00		781.00
	Excavator/loader, wheeled/tracked	2	714.04	1.95	16.64	732.63		732.63
	Generator, silenced, 75 dB(A) at 7 m	2	739.18	2.02	17.22	758.42		758.42
	Lorry	2	356.39	0.97	8.30	365.67		365.67
	Paint line marker	2	-	-	-		-	-
	Roller, vibratory	2	272.10	0.74	6.34	279.19		279.19
	Water pump, submersible	2	74.52				74.52	74.52
Culverts	Crane, mobile (diesel)	1	238.91	0.65	5.57	245.13		245.13
	Excavator/loader, wheeled/tracked	1	214.21	0.59	0.02	214.82		214.82
	Lorry	1	106.92	0.29	0.01	107.22		107.22
	Concrete lorry mixer	1	106.92	0.29	0.01	107.22		107.22
	Bar bender and cutter (electric)	1	74.52	-	-		74.52	74.52

Activity	Equipment		GHG emission					
	Type	Amount	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Scope 1 (ton CO_2-e)	Scope 2 (ton CO_2-e)	Total (ton CO_2-e)
	Poker, vibratory, hand-held	2	30.17	0.08	0.003	30.26		30.26
	Generator, silenced, 75 dB(A) at 7 m	1	221.75	0.61	5.167	227.53		227.53
	Saw, circular, wood	1	181.02	0.49	0.015	181.53		181.53
Slope Works	Breaker, hand-held, mass <= 10 kg	4	75.43	0.21	0.006	75.64		75.64
	Breaker, excavator mounted (hydraulic)	1	357.02	0.98	0.030	358.03		358.03
	Compactor, vibratory	1	251.42	0.69	0.021	252.13		252.13
	Drilling rig	1	471.42	1.29	0.040	472.75		472.75
	Excavator/loader, wheeled/tracked	1	357.02	0.98	0.030	358.03		358.03
	Generator, silenced, 75 dB(A) at 7 m	1	369.59	1.01	0.032	370.63		370.63
	Grout mixer	1	94.28	0.26	0.008	94.55		94.55
	Grout pump	1	118.95	0.33	0.010	119.29		119.29
	Lorry	1	178.20	0.49	0.015	178.70		178.70
Bridge Construction								
Piling Works	Air compressor, air flow > 10 m^3/min and <= 30 m^3/min	1	356.32	0.97	8.30	365.59		365.59
	Breaker, hand-held, mass <= 10 kg	1	30.17	0.08	0.00	30.26		30.26
	Concrete lorry mixer	1	285.11	0.78	0.02	285.92		285.92
	Crane, mobile	1	637.11	1.74	0.05	638.90		638.90
	Excavator/loader, wheeled/tracked	1	571.23	1.56	0.05	572.84		572.84
	Generator, silenced, 75 dB(A) at 7 m	1	591.35	1.62	0.05	593.01		593.01
	Lorry	1	285.11	0.78	0.02	285.92		285.92
	Piling, large diameter bored, grab and chisel	1	754.27	2.06	0.06	756.39		756.39
	Water pump	1	59.62	-	-		59.62	59.62
Construction of Pile Caps and Piers	Air compressor, air flow > 10 m^3/min and <= 30 m^3/min	1	133.62	0.37	3.11	137.10		137.10
	Bar bender and cutter	1	178.85				178.85	178.85
	Breaker, hand-held, mass <= 10 kg	1	11.31	0.03	0.26	11.61		11.61
	Concrete lorry mixer	1	106.92	0.29	2.49	109.70		109.70
	Concrete mixer (petrol)	1	29.65	0.29	1.37	31.32		31.32
	Concrete pump, stationary/lorry mounted	1	37.71	0.10	0.88	38.70		38.70
	Crane, mobile (diesel)	1	238.91	0.65	5.57	245.13		245.13
	Excavator/loader, wheeled/tracked	1	214.21	0.59	4.99	219.79		219.79
	Lorry	1	106.92	0.29	2.49	109.70		109.70
	Poker, vibratory, hand-held	2	30.17	0.08	0.70	30.96		30.96
	Generator, silenced, 75 dB(A) at 7 m	1	221.75	0.61	5.17	227.53		227.53
	Saw, circular, wood	2	362.05	0.99	8.44	371.47		371.47
Construction of Superstructure	Bar bender and cutter (electric)	1	178.85	-	-		178.85	178.85
	Concrete lorry mixer	1	106.92	0.29	2.49	109.70		109.70
	Concrete mixer (petrol)	1	29.65	0.29	1.37	31.32		31.32
	Concrete pump, stationary/lorry mounted	1	37.71	0.10	0.88	38.70		38.70
	Crane, mobile (diesel)	1	238.91	0.65	5.57	245.13		245.13
	Generator, silenced, 75 dB(A) at 7 m	1	221.75	0.61	5.17	227.53		227.53

Activity	Equipment		GHG emission					
	Type	Amount	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Scope 1 (ton CO_2-e)	Scope 2 (ton CO_2-e)	Total (ton CO_2-e)
	Lorry	1	106.92	0.29	2.49	109.70		109.70
	Poker, vibratory, hand-held	2	30.17	0.08	0.70	30.96		30.96
	Saw, circular, wood	2	362.05	0.99	8.44	371.47		371.47
	Large Travelling formwork for in-situ balanced cantilever construction	2	-	-	-			
Miscellaneous								
River Training Works	Crane, mobile (diesel)	1	159.28	0.44	3.71	163.42		163.42
	Excavator/loader, wheeled/tracked	1	142.81	0.39	3.33	146.53		146.53
	Generator, silenced, 75 dB(A) at 7 m	1	147.84	0.40	3.44	151.68		151.68
	Lorry	1	71.28	0.19	1.66	73.13		73.13
Landscape Works	Crane, mobile (diesel)	1	79.64	0.22	1.86	81.71		81.71
	Excavator/loader, wheeled/tracked	1	71.40	0.20	1.66	73.26		73.26
	Generator, silenced, 75 dB(A) at 7 m	1	73.92	0.20	1.72	75.84		75.84
	Lorry	1	35.64	0.10	0.83	36.57		36.57
Tree Felling / Transplanting Works	Breaker, hand-held	1	7.54	0.02	0.18	7.74		7.74
	Crane, mobile (diesel)	1	159.28	0.44	3.71	163.42		163.42
	Excavator/loader, wheeled/tracked	1	142.81	0.39	3.33	146.53		146.53
	Lorry	1	71.28	0.19	1.66	73.13		73.13
	Saw, circular, wood	1	120.68	0.33	2.81	123.82		123.82
Construction of Concrete Batching Plant	Air compressor, air flow > 10 m^3/min and <= 30 m^3/min		89.08	0.24	2.08	91.40		91.40
	Breaker, hand-held, mass > 35 kg	1	12.57	0.03	0.29	12.90		12.90
	Concrete lorry mixer	1	214.09	0.59	4.99	219.66		219.66
	Crane, mobile (diesel)	1	159.28	0.44	3.71	163.42		163.42
	Dump truck	1	152.24	0.42	3.55	156.20		156.20
	Excavator/loader, wheeled/tracked	1	142.81	0.39	3.33	146.53		146.53
	Generator, silenced, 75 dB(A) at 7 m	1	147.84	0.40	3.44	151.68		151.68
	Poker, vibratory, hand-held	1	49.68				49.68	49.68
Total			**17,328.36**	**47.85**	**264.97**	**17,67.15**	**363.02**	**18,034.38**

GHG emission calculation of operation phase, the calculation separated into Scenario 1 and 2. In both scenarios calculate based on same amount of vehicle and growth rate. The GHG emission calculation result is show in table below.

Scenario 1 GHG emission calculation

TABLE E-4 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF HEAVY VEHICLES (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	378,921	9,130	24	212	9,366
2030	413,851	9,971	27	232	10,230
2031	452,002	10,890	29	253	11,172
2032	493,669	11,894	32	277	12,203
2033	539,177	12,991	35	302	13,328
2034	588,881	14,188	38	330	14,556
2035	643,166	15,496	42	361	15,899
2036	659,190	15,883	43	370	16,296
2037	675,614	16,278	44	379	16,701
2038	692,447	16,684	45	388	17,117
2039	709,699	17,100	46	398	17,544
2040	727,382	17,526	47	408	17,981
2041	745,504	17,962	49	418	18,429
2042	764,078	18,410	50	428	18,888
2043	783,115	18,869	51	439	19,359
2044	802,627	19,339	52	450	19,841
2045	822,624	19,820	54	461	20,335
2046	843,120	20,314	55	473	20,842
2047	864,126	20,820	56	485	21,361
2048	885,656	21,339	58	497	21,894
2049	907,722	21,871	59	509	22,439
2050	930,338	22,416	61	522	22,999
2051	953,517	22,974	62	535	23,571
2052	977,274	23,547	64	548	24,159
2053	1,001,623	24,133	65	562	24,760

TABLE E-5 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF MEDIUM VEHICLES (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	243,349	3,823	10	89	3,922
2030	265,782	4,176	11	97	4,284
2031	290,282	4,561	12	106	4,679
2032	317,042	4,981	13	116	5,110
2033	346,268	5,441	14	126	5,581
2034	378,188	5,942	16	138	6,096
2035	413,051	6,490	17	151	6,658
2036	423,342	6,652	18	154	6,824
2037	433,890	6,818	18	158	6,994
2038	444,700	6,988	19	162	7,169
2039	455,780	7,162	19	166	7,347
2040	467,136	7,340	20	171	7,531
2041	478,774	7,523	20	175	7,718
2042	490,703	7,710	21	179	7,910
2043	502,929	7,903	21	184	8,108
2044	515,459	8,099	22	188	8,309
2045	528,302	8,301	22	193	8,516
2046	541,465	8,508	23	198	8,729
2047	554,955	8,720	23	203	8,946
2048	568,782	8,937	24	208	9,169
2049	582,953	9,160	25	213	9,398
2050	597,477	9,388	25	218	9,631
2051	612,363	9,622	26	224	9,872
2052	627,620	9,862	26	229	10,117
2053	643,258	10,108	27	235	10,370

TABLE E-6 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF LIGHT VEHICLES (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	2,485,447	27,990	76	652	28,718
2030	2,714,566	30,570	83	712	31,365
2031	2,964,805	33,388	91	777	34,256
2032	3,238,113	36,466	99	849	37,414
2033	3,536,615	39,828	108	927	40,863
2034	3,862,634	43,499	118	1,013	44,630
2035	4,218,707	47,509	129	1,106	48,744
2036	4,323,816	48,693	133	1,134	49,960
2037	4,431,544	49,906	136	1,162	51,204
2038	4,541,955	51,150	139	1,191	52,480
2039	4,655,118	52,424	143	1,221	53,788
2040	4,771,100	53,730	146	1,251	55,127
2041	4,889,972	55,069	150	1,283	56,502
2042	5,011,805	56,441	154	1,315	57,910
2043	5,136,674	57,847	158	1,347	59,352
2044	5,264,654	59,288	162	1,381	60,831
2045	5,395,823	60,766	166	1,415	62,347
2046	5,530,260	62,280	170	1,451	63,901
2047	5,668,046	63,831	174	1,487	65,492
2048	5,809,265	65,422	178	1,524	67,124
2049	5,954,003	67,052	183	1,562	68,797
2050	6,102,346	68,722	187	1,601	70,510
2051	6,254,386	70,435	192	1,641	72,268
2052	6,410,214	72,189	197	1,681	74,067
2053	6,569,924	73,988	202	1,723	75,913

TABLE E-7 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF LIGHT VEHICLES (GASOLINE)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	3,728,171	29,198	286	1,351	30,835
2030	4,071,849	31,889	312	1,476	33,677
2031	4,447,208	34,829	341	1,612	36,782
2032	4,857,169	38,040	372	1,761	40,173
2033	5,304,922	41,547	407	1,923	43,877
2034	5,793,951	45,377	444	2,100	47,921
2035	6,328,061	49,560	485	2,294	52,339
2036	6,485,724	50,794	497	2,351	53,642
2037	6,647,316	52,060	510	2,410	54,980
2038	6,812,933	53,357	522	2,470	56,349
2039	6,982,677	54,686	535	2,531	57,752
2040	7,156,650	56,049	549	2,595	59,193
2041	7,334,958	57,445	562	2,659	60,666
2042	7,517,708	58,877	576	2,725	62,178
2043	7,705,011	60,344	591	2,793	63,728
2044	7,896,981	61,847	606	2,863	65,316
2045	8,093,734	63,388	621	2,934	66,943
2046	8,295,389	64,967	636	3,007	68,610
2047	8,502,069	66,586	652	3,082	70,320
2048	8,713,897	68,245	668	3,159	72,072
2049	8,931,004	69,945	685	3,238	73,868
2050	9,153,519	71,688	702	3,319	75,709
2051	9,381,579	73,474	719	3,401	77,594
2052	9,615,321	75,305	737	3,486	79,528
2053	9,854,886	77,181	756	3,573	81,510

Scenario 2 GHG emission calculation

TABLE E-8 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF HEAVY VEHICLE (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	378,921	2,840	7	66	2,913
2030	413,851	3,102	8	72	3,182
2031	452,002	3,388	9	78	3,475
2032	493,669	3,700	10	86	3,796
2033	539,177	4,041	11	94	4,146
2034	588,881	4,414	12	102	4,528
2035	643,166	4,821	13	112	4,946
2036	659,190	4,941	13	115	5,069
2037	675,614	5,064	13	117	5,194
2038	692,447	5,190	14	120	5,324
2039	709,699	5,320	14	123	5,457
2040	727,382	5,452	14	127	5,593
2041	745,504	5,588	15	130	5,733
2042	764,078	5,727	15	133	5,875
2043	783,115	5,870	16	136	6,022
2044	802,627	6,016	16	140	6,172
2045	822,624	6,166	16	143	6,325
2046	843,120	6,320	17	147	6,484
2047	864,126	6,477	17	150	6,644
2048	885,656	6,639	18	154	6,811
2049	907,722	6,804	18	158	6,980
2050	930,338	6,973	19	162	7,154
2051	953,517	7,147	19	166	7,332
2052	977,274	7,325	20	170	7,515
2053	1,001,623	7,508	20	174	7,702

TABLE E-9 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF MEDIUM VEHICLE (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	243,349	1,189	3	27	1,219
2030	265,782	1,299	3	30	1,332
2031	290,282	1,419	3	33	1,455
2032	317,042	1,549	4	36	1,589
2033	346,268	1,692	4	39	1,735
2034	378,188	1,848	5	43	1,896
2035	413,051	2,019	5	47	2,071
2036	423,342	2,069	5	48	2,122
2037	433,890	2,121	5	49	2,175
2038	444,700	2,174	5	50	2,229
2039	455,780	2,228	6	51	2,285
2040	467,136	2,283	6	53	2,342
2041	478,774	2,340	6	54	2,400
2042	490,703	2,398	6	55	2,459
2043	502,929	2,458	6	57	2,521
2044	515,459	2,519	6	58	2,583
2045	528,302	2,582	7	60	2,649
2046	541,465	2,647	7	61	2,715
2047	554,955	2,713	7	63	2,783
2048	568,782	2,780	7	64	2,851
2049	582,953	2,849	7	66	2,922
2050	597,477	2,920	7	68	2,995
2051	612,363	2,993	8	69	3,070
2052	627,620	3,068	8	71	3,147
2053	643,258	3,144	8	73	3,225

TABLE E-10 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF LIGHT VEHICLE (DIESEL)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	2,485,447	8,708	23	202	8,933
2030	2,714,566	9,510	25	221	9,756
2031	2,964,805	10,387	28	242	10,657
2032	3,238,113	11,345	31	264	11,640
2033	3,536,615	12,391	33	288	12,712
2034	3,862,634	13,533	36	315	13,884
2035	4,218,707	14,780	40	344	15,164
2036	4,323,816	15,149	41	352	15,542
2037	4,431,544	15,526	42	361	15,929
2038	4,541,955	15,913	43	370	16,326
2039	4,655,118	16,309	44	379	16,732
2040	4,771,100	16,716	45	389	17,150
2041	4,889,972	17,132	46	399	17,577
2042	5,011,805	17,559	47	409	18,015
2043	5,136,674	17,997	49	419	18,465
2044	5,264,654	18,445	50	429	18,924
2045	5,395,823	18,905	51	440	19,396
2046	5,530,260	19,376	52	451	19,879
2047	5,668,046	19,858	54	462	20,374
2048	5,809,265	20,353	55	474	20,882
2049	5,954,003	20,860	57	486	21,403
2050	6,102,346	21,380	58	498	21,936
2051	6,254,386	21,913	59	510	22,482
2052	6,410,214	22,459	61	523	23,043
2053	6,569,924	23,018	62	536	23,616

TABLE E-11 GHG EMISSIONS CALCULATION IN OPERATION PHASE OF LIGHT VEHICLE (GASOLINE)

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2029	3,728,171	9,083	89	420	9,592
2030	4,071,849	9,921	97	459	10,477
2031	4,447,208	10,835	106	501	11,442
2032	4,857,169	11,834	115	547	12,496
2033	5,304,922	12,925	126	598	13,649
2034	5,793,951	14,117	138	653	14,908
2035	6,328,061	15,418	151	713	16,282
2036	6,485,724	15,802	154	731	16,687
2037	6,647,316	16,196	158	749	17,103
2038	6,812,933	16,600	162	768	17,530
2039	6,982,677	17,013	166	787	17,966
2040	7,156,650	17,437	170	807	18,414
2041	7,334,958	17,872	175	827	18,874
2042	7,517,708	18,317	179	848	19,344
2043	7,705,011	18,773	183	869	19,825
2044	7,896,981	19,241	188	890	20,319
2045	8,093,734	19,720	193	913	20,826
2046	8,295,389	20,212	198	935	21,345
2047	8,502,069	20,715	202	959	21,876
2048	8,713,897	21,231	208	983	22,422
2049	8,931,004	21,760	213	1,007	22,980

Year	Vehicle/year	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
2050	9,153,519	22,303	218	1,032	23,553
2051	9,381,579	22,858	223	1,058	24,139
2052	9,615,321	23,428	229	1,084	24,741
2053	9,854,886	24,012	235	1,111	25,358

TABLE E-12 SUMMARY OF GHG EMISSIONS CALCULATION IN OPERATION PHASE

	GHG emission			
	CO_2 (ton CO_2-e)	CH_4 (ton CO_2-e)	N_2O (ton CO_2-e)	Total GHG emission (ton CO_2-e)
Scenario 1	3,379,221	19,125	111,037	3,509,383
Scenario 2	1,051,279	5,916	34,512	1,091,707

B.5 OTHER REFERENCE

The source of fuel consumption that use in calculation are shown in table C1. Note that the fuel consumption that use in calculation comes from assumption by almost of fuel consumption that disclose as a public.

Equipment type	Source
Crane, mobile	Housing Element Update (2021-2029) Santamonica; https://www.santamonica.gov/media/Housing-Element-Update-2021-to-2029/APPENDIX%20E-ENERGY%20CAKCULATIONS.pdf
Excavator/loader, wheeled/tracked	Housing Element Update (2021-2029) Santamonica; https://www.santamonica.gov/media/Housing-Element-Update-2021-to-2029/APPENDIX%20E-ENERGY%20CAKCULATIONS.pdf
Lorry	U.S. Department of Energy; Energy Efficiency & Renewable Energy - Long-Haul Truck Idling Burns Up Profits ; https://afdc.energy.gov/files/u/publication/hdv_idling_2015.pdf
Air compressor, air flow > 10m^3/min and <= 30m^3/min	Housing Element Update (2021-2029) Santamonica; https://www.santamonica.gov/media/Housing-Element-Update-2021-to-2029/APPENDIX%20E-ENERGY%20CAKCULATIONS.pdf
Asphalt paver	AP1000F Asphalt Paver Fuel Burn – Medium ; https://www.ezyquip.com.au/product/ap1000f-asphalt-paver/
Dump truck	Equipment World ; https://www.equipmentworld.com/regulations/equipment/article/14948071/the-owning-and-operating-costs-of-dump-trucks?__cf_chl_tk=kZuW4y6OEb_d6lk5XQqrpJcwSEKEVeaJ9uWAN2Lfmzc-1728375797-0.0.1.1-10559
Generator, silenced, 75 dB(A) at 7 m	Housing Element Update (2021-2029) Santamonica; https://www.santamonica.gov/media/Housing-Element-Update-2021-to-2029/APPENDIX%20E-ENERGY%20CAKCULATIONS.pdf
Paint line marker	-
Roller, vibratory	Average from displacement from example roller of Sakai ; https://sakai.co.id/wp-content/uploads/2021/09/sv520_2018.01.19.pdf
Water pump, submersible	Energy Bot; https://www.energybot.com/energy-usage/water-pump.html
Concrete lorry mixer	U.S. Department of Energy; Energy Efficiency & Renewable Energy - Long-Haul Truck Idling Burns Up Profits ; https://afdc.energy.gov/files/u/publication/hdv_idling_2015.pdf
Concrete mixer	Adam jin ; https://www.scribd.com/document/458748773/fuel-consumption
Bar bender and cutter (electric)	Average Bar bender and Cutter; https://wmhkzw.en.made-in-china.com/product/nNqmLdMcXPVY/China-3kw-380V-Manual-Control-Electric-Steel-Bar-Bender-Machine.html
Poker, vibratory, hand-held	Average Poker, vibratory, hand-held; https://www.multivibe.com/gas-concrete-vibrators

Equipment type	Source
Saw, circular, wood	Average Saw, Circular, wood; https://shuntool.com/article/how-many-watts-circular-saw
Breaker, hand-held, mass <= 10kg	Average Breaker hand-held; https://www.atlascopco.com/content/dam/atlas-copco/construction-technique/portable-energy/documents/8_handheld_tools/tools-book/2023/handheld-tools-book-en.pdf
Breaker, excavator mounted (hydraulic)	Centex Excavation; https://centexexcavation.com/how-much-fuel-does-an-excavator-use-per-hour/
Compactor, vibratory	Adam jin ; https://www.scribd.com/document/458748773/fuel-consumption
Drilling rig	Adam jin ; https://www.scribd.com/document/458748773/fuel-consumption
Grout mixer	Average Grout mixer; https://quikspray.com/grout-mixers/
Grout pump	Average Grout pump; https://concretepumping.com/topic/schwing-runs-fuel-efficiency-test-4-pumps-pumping-into-each-other-for-5-hours
Piling, large diameter bored, grab and chisel	Adam jin ; https://www.scribd.com/document/458748773/fuel-consumption
Concrete pump, stationary/lorry mounted	Average concrete pump, stationary; http://schwingpartsstore.com/wp-content/uploads/2019/08/2019-SP-Product-Guide-min.pdf

*The fuel consumption values provided are general estimates and may not be highly accurate. However, if you have the energy consumption data for construction equipment, you can advise us accordingly.

APPENDIX F BIODIVERSITY BASELINE METHODOLOGY

F BIODIVERSITY BASELINE METHODOLOGY

F.1 DESKTOP REVIEW

A desktop review was undertaken to provide an initial understanding of the habitat and species within the Project Area, areas of potential biodiversity importance that may be affected by the project and to identify where critical data gaps may exist. The gap analysis was used to guide follow-up field surveys undertaken in July and August 2024 within the Project area and its proximity, which, along with secondary data and expert consultation (***Section F.2***) allowed development of a reasonably complete baseline biodiversity data set adequate for completion of the ESIA and associated Critical Habitat Assessment (CHA). This process was used to identify habitat contiguity, habitats of conservation significance (e.g., protected areas, key biodiversity areas, etc.) and probable hotspots for migratory and congregatory species. A list of key data used in the desktop review are listed in ***Table F***.1**;** additional secondary sources are referenced as footnotes in the respective chapters.

TABLE F.1 KEY SECONDARY DATA SOURCES

No.	Source	Purpose	Link
1.	Integrated Biodiversity Assessment Tool (IBAT) for Business	The IBAT tool screens a potential location for ecological sensitivity and provides a list of species occurring within a 50 km radius. The tool also highlights potential Critical Habitat triggers by determining proximity to migration pathways, legally protected areas and key biodiversity areas. An IBAT analysis was carried out with respect to the Project, under license 35468-63737, from the 9 May 2024.	None; IBAT is a licensed product that ERM has obtained for the purpose of biodiversity screening across projects.
2.	IUCN Red List for Threatened Species online version	The IUCN Red List provides a list of threatened species by classifying them from Least Concern (LC) to Critically Endangered (CR) through an understanding of their global distribution, population numbers, and trends in population decline and stresses on the species. As part of the classification, the global distribution and habitat preference of the species is described.	https://www.iucnredlist.org/
3.	Birdlife Data Zone	BirdLife International maintains a database on Endemic Bird Areas (EBA) and Important Bird Areas (IBAs) that provides a list of species found in these designated areas, measure of sensitivity of these habitats and identifies migratory, congregatory and threatened species in the area.	http://datazone.birdlife.org/home

No.	Source	Purpose	Link
4.	ebird.org	ebird.org provides a geo-referenced list of identified bird species in a given area. The ebird.org database was used to confirm presence/absence of bird species within the Project landscape.	https://ebird.org/home
5.	UNESCO World Heritage Site	This provides an insight into the network of "Biosphere Reserve" and "Natural World Heritage Sites"	https://whc.unesco.org/
6.	Alliance for Zero Extinction Sites	To identify proximity to any declared Alliance for Zero Extinction Sites	https://zeroextinction.org/
7.	Global Biodiversity Information Facility (GBIF) and iNaturalist	GBIF is an international network and research infrastructure funded by the world's governments and aimed at providing anyone, anywhere, open access to data about all types of life on Earth.	https://www.gbif.org/ https://www.inaturalist.org/
8.	World Database on Protected Areas	The World Database on Protected Areas is one of the largest assembly of data on the world's terrestrial and marine protected areas.	https://www.protectedplanet.net/en
9.	Ramsar convention	The Convention on Wetlands is the intergovernmental treaty that provides the framework for the conservation and wise use of wetlands and their resources.	https://www.ramsar.org/

F.2 EXPERT CONSULTATION

ERM conducted consultations with various Bhutanese species and conservation experts in July and August 2024 to gain a deeper understanding of the biological landscape of the Project area (***Table* F**.2).

TABLE F.2 KEY EXPERTS CONSULTED

No.	Name	Designation	Expertise	Engagement format
1	Phub Dhendup	Chief Forestry Officer, Ministry of Agriculture and Forests, Sarpang	Wildlife Management and Human Wildlife Conflict	Physical meeting and email correspondence
2	Dorji Rabten	Chief Forestry Officer, Phibsoo Wildlife Sanctuary	Wildlife management, biodiversity and ecology	Physical meeting and email correspondence
3	Samten Wangchuk	Forest Officer, Royal Manas National Park	Wildlife management, biodiversity and ecology	Physical meeting and email correspondence

No.	Name	Designation	Expertise	Engagement format
4	Dorji Wangchuk	Forest Officer, Royal Manas National Park	Wildlife management, biodiversity and ecology	Physical meeting
5	Sonam Tshewang	Officer, The National Development Centre for Aquaculture	Fish diversity and ecology	Physical meeting
6	Drukpola	Program director of Ecological Conservation and Fish Species, Sarpang	Fish diversity and ecology	Physical meeting
7	Jigme Tshering	Chief of Gelephu Thromde	Ecology of Sarpang	Physical meeting
8	Sherab Gyeltshen	Environment Officer of Gelephu Thromde	Ecology of Sarpang	Physical meeting
9	Sherub Sherub	Professor at Ugyen Wangchuck Institute for Conservation and Environment	Ecology and species diversity of Sarpang	Online meeting
10	Kinley Tenzin (PhD)	Executive Director, Royal Society for Protection of Nature	Biodiversity and conservation initiatives	Physical meeting
11	Chogyal Tenzin	Senior Program Officer, Civil Society Organizations Authority	Funding management of biodiversity-related initiatives	Physical meeting
12	Ugyen Dorji	Dean of Student Affairs, College of Natural Resources, Royal University of Bhutan	Aquatic ecology	Physical meeting

F.3 SUPPLEMENTAL FIELD SURVEYS

Supplemental field surveys were undertaken to improve the quality of the baseline data and better inform the project ESIA and CHA targeted the following:

- Flora composition and habitat health;
- Faunal presence / absence including:
  - Mammals;
  - Birds;
  - Herpetofauna;
  - Ichthyofauna; and
  - Macrozoobenthos.

It should be noted that, due to survey limitations, the species counts likely underestimate the true population. While the survey confirms the presence of species observed, it cannot definitively rule out the presence of others that were not detected.

F.3.1 TERRESTRIAL SURVEY

The terrestrial flora and fauna survey was conducted in the monsoon season from 12 July - 29 August 2024. In Bhutan, the monsoon season typically starts in June and lasts until September, bringing heavy rainfall, especially in the southern regions. Post-monsoon rains can also occur in October and November.

For the purpose of biodiversity management, the Government of Bhutan has divided the country into 2424 monitoring grids of 4x4 km, called Biodiversity Monitoring Grids (BMG). Each BMG is assigned a numeric code, with grid numbers starting from 0001 to 2424. The survey area included the proposed road alignment and a 750 m assessment buffer either side of the Project. Considering the survey covered a smaller area along the proposed highway, a grid size of 1x1 km or 2x2 km (camera trap) was adopted instead of the 4x4 km described in the Biodiversity Monitoring and Social Survey Protocol of Bhutan[29], (***Table F***.3**)**. The smaller grid ensures that biodiversity monitoring is tailored to the scale of the potential Impact Area and are nested within the country-level 4x4 grid.

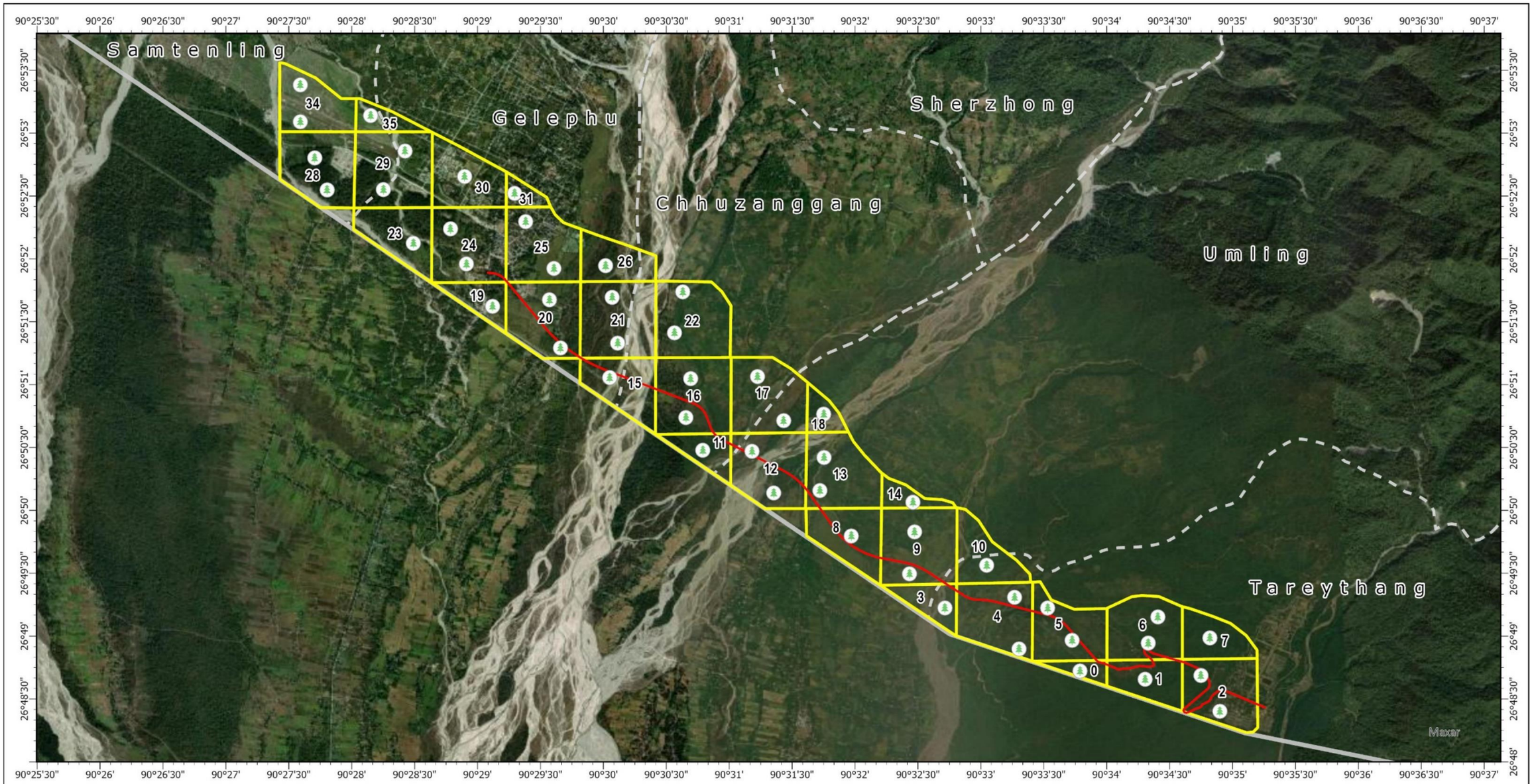
[29] DoFPS 2020. Biodiversity Monitoring and Social Surveying Protocol of Bhutan, Department of Forests and Park Services, Ministry of Agriculture and Forests, Thimphu, Bhutan.

TABLE F.3 TERRESTRIAL SURVEY METHODOLOGY

Survey	Date	Survey Technique	Survey Methods	Survey Effort
Flora (***Figure F-1***)	12 July – 02 August 2024	Quadrat survey	Inside the defined grid for the baseline survey, entering 200 m from the grid's boundary, two plots of 20x20 m were established as far as possible along the altitudinal gradient at 500 m apart. A vegetation plot inside the grid was chosen to represent the major forest type of the area. • Tree and shrub sampling: Both the trees (height > 1.3 m) and shrub species were recorded on the same data form as in Annexure 1 of the Flora Monitoring Protocol of Bhutan, 2020 (FMPB). Recorded data included Species name, Diameter at Breast Height (DBH), height, status, and stem type. • Herbs: a sub-plot size of 2x2 m quadrate was established and herbs data was recorded as in Annexure 2 of the FMPB, 2020. Species, height, and crown cover C (%) were noted. • Regeneration data collection: Regeneration data was collected inside the same herb plot (2x2 m). The data was collected as per Annexure 3 of the FMPB, 2020. Recorded data included Species, height, and age. • Epiphytic plants: Epiphyte data was recorded in the vegetation plot as per Annexure 4 of the FMPB, 2020.	71 vegetation plots were surveyed.
Bird (***Figure F-2***)	15 July – 02 August 2024	Transect survey	The survey aligns with the Bhutan Bird Monitoring Protocol (BBMP). The survey team walked along the existing path / road or proposed road alignment within the survey area in the morning (05:00 – 11:00) and evening (16:00 – 19:00) when birds are active. Birds were recorded when seen directly or from the call using the MacKinnon Listing Method. The MacKinnon List method listed all birds seen or heard in chronological order of detection.	A total of 33 grids were surveyed with a total of 58.65 km of transect.
Herpetofauna (***Figure F-3***)	13 July – 30 July 2024	Transect survey	The survey team walked along the transects from 8 am to 6 pm and occasionally 9 pm. Each transect lengths from 0.7 km to 3.2 km. Species presence was recorded either through visual encounter or sound. All the species detected or observed were photographed (mobile camera). The nocturnal Auditory Amphibian Counts method was used, which involved surveyors reaching the water bodies at night and listening to each wetland or water bodies. Those species with doubtful or unknown identities were captured/caught; amphibians and lizards with Frye net and hand with gloves and snake species using hook, tong or forked sticks, for proper observation and photography for identity confirmation. Night survey (19:00 – 22:00) was conducted for only transect in grid no. 9 given the inaccessibility from the base camp and Health and Safety risks related to elephants.	A total of 33 grids were surveyed with a total of 56.73 km of the transect.
Large and medium-sized mammals (***Figure F-4***)	13 July – 30 July 2024	Transect survey	The transect sampling was designed by the Distance for Windows software[30] with 1-2km transect line laid within a grid of 1x1 km covering the major habitat type. On occasion, a transect is continued into adjacent grid. A group of four (04) members were deployed for the data collection. Two (02) observers walked at the front (one observed the ground evidence and the other observed the tree canopy) followed by the data recorder. The security person is last. All sightings and signs, i.e., droppings, tracks, scrape marks, hairs, and scent marks were recorded along with a photo reference.	A total of 41.9 kilometers of transects were surveyed.
Mammals (***Figure F-5***)	13 July – 29 August 2024	Camera trap	A grid size of 2x2km was laid out along the Project Area spanning a length of 18 km. Camera trap Reconyx HC500 Hyperfire was used to capture five (05) consecutive images per trigger, during daytime and nighttime with no delay between triggers. Camera sensitivity was set to medium-high to detect small species. For each grid, two (02) camera stations were designated, with one camera installed at each station. Camera trap was placed at a height of 45-60 cm from the ground.	A total of 40 camera traps were installed with the number of trap nights of 17.26±2.06 per 2x2 km grid. Notably, three (03) camera traps were lost.

[30] Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., ... & Burnham, K. P. (2010). Distance software: design and analysis of distance sampling surveys for estimating population size. *Journal of Applied Ecology*, *47*(1), 5-14.

FIGURE F-1 TERRESTRIAL FLORA SURVEY



Legend

- Flora Plot Locations
- Preferred Road Alignment
- Biodiversity Survey Grid

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 1.3 2.6 km

Scale: 1:60,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

N

Locations of Flora Plot Survey

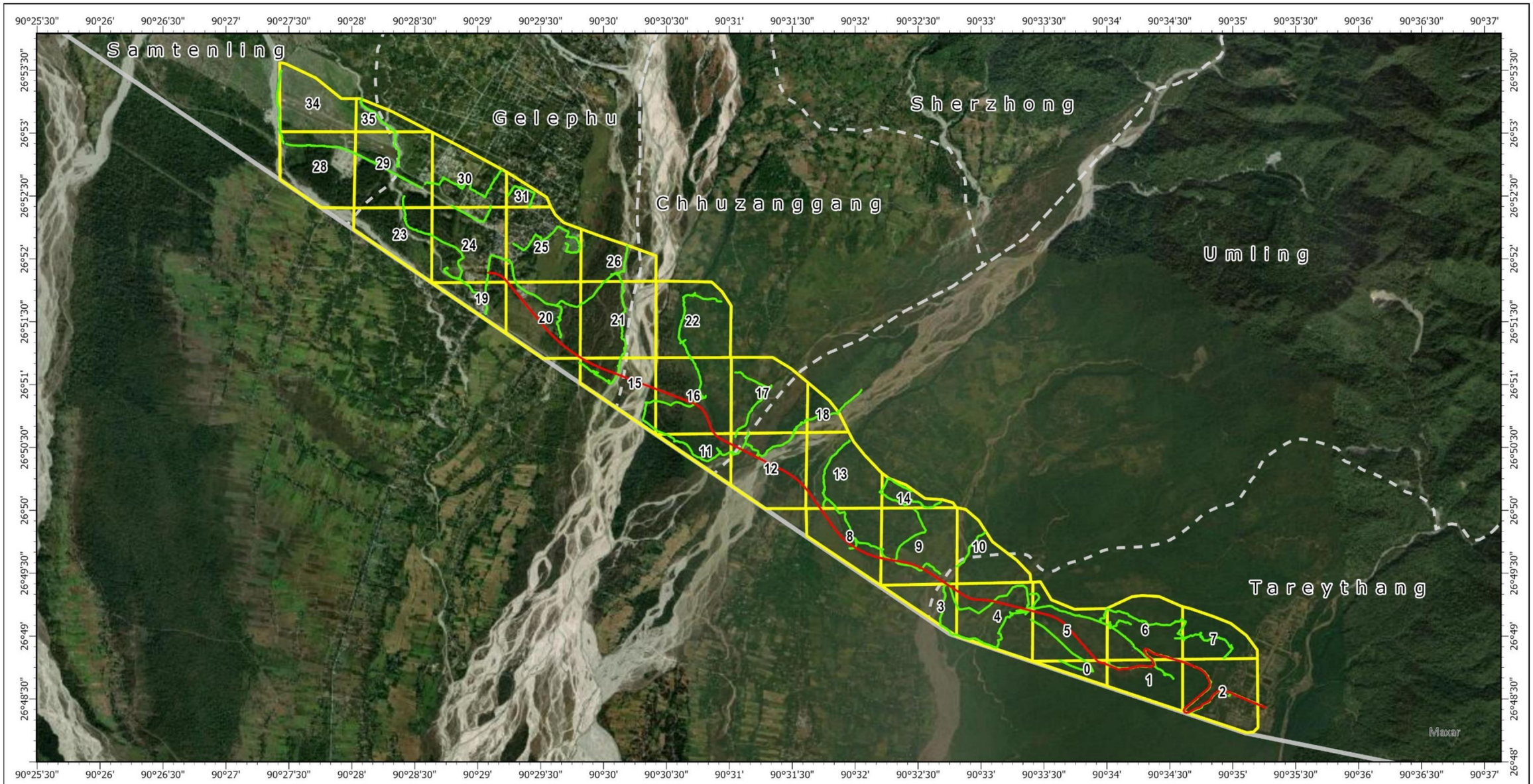
0737107 GMC ESIA Road and Bridges

Date: 18/11/2024

Drawn By: KS
Review By: MS

ERM

FIGURE F-2 BIRD TRANSECT SURVEY



Legend

- Bird Transect Routes
- Preferred Road Alignment
- Biodiversity Survey Grid

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 1.3 2.6 km

N

Scale: 1:60,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Locations of Birds Transect Survey

0737107 GMC ESIA Road and Bridges

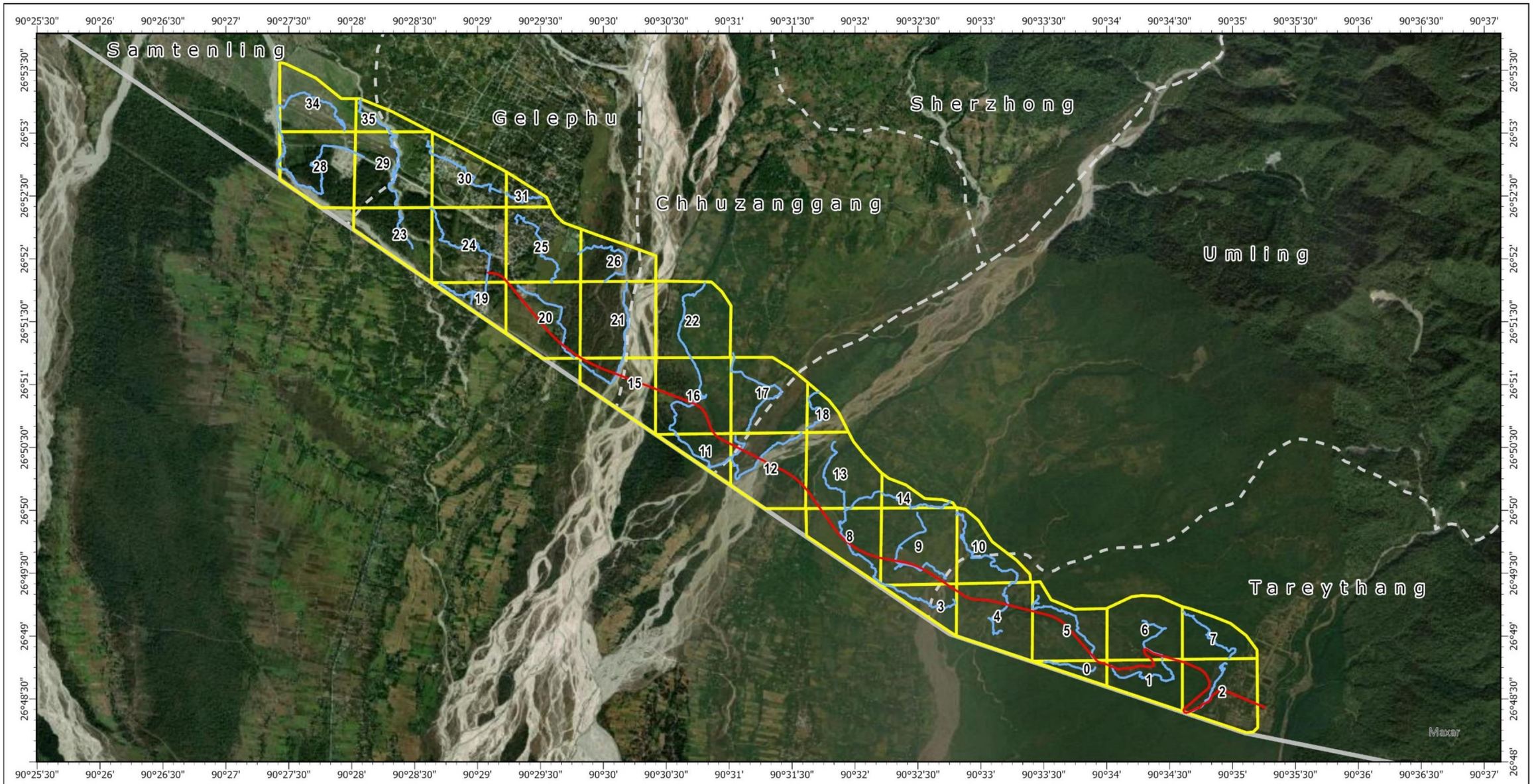
Date: 25/11/2024

Drawn By: KS

Review By: MS

ERM

FIGURE F-3 TERRESTRIAL HERPETOFAUNA TRANSECT SURVEY



Legend

- Herpetofauna Transect Routes
- Preferred Road Alignment
- Biodiversity Survey Grid

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 1.3 2.6 km

N

Scale: 1:60,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Locations of Herpetofauna Transect Survey

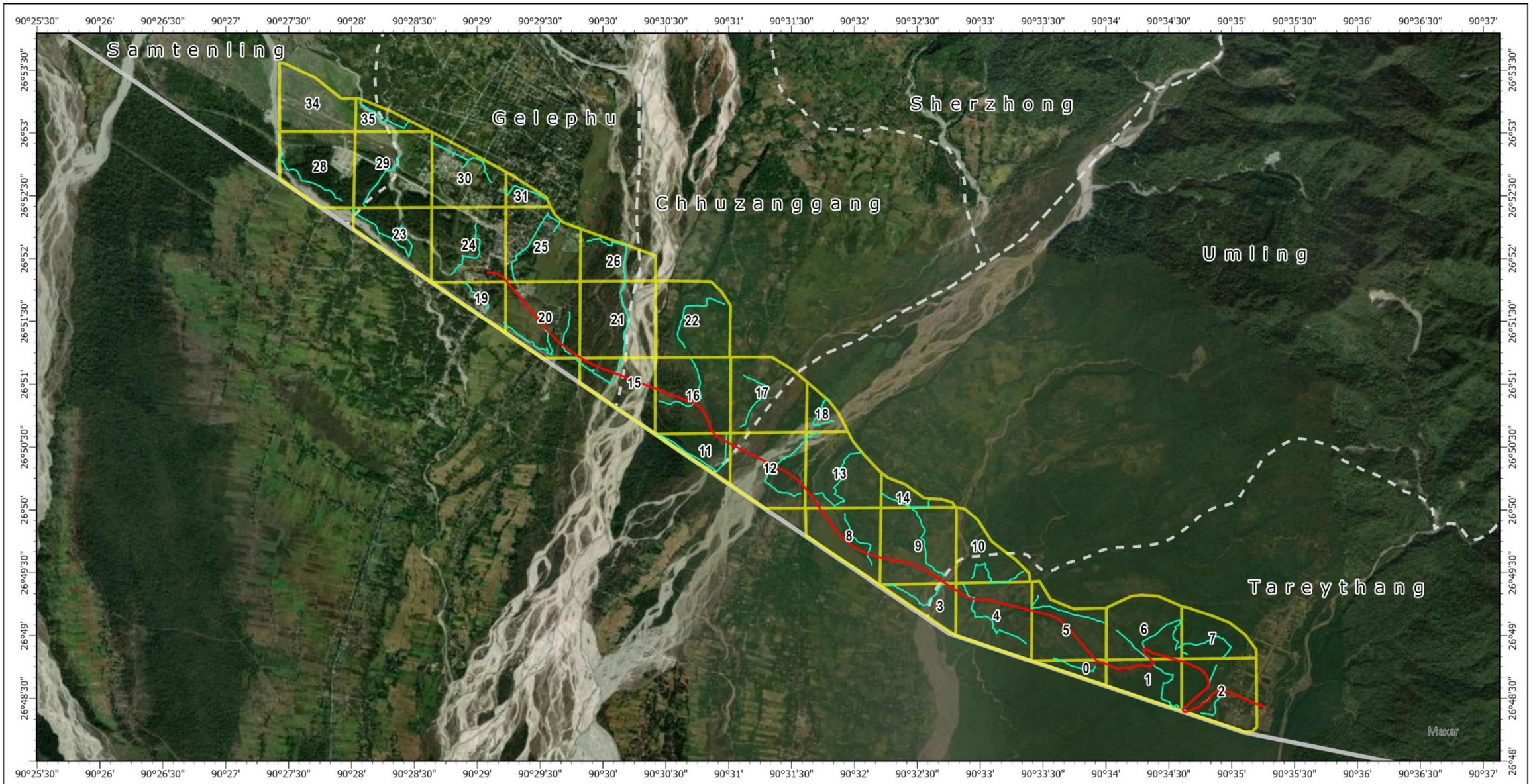
0737107 GMC ESIA Road and Bridges

Date: 25/11/2024

Drawn By: KS
Review By: MS

ERM

FIGURE F-4 TERRESTRIAL MAMMAL TRANSECTS SURVEY



Legend

- Mammal Transect Routes
- Preferred Road Alignment
- Biodiversity Survey Grid

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 1.3 2.6 km

N

Scale: 1:60,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Locations of Mammal Transect Survey

0737107 GMC ESIA Road and Bridges

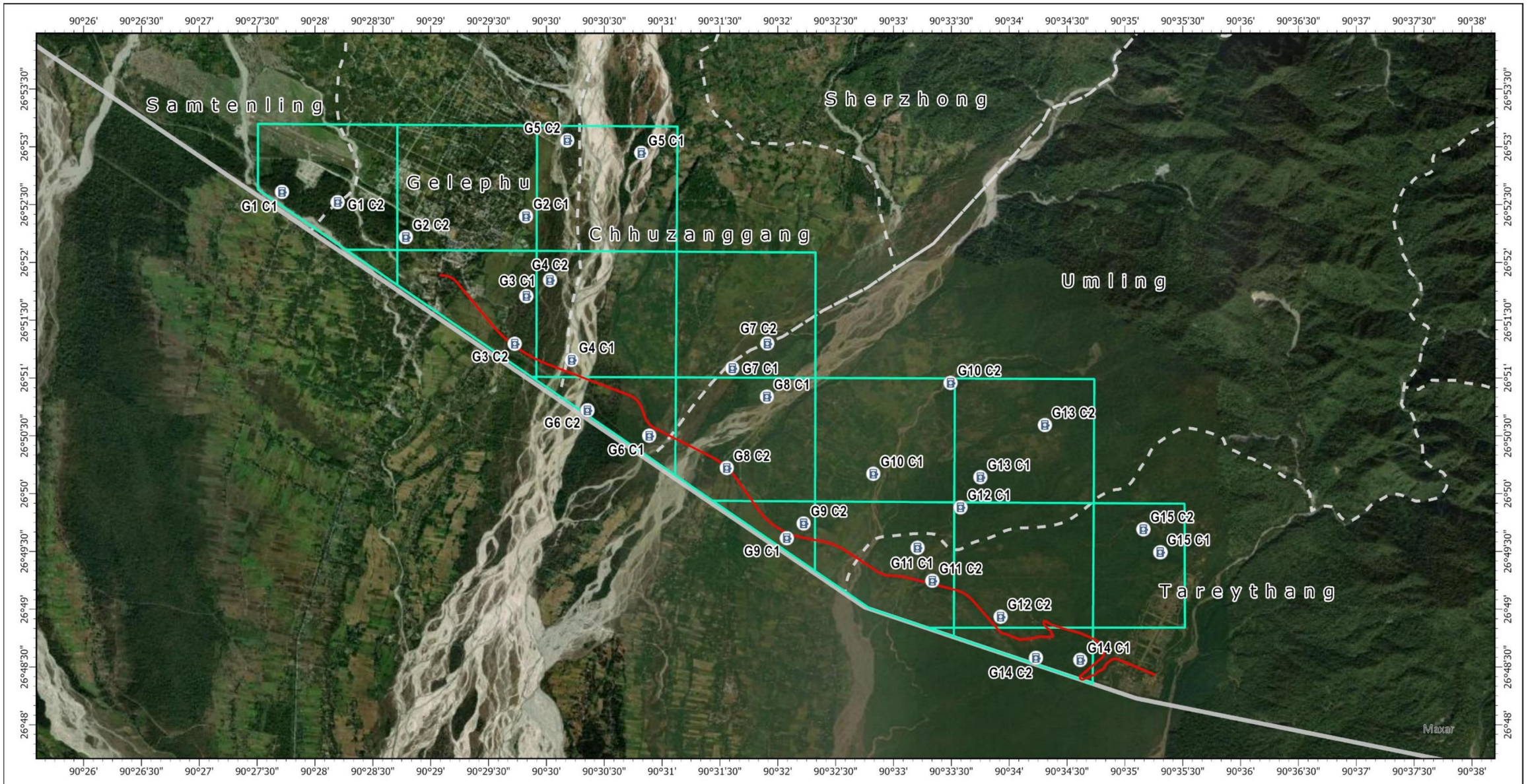
Date: 25/11/2024

Drawn By: KS

Review By: MS

ERM

FIGURE F-5 CAMERA TRAP SURVEY



Legend

- Preferred Road Alignment
- Camera Trap Locations
- Camera Trap Grid

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 1.4 2.8 km

N

Scale: 1:65,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Data Source(s):
1. Divisional Forest Office, Sarpang

Locations of Camera Trap Installation

0737107 GMC ESIA Road and Bridges

Date: 25/11/2024

Drawn By: KS
Review By: MS

ERM

F.3.2 AQUATIC SURVEY

Samples were collected following a systematic random sampling technique (***Table F***.4). Sampling points were laid with one (01) km between each of the five (05) sampling Plots.[31] A 200 m transect line which is also known as sample stretch was laid in one (01) km sample distance for collection of data. [32] Plots 1, 4 and 5 were in upstream Mau River; Plot 2 was situated along a branch of the Taklai River; and Plot 3 was in upstream Taklai River (***Figure F-6***).

TABLE F.4 AQUATIC SURVEY METHODOLOGY

Survey	Date	Survey Technique	Survey Methods	Survey Effort
Fish sampling	5-8 August 2024	Multiple sampling methods	Fish were sampled using fishing gears like cast net, spinner hook, temporary river diversion, seine net and electro-shocker. The catch-and-release method was adopted. A cast net of three (03) meters radius was used for the sampling and the distance of two sample points was 50 meters each stretch covered up to one (01) km. Coupled with the cast net, wherever possible, a Seine net was used via the rock flip and kick sampling method. The coordinates, water depth and mean water velocity of the site where the fish were caught were recorded using an AVFM 6.1 Area Velocity Flow Meter.	Five (05) aquatic plots
Macroinvertebrate Sampling	5-8 August 2024	Kick sampling	Kick-sampling technique with a D-frame net (1x1 feet; 600 µm net mesh) was used to collect macroinvertebrates (Gretchen, 2007). Simultaneously, mosquito nets from the local market were also used to maximize the collection and effort. To guarantee that most macroinvertebrates were collected, the substrate was disturbed and scooped with the net multiple times. Three replicates of samples were collected from the sampling sites covering all representative habitat types: pool, riffle and run within the project sites.	Five (05) aquatic plots
Water quality	5-8 August 2024	Electrometric and instrumental analysis	A total of six water quality parameters, i.e., pH (electrometric), temperature (electrometric), conductivity (electrometric), TDS (electrometric), Turbidity (instrumental) and dissolved	Five (05) aquatic plots

[31] Gyeltshen, T. (2018). Assessment of fish diversity in Bhutan: A systematic approach. Journal of Bhutan Studies, 38, 45-60.

[32] Wangmo, T., & Rai, S. (2019). Sampling techniques for ecological studies in Bhutan. Bhutan Journal of Ecology and Conservation, 2(1), 15-25. Zhang, Y., Liu, H., & Chen, X. (2023). Urbanization impacts

Survey	Date	Survey Technique	Survey Methods	Survey Effort
			oxygen (Winkler methods with azide modification) were analyzed for the water samples collected from the two (02) sampling plots.	

FIGURE F-6 AQUATIC FAUNA SAMPLING STATIONS

Legend

- Fish Sampling Location
- Macroinvertebrate Sampling Location
- Aquatic Plot
- Preferred Road Alignment

Administrative Boundary

- Bhutan National Border
- Gewog Boundary

0 2.2 4.4 km

N

Scale: 1:100,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Data Source(s):
1. College of Natural Resources

Locations of Aquatic Fauna Survey

0737107 GMC ESIA Road and Bridges
Date: 25/11/2024
Drawn By: KS
Review By: MS

ERM

APPENDIX G LEGALLY PROTECTED AND INTERNATIONALLY RECOGNIZED AREAS OF HIGH BIODIVERSITY VALUE

G LEGALLY PROTECTED AND INTERNATIONALLY RECOGNIZED AREAS OF HIGH BIODIVERSITY VALUE

G.1 INTRODUCTION

Legally Protected Areas ("PAs") include areas that are legally designated or officially proposed for biodiversity protection and conservation. Nationally recognized area as PA in Bhutan includes national parks, nature reserves, wildlife sanctuaries, and corridors.[33] Areas with recognized high biodiversity values, including PA, KBAs, AZEs, UNESCO World Heritage sites, Ramsar sites, and Endemic Bird Area (EBA) were reviewed. These areas are defined as follows:

- **KBAs** - Key Biodiversity Areas are sites that contribute significantly to the global persistence of biodiversity and being applicable to terrestrial, freshwater, and marine ecosystems.[34] Sites qualify as global KBAs if they meet one or more of eleven criteria, grouped into the following five (05) categories: threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, and irreplaceability. KBAs typically include:
  - Important Bird and Biodiversity Areas ("IBA") identified by the BirdLife International Partnership;
  - Alliance for Zero Extinction sites ("AZE") containing 95% or more of the remaining population of one or more species listed as Endangered (EN) or Critically Endangered (CR) on the IUCN Red List;
  - KBAs identified through hotspot ecosystem profiles supported by the Critical Ecosystem Partnership Fund; and
  - A small number of other KBAs such as Important Plant Areas ("IPA"), and KBAs covering multiple taxonomic groups in freshwater, marine, and terrestrial systems.
- **UNESCO World Heritage site** – a site selected by UNESCO as having cultural, historic, scientific or other forms of significance. These areas are legally protected by international treaties and demarcated by UNESCO as protected zones.
- **Ramsar site** – wetlands of 'international importance' identified under the International Convention of Wetlands, known as the Ramsar Convention, which is an intergovernmental treaty that provides the framework for the conservation and use of wetlands and their resources.
- **EBA** - EBA are regions that represent natural areas of bird endemism where the distribution of two (02) or more restricted-range bird species overlaps. Restricted range refers to a breeding range of no more than 50,000 km^2.[35]

G.2 ECOREGION

[33] Bhutan Biodiversity. Available at: Protected areas and Biological corridors of Bhutan | Bhutan Biodiversity (chm-cbd.net). Access date: September 25, 2024

[34] IUCN Species Survival Commission and IUCN. A Global Standard for the Identification of Key Biodiversity Areas - https://portals.iucn.org/union/sites/union/files/doc/a_global_standard_for_the_identification_of_key_biodiversity_areas_final_web.pdf

[35] BirdLife International (2023) EBA Summary. Retrieved from http://datazone.birdlife.org/eba on 14/03/23

Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar.[36] The Project area crosses two ecoregions, i.e., the Himalayan subtropical broadleaf forest and Brahmaputra Valley semi-evergreen forests.[37]

The Himalayan subtropical broadleaf forest ecoregion (38,271 km^2)[38] stretches from Bhutan in the east to Nepal in the west, traversing the Siwalik Hills, the southernmost range of the Himalayas.[39] The primary forest within the 800–2,200 m elevation range is characterized by warm broadleaf species, while elevations from 2,200 to 2,800 m are dominated by Fagaceae forests.[40] Forest cover declined by over 30% in warm broadleaf forest, and primary forest declined by 16% overall, with concomitant increases in secondary forest and agriculture.[41] This ecoregion accommodates almost 100 mammal species, e.g., Asian elephant (*Elephas maximus,* IUCN EN), Tiger (*Panthera tigris,* IUCN EN), Gaur (*Bos gaurus,* IUCN VU), and Clouded Leopard (*Neofelis nebulosa*, IUCN VU). and 340 bird species, e.g., white-winged duck (*Asarcornis scutulata,* IUCN EN), and five (05) species of hornbills.[42]

The Brahmaputra Valley Semi-Evergreen Forests ecoregion (5,684 km^2)[43] supports the world's largest single population of Greater One-Horned Rhino (*Rhinoceros unicornis,* IUCN VU) in Kaziranga National Park, located approximately 32 km from the Project site. [44] Due to the distance and the presence of a river, it is unlikely that these rhinos will have any contact with Project activities. The ecoregion also provides habitat for the largest populations of Asian elephants.[45]

[36] United States Environmental Protection Agency. Ecoregions. Available at: Ecoregions | US EPA Accessed date: Oct 16, 2024

[37] Olson, D. M., Dinerstein, E., Wikramanayake, E. D., Burgess, N. D., Powell, G. V. N., Underwood, E. C., D'Amico, J. A., Itoua, I., Strand, H. E., Morrison, J. C., Loucks, C. J., Allnutt, T. F., Ricketts, T. H., Kura, Y., Lamoreux, J. F., Wettengel, W. W., Hedao, P., Kassem, K. R. 2001. Terrestrial ecoregions of the world: a new map of life on Earth. Bioscience 51(11):933-938.

[38] One earth. Available at: Himalayan Subtropical Broadleaf Forests | One Earth. Access date: 09/19/2024.

[39] One earth. Available at: Himalayan Subtropical Broadleaf Forests | One Earth. Access date: 09/19/2024.

[40] Kanade, R., & John, R. (2018). Topographical influence on recent deforestation and degradation in the Sikkim Himalaya in India; Implications for conservation of East Himalayan broadleaf forest. *Applied Geography*, *92*, 85-93.

[41] Kanade, R., & John, R. (2018). Topographical influence on recent deforestation and degradation in the Sikkim Himalaya in India; Implications for conservation of East Himalayan broadleaf forest. *Applied Geography*, *92*, 85-93.

[42] One earth. Available at: Himalayan Subtropical Broadleaf Forests | One Earth. Access date: 09/19/2024.

[43] One earth. Available at: Brahmaputra Valley Semi-Evergreen Forests | One Earth

[44] Ibidem

[45] Ibidem

G.3 PROTECTED AREAS (PA)

Protected Areas located in the vicinity of the Project include the nationally designated Ripu and Chirang Reserve Forests, Royal Manas National Park, and Biological Corridor 3 (***Figure G-1***). The brief details of each PA are given in ***Table G***.1.

TABLE G.1 SUMMARY OF PROTECTED AREAS STATUS AND DESCRIPTION

Protected area	Designation Status	Distance from the Project (km)	Overlapping with AoA	Brief Description
Ripu and Chirang Reserve Forests	Reserve Forests	2	No	Ripu-Chirang Reserve Forests is located in Kokrajhar and Chirang district in Assam, India, and is legally notified as one part of Raimona National Park. The forests are adjacent to Buxa Tiger Reserve to the southwest and Phibsoo Wildlife Sanctuary in Bhutan to the north. Covering an area of 1,040 km^2, the forests are predominantly dense, with some settlements and agriculture land. The elevation ranges from 100 m to 400 m above sea level. The ecosystem of the forests is primarily composed of semi evergreen forest and moist-mixed deciduous forest with Sal forest, grassland and riverine forests also present.[46,47]
Royal Manas National Park	National Park	<1	No	Royal Manas National Park (RMNP) is the first and oldest national park in Bhutan, originally designated as a wildlife sanctuary and upgraded to national park in 1980s.[48] RMNP is located in Tareythang, Umling, Sherzhong and Jigmechhoeling Gewogs in Sarpang Dzongkhag; Phangkhar, Ngangla and Trong in Zhemgang Dzongkhag; and Norbugang Gewog in Pemagatshel Dzongkhag. The park is adjacent to Biological Corridor 3 to the west, Jigme Singye Wangchuck National

[46] Nath, A., Lahkar, B. P., Brahma, N., Sarmah, P., Das, A. K., Das, S., Basumatary, T., Islari, R., & Swargowari, A. (2023). Breaking Dawn: Factors influencing mammalian habitat usage in western Assam following socio-political instability. *Journal for Nature Conservation*, *72*, 126357. https://doi.org/10.1016/j.jnc.2023.126357

[47] Bhattacharjee, K., Boro, A., Das, A. K., Dutta, U., & Sarma, G. C. (2014). Phytogeography of Chirang Reserve Forest under Manas Biosphere Reserve in Assam (India).

[48] Royal Manas National Park. (2023). Conservation Management Plan (July 2023 - June 2033). Department of Forests and Park Services, Ministry of Energy and Natural Resources, Royal Government of Bhutan.

Protected area	Designation Status	Distance from the Project (km)	Overlapping with AoA	Brief Description
				Park and Biological Corridor 4 to the north, Manas Wildlife Sanctuary in India to the south and Biological Corridor 5 to the east.
Manas National Park	World Heritage Site, Wildlife Sanctuary / National Park	24	No	Manas Wildlife Sanctuary, also known as Manas National Park, is located at the foothills of the Himalayas in the Chirang and Baksa districts of Assam, India.[49,50] It lies adjacent to the RMNP in Bhutan to the north. The park is celebrated for its unique biodiversity and landscapes, encompassing semi-evergreen forests, mixed moist and dry deciduous forests, and alluvial grasslands.
Biological Corridor 3	Biological Corridor	9	No	Biological Corridors of Bhutan were declared in 1999 with, 12 corridors in total to connect all nine (9) protected areas, with the width ranging from 500 m to 3 km.[51] The main objective of these biological corridors is to ensure continuous gene flow by facilitating uninterrupted wildlife movement and habitat succession.[52] The Biological Corridor 3 spans Singye, Gakiling, Shompangkha, Dekiling, Samtenling, Gelephu, Chhudzom, Jigmechhoeling, Sherzhong and Umling Gewogs in Sarpang Dzongkhag, as well as Patshaling and Doogalagang Gewogs in Tsirang Dzongkhag. Biological Corridor 3 connects Phibsoo Wildlife Sanctuary to the southwest and RMNP and Jigme Singye Wangchuck National Park

[49] UNESCO. (n.d.). Manas Wildlife Sanctuary. In *UNESCO World Heritage Centre*. Retrieved August 15, 2024, from https://whc.unesco.org/en/list/338/.

[50] Barpeta District Administration. (n.d.). Bhutan and Barpeta - A Journey Through History. In Barpeta District, Assam Government. Retrieved June 6, 2024, from https://barpeta.assam.gov.in/tourist-place-detail/251.

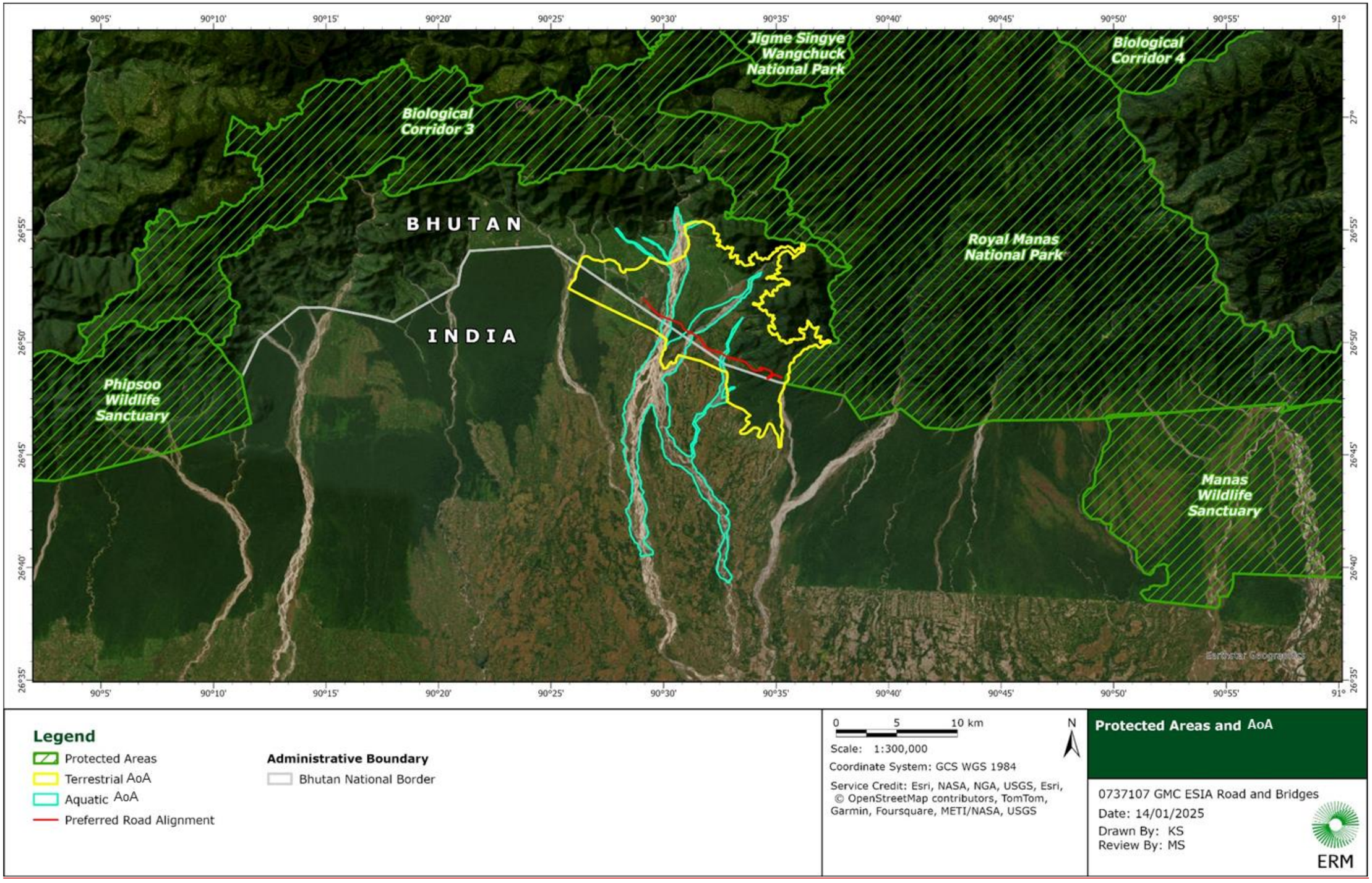
[51] Nature Conservation Division, Department of Forestry Services, Ministry of Agriculture. (2004). *Bhutan Biological Conservation Complex (Living in Harmony with the Nature)*. Retrieved from https://wwfasia.awsassets.panda.org/downloads/b2c2_20landscapeconservation_20plan.pdf.

[52] Nature Conservation Division, Department of Forestry Services, Ministry of Agriculture. (2004). *Bhutan Biological Conservation Complex (Living in Harmony with the Nature)*. Retrieved from https://wwfasia.awsassets.panda.org/downloads/b2c2_20landscapeconservation_20plan.pdf.

Protected area	Designation Status	Distance from the Project (km)	Overlapping with AoA	Brief Description
				to the east. The total area of Biological Corridor 3 is 408 km^2 with altitudes of 400 m to 2,400 m above sea level.
Phibsoo Wildlife Sanctuary	Wildlife Sanctuary	30.13	No	Phibsoo Wildlife Sanctuary (PWS), is the smallest protected area of Bhutan, covering 286 km^2. Established as Phibsoo Reserved Forests in 1974, it was promoted to Wildlife Sanctuary status in 1993.[53] PWS is situated in Singye Gewog in Sarpang Dzongkhag and Nichula Gewog in Dagana Dzongkhag. PWS is adjacent to Biological Corridor 3 to the northeast and Ripu and Chirang Reserve Forest in India to the south. The land cover is predominantly dense forest, with altitudes ranging from 120 m to 1,770 m above sea level The ecosystem of the area includes grassland, subtropical semi evergreen forest, subtropical moist deciduous forest and subtropical moist evergreen forest.

[53] Phibsoo Wildlife Sanctuary. (n.d.). In *Biodiversity.bt*. Retrieved June 6, 2024, from https://biodiversity.bt/group/Phibsoo_Wildlife_Sanctuary

FIGURE G-1 PROTECTED AREA WITHIN THE VICINITY OF THE AOA



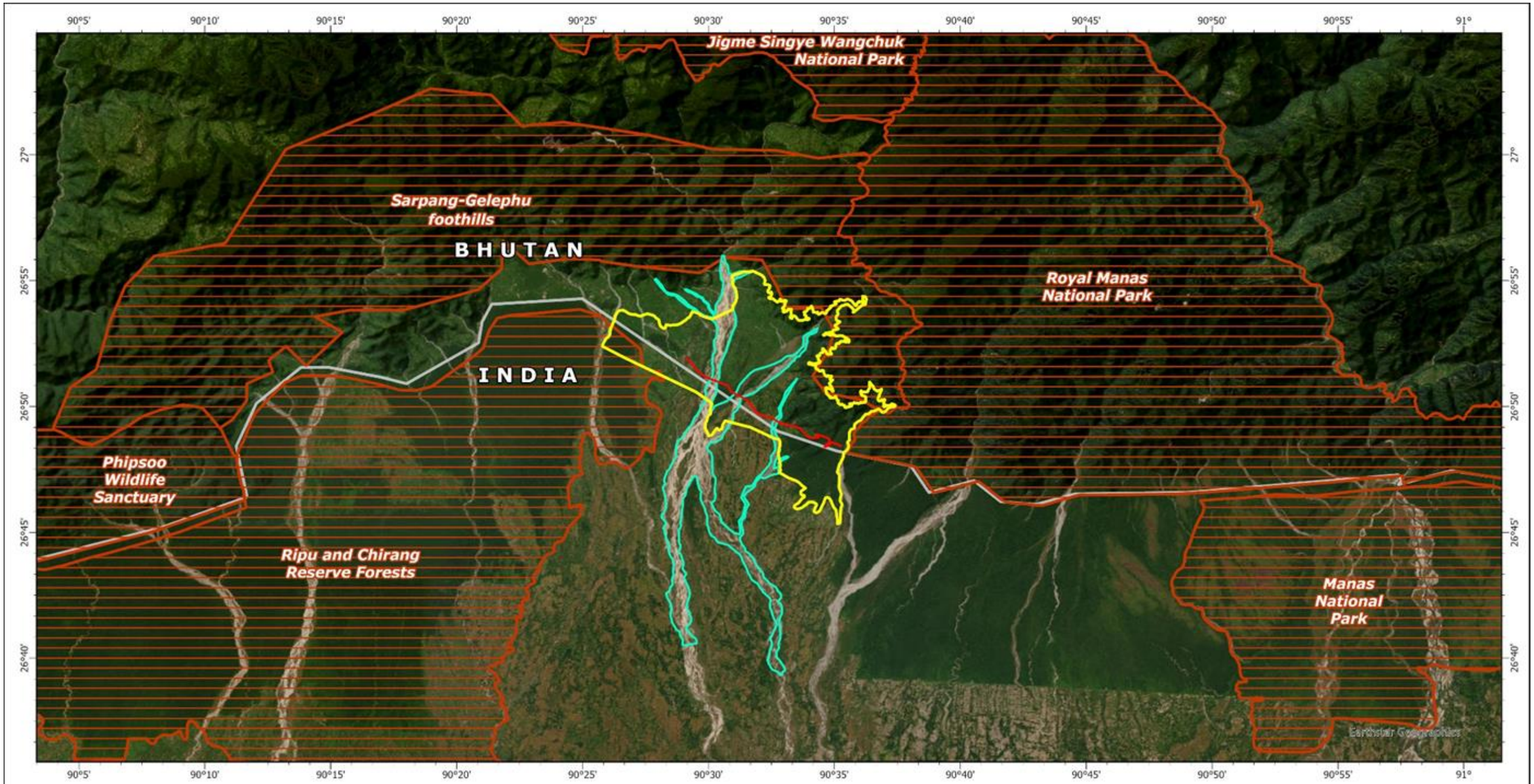
G.4 KEY BIODIVERSITY AREAS (KBA)

Five (05) KBAs were in the 50 km of the Project, i.e., the Royal Manas National Park KBA, Sarpang-Gelephu foothills, Phibsoo Wildlife Sanctuary, Ripu and Chirang Reserve Forests, and Manas National Park. The Project footprint does not overlap with these KBAs. The details of KBAs and the distance between the Project are shown in ***Table G***.2, and the extent of these KBAs are presented in ***Figure G-2***.

TABLE G.2 SUMMARY OF KEY BIODIVERSITY AREAS AND ASSOCIATED SPECIES WITH SPECIAL CONSERVATION CONCERN

KBA Name	KBA Site Type	Distance from the Project (km)	Overlapping with AoA	Reported Species of Conservation Concern
Royal Manas National Park	Important Bird Area	<1	No	• White-rumped Vulture (*Gyps bengalensis*, IUCN CR) • Indian Rhinoceros (*Rhinoceros unicornis*, IUCN VU) • Hispid Hare (*Caprolagus hispidus*, IUCN EN) • Asian Elephant (*Elephas maximus*, IUCN EN) • Tiger (*Panthera tigris*, IUCN EN) • Gee's Golden Langur (*Trachypithecus geei*, IUCN EN) • Pygmy Hog (*Porcula salvania*, IUCN EN) • Indian Water Buffalo (*Bubalus arnee*, IUCN EN)
Manas National Park (India)	Important Bird Area and Alliance for Zero Extinction	24	No	• Pygmy Hog (*Porcula salvania*, IUCN EN) • Black-breasted Parrotbill (*Paradoxornis flavirostris*, IUCN VU) • Jerdon's Babbler (*Chrysomma altirostre*, IUCN VU)
Sarpang-Gelephu Foothills	Important Bird Area	3	No	• Rufous-necked Hornbill (*Aceros nipalensis*, IUCN VU)
Phibsoo Wildlife Sanctuary	Important Bird Area	30	No	• Hispid Hare (*Caprolagus hispidus*, IUCN EN) • Asian Elephant (*Elephas maximus*, IUCN EN) • Tiger (*Panthera tigris*, IUCN EN) • Gee's Golden Langur (*Trachypithecus geei*, IUCN EN) • Pygmy Hog (*Porcula salvania*, IUCN EN)
Ripu and Chirang Reserve Forests (India)	Key Biodiversity Area	2	No	• Slender-billed Vulture (*Gyps tenuirostris*, IUCN CR) • White-rumped Vulture (*Gyps bengalensis*, IUCN CR) • Bengal Florican (*Houbaropsis bengalensis*, IUCN CR) • Asian Elephant (*Elephas maximus*, IUCN EN) • Tiger (*Panthera tigris*, IUCN EN) • Gee's Golden Langur (*Trachypithecus geei*, IUCN EN) • Assam Roofed Turtle (*Pangshura sylhetensis,* IUCN CR)

FIGURE G-2 KEY BIODIVERSITY AREAS WITHIN THE VICINITY OF THE AOA



G.5 WORLD HERITAGE SITES

World Heritage Areas are sites that are selected by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as having cultural, historic, scientific or other forms of significance. These areas are legally protected by international treaties and demarcated by UNESCO as protected zones. This allows for practical conservation of areas which would otherwise be subjected to threats such as uncontrolled and unrestricted access, and associated activities such as poaching and illegal logging.

Bhutan has no World Heritage Sites. The closest one is the Manas Wildlife Sanctuary in India, located approximately 24 km from the Project.

G.6 RAMSAR SITES

The Ramsar Convention is an intergovernmental treaty that provides the framework for the conservation and use of wetlands and their resources. The Ramsar Convention for Bhutan entered into force on 7 September 2012, and currently has three (03) sites designated as Wetlands of International Importance, which cover an approximate surface area of 1.225 ha.[54] There is no Ramsar site located within 50 km of the Project area. The closest Ramsar Site in Bhutan is Gangtey-Phobji, which is located approximately 69 km from the Project area.

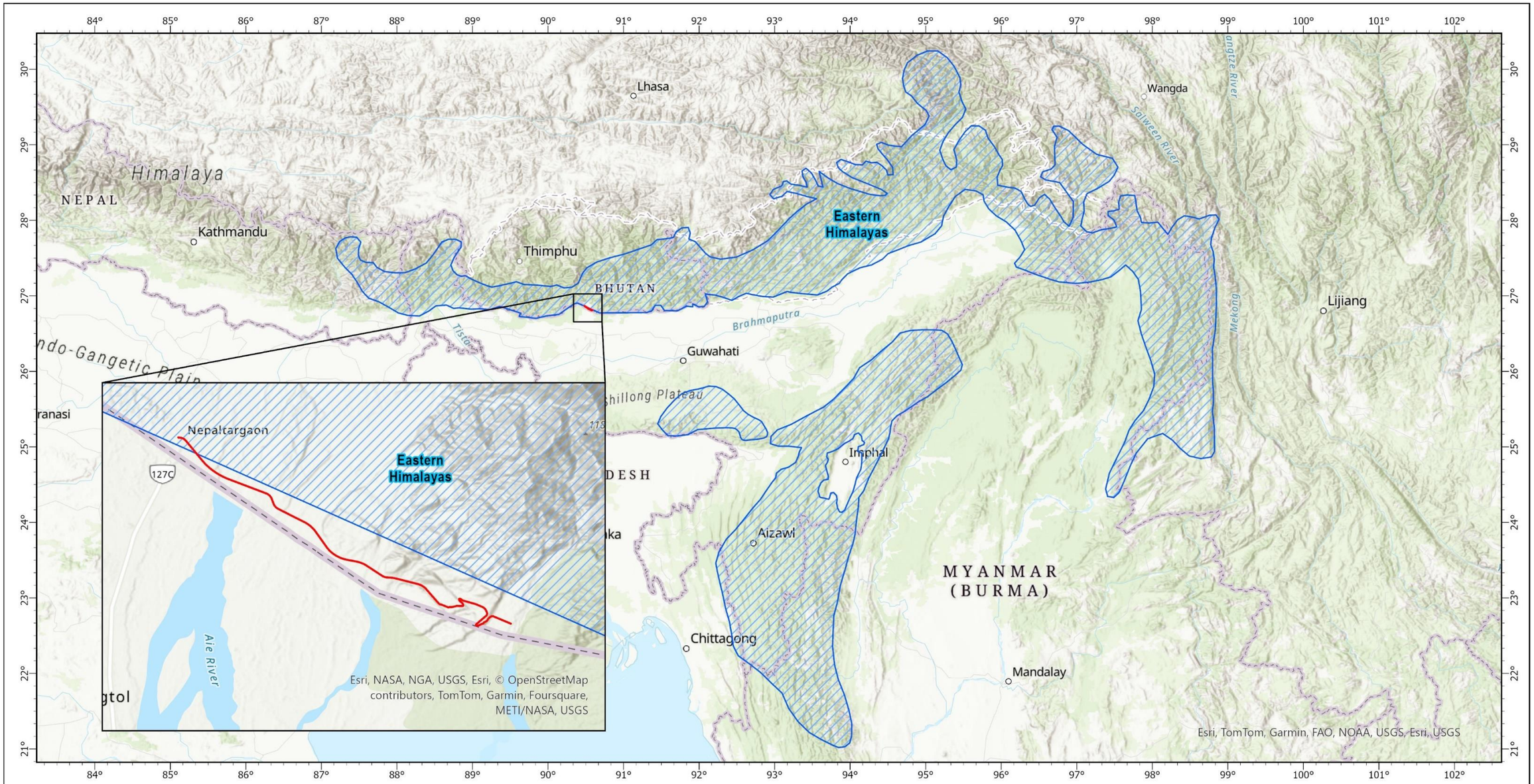
G.7 ENDEMIC BIRD AREA (EBA)

An EBA is a region designated by BirdLife International where the habitats of two or more bird species, restricted to that particular area, overlap. These areas are home to species that are not found anywhere else in the world, making them critical for conservation efforts. EBAs are typically located in biodiversity hotspots and are prioritized for protecting the unique birdlife and ecosystems they support. Restricted-range species are landbirds whose total global breeding range has been historically estimated to be less than 50,000 km² since ornithological records began after 1800. These species have very limited geographic distribution, making them more vulnerable to habitat loss and environmental changes, and thus are often a focus of conservation efforts.[55]

The project is located within the Eastern Himalayas EBA, which spans 220,000 km² along the Himalayan range. This EBA stretches eastward from the Arun-Kosi valley in eastern Nepal, through Bhutan, northeastern India, southeastern Tibet, northeastern Myanmar, and into southwestern China. The region is particularly rich in restricted-range bird species, with the genus *Sphenocichla* being endemic to this EBA, highlighting its significance for bird conservation. The extent of the Eastern Himalayas EBA is illustrated in ***Figure G-3***.

[54] The Ramsar Convention on Wetlands (2011) The Annotated Ramsar List of Wetlands of International Importance. Available from: https://www.ramsar.org/country-profile/bhutan [Accessed August 2024]
[55] BirdLife International. 2024. Endemic Bird Areas – Summary. Retrieved from https://datazone.birdlife.org/eba.

FIGURE G-3 THE EXTENT OF EASTERN HIMALAYAS ENDEMIC BIRD AREA



Legend

- Preferred Road Alignment
- Eastern Himalayas EBA

0 130 260 km

N

Scale: 1:6,000,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

Data Source(s):
1. BirdLife International

Extent of The Eastern Himalayas EBA

0737107 GMC ESIA Road and Bridges

Date: 25/11/2024

Drawn By: KS

Review By: MS

ERM

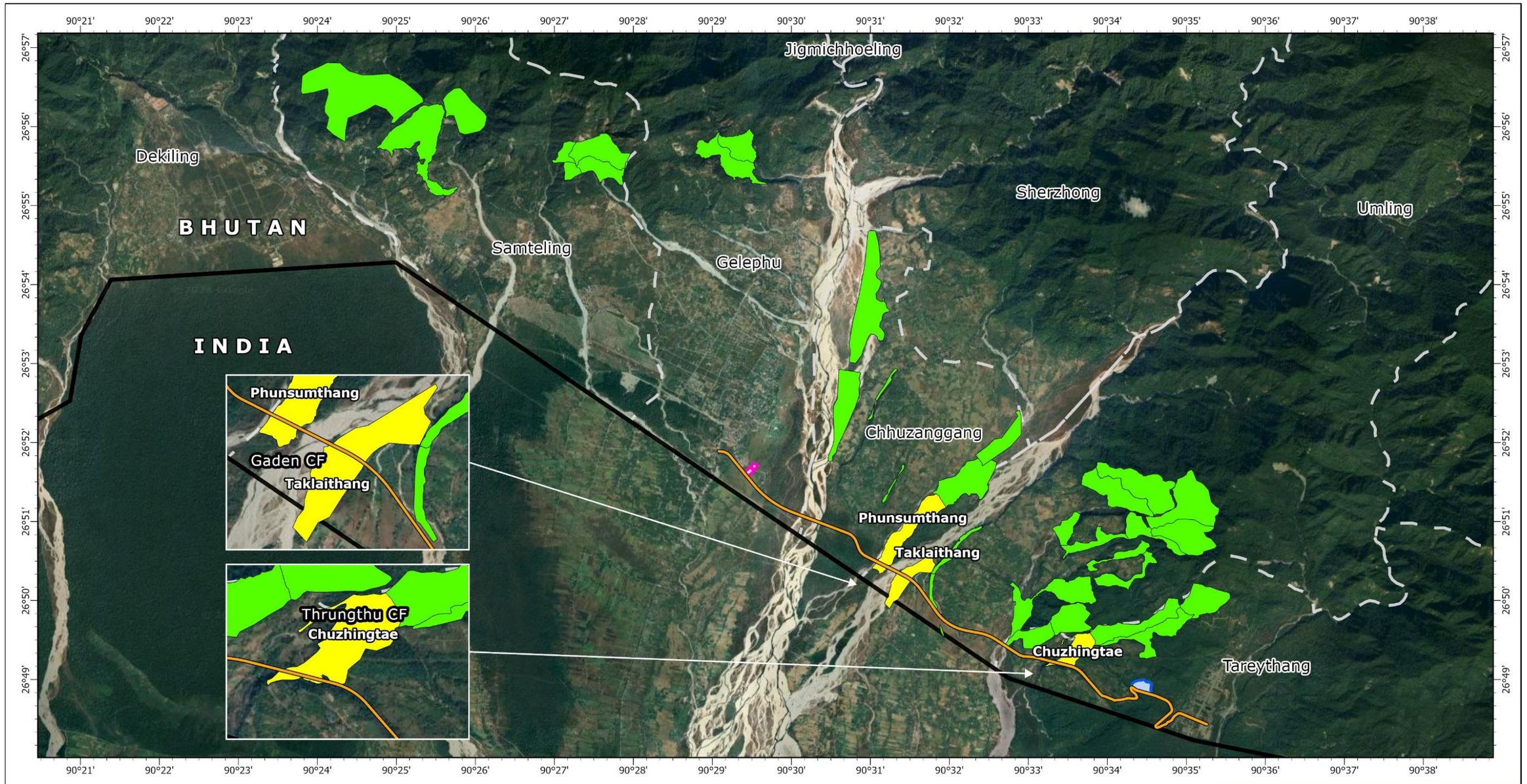
G.8 COMMUNITY FORESTS

A Community Forest (CF) in Bhutan refers to an area of Government Reserved Forest that has been designated for management by a local community, in accordance with the rules set under the Forest and Nature Conservation Act 1995. While members of the Community Forest Management Group have the right to use and manage trees and non-wood forest products, they do not hold ownership over the land itself or its underlying resources, such as water, soil, sand, stones, boulders, and riverbed materials within the Community Forest. This system promotes sustainable forest management while preserving the rights of the government over critical natural resources.[56] ***Figure G-4*** illustrates the extent of the community forests nearby the Project in Tareythang, Umling, Chhuzanggang, and Samtenling Gewogs. The specific forest products available in these areas are detailed as follows:

- Umling and Tareythang Gewogs: These community forests offer pipla, bamboo, soft broom, mushrooms, and timber.
- Chhuzanggang Gewog: Resources here include cham trees, firewood (from lower-quality trees), bamboo, N-trees, sand, gravel, boulders, wetlands, and water sources.
- Samtenling Gewog: Products from this area include Drashing, non-wood forest products (NWFPs) such as firewood, fencing posts, bamboo, fodder, leaf litter, agricultural tools, mushrooms, ferns, broom, cham, tsim, danchung, and additional firewood and bamboo.
- Gelegphu Gewog: Known for Drashing trees (potentially valuable for plywood production), firewood, and other non-wood forest products.

[56] Royal Government of Bhutan Ministry of Energy and Natural Resources Department of Forests and Park Services. 2023. Forest and Nature Conservation Rules and Regulations, 2023. Available from https://www.moenr.gov.bt/wp-content/uploads/2017/07/FNCRR-2023.pdf. [Accessed September 2024]

FIGURE G-4 COMMUNITY FORESTS NEAR THE PROJECT AREA



Legend

- Preferred Road Alignment
- Works Area and Camp 1
- Works Area and Camp 2
- Impacted Community Forest
- Community Forest

Administrative Boundary

- Gewog Boundary
- Bhutan National Border

0 2 4 km

N

Scale: 1:95,000

Coordinate System: GCS WGS 1984

Service Credit: Earthstar Geographics

Locations and Extent of Community Forests

0737107 GMC ESIA Road and Bridges

Date: 25/11/2024

Drawn By: NS

Review By: MS

ERM

APPENDIX H FINDINGS FROM THE EXPERT CONSULTATION

H FINDINGS FROM THE EXPERT CONSULTATION

Common Name	Scientific Name	IUCN status	Preferred habitat	Potential distribution
Mammal				
Chinese Pangolin	*Manis pentadactyla*	CR	This species can occupy modified habitat adjacent to forest habitat. This species is frequently recorded in Bhutan. Sarpang is one of three dzongkhags with record of Chinese Pangolin.	Forest, Shrubland, Grassland
Tiger	*Panthera tigris*	EN	Southern Bhutan is the important area of species population in the region. The species population has been estimated to be 2,608 – 3,905 individuals, while the Bhutan may support the species population in 131 individuals based on the recent survey in 2021 and 2022.[57]	Forest, Savanna, Shrubland, Grassland, Wetlands (inland), Marine Coastal/Supratidal, Artificial/Terrestrial
Gee's Golden Langur	*Trachypithecus geei*	EN	Species recorded mostly in Bhutan including area around Gelephu. The global species population has been estimated to be 6,000 – 6,500 individuals, while Bhutan may support a species population of 4,000 individuals based on the IUCN Red List assessment.	Forest, Artificial/Terrestrial
Red Panda	*Ailurus fulgens*	EN	The species known to occur in Eastern Himalayan Broadleaf and Conifer Ecoregion.[58] It depends on a bamboo diet and dwells in bamboo understories in temperate pine forests adjacent to broadleaf forests.[59]	High elevation sub-tropical forest and pine forest.
Hispid Hare	*Caprolagus hispidus*	EN	The species is strongly relying on the large, tall grass habitat.[60]	Low land grassland
Pygmy Hog	*Porcula salvania*	EN	This species occupies a highly restricted range of the sub-tropical grasslands of Assam, especially tall grass habitat.[61]	Low land grassland
Bengal Slow Loris	*Nycticebus bengalensis*	EN	This species is arboreal species that occupy dense forest canopy.[62] However, tropical plantation and modified forest can support species population as well.[63]	Dry dipterocarp forest, man-made plantation and sub-tropical forest
Asian Elephant	*Elephas maximus*	EN	They are generalists and feed on a variety of plants, which vary depending upon the habitat and season.	Low land grassland, agricultural land, man-made plantation, sub-tropical forest
Reptile				
Tricarinate Hill Turtle	*Melanochelys tricarinata*	EN	Core distribution area is associated with the Himalayan foothills. The global population of this species has not been estimated.	
Elongated Tortoise	*Indotestudo elongata*	CR	The species normally occurs in open deciduous forest patches, including Sal (*Shorea robusta*), as well as evergreen forest habitats, dry thorn forests and savannah grasslands.[64]	Dry dipterocarp forest and agricultural land
Bird				

[57] Alison Henry. (2023). In an astounding achievement, Bhutan tiger numbers grow by 27%. Accessed on 15 July 2024, from https://www.worldwildlife.org/stories/in-an-astounding-achievement-bhutan-tiger-numbers-grow-by-27.
[58] Williams, B. H. (2003). Red panda in eastern Nepal: how do they fit into ecoregional conservation of the eastern Himalaya. Conservation Biology in Asia, 16, 236-250.
[59] Yonzon, P. B., & Hunter Jr, M. L. (1991). Conservation of the red panda Ailurus fulgens. Biological conservation, 57(1), 1-11.
[60] Aryal, A., Brunton, D., Ji, W., Yadav, H. K., Adhikari, B., & Raubenheimer, D. (2012). Diet and habitat use of hispid hare Caprolagus hispidus in Shuklaphanta Wildlife Reserve, Nepal. Mammal Study, 37(2), 147-154.
[61] de Visser, M., Liu, L., & Bosse, M. (2021). Pygmy hogs. Current Biology, 31(8), R366-R368.
[62] Al-Razi, H., Hasan, S., Ahmed, T., & Muzaffar, S. B. (2020). Home range, activity budgets and habitat use in the Bengal slow loris (Nycticebus bengalensis) in Bangladesh. Evolution, Ecology and Conservation of Lorises and Pottos, 193-203.
[63] Barlow, J., Gardner, T. A., Araújo, I. S., Ávila-Pires, T. C., Bonaldo, A. B., Costa, J. E., ... & Peres, C. A. (2007). Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. Proceedings of the National Academy of Sciences, 104(47), 18555-18560.
[64] Das, I. (2015). Field guide to the reptiles of South-East Asia. Bloomsbury Publishing.

Common Name	Scientific Name	IUCN status	Preferred habitat	Potential distribution
White-bellied Heron	*Ardea insignis*	CR	Prefer deep forest stream but could occur in GMC AoA. Southern Bhutan is its core distribution area, in particular the Punatsangchhu basin. The global population of this species has been estimated as 50 – 249 individuals, and consultation with the Royal Society For Protection of Nature (23 July 2024) suggested that the population in Bhutan may be 25 to 30 individuals.	
Fish				
Golden Mahseer	*Tor putitora*	EN	Based consultations with local experts, it can be found in Mau River and other river in protected areas. The species population has not been estimated yet, but the IUCN red List states that several populations exist inside terrestrial protected areas where their populations are increasing or stable.[65]	
Flora				
	Hoya bhutanica	EN	This species is endemic to Sarpang, Bhutan and have a record in Gelephu. The species population has not been estimated yet.	
	Cheirostylis sherriffii	CR	This species is endemic to Bhutan. Occur in the montane habitat at 2,000 above sea level.[66]	High elevation sub-tropical forest.

[65] Jha, B.R., Rayamajhi, A., Dahanukar, N., Harrison, A. & Pinder, A. 2018. Tor putitora. The IUCN Red List of Threatened Species 2018: e.T126319882A126322226. http://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T126319882A126322226.en

[66] Pearce, N., & Cribb, P. (1999). Notes relating to the flora of Bhutan: XXXVII. New species and records of Orchidaceae from Bhutan and India (Sikkim). Edinburgh Journal of Botany, 56(2), 273-284.

APPENDIX I LIST OF RECORDED SPECIES

I LIST OF RECORDED SPECIES

I.1 LIST OF RECORDED FLORA SPECIES – TREES AND SHRUBS

Species	Family	IUCN Red List	Habitat found					
			Number of records	Forest	Grassland	Cropland	Settlement	Invasive
Alangium alpinum	Cornaceae	NE	15			x		
Sterculia villosa	Malvaceae	LC	29			x		
Gmelina arborea	Lamiaceae	LC	25			x		
Toona ciliata	Meliaceae	LC	23			x		
Mallotus philippensis	Euphorbiaceae	LC	59			x		
Schima wallichii	Theaceae	LC	97			x		
Dalbergia sericea	Fabaceae	LC	28			x		
Stereospermum chelonoides	Bignoniaceae	LC	15			x		
Aphanamixis polystachya	Meliaceae	LC	68			x		
Chukrasia tabularis	Meliaceae	LC	7			x		
Aporosa octandra	Phyllanthaceae	LC	36			x		
Magnolia champaca	Magnoliaceae	LC	32			x		
Morinda angustifolia	Rubiaceae	NE	49			x		
Areca catechu	Arecaceae	LC	45			x		
Tabernaemontana divaricata	Apocynaceae	LC	125	x				
Dillenia pentagyna	Dilleniaceae	NE	20	x				
Antidesma acuminatum	Phyllanthaceae	NE	17	x				
Persea sp	Lauraceae	-	28	x				
Syzygium formosum	Myrtaceae	LC	42	x				
Polyalthia simiarum	Annonaceae	LC	40	x				
Syzygium cumini	Myrtaceae	LC	28	x				
Drypetes sp	Putranjivaceae	-	12	x				
Helicia nilagirica	Proteaceae	LC	3	x				
Litsea monopetala	Lauraceae	LC	105	x				
Aglaia spectabilis	Meliaceae	LC	5	x				
Milusa roxburghiana	Annonaceae		24	x				
Alstonia scholaris	Apocynaceae	LC	7	x				
Choerospondias axillaris	Anacardiaceae	LC	4	x				

Species	Family	IUCN Red List	Habitat found					
			Number of records	Forest	Grassland	Cropland	Settlement	Invasive
Terminalia myriocarpa	Combretaceae	NE	19	x				
Maesa chisia	Primulaceae	NE	11	x				
Clerodendrum infortunatum	Lamiaceae	LC	22	x				
Litsea sp	Lauraceae	-	31	x				
Terminalia bellirica	Combretaceae	LC	21	x				
Actinodaphne sikkimensis	Lauraceae	NE	1	x				
Lagerstroemia parviflora	Lythraceae	LC	4				x	
Bombax ceiba	Malvaceae	LC	47				x	
Bridelia retusa	Phyllanthaceae	LC	37				x	
Mallotus nudiflorus	Euphorbiaceae	LC	127				x	
Wrightia arborea	Apocynaceae	LC	26				x	
Celtis tetrandra	Cannabaceae	LC	38				x	
Casearia vareca	Salicaceae	NE	28				x	
Lepisanthes senegalensis	Sapindaceae	LC	16	x				
Aporosa cardiosperma	Phyllanthaceae	VU	53	x				
Citrus medica	Rutaceae	LC	1	x				
Leea asiatica	Vitaceae	NE	6	x				
Clerodendrum viscosum	Lamiaceae	NE	9	x				
Careya arborea	Lecythidaceae	NE	14	x				
Catunaregam longispina	Rubiaceae	NE	11	x				
Ficus hirta	Moraceae	LC	1	x				
Holarrhena pubescens	Apocynaceae	LC	10	x				
Dalbergia assamica	Fabaceae	LC	19	x				
Eurya acuminata	Pentaphylacaceae	LC	4	x				
Albizia lucidior	Fabaceae	NE	39	x				
Phoebe lanceolata	Lauraceae	LC	4	x				
Flueggea virosa	Phyllanthaceae	LC	33	x				
Pterygota alata	Malvaceae	NE	28	x				

Species	Family	IUCN Red List	Habitat found					
			Number of records	Forest	Grassland	Cropland	Settlement	Invasive
Shorea robusta	Dipterocarpaceae	LC	3	x				
Gamblea ciliata	Araliaceae	LC	1	x				
Ailanthus grandis	Simaroubaceae	NE	6	x				
Spondias pinnata	Anacardiaceae	NE	5	x				
Anthocephalus cadamba	Rubiaceae	NE	5			x		
Tectona grandis	Lamiaceae	EN	19			x		
Duabanga grandiflora	Lythraceae	LC	9			x		
Zanthoxylum rhetsa	Rutaceae	LC	3	x				
Aglaia sp	Meliaceae	-	15	x				
Mackaya indica	Acanthaceae	NE	1	x				
Erythrina arborescens	Fabaceae	NE	3	x				
Syzygium sp	Myrtaceae	-	6	x				
Albizia procera	Fabaceae	LC	12	x				
Osbeckia nepalensis	Melastomataceae	NE	42			x		
Terminalia chebula	Combretaceae	LC	1			x		
Psidium guajava	Myrtaceae	LC	3			x		
Rhus chinensis	Anacardiaceae	LC	1			x		
Artocarpus heterophyllus	Moraceae	LC	1			x		
Bridelia tomentosa	Phyllanthaceae	LC	13			x		
Alstonia neriifolia	Apocynaceae	NE	2	x				
Glycosmis pentaphylla	Rutaceae	LC	5	x				
Crateva religiosa	Capparaceae	LC	27	x				
Ziziphus mauritiana	Rhamnaceae	LC	23	x				
Senegalia catechu	Fabaceae	LC	20	x				x
Brucea mollis	Simaroubaceae	DD	6	x				
Oroxylum indicum	Bignoniaceae	LC	6	x				
Litchi chinensis	Sapindaceae	LC	1			x		
Phyllanthus emblica	Phyllanthaceae	NE	1	x				
Alangium chinense	Cornaceae	NE	13			x		

Species	Family	IUCN Red List	Habitat found					
			Number of records	Forest	Grassland	Cropland	Settlement	Invasive
Ficus racemosa	Moraceae	LC	1				x	
Ficus hispida	Moraceae	LC	3				x	
Senna alata	Fabaceae	LC	1				x	
Dalbergia sissoo	Fabaceae	LC	3	x				x
Murraya koenigii	Rutaceae	LC	6	x				
Sapium insigne	Euphorbiaceae	NE	5	x				
Callicarpa arborea	Lamiaceae	LC	21	x				
Macaranga denticulata	Euphorbiaceae	LC	7	x				
Mallotus tetracoccus	Euphorbiaceae	NE	2	x				
Trema tomentosa	Cannabaceae	LC	1				x	
Ricinus communis	Euphorbiaceae	NE	1				x	
Leucaena leucocephala	Fabaceae	Lower Risk/conservation dependent	1				x	
Casearia glomerata	Salicaceae	LC	25	x				
Cinnamomum bejolghota	Lauraceae	LC	9	x				
Actinodaphne obovata	Lauraceae	LC	7	x				
Boehmeria polystachya	Urticaceae	NE	3	x				
Boehmeria macrophylla	Urticaceae	NE	4	x				
Phoebe sp	Lauraceae	-	4	x				
Mangifera sylvatica	Anacardiaceae	LC	1	x				
Litsea salicifolia	Lauraceae	LC	3	x				
Dysoxylum reticulatum	Meliaceae	NE	1	x				
Dendrocnide sinuata	Urticaceae	LC	1	x				
Psychotria nervosa	Rubiaceae	LC	1				x	
Citrus maxima	Rutaceae	LC	1				x	
Magnolia hodgsonii	Magnoliaceae	LC	8	x				
Pterospermum acerifolium	Malvaceae	LC	22	x				

Species	Family	IUCN Red List	Habitat found					
			Number of records	Forest	Grassland	Cropland	Settlement	Invasive
Bischofia javanica	Phyllanthaceae	LC	3	x				
Lindera neesiana	Lauraceae	LC	4				x	
Castanopsis indica	Fagaceae	LC	6	x				
Dillenia indica	Dilleniaceae	LC	2	x				
Alchornea mollis	Euphorbiaceae	NE	1		x			
Antidesma acidum	Phyllanthaceae	LC	2	x				
Baccaurea ramiflora	Phyllanthaceae	LC	2	x				
Justicia adhatoda	Acanthaceae	LC	15	x				
Sapium baccatum	Euphorbiaceae	LC	4				x	
Croton caudatus	Euphorbiaceae	LC	1	x				
Garuga pinnata	Burseraceae	NE	8	x				
Ficus roxburghii	Moraceae	LC	1	x				
Albizia lebbeck	Fabaceae	LC	1	x				
Phlogacanthus thyrsiformis	Acanthaceae	NE	2				x	
Bauhinia variegata	Fabaceae	LC	1				x	
Lagerstroemia hirsuta	Lythraceae	NE	1				x	

I.2 LIST OF RECORDED FLORA SPECIES – HERBS

Species	Family	Number of records	IUCN Red List	Invasive
Chromolaena odorata	Asteraceae	36	NE	x
Impatiens tripetala	Balsaminaceae	16	NE	
Cyathula prostrata	Amaranthaceae	20	NE	
Tabernaemontana divaricata	Apocynaceae	15	LC	
Psilanthus bengalensis	Rubiaceae	20	NE	
Piper betleoides	Piperaceae	11	NE	
Triumfetta rhomboidea	Malvaceae	8	NE	
Urena lobata	Malvaceae	29	LC	
Senna tora	Fabaceae	20	NE	
Sida acuta	Malvaceae	22	NE	x
Spermacoce latifolia	Rubiaceae	36	NE	

Species	Family	Number of records	IUCN Red List	Invasive
Cyanotis sp	Commelinaceae	2	NE	
Curcuma sp	Zingiberaceae	2	NE	
Boehmeria macrophylla	Urticaceae	5	NE	
Globba clarkei	Zingiberaceae	7	NE	
Ageratum conyzoides	Asteraceae	31	LC	
Persicaria capitata	Polygonaceae	12	NE	
Bidens pilosa	Asteraceae	19	NE	x
Phyllanthus urinaria	Phyllanthaceae	4	NE	
Holmskioldia sanguinea	Lamiaceae	2	NE	
Diplazium esculentum	Athyriaceae	10	LC	
Tetrastigma sp	Vitaceae	2	NE	
Mikania micrantha	Asteraceae	21	NE	
Commelina benghalensis	Commelinaceae	4	LC	
Desmodium heterocarpon	Fabaceae	4	NE	
Solanum viarum	Solanaceae	2	LC	
Osbeckia nepalensis	Melastomataceae	1	NE	
Clerodendrum viscosum	Lamiaceae	2	NE	
Apios carnea	Fabaceae	4	NE	
Acmella uliginosa	Asteraceae	6	LC	x
Clerodendrum infortunatum	Lamiaceae	19	LC	
Thelypteris sp	Thelypteridaceae	2	NE	
Tinospora cordifolia	Menispermaceae	1	NE	
Momordica sp	Cucurbitaceae	1	NE	
Sesamum sp	Pedaliaceae	4	NE	
Mitracarpus hirtus	Rubiaceae	1	NE	
Euphorbia hirta	Euphorbiaceae	1	NE	
Dioscorea bulbifera	Dioscoreaceae	2	NE	x
Drymaria cordata	Caryophyllaceae	4	NE	
Argyreia hookeri	Convolvulaceae	2	NE	
Desmodium elegans	Fabaceae	3	LC	

Species	Family	Number of records	IUCN Red List	Invasive
Mimosa pudica	Fabaceae	3	LC	x
Clerodendrum chinense	Lamiaceae	2	LC	
Solanum nigrum	Solanaceae	2	NE	
Physalis divaricata	Solanaceae	1	NE	
Hyptis suaveolens	Lamiaceae	2	NE	x
Galinsoga parviflora	Asteraceae	1	NE	
Crotalaria pallida	Fabaceae	2	NE	
Pouzolzia zeylanica	Urticaceae	3	NE	
Alternanthera sessilis	Amaranthaceae	6	LC	
Colocasia sp	Araceae	2	NE	
Persicaria chinensis	Polygonaceae	1	NE	
Scoparia dulcis	Plantaginaceae	3	NE	x
Achyranthes aspera	Amaranthaceae	12	NE	
Costus speciosa	Costaceae	1	NE	
Croton caudatus	Euphorbiaceae	1	LC	
Achryospermum wallichianum	Lamiaceae	2	NE	
Strobilanthes sp	Acanthaceae	2	NE	
Pouzolzia sanguinea	Urticaceae	1	NE	
Colocasia esculenta	Araceae	1	LC	
Piper sp	Piperaceae	1	NE	
Gynura crepidioides	Asteraceae	7	NE	
Amaranthus sp	Amaranthaceae	5	NE	
Persicaria barbata	Polygonaceae	1	LC	
Peperomia pellucida	Piperaceae	1	NE	
Solanum torvum	Solanaceae	1	NE	
Piper mullesua	Piperaceae	1	NE	
Boehmeria polystachya	Urticaceae	1	NE	
Segesbeckia orientalis	Asteraceae	1	NE	

I.3 LIST OF RECORDED FLORA SPECIES – REGENERATION

Species	Family name	IUCN Red List	Number of records	Invasive
Schima wallichii	Theaceae	LC	9	
Stereospermum chelonoides	Bignoniaceae	LC	6	
Toona ciliata	Meliaceae	LC	5	
Sterculia villosa	Malvaceae	LC	2	
Syzygium formosum	Myrtaceae	LC	8	
Persea sp	Lauraceae	NE	8	
Aphanamixis polystachya	Meliaceae	LC	14	
Terminalia bellirica	Combretaceae	LC	12	
Casearia vareca	Salicaceae	NE	7	
Helicia nilagirica	Proteaceae	LC	6	
Leea asiatica	Vitaceae	NE	15	
Morinda angustifolia	Rubiaceae	NE	7	
Polyalthia simiarum	Annonaceae	LC	5	
Litsea monopetala	Lauraceae	LC	28	
Aglaia sp	Meliaceae	NE	6	
Litsea sp	Lauraceae	NE	6	
Albizia lucidior	Fabaceae	NE	8	
Albizia procera	Fabaceae	LC	26	
Aporosa cardiosperma	Phyllanthaceae	**VU**	8	
Dillenia pentagyna	Dilleniaceae	NE	3	
Bridelia retusa	Phyllanthaceae	LC	4	
Ficus hispida	Moraceae	LC	2	
Brucea mollis	Simaroubaceae	DD	1	
Morus alba	Moraceae	LC	5	
Morus laevigata	Moraceae	NE	1	
Wrightia arborea	Apocynaceae	LC	5	
Mallotus philippensis	Euphorbiaceae	LC	2	
Chukrasia tabularis	Meliaceae	LC	3	
Flueggea virosa	Phyllanthaceae	LC	8	

Species	Family name	IUCN Red List	Number of records	Invasive
Celtis tetrandra	Cannabaceae	LC	4	
Bridelia tomentosa	Phyllanthaceae	LC	1	
Boehmeria macrophylla	Urticaceae	NE	1	
Senegalia catechu	Fabaceae	LC	7	X
Phoebe lanceolata	Lauraceae	LC	1	
Alangium chinense	Cornaceae	NE	5	
Mangifera sylvatica	Anacardiaceae	LC	2	
Psidium guajava	Myrtaceae	LC	2	
Bombax ceiba	Malvaceae	LC	3	
Bauhinia purpurea	Fabaceae	LC	1	
Mallotus nudiflorus	Euphorbiaceae	LC	3	
Crateva religiosa	Capparaceae	LC	2	
Kydia calycina	Malvaceae	LC	1	
Murraya koenigii	Rutaceae	LC	1	
Ardisia involucatra	Primulaceae	NE	1	
Maesa indica	Primulaceae	LC	4	
Syzygium cumini	Myrtaceae	LC	3	
Magnolia champaca	Magnoliaceae	LC	6	
Alangium alpinum	Cornaceae	NE	3	
Maesa chisia	Primulaceae	NE	2	
Antidesma acidum	Phyllanthaceae	LC	2	
Citrus medica	Rutaceae	LC	1	
Dalbergia assamica	Fabaceae	LC	2	
Macaranga denticulata	Euphorbiaceae	LC	1	
Magnolia hodgsonii	Magnoliaceae	LC	1	
Clerodendrum infortunatum	Lamiaceae	LC	1	
Tabernaemontana divaricata	Apocynaceae	LC	4	
Pterospermum acerifolium	Malvaceae	LC	1	
Phlogacanthus thyrsiformis	Acanthaceae	NE	1	
Erythrina arborescens	Fabaceae	NE	1	

I.4 LIST OF RECORDED FLORA SPECIES – EPIPHYTES

Species	Family name	IUCN Red List	Number of records	Invasive
Ficus virens	Moraceae	LC	3	
Mikania micrantha	Asteraceae	NE	26	
Adiantum sp	Pteridaceae	-	4	
Drynaria propinqua	Polypodiaceae	NE	9	
Thunbergia grandiflora	Acanthaceae	NE	10	
Asplenium nidus	Aspleniaceae	NE	23	
Smilax ferox	Smilacaceae	NE	1	
Dioscorea pentaphylla	Dioscoreaceae	NE	6	
Cucumi maderaspatanus	Cucurbitaceae	NE	3	
Millettia sp	Fabaceae	-	3	
Dioscorea bulbifera	Dioscoreaceae	NE	20	x
Senegalia pennata	Fabaceae	LC	4	
Apios carnea	Fabaceae	NE	9	
Tetrastigma sp	Vitaceae	-	7	
Pothos cathcartii	Araceae	NE	10	
Tinospora cordifolia	Menispermaceae	NE	2	
Rhynchostylis sp	Orchidaceae	-	3	
Bulbophyllum sp	Orchidaceae	-	10	
Hiptage benghalensis	Malpighiaceae	LC	2	
Argyreia hookeri	Convolvulaceae	NE	9	
Momordica sp	Cucurbitaceae	-	1	
Cuscuta reflexa	Convolvulaceae	LC	5	
Desmodium sp	Fabaceae	-	1	
Piper betleoides	Piperaceae	NE	2	
Thelypteris sp	Thelypteridaceae	-	2	
Phrynium sp	Marantaceae	-	1	
Croton sp	Euphorbiaceae	-	1	
Raphidophora decursiva	Araceae	NE	1	
Dryopteris sp	Dryopteridaceae	-	1	

Species	Family name	IUCN Red List	Number of records	Invasive
Pteridium sp	Dennstaedtiaceae	-	1	
Dioscorea sp	Dioscoreaceae	-	3	
Ipomoea quamoclit	Convolvulaceae	NE	2	
Stephania glabra	Menispermaceae	NE	1	
Pueraria tuberosa	Fabaceae	NE	1	
Schefflera sp	Araliaceae	-	1	
Dioscorea deltoidea	Dioscoreaceae	NE	1	
Cryptolepis buchananii	Apocynaceae	NE	1	

I.5 LIST OF RECORDED BIRD SPECIES

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
1	Pycnonotidae	Red-vented Bulbul	*Pycnonotus cafer*	LC	85			x
2	Columbidae	Eastern Spotted Dove	*Spilopelia chinensis*	LC	64			x
3	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	LC	47			x
4	Sturnidae	Common Myna	*Acridotheres tristis*	LC	41, camera trap			x
5	Leiotrichidae	Jungle Babbler	*Argya striata*	LC	38			x
6	Megalaimidae	Lineated Barbet	*Ducula badia*	LC	38			x
7	Pittidae	Oriental Magpie Robin	*Pitta sordida*	LC	36			x
8	Sturnidae	Chestnut-tailed Starling	*Halcyon gularis*	LC	32			x
9	Pycnonotidae	Black-crested Bulbul	*Rubigula flaviventris*	LC	30			x
10	Ardeidae	Cattle Egret	*Gracula religiosa*	LC	25, camera trap			x
11	Chloropseidae	Golden-fronted Leafbird	*Chloropsis aurifrons*	LC	24			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
12	Megalaimidae	Blue-throated Barbet	*Halcyon gularis*	LC	24			x
13	Aegithinidae	Common Iora	*Aegithina tiphia*	LC	23			x
14	Phasianidae	Indian Peafowl	*Pavo cristatus*	LC	21, camera trap			x
15	Columbidae	Green Imperial Pigeon	*Ducula aenea*	NT	21			x
16	Corvidae	Grey Treepie	*Dendrocitta formosae*	LC	20			x
17	Muscicapidae	Hill Myna	*Copsychus saularis*	LC	20			x
18	Dicruridae	Black Drongo	*Copsychus saularis*	LC	20			x
19	Alcedinidae	White-throated Kingfisher	*Halcyon gularis*	LC	19			x
20	Sturnidae	Asian Pied starling	*Gracupica contra*	LC	19			x
21	Meropidae	Chestnut-headed Bee-eater	*Merops leschenaulti*	LC	18			x
22	Dicruridae	Hair-crested Drongo	*Dicrurus hottentottus*	LC	18			x
23	Oriolidae	Black-hooded Oriole	*Oriolus xanthornus*	LC	18		x	
24	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	LC	18		x	
25	Leiotrichidae	Rufous-necked Laughing thrush	*Pterorhinus ruficollis*	LC	17			x
26	Cuculidae	Lesser Coucal	*Centropus bengalensis*	LC	17			x
27	Corvidae	Rufous Treepie	*Dendrocitta vagabunda*	LC	17			x
28	Nectariniidae	Crimson Sunbird	*Reinwardtoena browni*	LC	17		x	

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
29	Paridae	Great Tit	*Macropygia unchall*	LC	15			x
30	Coraciidae	Indian Roller	*Pterorhinus pectoralis*	LC	15			x
31	Campephagidae	Large Cuckoos hrike	*Coracina javensis*	LC	15			x
32	Sturnidae	Jungle Myna	*Ducula badia*	LC	14			x
33	Timaliidae	Pin-striped Tit Babbler	*Mixornis gularis*	LC	13			x
34	Artamidae	Ashy Woodsw allow	*Macropygia unchall*	LC	12			x
35	Muscicapidae	White-rumped Shama	*Copsychus malabaricus*	LC	12			x
36	Phalacrocoracid ae	Little Cormora nt	*Microcarbo niger*	LC	11			x
37	Psittacidae	Red-breasted Parakeet	*Psittacula alexandri*	NT	11			x
38	Columbidae	Pin-tailed Green Pigeon	*Treron apicauda*	LC	10			x
39	Corvidae	House Crow	*Corvus splendens*	LC	10			x
40	Columbidae	Emerald Dove	*Chalcophaps indica*	LC	10		x	
41	Picidae	Grey-headed Woodpe cker	*Picus canus*	LC	9			x
42	Pycnonotidae	Red-whiskere d Bulbul	*Pycnonotus jocosus*	LC	8			x
43	Dicruridae	Bronzed Drongo	*Gracula religiosa*	LC	8			x
44	Campephagidae	Scarlet Minivet	*Gracula religiosa*	LC	8			x
45	Picidae	Fulvous-breasted	*Dendrocopos macei*	LC	7			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
		Woodpecker						
46	Picidae	Greater Flameback	*Copsychus saularis*	LC	7			x
47	Picidae	Greater Yellownape	*Pitta sordida*	LC	7			x
48	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	LC	7			x
49	Sturnidae	Great Myna	*Acridotheres grandis*	LC	7			x
50	Leiotrichidae	Asian Koel	*Eudynamys scolopaceus*	LC	7		x	
51	Strigidae	Asian Barred Owlet	*Glaucidium cuculoides*	LC	7		x	
52	Cuculidae	Green-billed Malkoha	*Phaenicophaeus tristis*	LC	6			x
53	Rallidae	White-breasted Waterhen	*Ducula badia*	LC	6, camera trap			x
54	Dicruridae	Greater Racquet-tailed Drongo	*Dicrurus paradiseus*	LC	6			x
55	Passeridae	Eurasian Tree Sparrow	*Passer montanus*	LC	6		x	
56	Columbidae	Rock Dove	*Columba livia*	LC	6		x	
57	Columbidae	Wedged-tailed Green Pigeon	*Treron sphenurus*	LC	6		x	
58	Monarchidae	Black-naped Monarch	*Hypothymis azurea*	LC	6		x	
59	Charadriidae	River Lapwing	*Vanellus duvaucelii*	NT	5			x
60	Pittidae	Mountain Imperial Pigeon	*Pitta sordida*	LC	5			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
61	Corvidae	Large-billed Crow	*Corvus macrorhynchos*	LC	5			x
62	Ardeidae	Little Egret	*Egretta garzetta*	LC	5			x
63	Picidae	Grey-capped Pygmy Woodpecker	*Picoides canicapillus*	LC	5			x
64	Phasianidae	Black Francolin	*Francolinus francolinus*	LC	5			x
65	Psittacidae	Alexandrine Parakeet	*Palaeornis eupatria*	NT	5			x
66	Leiotrichidae	Lesser Necklaced Laughingthrush	*Garrulax monileger*	LC	4			x
67	Bucerotidae	Oriental Pied Hornbill	*Anthracoceros albirostris*	LC	4			x
68	Strigidae	Spotted Owlet	*Athene brama*	LC	4			x
69	Meropidae	Blue-tailed Bee-eater	*Merops philippinus*	LC	4		x	
70	Cuculidae	Greater Coucal	*Centropus sinensis*	LC	4			x
71	Alcedinidae	Common Kingfisher	*Alcedo atthis*	LC	4	x		
72	Phasianidae	Red Junglefowl	*Gallus gallus*	LC	4, camera trap		x	
73	Alcedinidae	Crested Kingfisher	*Megaceryle lugubris*	LC	4	x		
74	Meropidae	Blue-bearded Bee-eater	*Nyctyornis athertoni*	LC	4			x
75	Bucerotidae	Great Hornbill	*Buceros bicornis*	VU	4			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
76	Corvidae	Common Green Magpie	*Cissa chinensis*	LC	3			x
77	Estrildidae	White-rumped Munia	*Halcyon gularis*	LC	3			x
78	Vangidae	Large Woodshrike	*Macropygia unchall*	LC	3			x
79	Sturnidae	Bank Myna	*Copsychus saularis*	LC	3			x
80	Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*	LC	3			x
81	Cuculidae	Chestnut-winged Cuckoo	*Clamator coromandus*	LC	3			x
82	Turnicidae	Barred Buttonquail	*Turnix suscitator*	LC	3			x
83	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	LC	3		x	
84	Hirundinidae	Red-rumped Swallow	*Cecropis daurica*	LC	3		x	
85	Coraciidae	Dollarbird	*Eurystomus orientalis*	LC	3			x
86	Motacillidae	White Wagtail	*Motacilla alba*	LC	3	x		
87	Picidae	Lesser Yellownape	*Picus chlorolophus*	LC	3			x
88	Dicruridae	Crow-billed Drongo	*Dicrurus annectens*	LC	3			x
89	Columbidae	Barred Cuckoo Dove	*Macropygia unchall*	LC	3		x	
90	Picidae	Rufous Woodpecker	*Micropternus brachyurus*	LC	3			x
91	Strigidae	Tawny Fish Owl	*Ketupa flavipes*	LC	2			x
92	Sittidae	Chestnut-bellied Nuthatch	*Pitta sordida*	LC	2			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
93	Sturnidae	Wreathed Hornbill	*Rhyticeros undulatus*	VU	2			x
94	Nectariniidae	Black-throated Sunbird	*Aethopyga saturata*	LC	2			x
95	Sturnidae	Common Myna	*Acridotheres tristis*	LC	2			x
96	Accipitridae	Shikra	*Accipiter badius*	LC	2		x	
97	Passeridae	House Sparrow	*Passer domesticus*	LC	2		x	
98	Nectariniidae	Purple Sunbird	*Hierococcyx sparverioides*	LC	2		x	
99	Psittacidae	Slaty-headed Parakeet	*Himalayapsitta himalayana*	LC	2		x	
100	Ardeidae	Intermediate Egret	*Ardea intermedia*	LC	2		x	
101	Columbidae	Asian Palm Swift	*Cypsiurus balasiensis*	LC	2		x	
102	Megalaimidae	Coppersmith Barbet	*Psilopogon haemacephalus*	LC	2		x	
103	Picidae	Himalayan Goldenback	*Dinopium shorii*	LC	2			x
104	Meropidae	Green Bee-eater	*Merops orientalis*	LC	2			x
105	Ciconiidae	Lesser Adjutant	*Leptoptilos javanicus*	NT	2	x		
106	Ardeidae	Cinnamon Bittern	*Ixobrychus cinnamomeus*	LC	2	x		
107	Anatidae	Lesser Whistling Duck	*Dendrocygna javanica*	LC	2	x		
108	Scolopacidae	Green Sandpiper	*Tringa ochropus*	LC	2	x		
109	Rhipiduridae	White-throated Fantail	*Rhipidura albicollis*	LC	2		x	

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
110	Dicaeidae	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	LC	2			x
111	Ardeidae	Striated Heron	*Butorides striata*	LC	2	x		
112	Accipitridae	Shikra	*Accipiter badius*	LC	2		x	
113	Pycnonotidae	Black Bulbul	*Irena puella*	LC	2		x	
114	Irenidae	Asian Fairy Bluebird	*Irena puella*	LC	2		x	
115	Pellorneidae	Abbott's Babbler	*Malacocincla abbotti*	LC	2			x
116	Pycnonotidae	White-throated Bulbul	*Alophoixus flaveolus*	LC	2			x
117	Leiotrichidae	White-crested Laughing thrush	*Garrulax leucolophus*	LC	1			x
118	Columbidae	Barred Cuckoo Dove	*Macropygia unchall*	LC	1			x
119	Columbidae	Hooded Pita	*Ducula badia*	LC	1			x
120	Psittacidae	Rose-ringed Parakeet	*Alexandrinus krameri*	LC	1			x
121	Accipitridae	Mountain Hawk Eagle	*Nisaetus nipalensis*	NT	1			x
122	Accipitridae	Black Baza	*Picoides canicapillus*	LC	1			x
123	Motacillidae	Paddyfield Pipit	*Anthus rufulus*	LC	1			x
124	Motacillidae	Richard's Pipit	*Anthus richardi*	LC	1			x
125	Leiotrichidae	Greater-necklaced Laughing thrush	*Pterorhinus pectoralis*	LC	1			x
126	Elanidae	Black-winged Kite	*Elanus caeruleus*	LC	1			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
127	Cisticolidae	Grey-breasted Prinia	*Prinia hodgsonii*	LC	1			x
128	Laniidae	Grey-backed Shrike	*Lanius tephronotus*	LC	1			x
129	Burhinidae	Indian Thick-knee	*Burhinus indicus*	LC	1			x
130	Cuculidae	Pied Cuckoo	*Reinwardtoena browni*	NT	1		x	
131	Apodidae	Large Hawk Cuckoo	*Hierococcyx sparverioides*	LC	1		x	
132	Accipitridae	Orietal Honey-buzzard	*Pernis ptilorhynchus*	LC	1		x	
133	Columbidae	Yellow-footed Green Pigeon	*Treron phoenicopterus*	LC	1		x	
134	Laniidae	Long-tailed Shrike	*Lanius schach*	LC	1		x	
135	Rallidae	Watercock	*Gallicrex cinerea*	LC	1		x	
136	Acrocephalidae	Thick-billed Warbler	*Arundinax aedon*	LC	1			x
137	Eurylaimidae	Long-tailed Broadbill	*Psarisomus dalhousiae*	LC	1			x
138	Apodidae	Himalayan Swiftlet	*Spilornis cheela*	LC	1			x
139	Accipitridae	Crested Serpent Eagle	*Spilornis cheela*	LC	1			x
140	Hirundinidae	Barn Swallow	*Ardeola grayii*	LC	1			x
141	Picidae	Lesser Goldenback	*Dinopium benghalense*	LC	1			x
142	Ardeidae	Indian Pond Heron	*Ardeola grayii*	LC	1	x		
143	Timaliidae	White-browed	*Pomatorhinus schisticeps*	LC	1			x

SN.	Family Name	Common name	Scientific name	IUCN Red list	Number of records	Found in habitat		
						Waterbodies & Wetland	Settlement & Farmlands	Sub-tropical Broadleaf Forest
		Scimitar Babbler						
144	Falconidae	Common Kestrel	*Falco tinnunculus*	LC	1			x
145	Apodidae	Pacific Swift	*Apus pacificus*	LC	1			x
146	Pellorneidae	Spot-throated Babbler	*Pellorneum albiventre*	LC	1			x
147	Motacillidae	White-browed Wagtail	*Motacilla maderaspatensis*	LC	1			x
148	Upupidae	Common Hoopoe	*Upupa epops*	LC	1			x
149	Falconidae	Peregrine Falcon	*Falco peregrinus*	LC	1		x	
150	Muscicapidae	Rufous-bellied Niltava	*Niltava sundara*	LC	1		x	
151	Burhinidae	Great Thick-knee	*Esacus recurvirostris*	NT	1	x		
152	Pellorneidae	Puff-throated Babbler	*Pellorneum ruficeps*	LC	1			x
153	Cuculidae	Common Hawk Cuckoo	*Hierococcyx varius*	LC	1			x
154	Nectariniidae	Mrs Gould's Sunbird	*Aethopyga gouldiae*	LC	1		x	
155	Accipitridae	Jerdon's Baza	*Aviceda jerdoni*	LC	1			x
156	Megalaimidae	Blue-eared Barbet	*Psilopogon cyanotis*	LC	1			x
157	Nectariniidae	Streaked Spiderhunter	*Arachnothera magna*	LC	1			x
158	Accipitridae	Black Eagle	*Ictinaetus malaiensis*	LC	1			x

I.6 LIST OF RECORDED HERPETOFAUNA SPECIES

Species Group	Common Name	IUCN Status	Number of Individuals
Amphibian			**166**

Species Group	Common Name	IUCN Status	Number of Individuals
Duttaphrynus melanostictus	-	LC	2
Euphlyctis cyanophlyctis	Skipper Frog	LC	22
Euphlyctus sp.	-	-	1
Fejervarya sp.	-	-	66
Fejervarya teraiensis	-	LC	1
Hoplobatrachus tigerinus	Indian Bullfrog	LC	27
Hylarana leptoglossa	Cope's Assam Frog	LC	1
Minevarya sp.	-	-	33
Polypedates sp.	-	-	10
Theloderma asperum	Hill Garden Bug-eyed Frog	LC	1
Uperodon globulosus	Indian Globular Frog	LC	1
Zhangixalus smaragdinus	Nepal Flying Frog	LC	1
Reptile			**166**
Amphiesma stolatum	Buff Striped Keelback	LC	1
Boiga gokool	Eastern Cat Snake	LC	1
Bungarus fasciatus	Banded Krait	LC	3
Calotes irawadi	-	LC	34
Calotes sp.	-	-	16
Calotes versicolor	Changeable Lizard	LC	15
Coelognathus helena	-	LC	2
Cyrtodactylus bhupathyi	-	DD	1
Cyrtodactylus septentrionalis	-	DD	1
Cyrtodactylus sp.	-	-	1
Daboia russelii	-	LC	1
Dendrelaphis proarchos	-	NE	1
Dendrelaphis tristis	-	LC	1
Eutropis dissimilis	Striped Grass Mabuya	LC	4
Eutropis macularia	Bronze Mabuya	LC	7
Eutropis multifasciata	Common Mabuya	LC	2
Eutropis sp.	-	-	1
Hemidactylus bowringii	-	LC	1
Hemidactylus frenatus	-	LC	11
Hemidactylus kushmorensis	-	DD	5

Species Group	Common Name	IUCN Status	Number of Individuals
Hemidactylus platyurus	-	LC	1
Hemidactylus sp.	-	-	12
Indotyphlops braminus	Brahminy Blind Snake	LC	5
Melanochelys tricarinata	Tricarinate Hill Turtle	EN	1
Naja kaouthia	-	LC	1
Naja naja	Indian Cobra	LC	2
Ophiophagus hannah	King Cobra	VU	5
Ptyas mucosa	-	LC	5
Ptyas nigromarginata	Green Rat Snake	LC	1
Python bivittatus	Burmese Python	VU	1
Rhabdophis subminiatus	Red-necked Keelback	LC	1
Riopa punctata	-	LC	1
Sphenomorphus indicus	-	LC	2
Sphenomorphus maculatus	-	LC	7
Sphenomorphus sp.	-	-	3
Trimeresurus salazar	-	NE	1
Varanus bengalensis	Bengal Monitor Lizard	NT	5
Varanus salvator	-	LC	1
Xenochrophis piscator	-	LC	2
Total			**332**

I.7 CAMERA TRAP SURVEY REPORT

Camera Trap Survey Report for Wet Season

Camera Trap Survey Report for Dry Season

I.8 LIST OF RECORDED FISH

I.8.1 SPECIES FOUND IN MAU RIVER

	Species	Family	IUCN Red List	Invasive	plot 1	plot 4	plot 5
1	*Aborichthys elongatus*	*Nemacheilidae*	LC				1
2	*Amblyceps apangi*	*Amblycipitidae*	LC		1	1	3
3	*Balitora brucei*	*Balitoridae*	NT		1		
4	*Bangana dero*	*Cyprinidae*	LC		4	1	
5	*Barilius barna*	*Cyprinidae*	LC		7	2	3
6	*Barilius bendelisis*	*Cyprinidae*	LC			1	
7	*Barilius vagra*	*Cyprinidae*	LC		1		
8	*Batasio merianiensis*	*Bagridae*	DD			1	1
9	*Botia almorhae*	*Botiidae*	LC		1		1
10	*Channa striata*	*Channidae*	LC			2	1
11	*Cirrhinus cirrhosus*	*Cyprinidae*	VU	x			1
12	*Crossocheilus latius*	*Cyprinidae*	LC		1	1	1
13	*Cyprinion semiplotus*	*Cyprinidae*	DD				2
14	*Devario aequipinnatus*	*Cyprinidae*	LC		2	2	1
15	*Garra annandalei*	*Cyprinidae*	LC		3	20	2
16	*Garra birostris*	*Cyprinidae*	NE		5	12	5
17	*Glyptothorax striatus*	*Sisoridae*	NT		3		
18	*Glyptothorax trilineatus*	*Sisoridae*	LC			1	
19	*Macrognathus pancalus*	*Mastacembelidae*	LC				1
20	*Mastacembelus armatus*	*Mastacembelidae*	LC			2	
21	*Neolissochilus hexagonolepis*	*Cyprinidae*	NT		4	2	
22	*Pethia conchonius*	*Cyprinidae*	LC				
23	*Pseudecheneis sulcata*	*Sisoridae*	LC		6		
24	*Pseudolaguvia shawi*	*Sisoridae*	LC			1	
25	*Psilorhynchus balitora*	*Psilorhynchidae*	LC			1	
26	*Puntius sophore*	*Cyprinidae*	LC				1
27	*Schistura devdevi*	*Nemacheilidae*	NT		1		3
28	*Schistura reticulofasciata*	*Nemacheilidae*	VU			10	2
29	*Xenentodon cancila*	*Belonidae*	LC				1

I.8.2 SPECIES FOUND IN TAKLAI RIVER

SN.	Species	Family	IUCN Red List	Invasive species	plot 2	plot 3
1	*Aborichthys elongatus*	Nemacheilidae	LC			3
2	*Amblyceps apangi*	Amblycipitidae	LC		12	2
3	*Badis badis*	Badidae	LC		1	1
4	*Balitora brucei*	Balitoridae	NT		4	
5	*Bangana dero*	Cyprinidae	LC		1	
6	*Barilius barna*	Cyprinidae	LC		14	5
7	*Barilius bendelisis*	Cyprinidae	LC			9
8	*Channa striata*	Channidae	LC			7
9	*Cirrhinus cirrhosus*	Cyprinidae	VU	x	1	
10	*Cyprinion semiplotus*	Cyprinidae	DD		1	3
11	*Danio dangila*	Cyprinidae	NE			5
12	*Devario aequipinnatus*	Cyprinidae	LC			1
13	*Garra annandalei*	Cyprinidae	LC		10	
14	*Garra birostris*	Cyprinidae	NE		15	3
15	*Amblyceps apangi*	Amblycipitidae	LC		13	
16	*Mastacembelus armatus*	Mastacembelidae	LC			2
17	*Neolissochilus hexagonolepis*	Cyprinidae	NT		1	2
18	*Olyra longicaudata*	Bagridae	LC			1
19	*Oreichthys crenucoides*	Cyprinidae	NE			5
20	*Pseudolagovia shawi*	Sisoridae	NE		1	
21	*Psilorhynchus balitora*	Psilorhynchidae	LC		6	5
22	*Puntius sophore*	Cyprinidae	LC			3
23	*Schistura devdevi*	Nemacheilidae	NT			1
24	*Schistura reticulofasciata*	Nemacheilidae	VU			6

I.9 LIST OF RECORDED MACROBENTHIC

SN.	Site	Count	Habitat	Common Name
1	Aquatic Plot 1	3	Pool	Small Minnow Mayfly
2	Aquatic Plot 1	15	Riffle	Small Minnow Mayfly
3	Aquatic Plot 1	14	Run	Small Minnow Mayfly
4	Aquatic Plot 1	3	Pool	Flat-headed Mayfly
5	Aquatic Plot 1	15	Riffle	Flat-headed Mayfly
6	Aquatic Plot 1	5	Run	Flat-headed Mayfly
7	Aquatic Plot 1	2	Pool	Free-living Caddisfly
8	Aquatic Plot 1	3	Pool	Small Minnow Mayfly
9	Aquatic Plot 1	5	Riffle	Spiny Crawler Mayfly
10	Aquatic Plot 2	4	Pool	Common Stonefly
11	Aquatic Plot 2	10	Pool	Creeping Water Beetle
12	Aquatic Plot 2	19	Pool	Small Minnow Mayfly
13	Aquatic Plot 2	7	Riffle	Spiny Crawler Mayfly
14	Aquatic Plot 2	2	Riffle	Flat-headed Mayfly
15	Aquatic Plot 2	1	Run	Common Stonefly
16	Aquatic Plot 2	5	Run	Flat-headed Mayfly
17	Aquatic Plot 2	3	Riffle	Creeping Water Beetle
18	Aquatic Plot 3	27	Pool	Creeping Water Beetle
19	Aquatic Plot 3	40	Riffle	Creeping Water Beetle
20	Aquatic Plot 3	29	Run	Creeping Water Beetle
21	Aquatic Plot 3	68	Riffle	Small Minnow Mayfly
22	Aquatic Plot 3	8	Riffle	Net-spinning Caddisfly
23	Aquatic Plot 3	10	Run	Small Minnow Mayfly
24	Aquatic Plot 4	7	Pool	Small Minnow Mayfly
25	Aquatic Plot 4	12	Riffle	Small Minnow Mayfly
26	Aquatic Plot 4	5	Run	Small Minnow Mayfly
27	Aquatic Plot 4	8	Pool	Flat-headed Mayfly
28	Aquatic Plot 5	7	Pool	Small Minnow Mayfly
29	Aquatic Plot 5	12	Riffle	Small Minnow Mayfly
30	Aquatic Plot 5	11	Run	Small Minnow Mayfly
31	Aquatic Plot 5	7	Riffle	Spiny Crawler Mayfly

I.10 AQUATIC SURVEY REPORT

Aquatic Survey Report – Wet Season

Aquatic Survey Report – Dry Season

APPENDIX J CRITICAL HABITAT ASSESSMENT

APPENDIX K SOCIO-ECONOMIC BASELINE METHODOLOGY

J SOCIO-ECONOMIC BASELINE METHODOLOGY

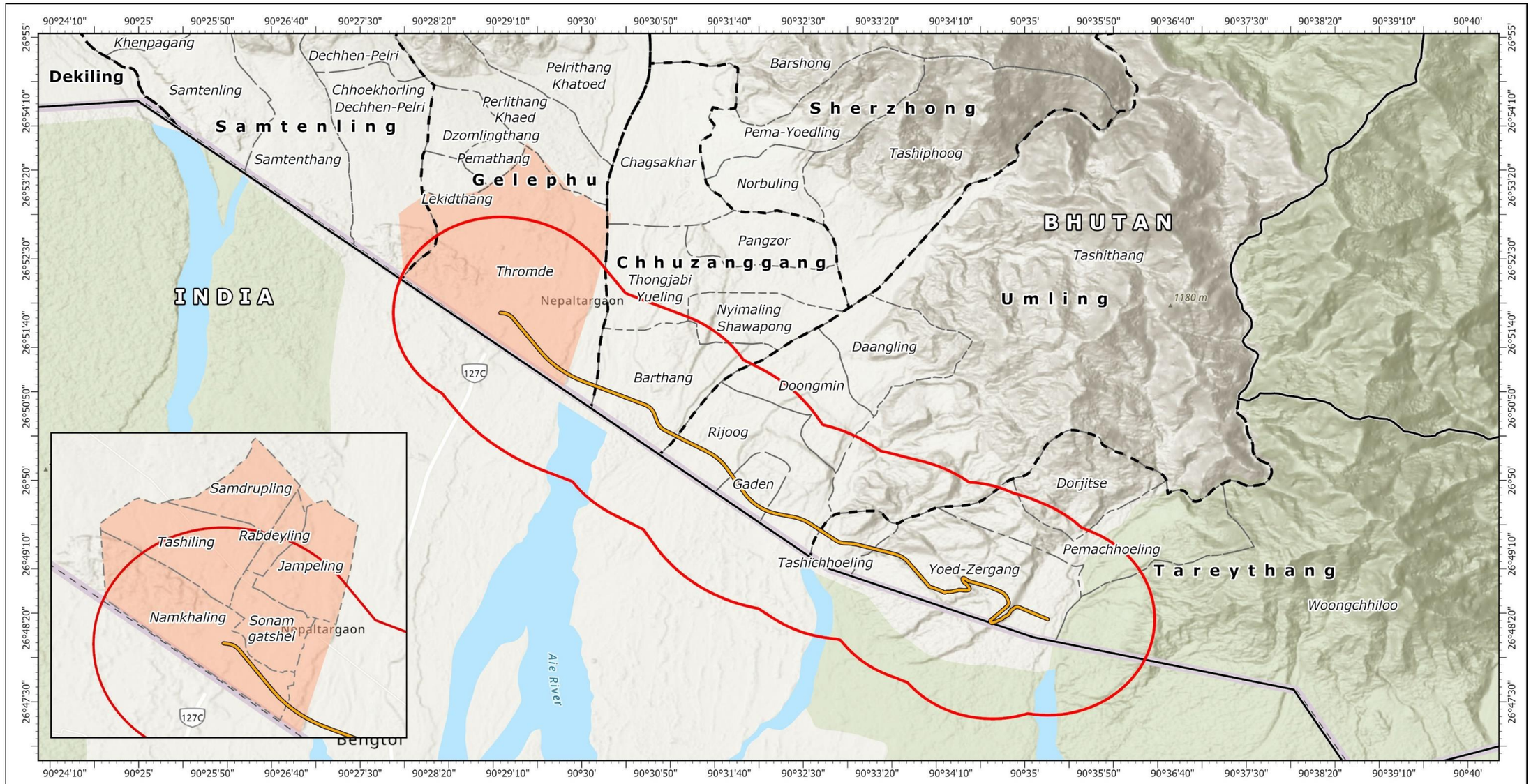
The socio-economic profile or baseline for the Project is focused on the Impact Area. An area of up to two (02) km either side of the road alignment has been defined as the Impact Area. This captures the areas that will likely be directly impacted by the Project, specifically social receptors and resources, such as local communities, existing infrastructure, common property resources and cultural heritage values. This also covers the areas where physical and economic displacement will likely occur as a result of the Project.

Additionally, the Impact Area factors in urban and rural areas that are likely to service the Project during the construction phase, mostly notably, areas where worker accommodation facilities or camps, sites used to store construction materials and locations of other essential services. The latter includes the Project's associated facilities, which refers to facilities or activities that are not funded by the Project, however, are directly related to the Project, carried out or planned to be carried out contemporaneously by the Project, and are necessary for the Project to be viable and would not have been constructed, expanded or conducted if the Project did not exist[67].

Topography was also considered when it came to delineating the Impact Area. Specifically, the mountains in the area act as a natural buffer in helping to mitigate potential social impacts. The socio-economic impact area is indicated in ***Figure J-1***.

[67] 2017 International Bank for Reconstruction and Development, The World Bank.

FIGURE J-1 SOCIO-ECONOMIC IMPACT AREA



Legend

- Social Area of Influence (SAoI)
- Preferred Road Alignment

Administrative Boundary

- Dzongkhag
- Gewog
- Thromde
- Chiwog

0 1.4 2.8 km

Scale: 1:85,000

Coordinate System: GCS WGS 1984

Service Credit: Esri, NASA, NGA, USGS, Esri, © OpenStreetMap contributors, TomTom, Garmin, Foursquare, METI/NASA, USGS

N

Socio-Economic Study Area

0737107 GMC ESIA Road and Bridges

Date: 16/10/2024

Drawn By: NS

Review By: DJ

ERM

The Impact Area extends through a total of seven (07) administrative units and includes six (06) rural areas (or Gewogs) and one (01) urban area (or Thromde) (***Table J***.1).

TABLE J.1 PROJECT IMPACT AREA

S. No.	Thromde / Gewog	Demkhong / Chiwog
1.	Gelephu Thromde	Jampeling Demkhong Namkhaling Demkhong Rabdeling Demkhong Samdrupling Demkhong Sonam Gatshel Demkhong Tashiling Demkhong
2.	Gelegphu Gewog	Perlithang Khatoed Chiwog Perlithang Khaed Chiwog Dzomlingthang Chiwog Pemathang Chiwog Lekidthang Chiwog
3.	Samtenling Gewog	Khenpagang Chiwog Samtenling Chiwog Samtenthang Chiwog Dechen-Pelri Chiwog Chhokorling Dechen-Pelri Chiwog
4.	Umling Gewog	Tashithang Chiwog Daangling Chiwog Dungmin Chiwog Rijoog Chiwog Gaden Chiwog
5.	Chhuzanggang Gewog	Chagsakhar Chiwog Pangzor Chiwog Nyimaling Shawapong Chiwog Thongjabi Yueling Chiwog Barthang Chiwog
6.	Serzhong Gewog	Serzhong Chiwog Barshong Chiwog Pema-Yoedling Chiwog Tashiphoog Chiwog Norbuling Chiwog
7.	Tareythang Gewog	Tashichhoeling Chiwog Yoed-Zergang Chiwog Pemacholing Chiwog Dorjitse Chiwog Woongchhilu Chiwog

J.1 DATA COLLECTION

In preparing the baseline, the initial step was a review of relevant publicly available data. This involved a review of information readily available in the public domain, including the following documents:

- Population and Housing Census of Bhutan, 2017.
- Bhutan Living Standard Survey (BLSS), 2022.
- National Land Use Zoning, A Baseline Report, 2023, Royal Government of Bhutan.
- Bhutan Vulnerability Baseline Assessment, 2016, Gross National Happiness Commission Secretariat, Bhutan.
- Labor Force Survey Quarterly Report, Second Quarter, 2024, National Statistical Bureau.
- Articles and information available in the public domain on aspects such as irrigation, drinking water supply, livelihood patterns, land, local governance, and active NGOs in the area and government development plans for the study area.

A comprehensive list of the documents reviewed during the desktop review is contained in ***Appendix J.2.***

To fill gaps in the available secondary data, primary data was collected. This involved a field visit between 20 August and 4 September 2024. The field visit involved:

- Key information interviews (KIIs): Representatives from various stakeholder groups took part in the key informant interviews. This included but was not limited to representatives from NGOs operating in the Impact Area, leaders of the Gewog and Chiwogs listed in ***Table J***.1, the Land Commission, local health care service providers, local police, local schools, and businesses. A full list of those interviewed is contained in ***Appendix J.3***. In total, 72 representatives were interviewed.

  An interview guide was developed to guide the conversation with key informants, ensuring a consistent set of information was collected across each interview. The aim was to collect their views and perspectives of the Project, insights on their local community, and feedback based on their role in their community.
- Focused group discussions (FGDs): A total of 18 FGDs were undertaken with adolescent girls (between the ages of 15 and 18 years of age), women (above 18 years of age), and men (above 18 years of age). A total of 69 women and 49 men participated in the FGDs. Of these, 39 were adolescent girls between the ages of 15 and 18 years of age. A full list of the FDG participants and community members who were consulted is provided in ***Appendix J.4***.
- An interview guide was developed to inform the FDG conversations, ensuring that a consistent set of questions was asked in each of the FDGs. The aim was to better understand not only stakeholder views and perspectives of the Project, but also the role and treatment of girls and women in the Impact Area.

TABLE J.2 FOCUS GROUPS DISCUSSIONS

Thromde/Gewog	FGDs	
	Male	Female
Gelephu Thromde	10	15
Gelegphu Gewog	7	14
Samtenling Gewog	7	10
Umling Gewog	6	12
Chhuzanggang Gewog	6	12
Tareythang Gewog	6	13

Through the KIIs and FDGs both quantitative and qualitative data was collected. In terms of quantitative data, this included details on local crime rates, domestic violence rates, health services, infectious and non-communicable disease rates, birth and death rates, data on community forest user groups and forest produce, as well as cultural heritage sites and practices.

Analysis of the qualitative data collected through the KIIs and FDGs was done by using a technique called thematic coding. This involved reviewing the results from the KIIs and FDGs multiple times to draw out themes, and then these themes were used to code the results from the KIIs and FDGs. This helped to understand key issues and concerns within the communities within the Impact Area and provide context and on-ground understanding of the quantitative data collected through a review of secondary data.

Findings from KIIs and FDGs, coupled with the second information, has been used to inform the baseline. Using the combination of primary and secondary data, and qualitative and quantitative data, provides for a more robust picture of the current local socio-economic environment. In addition, where appropriate national and district level data has incorporated for context purposes.

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J.3 CONSULTATIONS AND KIIS PARTICIPANTS

SN.	Organization / Affiliation	Name / Designation
1.	RGoB	Dr. Lotay, Governor of GMC and Former Prime Minister of Bhutan
2.	National Land Commission	Geley Norbu, Director General
3.	Gelephu Regional Referral Hospital	Dr. Sangay Wangmo, General Surgeon
4.	Gelephu Regional Referral Hospital	Neelima Chhetri, Clinical Nurse
5.	Department of Forests and Park Services	Samten Wangchuk, Chief Forestry Officer
6.	Chhuzanggang Gewog	Karmashree, Chhuzanggang Gup
7.	Chhuzanggang Primary School	Cheten Wangchu, Principal
8.	Chhuzanggang Gewog	Healthcare workers – Grade 1 Hospital
9.	Umling Gewog	Sangay Tenzin, Gup

SN.	Organization / Affiliation	Name / Designation
10	Umling Gewog	Kezang Gyeltshen – Principal Umling Middle Secondary School
11	Umling Range Office	Duptho Ugyen in Umling, Royal Manas National Park
12	Tareythang Gewog	Dhankan Gurung – Tareythang Gup
13	Tareythang Gewog	Jigme Dorji, Tareythang Gewog Administrative Officer
14	Tareythang Gewog	Ningkhar Pemo, Tareythang community forest
15	Tareythang Gewog	Dorji, Principal, Tareythang School
16	Jampeling Demkhong, Gelephu Thromde	People's representative, Jampeling Demkhong – Lal Bahadur Chhetri
17	Namkheling Demkhong, Gelephu Thromde	People's representative, Namkheling Demkhong – Sanjog Pradhan
18	Samtenling Gewog	Gewog Representatives
19	Samtenling Gewog	Community Service Executive, Samtenling Gewog
20	Samtenling Gewog	Early Childcare Development (ECCD) Facilitator – Samtenling Gewog
21	Samtenling Gewog	Non-Formal Education (NFE) Instructor
22	Bhutan Youth Development Fund	Pema Wangdi, Programme Officer
23	RENEW	Gita Darnan, Centre Manager
24	Gelephu Thromde	Tshering Norbu, Mayor
25	Sonam Gatshel Demkhong, Gelephu Thromde	Tika Maya Karki, Thromde Thuemi
26	Gelephu Thromde	Chimi, Thromde Thimi
27	Gelephu Thromde	Pasang Dori Thromde Thimi, Tashilily
28	Bhutan Kidney Foundation	Tashi Namgay - Executive director
29	Gelegphu Gewog	Prem Prasad Katel (Local Leader)
30	Gelegphu Gewog	Sanam Drakpa (Dy Local Leader)
31	Gelegphu Gewog	Ajay Kr. Monger, Tshogpa
32	Gelegphu Gewog	Dena Rath Nepal, Tshogpa
33	Gelegphu Gewog	Ugyen Tshering, Tshogpa
34	Gelegphu Gewog	Rinzen Thamo, Tshogpa
35	Gelegphu Gewog	Kharananda Khatiwara, Tshogpa
36	Community Rai Dara Forest	Tshulthrim Dorji, Chairman
37	Gelegphu Gewog	Geeta Monger (Gewog Community Executive – CSE)
38	Gelegphu Gewog	Sonam Choki (Non-Formal Education Instructor)
39	Gelegphu Gewog	Sonam Zangmo (Early Childhood Care and Development Facilitator - ECCDF)
40	Gelephu Thromde	Sherub Gyeltshen – Environment Officer
41	Gelephu Thromde	Pema Wangmo – Land Register

SN.	Organization / Affiliation	Name / Designation
42	Gelephu Thromde	Needup Zangmo, Thromde Officer
43	Gelephu Thromde	Tashi Wangdi, Thromde Officer
44	Gelephu Thromde	Senior Forest Ranger (Divisional Forest Office, Sarpang)
45	Labour Office	Rigzing Dorji, Labour Officer and Employment Counsellor
46	Royal Bhutan Police, Gelephu	Superintendent of Police (SSP), Division V
47	Sarpang Judiciary	Sarpang Judicial Representatives

J.4 FGD AND GENERAL CONSULTATION PARTICIPANTS' LIST

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
1.	Umling Gewog	Kunzang Choden	Adolescent Girls (15-18 years)
2.	Umling Gewog	Tenzin Yangki	Adolescent Girls (15-18 years)
3.	Umling Gewog	Chencho Wangmo	Adolescent Girls (15-18 years)
4.	Umling Gewog	Anita Monger	Adolescent Girls (15-18 years)
5.	Umling Gewog	Yeshi Tshoki Dema	Adolescent Girls (15-18 years)
6.	Umling Gewog	Sangay Chezom	Adolescent Girls (15-18 years)
7.	Umling Gewog	Tshewang Dorji	Men and Boys (Below and above 18 years)
8.	Umling Gewog	Sangay Nima	Men and Boys (Below and above 18 years)
9.	Umling Gewog	Tshering Tobgay	Men and Boys (Below and above 18 years)
10.	Umling Gewog	Leki Drugyel	Men and Boys (Below and above 18 years)
11.	Umling Gewog	Dechen Lhaden	Men and Boys (Below and above 18 years)
12.	Umling Gewog	Passang Dorji	Men and Boys (Below and above 18 years)
13.	Umling Gewog	Tshering Choki	Women (Above 18)
14.	Umling Gewog	Dorji Wangmo	Women (Above 18)
15.	Umling Gewog	Thukten Wangmo	Women (Above 18)
16.	Umling Gewog	Sangay Dema	Women (Above 18)
17.	Umling Gewog	Sangay Wangmo	Women (Above 18)
18.	Umling Gewog	Sherab Wangmo	Women (Above 18)
19.	Umling Gewog	Tshering Dorji (landowner)	Consultation
20.	Umling Gewog	Tshering Bidha (Shopkeeper)	Consultation
21.	Umling Gewog	Sangay (Under Poverty line)	Consultation
22.	Umling Gewog	Cheyche (Farmer)	Consultation
23.	Umling Gewog	Perna Drakpa (Tenant farmer)	Consultation

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
24.	Tareythang Gewog	Sonam Choden	Adolescent Girls (15-18 years)
25.	Tareythang Gewog	Jigme Kinga Wangmo	Adolescent Girls (15-18 years)
26.	Tareythang Gewog	Tshering Rinchen Lhaden	Adolescent Girls (15-18 years)
27.	Tareythang Gewog	Jigme Deki	Adolescent Girls (15-18 years)
28.	Tareythang Gewog	Deepika Neopany	Adolescent Girls (15-18 years)
29.	Tareythang Gewog	Thinley Denkar	Adolescent Girls (15-18 years)
30.	Tareythang Gewog	Pema Zangmo	Adolescent Girls (15-18 years)
31.	Tareythang Gewog	Jigme Wangchuk	Men and Boys (Below and above 18 years)
32.	Tareythang Gewog	Narayan Neopany	Men and Boys (Below and above 18 years)
33.	Tareythang Gewog	Kharka Bdr. Rai	Men and Boys (Below and above 18 years)
34.	Tareythang Gewog	Bir Man Rai	Men and Boys (Below and above 18 years)
35.	Tareythang Gewog	Samdrup Dorji	Men and Boys (Below and above 18 years)
36.	Tareythang Gewog	Tshering Wangdi	Men and Boys (Below and above 18 years)
37.	Tareythang Gewog	Kelzaog Choden	Women (Above 18)
38.	Tareythang Gewog	Choney Dema	Women (Above 18)
39.	Tareythang Gewog	Phurpa Wangzom	Women (Above 18)
40.	Tareythang Gewog	Pema Cheki	Women (Above 18)
41.	Tareythang Gewog	Damanti Guragai	Women (Above 18)
42.	Tareythang Gewog	Ningkhar Pemo	Women (Above 18)
43.	Tareythang Gewog	Tshewang Jurmey	Consultation
44.	Tareythang Gewog	Sonam Tashi	Consultation
45.	Tareythang Gewog	Radhika Raini	Consultation
46.	Tareythang Gewog	Ugyen Tshering	Consultation
47.	Tareythang Gewog	Cheki Lhamo	Consultation
48.	Samtenling Gewog	Anjana Rai	Adolescent Girls (15-18 years)
49.	Samtenling Gewog	Kalpana Rai	Adolescent Girls (15-18 years)
50.	Samtenling Gewog	Beena Rai	Adolescent Girls (15-18 years)
51.	Samtenling Gewog	Durga Dungana	Adolescent Girls (15-18 years)
52.	Samtenling Gewog	Manjo Bastola	Adolescent Girls (15-18 years)
53.	Samtenling Gewog	Benita Suberdi	Adolescent Girls (15-18 years)
54.	Samtenling Gewog	Suk Lal Tamang	Men and Boys (Below and above 18 years)
55.	Samtenling Gewog	Suk Bal Tamang	Men and Boys (Below and above 18 years)
56.	Samtenling Gewog	Kasinath Mongar	Men and Boys (Below and above 18 years)
57.	Samtenling Gewog	Narayan Katiwara	Men and Boys (Below and above 18 years)

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
58.	Samtenling Gewog	Sonam Dorji Tamang	Men and Boys (Below and above 18 years)
59.	Samtenling Gewog	Singh Bal Tamang	Men and Boys (Below and above 18 years)
60.	Samtenling Gewog	Ramesh Monger	Men and Boys (Below and above 18 years)
61.	Samtenling Gewog	Pema Wangmo	Women (Above 18)
62.	Samtenling Gewog	Laclin Maya Mongar	Women (Above 18)
63.	Samtenling Gewog	Suk Maya Tamang	Women (Above 18)
64.	Samtenling Gewog	Meenuka Mongar	Women (Above 18)
65.	Gelephu Thromde	Tanusha Wakhley	Adolescent Girls (15-18 years)
66.	Gelephu Thromde	Tansin Seldon	Adolescent Girls (15-18 years)
67.	Gelephu Thromde	Reya Rana	Adolescent Girls (15-18 years)
68.	Gelephu Thromde	Sonu Barman	Adolescent Girls (15-18 years)
69.	Gelephu Thromde	Tshering Yangchen Dadhuel	Adolescent Girls (15-18 years)
70.	Gelephu Thromde	Yojna Acharya	Adolescent Girls (15-18 years)
71.	Gelephu Thromde	Tandin wangmo	Adolescent Girls (15-18 years)
72.	Gelephu Thromde	Wangda	Men and Boys (Below and above 18 years)
73.	Gelephu Thromde	Ganga Ram Galley	Men and Boys (Below and above 18 years)
74.	Gelephu Thromde	Sonam Tshering	Men and Boys (Below and above 18 years)
75.	Gelephu Thromde	Sumit Chhetri	Men and Boys (Below and above 18 years)
76.	Gelephu Thromde	Sonam Rangdol	Men and Boys (Below and above 18 years)
77.	Gelephu Thromde	Ugyen Nima	Men and Boys (Below and above 18 years)
78.	Gelephu Thromde	Sonam Tenzin Chophel	Men and Boys (Below and above 18 years)
79.	Gelephu Thromde	Tashi Wangchuk	Men and Boys (Below and above 18 years)
80.	Gelephu Thromde	Yeshi Dorji	Men and Boys (Below and above 18 years)
81.	Gelephu Thromde	Thinley Penjore	Men and Boys (Below and above 18 years)
82.	Gelephu Thromde	Cheki	Women (Above 18)
83.	Gelephu Thromde	Nidup Sedon	Women (Above 18)
84.	Gelephu Thromde	Sushma Lama	Women (Above 18)
85.	Gelephu Thromde	Eden Lhamo	Women (Above 18)
86.	Gelephu Thromde	Tshering Choden	Women (Above 18)
87.	Gelephu Thromde	Sharan Lameychamey	Women (Above 18)
88.	Gelephu Thromde	Sita Timsina	Women (Above 18)
89.	Gelephu Thromde	Wangchuk Lhamu	Women (Above 18)
90.	Gelephu Thromde	Lobzang Tshering (High Income)	Consultation

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
91.	Gelephu Thromde	Tulsi Ram Oli (Landowner)	Consultation
92.	Gelephu Thromde	Kamal Pradhan (Business)	Consultation
93.	Gelephu Thromde	Tashi Tobgay (Employee of Gelephu Digital Network (GDN)	Consultation
94.	Gelephu Thromde	Sonam Dorji (Yanjung Sonam Enterprise)	Consultation
95.	Gelegphu Gewog	Leki Zangmo	Adolescent Girls (15-18 years)
96.	Gelegphu Gewog	Kinzang Choki	Adolescent Girls (15-18 years)
97.	Gelegphu Gewog	Sonam Yuden	Adolescent Girls (15-18 years)
98.	Gelegphu Gewog	Choni Choden	Adolescent Girls (15-18 years)
99.	Gelegphu Gewog	Kinley Lhazom	Adolescent Girls (15-18 years)
100.	Gelegphu Gewog	Sonam Zangmo	Adolescent Girls (15-18 years)
101.	Gelegphu Gewog	Dechen Rinchen Pem	Adolescent Girls (15-18 years)
102.	Gelegphu Gewog	Sonam Tobgay	Men and Boys (Below and above 18 years)
103.	Gelegphu Gewog	Yadhu Katel	Men and Boys (Below and above 18 years)
104.	Gelegphu Gewog	Ram Chadra Gurung	Men and Boys (Below and above 18 years)
105.	Gelegphu Gewog	Moni Ram Monger	Men and Boys (Below and above 18 years)
106.	Gelegphu Gewog	Ugyen Namgyel	Men and Boys (Below and above 18 years)
107.	Gelegphu Gewog	Prakash Acharja	Men and Boys (Below and above 18 years)
108.	Gelegphu Gewog	Yesheyla	Men and Boys (Below and above 18 years)
109.	Gelegphu Gewog	Karma Dema	Women (Above 18)
110.	Gelegphu Gewog	Pema Dema	Women (Above 18)
111.	Gelegphu Gewog	Jhoti Katel	Women (Above 18)
112.	Gelegphu Gewog	Radhika Khatiwara	Women (Above 18)
113.	Gelegphu Gewog	Chandra Maya Phuyel	Women (Above 18)
114.	Gelegphu Gewog	Kezang Dema	Women (Above 18)
115.	Gelegphu Gewog	Pema Jamphel Tshomo	Women (Above 18)
116.	Gelegphu Gewog	Ugyen Wangchuk (Landowner)	Consultation
117.	Gelegphu Gewog	Deki (Shopkeeper)	Consultation
118.	Gelegphu Gewog	Tshering Dendup (Person with disabilities)	Consultation
119.	Gelegphu Gewog	Tsheten Lhendup (Farmer)	Consultation

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
120.	Gelegphu Gewog	Lok Bdr Rai (Tenant farmer)	Consultation
121.	Chhuzanggang Gewog	Pema Choki	Adolescent Girls (15-18 years)
122.	Chhuzanggang Gewog	Kalpana Rai	Adolescent Girls (15-18 years)
123.	Chhuzanggang Gewog	Sangay Zangmo	Adolescent Girls (15-18 years)
124.	Chhuzanggang Gewog	Pema Choden	Adolescent Girls (15-18 years)
125.	Chhuzanggang Gewog	Yamtshen Choden	Adolescent Girls (15-18 years)
126.	Chhuzanggang Gewog	Sonam Choki	Adolescent Girls (15-18 years)
127.	Chhuzanggang Gewog	Sonam Wangchuk	Men and Boys (Below and above 18 years)
128.	Chhuzanggang Gewog	Jigme	Men and Boys (Below and above 18 years)
129.	Chhuzanggang Gewog	Rinzin Dorji	Men and Boys (Below and above 18 years)
130.	Chhuzanggang Gewog	Karma Tenzin	Men and Boys (Below and above 18 years)
131.	Chhuzanggang Gewog	Dorji Namgay	Men and Boys (Below and above 18 years)
132.	Chhuzanggang Gewog	Tshering Lethro	Men and Boys (Below and above 18 years)
133.	Chhuzanggang Gewog	Sangita Rai	Women (Above 18)
134.	Chhuzanggang Gewog	Ash Maya Rai	Women (Above 18)
135.	Chhuzanggang Gewog	Zangmo	Women (Above 18)
136.	Chhuzanggang Gewog	Sadi Gyalmo	Women (Above 18)
137.	Chhuzanggang Gewog	Sangay Dema	Women (Above 18)
138.	Chhuzanggang Gewog	Karma Dema	Women (Above 18)
139.	Chhuzanggang Gewog	Karchung (Landowner)	Consultation
140.	Chhuzanggang Gewog	Dema (Shopkeeper)	Consultation
141.	Chhuzanggang Gewog	Lhazom (Person with disability)	Consultation

SN.	Thromde/Gewog	Name	FGD Group Category and Consultation with Communities
142.	Chhuzanggang Gewog	Dechen (Farmer)	Consultation
143.	Chhuzanggang Gewog	Mon Maya Rai (Tenant Farmer)	Consultation

J.5 RELIGIOUS STRUCTURES IN THE IMPACT AREA

S. No.	Gewog / Thromde	Dratsang and Lakhang, Mandir, Chorten, Dungkhor/Chukhor	Ownership / Type	Year of Establishment
Dratsang and Lakhang (Buddhist)				
1.	Gelephu Thromde	Namgyal Choeling Lhakhang	Community	2000
2.		Yoesel Thekchogchoeling, Sarpang Rabdey	Government	
3.		Neykhang	Government	
4.		Tharpaling Guru Lhakhang	Government	
5.		Nimalung Dratshang	Government	
6.		Thechog Kharo Yangtse Threma Lhakhang	Private	
7.		Gelephu Thrimsing Lhakhang	Government	
8.	Samtenling Gewog	Dechenpelri Lhakhang	Community	2009
9.		Phulahari Neykhang	Government	2011
10.	Umling Gewog	Umling Lhakhang	Government	1998
11.		Gadhen Lakhang	Private	NA
12.		Threma Lhakhang	Community	NA
13.	Chhuzanggang Gewog	Namgyal Choeling Lhakhang	Community	2000
14.		Sherabchoeling Anim Dratshang	Government	2005
15.	Serzhong Gewog	Donga Kunzangchhoeling Dratshang	Latrul	1977
16.		Shedrupchhoeling Anim Dratshang	Latrul	1995
17.		Pema Lhuendrupling Chhoerkhorling Lobdra	Government	1967
18.		Ugyen Lhuendrupling Lhakhang	Private	1991
19.	Tareythang Gewog	Kuengachhoeling Lhakhang	Community	2013
Mandir (Hindu)				
20.	Gelephu Thromde	Hindu Mandir	Community	2011

S. No.	Gewog / Thromde	Dratsang and Lakhang, Mandir, Chorten, Dungkhor/Chukhor	Ownership / Type	Year of Establishment
21.		Radha Krishna Mandir	Community	1970
22.		Yogeshwar Mahadev Shivalaya Mandir	Government	2017
23.	Samtenling Gewog	Shiva Mandir	Community	1966
24.	Chhuzanggang Gewog	Shiva Mandir	Community	2014
25.		Shiva Mandir	Private	2011
Chorten (Buddhist)				
26.	Gelephu Thromde	Pelrithang Khamaed	Yangduel	2008
27.		Pelrithang Khamaed	Jangchub Chorten	2002
28.		Pemathang	Jangchub Chorten	2013
29.		Pelrithang Khamaed	Namgay Khangzang	2011
30.		Pelrithang Khamaed	Jangchub Chorten	2021
31.		Pelrithang Khamaed	Jangchub Chorten	2021
32.		Pelrithang Khatoed	Jangchub Chorten	2014
33.	Umling Gewog	Dungmin	Jangchub Chorten	2003
34.		Rejook/Near Gewog Office	Jangchub Chorten	2019
35.		Thongjazor	Jangchub Chorten	2020
36.		Duthroe	Jangchub Chorten	2018
37.	Tareythang Gewog	Yoesergang	Jangchub Chorten	2014
38.	Serzhong	Serzhong/Tsachu Pokto	Jangchub Chorten	1994
39.		Tsachu	Jangchub Chorten	1994
40.		Serzhong (above cremation ground)	Jangchub Chorten	1976
41.		Norbuling (NCS)	Droedul Chorten	2020
42.		Serzhong Dratshang	Chorten Namdag Gay	2004
43.		Norbuling	Jangchub Chorten	2017
44.		Tashipu	Jangchub Chorten	2018
45.		Serzhong Chiwog	Namkhazang Chorten	2014
46.	Chhuzanggang Gewog	Pangzur/Sansari	Namgyal Chorten	2018
47.		Shawapong	Jangchub Chorten	2019
48.		Shawapong	Namgyal Chorten	2019
49.		Yueling	Jangchub Chorten	2014
50.		Yueling	Jangchub Chorten	2016

S. No.	Gewog / Thromde	Dratsang and Lakhang, Mandir, Chorten, Dungkhor/Chukhor	Ownership / Type	Year of Establishment
51.		Pangzur	Jangchub Chorten	2013
52.	Samtenling Gewog	Samthenthang	Droduelphendyling	2008
Dungkhor/Chukhor				
53.	Chhuzanggang Gewog	Yueling	Dungkhor	2016
54.		Yueling	Dungkhor	2020
55.		Thonjabi-Yueling	Dungkhor	2022
56.		Chaskar	Dungkhor	2011
57.		Chaskar	Dungkhor	2015
58.		Barthang	Dungkhor	2016
59.		Pangzur	Dungkhor	2016
60.	Gelephu Thromde	Pelrithang Khatoed (RBA)	Dungkhor	2017
61.		Pelrithang Khamaed (PHSS)	Dungkhor	2019
62.		Pelrithang Khatoed	Dungkhor	2010
63.	Serzhong Gewog	Pemaling	Dungkhor	2016
64.		Pemaling/Pangkhar	Dungkhor	2022
65.		Serzhong	Dungkhor	2006
66.		Norbuling	Dungkhor	2013
67.		Norbuling	Dungkhor	2007
68.		Barshong	Dungkhor	2016
69.	Tareythang Gewog	Tareythang Primary School	Dungkhor	2019
70.	Samtenling Gewog	Samtenling	Chhukhor	2013
71.		Khempagang	Chhukhor	2012
72.		Dechenpelri	Dungkhor	2016
73.		Dechenpelri	Dungkhor	2016
74.		Dechenpelri	Dungkhor	2016
75.		Dechenpelri	Dungkhor	2016
76.		Dechenpelri	Dungkhor	2016
77.		Dechenpelri	Dungkhor	2016
78.		Dechenpelri	Dungkhor	2016
79.		Dechenpelri	Dungkhor	2016
80.		Dechenpelri	Dungkhor	2016
81.		Dechenpelri	Dungkhor	2016

S. No.	Gewog / Thromde	Dratsang and Lakhang, Mandir, Chorten, Dungkhor/Chukhor	Ownership / Type	Year of Establishment
82.		Dechenpelri	Dungkhor	2016

Source: DoST, 2024

Note: Information as of 18 October 2022

J.6 CULTURAL HERITAGE BASELINE GAZETTEER

Unique Identifier	Type	Name	Sensitivity	Northing	Easting
BT_CH_001	Temple	Gelephu dratshang	Low	26°52'14.57"N	90°29'9.87"E
BT_CH_002	Temple	GE_Buddha Statue	Low	26°52'14.37"N	90°29'9.88"E
BT_CH_003	Temple	Prayer wheel	Low	26°52'13.77"N	90°29'9.92"E
BT_CH_004	Temple	GE_Hindu Mandir	Low	26°51'59.97"N	90°29'7.39"E
BT_CH_005	Temple	Shiva Mandhir	Low	26°52'0.77"N	90°29'7.54"E
BT_CH_006	Temple	Prayer wheel	Low	26°52'4.14"N	90°29'14.16"E
BT_CH_007	Temple	GE_Gelephu Thrimsung Lhakhang	Low	26°52'11.79"N	90°29'16.25"E
BT_CH_008	Temple	Prayer wheel	Low	26°52'3.15"N	90°29'14.97"E
BT_CH_009	Temple	Tharpaling Dratshang	Low	26°52'9.60"N	90°29'18.75"E
BT_CH_010	Temple	GE_Tharpaling Guru Lhakhang	Low	26°52'9.06"N	90°29'18.96"E
BT_CH_011	Community forest	Chhuzanggang Nimaling Block	Medium	26°51'13.34"N	90°31'12.28"E
BT_CH_012	Community forest	Gaden Phunsumthang	Medium	26°50'53.74"N	90°31'28.49"E
BT_CH_013	Community forest	Gaden Community Forest	Medium	26°50'16.50"N	90°31'26.93"E
BT_CH_014	Community forest	Gaden Drupchugapa	Medium	26°50'18.08"N	90°31'46.64"E
BT_CH_015	Community forest	Lingar Gyapa Block	Medium	26°50'32.14"N	90°31'59.67"E
BT_CH_016	Temple	Gaden	Low	26°50'5.76"N	90°32'6.41"E
BT_CH_017	Temple	UM_Gadhen Lhakhang	Low	26°50'5.44"N	90°32'6.85"E
BT_CH_018	Community forest	Tshome Community Forest	Medium	26°49'30.83"N	90°32'46.64"E
BT_CH_019	Community forest	Tashithang Community Forest	Medium	26°49'28.16"N	90°32'45.33"E
BT_CH_020	Community forest	Gayser Trashicholing	Medium	26°49'26.51"N	90°32'58.23"E

Unique Identifier	Type	Name	Sensitivity	Northing	Easting
BT_CH_021	Community forest	Thrungthu Community Forest	Medium	26°49'15.58"N	90°33'29.86"E
BT_CH_022	Temple	JAngchub Choeten	Low	26°49'4.11"N	90°33'9.81"E
BT_CH_023	Temple	TA_Kuengachhoeling Lhakhang	Low	26°49'7.04"N	90°33'30.40"E
BT_CH_024	Temple	Kuengachhoeling Lhakhang	Low	26°49'6.67"N	90°33'30.02"E
BT_CH_025	Temple	Kuenga Chholing	Low	26°49'7.10"N	90°33'30.55"E
BT_CH_026	Temple	Manual Prayerwheel	Low	26°48'57.04"N	26°48'57.04"N

APPENDIX L PHYSICAL ENVIRONMENT IMPACT ASSESSMENT

K DETAILED AIR QUALITY METHODOLOGY

K.1 PHYSICAL RESOURCES AND RECEPTORS

A physical resource is determined to be:

- a 'human receptor' within:
  - 250 m of the boundary of the site; and/or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s).
- an 'ecological receptor' within:
  - 50 m of the boundary of the site; and/or
  - 50 m of the route(s) used by construction vehicles on the public highway, up to 250 m from the site entrance(s)

The nearest sensitive human and environmental receptors which may be impacted by construction activities are:

- The closest dwellings, including schools, shopping centres, hospitals, and churches, rivers, forests and agricultural lands which are located within 2 km of the site.

The baseline study has shown the airshed[68] in the Project area is not degraded for both SO_2, NO_x, NO_2 and PM_{10} against IFC standards. The potential human receptors are of moderate sensitivity.

K.1.1 CONSTRUCTION DUST

Construction activities can lead to emissions of dust. The process for the air quality assessment for construction dust impacts is based on the methodology shown in Figure K-1.

In lieu of international guidance the Institute of Air Quality Management (IAQM) guidelines [69] have been adopted and adapted for this project. Following the guidelines high-risk assessments must be carried out in areas where human receptors are located within 250 m of the site's boundary. These assessments are crucial to evaluate the potential impacts on air quality and the health risks posed to nearby residents. The IAQM emphasizes the importance of identifying and managing risks to ensure that any significant adverse effects on the local population are minimized. This process involves detailed monitoring and analysis of pollutant levels, as well as the implementation of appropriate mitigation measures to protect public health and maintain compliance with air quality standards.

K.1.2 CONSTRUCTION TRAFFIC

Project construction can generate traffic on nearby roads and thereby associated combustion emissions and dust level raising. The process for the air quality assessment for traffic-related

[68] Airshed is a geographical area that often shares the same air because of topography, meteorology, and/or climate. The air is generally confined or channeled, with all parts of the area therefore being subject to similar conditions of air pollution.

[69] IAQM (2024) Assessment of dust from demolition and construction V2.2

impacts associated with the construction phase of the project is based on the methodology as shown in the infographic in Figure K-2.

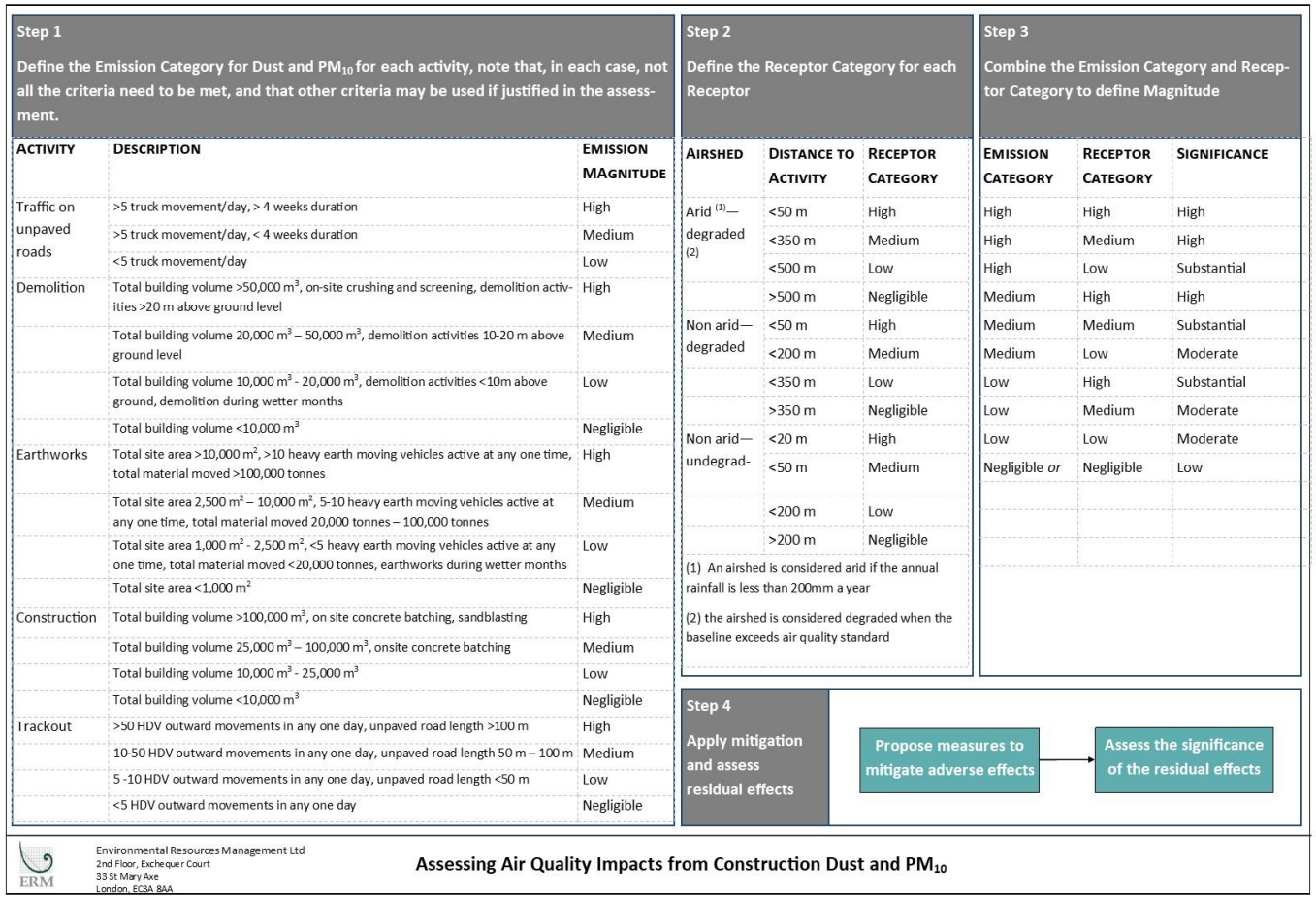
The World Bank and the national Bhutan regulations do not provide prescriptive methodologies for assessing road traffic. Instead, a screening method has been used based upon the UK Highways Agency Design Manual for Roads and Bridges (DMRB) [70] and IFC Toll Road guidelines adapted for the traffic fleet likely to be in place in Bhutan. DMRB is a semi-quantitative method that utilises traffic emission factors, and a dispersion factor derived from ADMS-Roads model for a typical road to estimate roadside concentrations at increments away from the roadside. This approach provided a set of traffic screening criteria corresponding to thresholds for Minor, Moderate and Major Impacts. These screening thresholds can be used in the future to identify the potential for significant impacts to arise.

K.1.3 OPERATIONAL TRAFFIC

The methodology used to assess the impacts of construction traffic has been similarly applied to evaluate the impacts during the operational phase of the Project. This approach ensures a consistent and comprehensive analysis of potential air quality effects associated with ongoing traffic once the project becomes operational.

UK Highways Agency (2008) Design Manual for Roads and Bridges: http://www.standardsforhighways.co.uk/dmrb/vol11/section3/11s3p01.pdf

FIGURE K-1 INFOGRAPHIC FOR AIR QUALITY ASSESSMENT OF DUST



Step 1

Define the Emission Category for Dust and PM_{10} for each activity, note that, in each case, not all the criteria need to be met, and that other criteria may be used if justified in the assessment.

Activity	Description	Emission Magnitude
Traffic on unpaved roads	>5 truck movement/day, > 4 weeks duration	High
	>5 truck movement/day, < 4 weeks duration	Medium
	<5 truck movement/day	Low
Demolition	Total building volume >50,000 m^3, on-site crushing and screening, demolition activities >20 m above ground level	High
	Total building volume 20,000 m^3 – 50,000 m^3, demolition activities 10-20 m above ground level	Medium
	Total building volume 10,000 m^3 - 20,000 m^3, demolition activities <10m above ground, demolition during wetter months	Low
	Total building volume <10,000 m^3	Negligible
Earthworks	Total site area >10,000 m^2, >10 heavy earth moving vehicles active at any one time, total material moved >100,000 tonnes	High
	Total site area 2,500 m^2 – 10,000 m^2, 5-10 heavy earth moving vehicles active at any one time, total material moved 20,000 tonnes – 100,000 tonnes	Medium
	Total site area 1,000 m^2 - 2,500 m^2, <5 heavy earth moving vehicles active at any one time, total material moved <20,000 tonnes, earthworks during wetter months	Low
	Total site area <1,000 m^2	Negligible
Construction	Total building volume >100,000 m^3, on site concrete batching, sandblasting	High
	Total building volume 25,000 m^3 – 100,000 m^3, onsite concrete batching	Medium
	Total building volume 10,000 m^3 - 25,000 m^3	Low
	Total building volume <10,000 m^3	Negligible
Trackout	>50 HDV outward movements in any one day, unpaved road length >100 m	High
	10-50 HDV outward movements in any one day, unpaved road length 50 m – 100 m	Medium
	5 -10 HDV outward movements in any one day, unpaved road length <50 m	Low
	<5 HDV outward movements in any one day	Negligible

Step 2

Define the Receptor Category for each Receptor

Airshed	Distance to Activity	Receptor Category
Arid (1)—degraded (2)	<50 m	High
	<350 m	Medium
	<500 m	Low
	>500 m	Negligible
Non arid—degraded	<50 m	High
	<200 m	Medium
	<350 m	Low
	>350 m	Negligible
Non arid—undegrad-	<20 m	High
	<50 m	Medium
	<200 m	Low
	>200 m	Negligible

(1) An airshed is considered arid if the annual rainfall is less than 200mm a year

(2) the airshed is considered degraded when the baseline exceeds air quality standard

Step 3

Combine the Emission Category and Receptor Category to define Magnitude

Emission Category	Receptor Category	Significance
High	High	High
High	Medium	High
High	Low	Substantial
Medium	High	High
Medium	Medium	Substantial
Medium	Low	Moderate
Low	High	Substantial
Low	Medium	Moderate
Low	Low	Moderate
Negligible *or*	Negligible	Low

Step 4

Apply mitigation and assess residual effects

Propose measures to mitigate adverse effects → **Assess the significance of the residual effects**

Environmental Resources Management Ltd
2nd Floor, Exchequer Court
33 St Mary Axe
London, EC3A 8AA

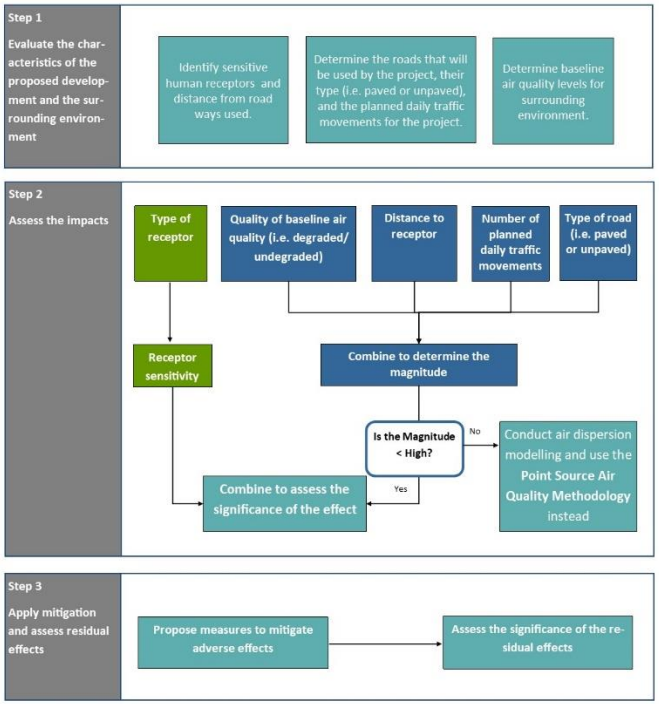
Assessing Air Quality Impacts from Construction Dust and PM_{10}

FIGURE K-2 TRAFFIC INFOGRAPHIC FOR AIR QUALITY ASSESSMENT

Overview

The IFC are not prescriptive in determining the threshold of road traffic which may result in significant impacts. The only guidance provided is that operators of fleets with greater than 120 Heavy Goods Vehicles should consider using lower emission vehicles. This methodology is therefore based upon the UK Highways Agency Design Manual for Roads and Bridges assuming Euro 3 or equivalent fleet .

The methodology is based upon the calculated increases in vehicles needed to trigger the significance thresholds, based upon the interpretation of the IFCs significance criteria.



Receptor Sensitivity

Note that this methodology applies only to human receptors (i.e. not ecological receptors). The table below provides receptor sensitivity with respects to human health.

Sensitivity	Description
Low	N/A
Moderate	N/A
Substantial	General population
High	Particularly vulnerable individuals, e.g. a hospital with intensive care ward

Magnitude of Change

The magnitude of the impacts to air quality from project traffic are determined using the combination of factors illustrated to the left. The first step in this process is identifying the relative level of traffic.

Road Type	Type of Traffic	Annual Average Daily Traffc (AADT), e.g. number of traffic movements	Level of Project Traffic (Relative to the Baseline Air Quality)	
			Undegraded Airshed	Degraded Airshed
Paved Roads	Heavy Duty Vehicles (HDV)	<440	Low	Low
		<1000	Low	Moderate
		<3200	Low	Substantial
		<15000	Moderate	High
		>15000	High	High
	Light Duty Vehicles (LDV)	<7600	Low	Low
		<17000	Low	Moderate
		<55000	Moderate	Substantial
		<250000	Substantial	High
		>250000	High	High

This methodology applies to road traffic exhaust emissions. Emissions of dust arising from the use of unpaved roads by vehicles is assessed separately .

The magnitude can then be determined using the matrix below.

Level of Project Traffic	Distance of Receptor to Road				
	>100m	<100m	<50m	<20m	<5m
High	Low	Low	Substantial	High	High
Substantial	Low	Moderate	Moderate	Substantial	High
Moderate	Low	Low	Low	Low	Moderate
Low	Low	Low	Low	Low	Low

ERM
Environmental Resources Management Ltd
2nd Floor, Exchequer Court
33 St Mary Axe
London, EC3A 8AA

Assessing Air Quality Impacts from Road Traffic

K.2 DETAILED NOISE IMPACT METHODOLOGY

To evaluate the impact of noise effects during the construction and operation phases, it is necessary to establish criteria at which some significant adverse effect may be experienced.

As noted in Chapter 3, The Royal Government of Bhutan provides criteria[71] for external noise. These criteria are generally in-line with the World Bank Group (WB) Environmental, Health, and Safety (EHS) Guidelines[72] (hereafter referred to as the EHS Guidelines). The criteria are presented in ***Table K***.1***.***

TABLE K.1 NATIONAL AND INTERNATIONAL GUIDELINES FOR EXTERNAL NOISE

	Environmental Standards 2020[b]		**EHS Guidelines[c]**	
Parameter	Day (0600-2200hrs)	Night (2200-0600hrs)	Day (0700-2200hrs)	Night (2200-0700hrs)
Industrial area	75 dB	65 dB	70 dB	70 dB
Mixed area	65 dB	55 dB	-	-
Sensitive area[a]	55 dB	45 dB	55 dB	45 dB

Source:
Royal Government of Bhutan; WB
Note:
[a] Also referred to as "Residential; institutional; educational" in the EHS Guidelines
[b] Values stated as "maximum" and A-weighted
[c] Values stated as $L_{Aeq,T}$
[d] EHS Guidelines also state that noise levels also should not result in a maximum increase in background noise levels of 3 dB at the nearest receptor

Construction noise impact magnitude is often judged by the exceedance of absolute noise thresholds, given that predicted noise emissions are typically well above baseline noise levels. In the absence of specific national/international guidance on construction noise, it is considered best practice to adopt thresholds based on the guidance given in BS 5228[73] to represent the point at which a 'Medium' magnitude noise impact would occur. The following criteria apply at 1m from the façades of sensitive receptors and take into account reflection effects[74]. Specific details on construction operating times were not available at the time of the assessment, and therefore it has been assumed for the purpose of the assessment that no construction activities will be largely conducted outside of 0700-1900hrs. Instances where activities proceed into the night (e.g., for particularly large concrete pours) it is assumed that these instances are isolated and very short in duration, thus unlikely to lead to a significant impact. This will be confirmed in due course as part of the final ESIA submission.

- 70 dB $L_{Aeq,12h}$ at during the day (0700-1900hrs) for residential properties in rural, suburban and urban areas away from main road traffic;

[71] Environmental Standards, 2020. National Environment Commission; Royal Government of Bhutan. 2020
[72] Environmental, Health and Safety (EHS) Guidelines – General EHS Guidelines: Introduction. World Bank Group; International Finance Corporation. 2007
[73] BS 5228-1:2009+A1:2014. The British Standards Institution 2014
[74] Sound can be amplified as it reflects from nearby surfaces. Sound measured within close proximity to a reflective surface is typically expected to be up to 3 dB higher than when in free-field conditions.

- 65 dB $L_{Aeq,12h}$ during the day (0700-1900hrs) for hospitals and educational buildings.

The impact magnitudes of the construction noise are presented in Table K.2, based on the above thresholds.

TABLE K.2 MAGNITUDE OF CONSTRUCTION NOISE EFFECTS

Description[a,b]	**Residential properties in rural, suburban and urban areas, dB $L_{Aeq,12h}$**	**Hospitals and educational buildings, dB L_{Aeq12h}**	**Magnitude of predicted impact**
5 or more below the criteria	<65	<60	Negligible
> 5 below, up to the criteria	≥65 to <70	≥60 to <65	Low
Up to 5 dB above the criteria	≥70 to <75	≥65 to <70	Medium
> 5 above the criteria	≥75	≥70	High

Note:
[a] Criteria for residential properties in rural, suburban and urban areas away from main road traffic is 70 dB $L_{Aeq,12h}$.
[b] Criteria for hospitals and educational buildings is 65 dB $L_{Aeq,12h}$.

For the assessment of operation road traffic noise, the thresholds in the EHS Guidelines are regarded as 'preferred noise levels', above which, in general terms noise is likely to cause some disturbance.

An alternative WB and IFC guidance document relating to toll roads[75] (hereafter referred to as the WB Toll Roads Guidance) has also been considered, which provides a specific noise impact example of 70 dB L_{A10} as being the upper road traffic noise limit for residential land use in the USA. L_{A10} levels are usually a few decibels higher than L_{Aeq} levels for road traffic noise so the value can be broadly converted to 65 dB $L_{Aeq,T}$ (the difference is typically 3-5 dB), which in other countries, similar levels are used to indicate that mitigation is required. Thus, noise levels above this precautionary level of 65 dB $L_{Aeq,T}$ during the day can be considered high and will, in general, warrant consideration of further mitigation where practicable, noting there are no national requirements to mitigate at that level.

The EHS Guidelines also require that the baseline noise levels must increase for an impact to be predicted. The noise survey results suggest that baseline noise levels fluctuate between 52-60 dB throughout the day. Baseline noise levels are expected to be increased for most affected receptors so therefore impacts can be derived based on absolute thresholds, as shown in Table K.3 below.

[75] Environmental, Health, and Safety Guidelines – Toll Roads. World Bank Group; International Finance Corporation. 2007

TABLE K.3 MAGNITUDE OF OPERATION NOISE EFFECTS

Absolute thresholds during the day, dB $L_{Aeq,16h}$	**Absolute thresholds during the night, dB $L_{Aeq,8h}$[a]**	**Magnitude of predicted impact**
≤55	≤45	Negligible
>55 to <60	>45 to <50	Low
≥60 to <65	≥50 to <55	Medium
≥65	≥55	High

Note:
[a] Night-time threshold derived on the basis that the EHS guidelines night-time thresholds are 10 dB lower than during the day.

When assessing the significance of an impact for the noise assessment, the process is slightly different to most other topics in this ESIA. The significance of an impact is derived from the impact magnitude, along with professional judgement on other factors such as:

- The duration of the noise event;
- The time when it occurs;
- The characteristics of the noise (e.g., whether the noise is tonal or impulsive); and
- The estimated sensitivity of the receptor.

For example, if the noise effect is loud, but very brief, broadband (without audible tones) and happens during times when residential properties are likely less noise sensitive then the significance may be downgraded.

The overall significance of the noise impact will be derived using the matrix in Chapter 5. Where the significance of an impact warrants an amendment based on the contextual considerations mentioned above, clear justification will be provided.

K.2.1 CONSTRUCTION NOISE CALCULATION DETAILS

1. Introduction

This appendix presents the construction plant information used to inform the construction noise impact assessment. This information was omitted from the main text for clarity.

Sound power levels for plant items and activities have been extracted from Annex C of BS5228 unless otherwise stated.

Details of the plant 'percentage on time' were not available at the time of the assessment so it has been assumed that each plant item / activity operates of the 50% of the time. It should be noted however that this is still considered conservative for some activities.

Based on the successful implementation of the noise control mitigation and management measures described above, it is envisaged that a reduction in the overall noise from construction plant teams of approximately 3 dB is achievable from the noise data provided in BS 5228.

2.0 Road construction

TABLE K.4 SITE PREPARATION, LAND CLEARANCE AND EARTHWORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			102
Lorry	1	C9.25			104
				Total	106

TABLE K.5 ROAD SURFACING AND RETAINING WALLS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	2	C5.5	50	3 dB	90
Asphalt paver	2	C5.31			102
Crane, mobile (diesel)	2	C3.30			95
Dump truck	2	C1.11			105
Excavator/loader, wheeled/tracked	2	C5.35			99
Generator, silenced, 75 dB(A) at 7 m	2	Project team			98

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Lorry	2	C9.25			107
Paint line marker	2	C4.76			86
Roller, vibratory	2	C5.20			100
Water pump, submersible (electric)	2	C2.45			90
				Total	111

TABLE K.6 CONSTRUCTION OF CULVERTS, DRAINAGE AND WATER MANAGEMENT STRUCTURES

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Concrete lorry mixer	1	C4.20			102
Poker, vibratory, hand-held	2	C4.33			103
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Saw, circular, wood	1	C4.70			113
				Total	114

TABLE K.7 SLOPE WORKS FOR EXISTING ROAD WIDENING

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Breaker, hand-held	4	C5.3	50	3 dB	110
Breaker, excavator mounted (hydraulic)	1	C5.2			105
Compactor, vibratory	1	C2.42			100
Drilling rig	1	C6.35			108

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project Team			95
Grout mixer	1	C4.19			93
Grout pump	1	C4.18			97
Lorry	1	C9.25			104
				Total	114

3. Bridge Construction

TABLE K.8 PILING WORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held, mass <= 10kg	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
Piling, large diameter bored, grab and chisel	1	C3.14			105
Water pump, submersible (electric)	1	C2.45			87
				Total	110

TABLE K.9 CONSTRUCTION OF PILING CAPS AND PIERS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held, mass <= 10kg	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Concrete pump, lorry mounted	1	C4.18			97
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Poker, vibratory, hand-held	2	C4.33			103
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Saw, circular, wood	2	C4.70			116
				Total	117

TABLE K.10 CONSTRUCTION OF SUPERSTRUCTURES

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Concrete lorry mixer	1	C4.20	50	3 dB	102
Concrete mixer (petrol)	1	C4.20			102
Concrete pump, lorry mounted	1	C4.18			97
Crane, mobile (diesel)	1	C3.30			92
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
Poker, vibratory, hand-held	1	C4.33			100
Saw, circular, wood	1	C4.70			113

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Travelling formwork / falsework (for in-situ box only)	2	C5.37			98
				Total	115

4.0 Miscellaneous Works

TABLE K.11 RIVER TRAINING WORKS AND LANDSCAPE WORKS

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Crane, mobile (diesel)	1	C3.30	50	3 dB	92
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Lorry	1	C9.25			104
				Total	105

TABLE K.12 TREE FELLING

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Breaker, hand-held	1	C5.3	50	3 dB	104
Crane, mobile (diesel)	1	C3.30			92
Excavator/loader, wheeled/tracked	1	C5.35			96
Lorry	1	C9.25			104
Saw, circular, wood	1	C4.70			113
				Total	114

TABLE K.13 CONSTRUCTION OF CONCRETE BATCHING PLANT

Equipment	Qty.	Source	% on time	Assumed reduction from use of BPM	Resultant Lw, dB(A)
Air compressor, air flow > 10m3/min and <= 30m3/min	1	C5.5	50	3 dB	87
Breaker, hand-held	1	C5.3			104
Concrete lorry mixer	1	C4.20			102
Crane, mobile (diesel)	1	C3.30			92
Dump truck	1	C1.11			102
Excavator/loader, wheeled/tracked	1	C5.35			96
Generator, silenced, 75 dB(A) at 7 m	1	Project team			95
Poker, vibratory, hand-held	1	C4.33			100
				Total	109

K.2.2 OPERATION NOISE CALCULATION DETAILS

1.0 Introduction

This appendix presents the road traffic data used for the noise modelling, as well as calculation settings. This information was omitted from the main text for clarity.

2.0 Calculation Settings and Assumptions

Road traffic noise emissions were assumed to be propagating across a flat ground with mixed absorption (G=0.5). No buildings have been included in the noise model so therefore it is appropriate to assume a reflection order of 1.

Grid and receiver heights were set to 1.5m above ground.

Road traffic noise emissions were calculated in accordance with the methodology set out in CoRTN, based on hourly traffic flows and composition presented in the tables below.

CoRTN calculates road traffic noise emissions as L_{A10} values, so the following approximate relationship was used to derive $L_{Aeq,T}$ daytime and night-time values: $L_{Aeq,T} \approx L_{A10} - 3$ dB.

No traffic flow data was provided for the segment of existing road that will be widened as part of the Project. It was therefore assumed that road traffic flows and composition along this road is the same as Segment 6.

Road traffic was assumed to be flowing consistently at 60 km/h.

3.0 Traffic flow data

FIGURE K-3 ROAD TRAFFIC FLOW SEGMENTS

Source: Arup

TABLE K.14 YEAR 2035 TRAFFIC (SCENARIO 1)

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
Car and LGV	0000	97	111	121	27	1	15
	0100	55	62	68	15	1	8
	0200	66	74	82	18	1	10
	0300	64	72	79	18	1	10
	0400	158	179	196	44	2	24
	0500	409	464	509	115	4	61
	0600	1042	1181	1296	292	10	156

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
	0700	2251	2552	2800	630	22	337
	0800	2254	2556	2804	631	22	338
	0900	1799	2039	2238	504	18	269
	1000	1568	1778	1951	439	16	235
	1100	1489	1688	1852	417	15	223
	1200	1613	1828	2006	452	16	242
	1300	1627	1844	2024	456	16	244
	1400	1880	2132	2339	527	19	282
	1500	2063	2339	2566	578	21	309
	1600	2394	2714	2978	671	24	359
	1700	2391	2710	2974	670	24	358
	1800	1655	1877	2059	464	17	248
	1900	948	1075	1179	266	9	142
	2000	753	854	937	211	8	113
	2100	615	697	765	172	6	92
	2200	436	494	542	122	4	65
	2300	229	259	284	64	2	34
HGV	0000	5	8	6	1	0	1
	0100	3	5	3	1	0	0
	0200	3	5	4	1	0	0
	0300	3	5	4	1	0	0
	0400	8	13	10	2	0	1
	0500	20	34	25	6	0	3
	0600	50	87	63	14	1	8
	0700	109	188	136	31	1	16
	0800	109	189	136	31	1	16
	0900	87	151	108	24	1	13
	1000	76	131	95	21	1	11
	1100	72	125	90	20	1	11
	1200	78	135	97	22	1	12

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
	1300	79	136	98	22	1	12
	1400	91	157	113	26	1	14
	1500	100	173	124	28	1	15
	1600	116	200	144	32	1	17
	1700	116	200	144	32	1	17
	1800	80	139	100	22	1	12
	1900	46	79	57	13	0	7
	2000	36	63	45	10	0	5
	2100	30	51	37	8	0	4
	2200	21	36	26	6	0	3
	2300	11	19	14	3	0	2

Source: Arup

TABLE K.15 YEAR 2053 TRAFFIC (SCENARIO 2)

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	**2**	**3**	**4**	**5**	**6**
Car and LGV	0000	150	163	186	42	1	22
	0100	84	92	105	24	1	13
	0200	101	110	125	28	1	15
	0300	98	107	122	27	1	15
	0400	242	264	302	68	2	36
	0500	629	684	783	176	6	94
	0600	1602	1741	1993	449	16	240
	0700	3459	3760	4304	969	34	518
	0800	3465	3766	4310	970	35	519
	0900	2765	3005	3439	774	28	414
	1000	2411	2620	2999	675	24	361
	1100	2288	2487	2846	641	23	343
	1200	2479	2694	3084	694	25	371
	1300	2501	2718	3111	700	25	375

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
	1400	2890	3142	3595	809	29	433
	1500	3171	3447	3944	888	32	475
	1600	3680	4000	4578	1031	37	551
	1700	3675	3994	4571	1029	37	550
	1800	2544	2766	3165	713	25	381
	1900	1457	1584	1813	408	15	218
	2000	1158	1258	1440	324	12	173
	2100	945	1027	1176	265	9	142
	2200	670	728	834	188	7	100
	2300	351	382	437	98	4	53
HGV	0000	9	13	12	3	0	1
	0100	5	7	7	1	0	1
	0200	6	9	8	2	0	1
	0300	6	8	8	2	0	1
	0400	15	21	19	4	0	2
	0500	39	54	49	11	0	6
	0600	100	136	124	28	1	15
	0700	215	295	268	60	2	32
	0800	216	295	268	60	2	32
	0900	172	236	214	48	2	26
	1000	150	205	187	42	1	22
	1100	142	195	177	40	1	21
	1200	154	211	192	43	2	23
	1300	156	213	194	44	2	23
	1400	180	246	224	50	2	27
	1500	197	270	246	55	2	30
	1600	229	313	285	64	2	34
	1700	229	313	285	64	2	34
	1800	158	217	197	44	2	24
	1900	91	124	113	25	1	14

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
	2000	72	99	90	20	1	11
	2100	59	81	73	16	1	9
	2200	42	57	52	12	0	6
	2300	22	30	27	6	0	3

Source: Arup

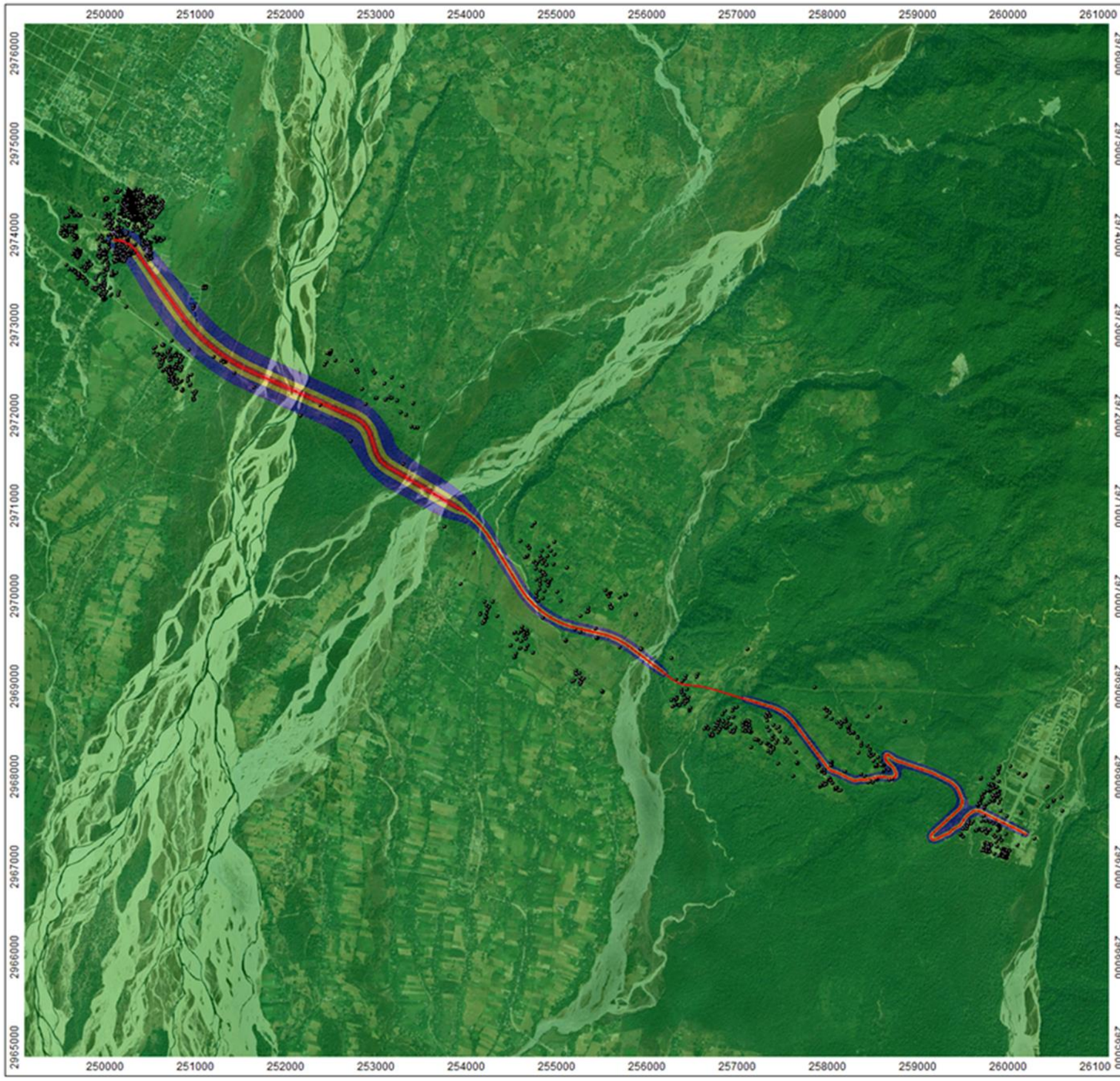
TABLE K.16 CAPACITY TRAFFIC (SCENARIO 3)

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
Car and LGV	0000	232	232	232	116	116	116
	0100	131	131	131	65	65	65
	0200	156	156	156	78	78	78
	0300	152	152	152	76	76	76
	0400	375	375	375	188	188	188
	0500	973	973	973	487	487	487
	0600	2478	2478	2478	1239	1239	1239
	0700	5352	5352	5352	2676	2676	2676
	0800	5360	5360	5360	2680	2680	2680
	0900	4277	4277	4277	2139	2139	2139
	1000	3729	3729	3729	1865	1865	1865
	1100	3540	3540	3540	1770	1770	1770
	1200	3835	3835	3835	1917	1917	1917
	1300	3868	3868	3868	1934	1934	1934
	1400	4471	4471	4471	2235	2235	2235
	1500	4905	4905	4905	2452	2452	2452
	1600	5693	5693	5693	2846	2846	2846
	1700	5684	5684	5684	2842	2842	2842
	1800	3936	3936	3936	1968	1968	1968
	1900	2254	2254	2254	1127	1127	1127
	2000	1791	1791	1791	895	895	895

Vehicle type	Time	Hourly traffic count per segment (see Figure K-3)					
		1	2	3	4	5	6
	2100	1462	1462	1462	731	731	731
	2200	1037	1037	1037	518	518	518
	2300	544	544	544	272	272	272
HGV	0000	20	20	20	10	10	10
	0100	11	11	11	6	6	6
	0200	14	14	14	7	7	7
	0300	13	13	13	7	7	7
	0400	33	33	33	16	16	16
	0500	85	85	85	42	42	42
	0600	216	216	216	108	108	108
	0700	466	466	466	233	233	233
	0800	467	467	467	233	233	233
	0900	372	372	372	186	186	186
	1000	325	325	325	162	162	162
	1100	308	308	308	154	154	154
	1200	334	334	334	167	167	167
	1300	337	337	337	168	168	168
	1400	389	389	389	195	195	195
	1500	427	427	427	214	214	214
	1600	496	496	496	248	248	248
	1700	495	495	495	247	247	247
	1800	343	343	343	171	171	171
	1900	196	196	196	98	98	98
	2000	156	156	156	78	78	78
	2100	127	127	127	64	64	64
	2200	90	90	90	45	45	45
	2300	47	47	47	24	24	24

Source: Arup

Annex A – Operation Noise Modelling results



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2035
Result number 105
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

Signs and symbols

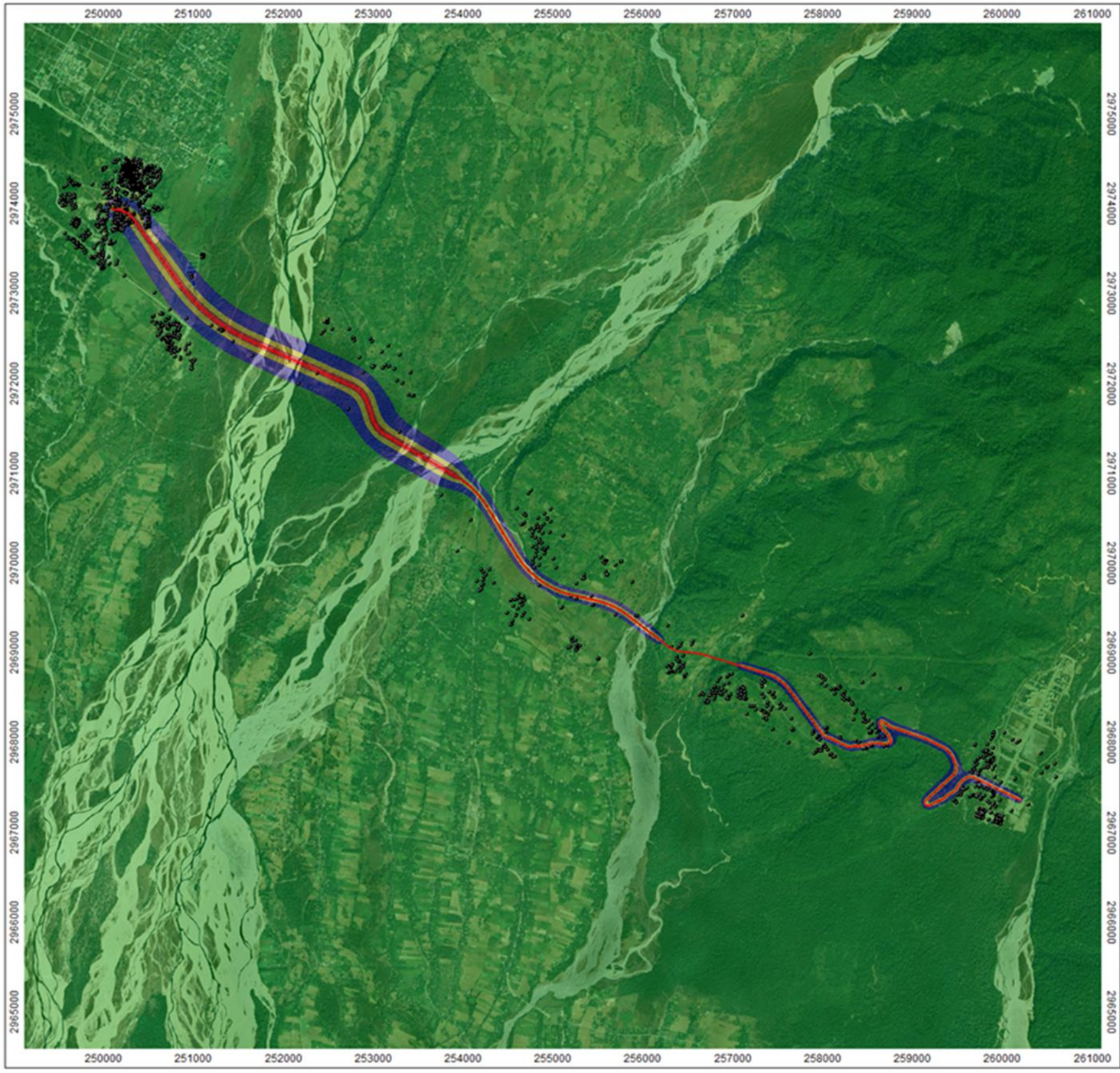
- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:42859

0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2035
Result number 105
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

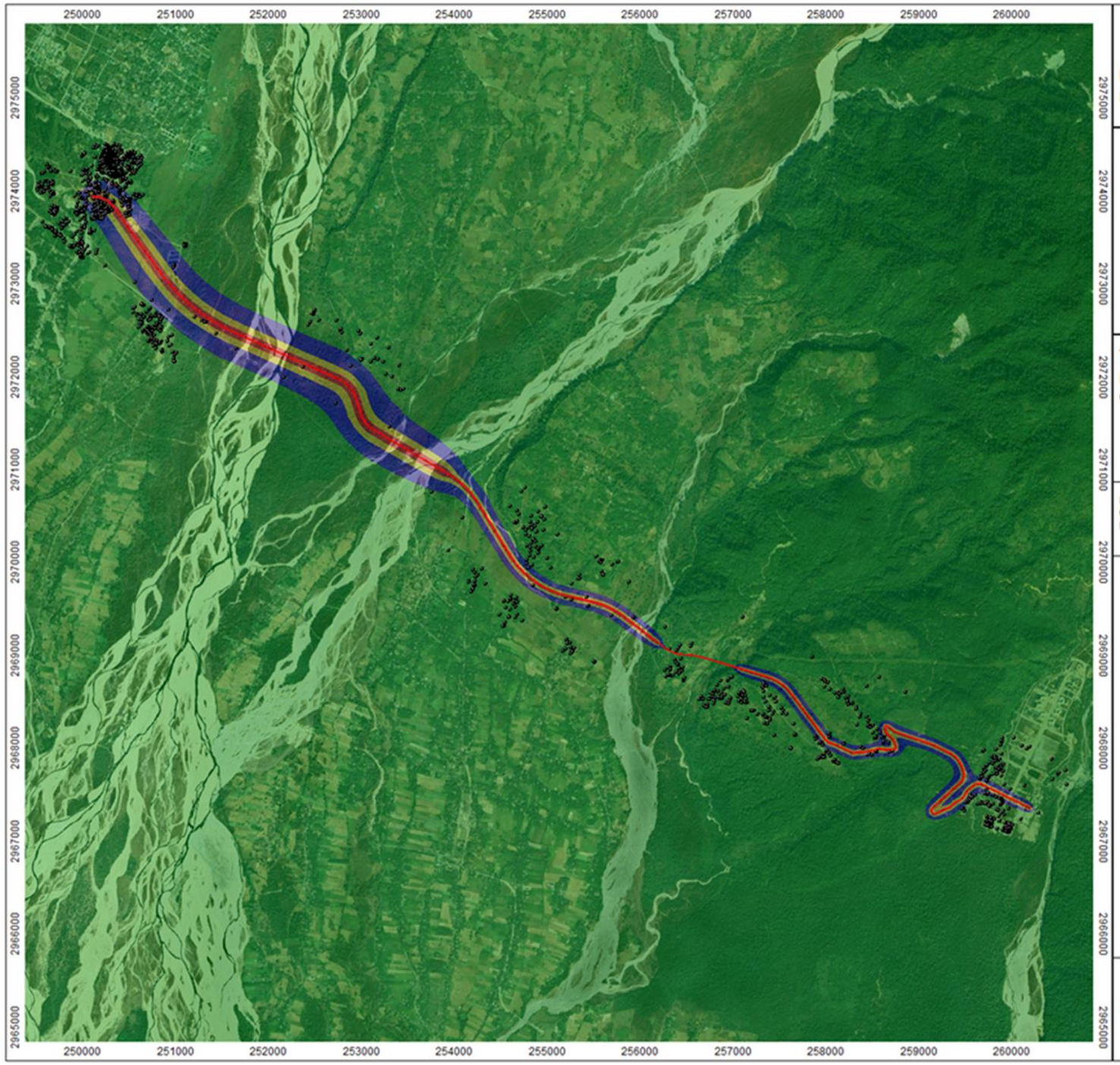
< 45
>= 45
>= 50
>= 55

Signs and symbols
- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:42784
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2053
Result number 103
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

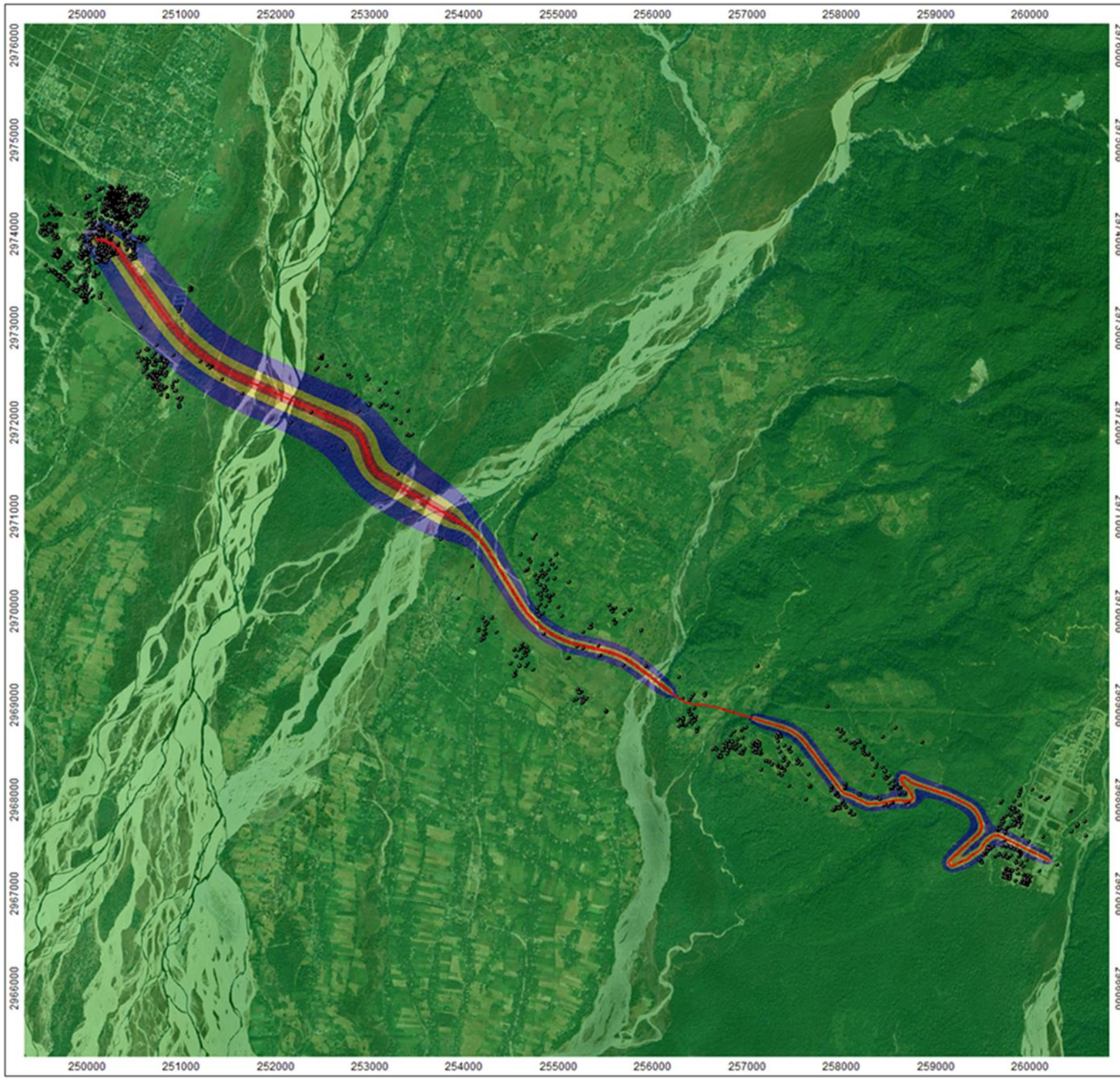
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

Length scale 1:41060
0 350 700 1400 2100 2800 m

N

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Year 2053
Result number 103
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

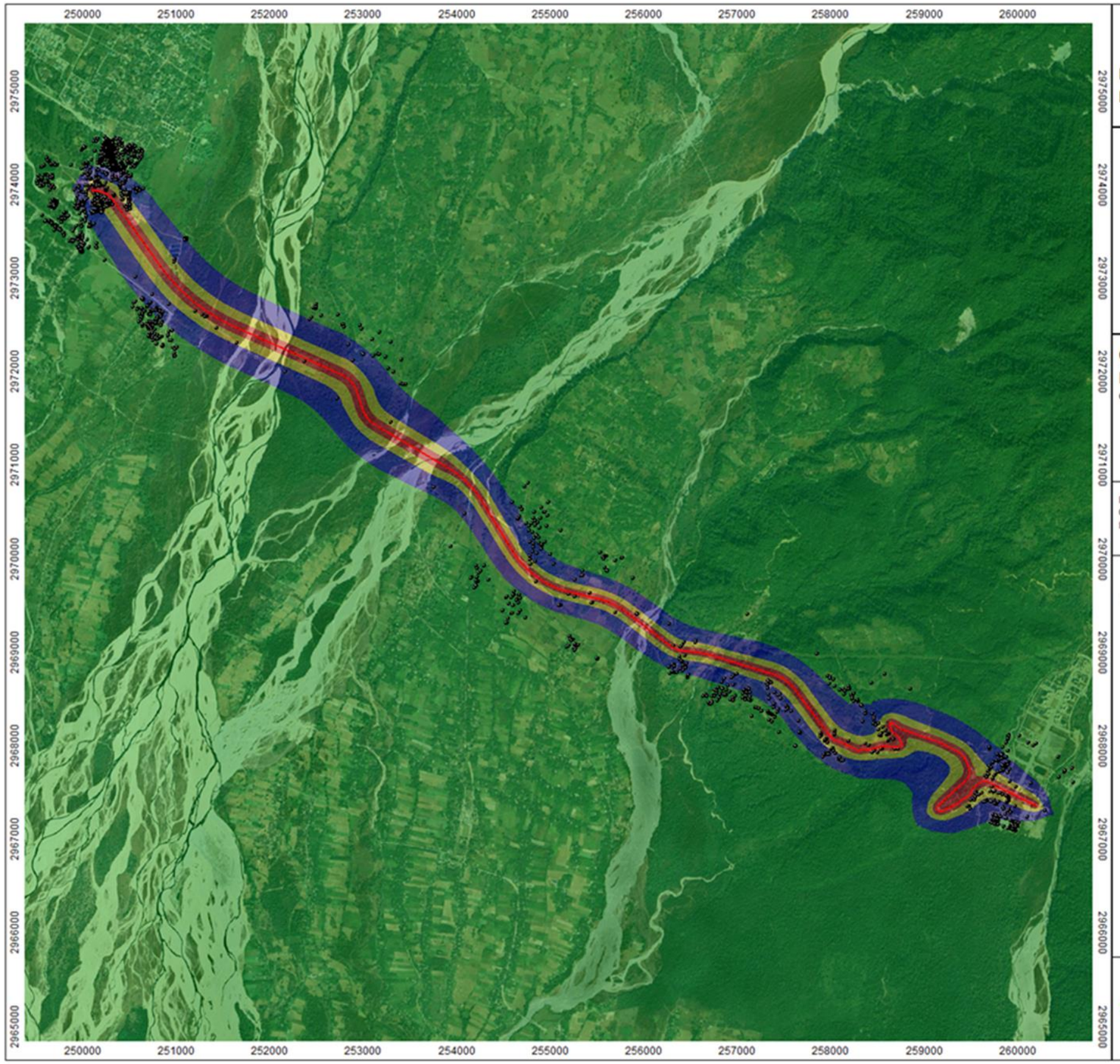
< 45
>= 45
>= 50
>= 55

Signs and symbols
- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:41060
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Capacity
Result number 101
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,16h (Daytime)
in dB(A)

- < 55
- >= 55
- >= 60
- >= 65

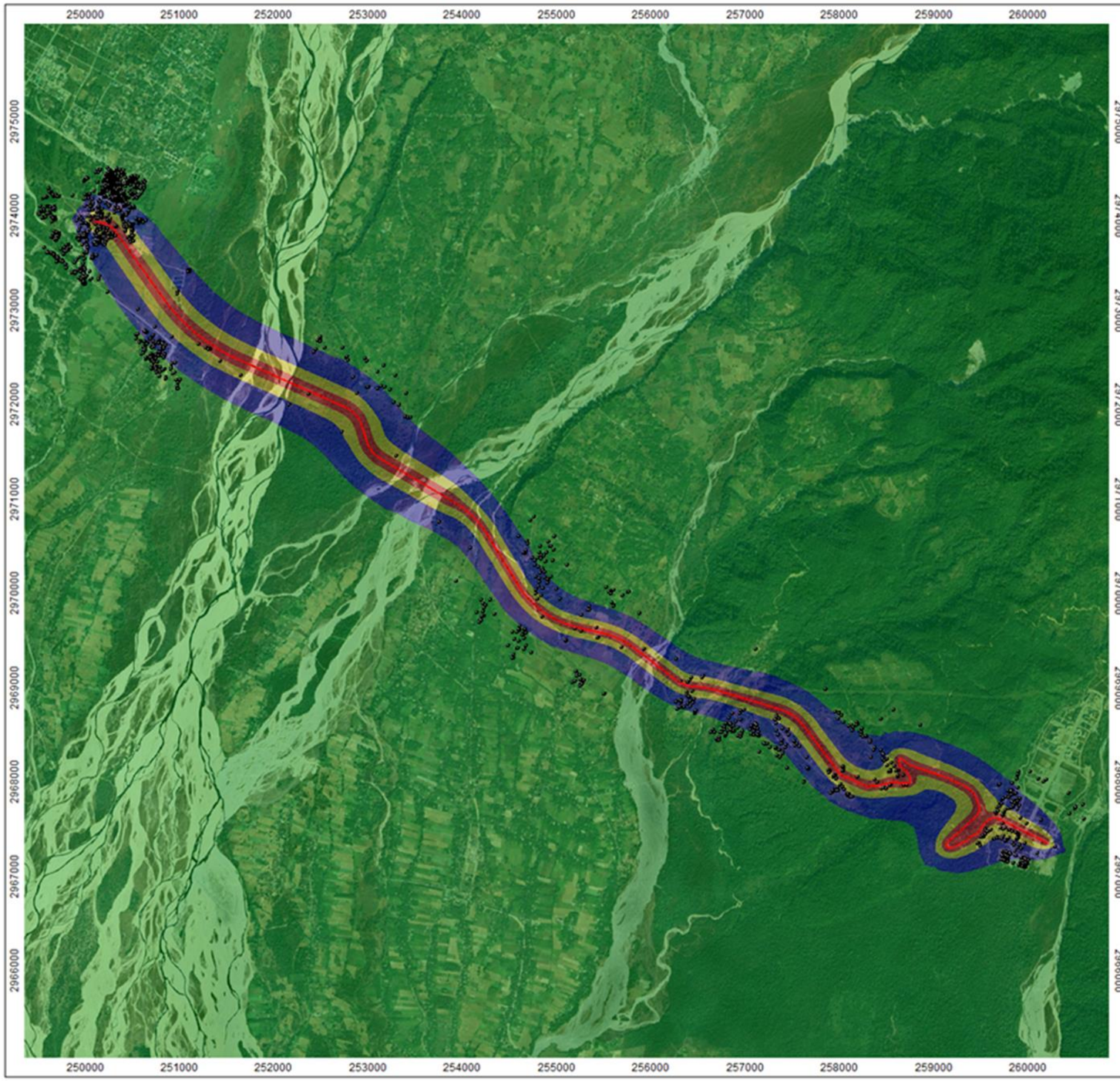
Signs and symbols

- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:40771
0 350 700 1400 2100 2800 m

ERM



Project: Gelephu road and Bridge ESIA
Project-No. 0743906

Map
1

Capacity
Result number 101
Calculation in 1.5 m above ground

Project engineer: ROO
Created: 15/11/2024
Processed with SoundPLAN 9.1, Update 08/10/2024

LAeq,8h (Night)
in dB(A)

< 45
>= 45
>= 50
>= 55

Signs and symbols
- Road axis
- Emission line
- Point receiver
- Surface

N

Length scale 1:41060
0 350 700 1400 2100 2800 m

ERM

APPENDIX M IMPACTS TO GREENHOUSE GAS EMISSIONS

L IMPACTS TO GREENHOUSE GAS EMISSIONS

APPENDIX N MINUTES OF CONSULTATION FOR ESIA

M MINUTES OF CONSULTATION FOR ESIA

Key Informant Interviews Venue: Date:

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
Lal Bahadur Chhetri	People's Representative of Jampeling Demkhong	31-08-2023	M	• 1733 total population • Agriculture – rice. However, this stopped because of elephants. The lands are now fallow • Agriculture has completely stopped • Water source is reliable • Some cattle grazing takes place • Electricity – 24 hours from Chuka and Magni Hydropower projects • Students go for higher education to Phuntsoling and Thimpu, India, Australia, Japan, Thailand, Canada	None. Baseline data collection.
Sanjog Pradhan	Peoples Representative, Namkheling Demjhong	31-08-2023	M	• Earlier – agriculture, now land is fallow • Namkheling settlement where we visited during scoping visit has about 40 households, called Tanke Basti. The proposed alignment will go through this settlement • Some cases of arranged marriages • Unemployment rate is very low as compared to before • 106 households	None. Baseline data collection.
Samtenling Gewog	Consultation with Gewog Representatives	31-08-2024	Mix	• 5 Chiwogs • Population is 3336 • 2 community forests • Dryland 888 acres • Wetland 214 acres	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• Bhutan has landownership ceiling of 25 acres • Each Chiwog has at least one sacred site near spring water sources • Religious festivals • No major health issues other than BP and Diabetes etc. • Increased elephants' movement in this area is high this year • Electricity supply – fluctuations during summer	
Community Service Executive	Samtenling Gewog	31-08-2024	F	• The executive's role includes providing government services to communities such as birth and death registration, HH information such as family tree, NOCs, audit clearances, licenses, and similar. Many other. • Online services include Photocopy, printing, letter drafting, IT training, mostly for family tree; details of the family.	None. Baseline data collection.
Early Childcare Development Facilitator	Samtenling Gewog	31-08-2024	F	• Role of facilitator is to make readiness for schools. Initiative falls under the Ministry of Education • 2 ECCD centres in Samtenling • 15 centres at least for 1 facilitator • 3-5 years of age • No fees are charged for this initiative and food is not provided. The parents are expected to drop food themselves • This is not compulsory for kids and is like a day care	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• ECCD timing is 8:30am to 2:30pm	
Non-Formal Education (NFE) Instructor	Samtenling Gewog	31-08-2024	F	• Objective to teach national language and English • For adults ages 25-80 who have not been able to complete their education • Voluntary • NFE visits village to village • Current group is all farmers • Completion certificate equal to class 6 syllabus	None. Baseline data collection.
Pema Wangdi and Gita Darnan	Programme Officer, Bhutan Youth Development Fund Centre Manager, RENEW	31-08-2024	F	• Cases of domestic violence 16-17 • Monthly about 10 cases • Child and sexual abuse cases • RENEW is engaged in risk level assessment • Target its youth below 25 years of age • Root causes of domestic, sexual and gender-based violence is alcoholism • Acceptance of violence is high • In migration risks are prevalent • Other reasons include unemployment of people living in Gelephu • Financial issues also reason for violence • Losing local changes in lifestyles, mental health, stress, mismatch of skills is a cause of concern • Human trafficking is not a big issue	None. Baseline data collection.
Tshering Norbu	Mayor, Gelephu Thromde	31-08-2024	M	• Questions from community – they would like to know the GMC, the masterplan and land acquisition system	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• Nepali Refugee – No in this area, only the legal workers who can stay here • Wants country to be same as Singapore – everyone can speak English and zero corruption • The out migration has been started since few years to earn money and come back •	
Tika Maya Karki, Thromde Thuemi, Sonam Gatshel Demkhong	Elected official person	31-08-2024	F	• When the GMS will be started? • Whether they are allowed to stay here or need to move? (community) • Senior citizens – they scared of noise, dirt, crowded, some of them are planning to move outside • 3 biggest challenges of the community – conflicts with elephant, land taxes high, drinking water – not every household cannot reach the water as water connection systems are dead and cannot renew the system now • The community area is being developed and very limited. Now it is mostly rough and narrow road, limited facilities, no proper drainage system and ask for the compensation	None. Baseline data collection.
Chimi, Thromde Thimi, and Pasang Dori Thromde Thimi, Tashilily		31-08-2024	F	• No complaint from the community • When will the GMC be started? • Human/elephant wildlife – destroy their crop but no death • Question from GMC – what GMC is – is it a plan and might know in October	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
Tashi Namgay	Executive director of Bhutan Kidney Foundation, NGO	31-08-2024	M	• Need to support the community on essential care including vulnerable groups. • The executive director also mentioned about physical disabilities among the communities including physically and mentally problem. • Should focus on the prevention of disease as it is potentially on a rise.	None. Baseline data collection.
Prem Prasad Katel Sanam Drakpa	Local Leader Dry Local Leader	31-08-2024	M	• Don't have good market for the local to sell the products • Complain need drinking water, education channels, road • 1 water resources not sufficient	None. Baseline data collection.
Ajay Kr. Mongerm Kharananda Khatiwara, Dena Rath Nepal, Ugyen Tshering and Rinzen Thamo (Tshopga)		31-08-2023	M	• Water/drinking water not enough • Flooding every year monsoon season • Road – very rough road • Intangible 2 tree 1 female 1 male	None. Baseline data collection.
Tshulthrim Dorji	Charman Community Rai Dara Community Forest	31-08-2024	M	• No access road • No for medical but the forest suggests planning Amla	None. Baseline data collection.
Geeta Monger Sonam Choki	Gewog Community Executive – CSE Non-Formal Education Instructor (NFE)	31-08-2024	F F F	• CSE provides offline - administrative works and help to fill forms for farmers and provide online services to public such as provide household information, • 60% educated in the Samtenling Gewog. • Sonam Choki – NFE is for people who cannot complete their education and also senior citizens who are interested.	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
Sonam Zangmo	Early Childhood Care and Development Facilitator – ECCDF			• Free education in Bhutan up to class 12. • Primary school start at 5 years kid • Sonam Zangmo – ECCDF – Includes taking care of small children for pre-primary school before entering to school at 9 am - 2.30 pm • 3 biggest challenges in the Geog include the need for a day care center, but the government has not permitted one. The Gewog has water problem of flooding from June- August. And poor quality of roads. • Perception - excited about the project. We would like to see the global presence of such as city (GMC) and global opportunities. • Expectation – To grown economically and provide increased opportunities for youth, which reduces the number of youths that move out of the country.	
Sherub Gyeltshen - Environment Officer, Pema Wangmo – Land Register, Needup Zangmo (Gelephu Thromde) and Tashi Wangdi, Senior Forest Ranger (Divisional Forest Office, Sarpang)		31-08-2024	F M M	• Community complaint – service delivery as sometimes delayed process, limited budget cannot manage big project • Looking at human life with environment mitigation • Economy down – covid one as well • Less population • Gelephu needs to develop infrastructure • Quality roads • Migration leaving for Australia and Canada • Expectation from GMC Project – get more income and good livelihood, good for young generation	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
Rigzing Dorji	Labour Officer and Employment Counsellor	03-09-2024	M	• 99% of workers imported from India • Discussed low wages in Bhutan • Only families of professional workers allowed • Labour and Employment Act of Bhutan, 2007, Regulation on Working Conditions 2022 • GMC's focus is skilled workers • Consideration of Labour agencies • Under GMC, accommodation of workers will be an issue • Discussed issues – local infrastructure, waste management • Reliance on contractors is quite high • Water supply won't be an issue • Worker's health and safety, use of PPEs will be issue • Under GMC, accommodation of workers will be an issue	1. Information on Strategy for import of both skilled and unskilled workers to be shared by RGoB with ERM 2. RGoB to share accommodation standards for workers in Bhutan with ERM 3. RGoB to share the Internal Supply Chain (workers) Assessment Protocol with ERM
Superintendent of Police	SSP, Division V, Royal Bhutan Police	03-09-2024	M	• Discussed crimes, (anti)suicides, and statistics • Namkheling has highest crime rate due to high population • Domestic violence • Advocacy programmes for crime prevention • Prostitution/brothels is a concern but no data available on this. Police could only file chargesheets on such cases in the last three years • Drunk driving and battery an issue • Police is not well equipped currently	1. 37.12 million Nu allocated for development of 'Safe City Project' in Gelephu, to come up by March 2025. Four rounds of public consultations are already completed under this initiative.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• Plans to expand police force and canine breeding centre, • Speed limit is a national policy. Issue sometimes is with migrants' workers or foreign visitors • Demands for CCTVs are higher now.	2. Under public consultations, the police are encouraging local monitoring. 1. Demands for CCTV's are higher now. 2. Canine breeding centre to be setup in Gelephu, 3. Plans to expand police force is in place.
Sarpang Judicial Representatives		03-09-2024	Mix	• GMC Charter is out since February 2024. • Access to justice under GMC. • Other regulatory aspects under GMC. • Discussion any issues and aspects of collaboration between the judiciary and the GMC. • Gelephu court established in 1999. • The court has not taken any decisions yet on land transaction, • Moratorium-Applicable since July 14, 2023, and stopped 3 months ago. • Beginning to transfer to GMC norms. • Transition is being initiated. • No changes in norms at all. (current regulations). • No norms have been changed except the moratorium on land transactions, which have been lifted two months ago.	None. Baseline data collection.

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• GMC will have an executive, judicial and legislative authority. • Language of communication will preferably be English. • Non-Bhutanese nationals can own land or properties in GMC- 100% ownership. • Bhutan- Population increasing but birth rate is low. Number of births is much less than number of deaths. • Free health and education in Bhutan. Healthcare, which is not available in Bhutan, is being provided by the government in India at private hospitals. • 60 to 70K Bhutanese are working outside the country, which is about 10% of the population. • Remittance in Bhutan are high. • GMC is two system one country. • RGoB will have no authority over GMC. • 4 lane highway with provision for railway + 5 bridges. The road will be approx 15km. • An international airport planned in Gelephu (airport expansion). • Paro zone - Phulari viewpoint being planned. Soil stability study ongoing. • Airports roads starting sometime next year. • This is Phase 1 of the master plan. • No provision to reject (Eminent Domain). But compensation mandatory. Activity of national importance. • Alternate land can be identified by the Affected Person (land for land).	

Name	Organization	Date	Gender (F/M)	Issues/concerned	Outcome
				• Land compensation currently follows PAVA. This will not be applicable. • GMC will follow the principle of 'value for value. • Previous PAVA rate calculation was undertaken in 2021. • Token system is being explored by GMC. Ownership continues, but no use, however, token will be received on a time-to-time manner. • Valuation of land will be undertaken for at least future 10 years (multiple factors will be calculated). • Use current laws to resolve existing land cases, but recommendation is to expedite such cases. • GMC will be governed by anyone who has domain expertise. • Question on token system: This sounds beneficial, but what if the land needs to be divided between two children? Answer- Token around will be divided between the children based on what percentage of land is held by the Child. • Landless won't be allowed. Tober plus users right for life will be provided to the person. • Moratorium + Addendum in 2024 (1st May). • Transactions during the moratorium cannot be accepted- these must be null and void. • Announcement on GMC in October 2024 (milestone).	
Total - 22					

Group Discussion with Communities Venue: Date:

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
Girls (15-18 years)	Chhuzaggang	02/09/24	F	6	1. would feel insecure and unsafe about men being hired from outside. 2. feel insecure whenever we go out to fetch water as the spring is in an isolated place. 3. Water supply is not reliable and access to water is only for few hours a day. Women are most affected by the water shortage as we do most of the household chores. 4. Girls drop out of school after class 9/10 because of health issue, losing interest in studies, teenage pregnancy, financial issues, lack of family support for continuation of school. 5. Parents worried about girls going out alone, or with boys, especially late at night. As well as gadgets and social media.	1. CCTV installed and set strict rules for the men hired from outside.
Men and Boys (Above 18 years)	Chhuzanggang	02/09/24	M	6	1. Feel insecure about the presence of outside men and have safety concerns for women and girls 2. Boys usually complete class 10. Girls drop out of school because of family problem, due to unemployment scenario they lose interest. For boys, losing interest, peer pressure, other job opportunities. school system and policies. 3. Women have to walk to collect water 4. Only those households with women as head of household have land in their name	1. Monitoring during the project by the concerned office or Local government. Need to create awareness among the workers. And increased security.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					5. Women can work in jobs that don't require staying out late, there are no restrictions for men. 6. Parental concerns are more for their daughters - teenage pregnancy, substance abuse, work related. For sons - substance abuse, domestic violence. 7. Safety concerns with women leaving the house alone, especially at night and/or near forest/river. 8. Women aren't scolded/punished for saying no to husbands, but they are advised gentle, and family intervention may be required. 9. Environmental impacts and overcrowding.	
Women (Above 18 years)	Chhuzanggang	02/09/24	F	5	1. Women and girls would feel insecure, and their safety would be at risk, especially by hiring men from outside village for construction. 2. Difficult for women to access employment 3. Girld drop out of school due to losing interest (failing repeatedly in the same class), financial issues, family problems, and boys due to substance abuse and peer pressure. Most dropouts are girls. 4. Majority of household income from areca nut 5. Power (hydroelectricity) outages affect household chores.	1. Set strong rules and regulations outsider workers working in the constructions.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					6. Concerns for safety of women and girls where toilets are outside the house (most have indoor flushing toilets) 7. Fear of snakes and wild animals when collecting water from streams (during times of water shortage when pipes aren't working) 8. Women only work in jobs that do not require heavy manual work. Not to work at night hours like (bar and restaurant and karaoke 9. Concerns for daughters educations, teenage pregnancy, going out alone, taking shortcut to Gelephu through Mau River, swimming in River 10. Restrictions on women in terms of: karaoke, being friends with boys, dressing, whilst on period going to bars/restaurants. 11. Health issues faced by women are gout, high blood pressure, diabetes. 12. Child rearing and parenting is challenging	
Girls (15-18 years)	Gelephu		F	7	1. Both insecure and excited about men from outside of the village coming for construction - might explore sexual exploitation, might spread sexually transmitted diseases 2. Feeling insecure that people may record or take photos when we go to toilet outside (in army camp/colony) 3. Girls may drop out of school - teenage pregnancy. Family problem (Financial problem). Some are not interested. Peer pressure.	1. Girls need to wear descent clothes; strict rules need to enforce in the working aera by relevant stakeholders. Community girls and women need to stay away from the workers.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					(Looking at others and leave school). Health related problem (Not able to treat the disease, long term ill). 4. Parents may object to friendships or marriage. But also, sometimes pressure from families to get married. 5. Restrictions on visiting entertainment centers, jobs there are also looked down upon. 6. Parental concern about rape, completion of education, teenage pregnancy, substance abuse, influence from abused friends. Can lead to restrictions.	
Men and Boys (Above 18 years)	Gelephu		M	6	1. Project will lead to some harm to women and girls. More divorce case and family disruption, more domestic problem. 2. Men from outside will increase chances of privacy intervention (digital recording), sexual harassment, teenage pregnancy, unwanted pregnancy. 3. Girls drop out of school due to financial problems, early marriage, separated parents (family disruption), substance abuse, pregnancy cases, lack of parental care. Boys because they are able to get the job (physically strong and get manual job), alcohol usage, lack of personal interest, bully cases in school, low self-esteem. 4. Concerns for daughters surround safety while traveling, about marrying a good husband,	2. Educate girls about decent dressing, girls to go in group with trusted person.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					education and reproductive health, and for sons it is substance abuse, finding a decent job, completing education and may engage with abused friends. 5. Concerns about women going out alone - fighting. Elopement, accident while traveling. Unknown people may cause harm. Rape case, molestation, harassment at workplace.	
Women (Above 18 years)	Gelephu		F	7	1. Although Project may create jobs for women, worries about spread of diseases, safety of women, rape cases. Fear of loss of life (believe that live human need to put in construction site) 2. Concern for the safety of girl children re men from outside village 3. Girls drop out of school due to poor financial background, early marriage, poor academic performances, pregnancy, substance abuse. Boys because of substance abuse, elopement, family problem. 4. Impacts from in migration - Insecure for women, burglary cases. Fighting and murder cases. 5. Electric short circuit and damage to electrical appliances (hydroelectricity) 6. Risk to womean during delivery, premature birth, breast and cervical cancer, spread of diseases. 7. Boys have much better education than girls	

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					8. Men are jealous of and blame women who undertake paid work 9. Worries from parents on substance abuse, harassment, unwanted pregnancy. 10. Concerns around young girls regarding substance abuse, harassment, unwanted pregnancy 11. Domestic violence is present in area. Physical, emotional, sexual, economic violence. Alcohol, lack of income, jealousy, down look, unemployed, influence by in-laws. 12. Women feel insecure at night from wild animals, might encounter with miscreants. 13. Financial concerns around child rearing	
Girls (15-18 years)	Gelephu Thromde	31/08/24	F	8	1. girls will have additional safety concerns and unknown men in the community could be dangerous 2. water is sometimes muddy 3. toilets are dirty and can lead to UTIs. Concerns around being filmed in the toilet. 4. Women working in blue collar jobs/ entertainment/construction (male jobs) are looked down upon 5. parents are concerned about girls getting into substance abuse and teenage pregnancy, require daughters to dress certain way, share	1. more stringent rules and regulations are required. Allow men to bring their families so they don't have sexual urges towards local girls.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					their whereabouts, not spend time with boys, be home before sunset.	
Men and Boys (Above 18 years)	Gelephu Thromde	01/09/24	M	6	1. sites also often give rise to prostitution cases and young girls looking for the opportunity to get into illicit relationships with 'sugar daddies' who give them money in return for favors which are not necessarily sexual 2. girls drop out because teenage pregnancy and for boys, mostly substance abuse. 3. the condition of the toilets at the school is not good 4. concerns for daughters being out late (safety) and sons' substance abuse. Girls are seen as more vulnerable. 5. school principal advises us not to visit pubs or places near the hotels and construction area. 6. In general, women should be punished if they make mistakes	1. for these projects to really benefit girls and women, strict rules must be implemented. Project must have strong safety rules to ensure these (safety concerns) do not happen
Women (Above 18 years)	Gelephu Thromde	01/09/24	F	11	1. worried for the younger generation and children, mainly girls with foreign workers coming because the younger generation has values different to us, safety issues, disease 2. internet connectivity fluctuates a lot 3. School dropouts due to financial reasons (work in karaokes), lack of interest, teenage pregnancy. Boys drop out of school more.	1. more awareness programs provided, guidance by schools or workplace, town people could also place a big part in informing the people and ensuring safety 7. Need people guarding toilets

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					4. Drugs are accessible as Gelephu is near the border 5. Issues with in-migration include – lack of work, overcrowding in schools, resource constraints 6. Female health – workload pressure, diabetes, mental health, sanitation (especially toilets). Reproductive issues surrounding chemicals in food products. 7. Lack of toilets and lack of safety for women as men can take advantage there. 8. Concerns for daughters – pregnancy, education, early marriage, work, going out alone, routes through town (washroom near JSJ dewang is unsafe) 9. Personal safety surrounding wildlife, alcoholics/stalkers at night, drunk driving and road accidents.	
Women (Above 18 years)	Samtenling	01/09/24	F	4	1. Might cause harm to the girls and boys both as there will be many workers around the area. 2. Women and girls might not be safe and secure due to men from outside your village. 3. Generally, by the age of 14-16 years old, girls would drop out of school-loss of interest in study due to influence of social medias like facebook, tiktok, etc. Financial problems, family issues. Boys drop out of school to earn money, due to substance abuse. Lose interest for further studies	1. If there would be a bus service for the students till school, they would be safe and would be home on time.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					because of the unemployment scenarios in the country. 4. Hydropower is the main source of electricity. When electricity goes off women are worried about meals preparation and other electricity required household chores. 5. Health concerns: Mental health issues, emotional breakdown, high blood pressure, diabetes. 6. Safety concerns especially of teenage pregnancy. 7. Women face restrictions on dress code, while going out of home.	
Girls (15-18 years)	Samtenling	31/08/24	F	6	1. We are concerned about the safety since there will be strangers working in and around the community. 2. Water taps available in every household. 24 x7 water available. However, during rainy season, maintenance work is managed by men. 3. Water shortage in summer affects daily chores, with the mother most impacted as women and girls must carry out daily home chores. 4. The reasons girls drop out of school include health issues, teenage marriage, teenage pregnancy, fear of board exams, financial difficulties, and teenage relationships. 5. There was limited training available in the community, except for mushroom farming training provided to women.	1. For improved safety, increasing police patrolling, an awareness program in schools for students, an orientation program for hired workers to clearly outline their roles and responsibilities. If possible, It is preferable if local workers are hired for construction to enhance safety.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					6. Girls are not permitted for sleepovers at friends' houses, outings for shopping, picnics, or hanging out with friends. For these activities, girls need to seek permission from their parents and guardians. 7. There are concerns when girls go out alone. They fear of encountering strangers, especially near riversides, traveling long distances, particularly going out to border towns. Additionally, they are particularly worried about areas with stray dogs, jungle areas, and entertainment places like karaoke venues.	
Men and Boys (Above 18 years)	Samtenling	01/09/24	M	8	1. Safety concerns for women when the workers are hired from outside. 2. Reasons for dropping out of school- domestic reasons(divorce), financial issues, alcohol. 3. The main concern about girls is teenage pregnancy, and other safety concerns. For boys, substance abuse. Men have less concerns for boys compared to girls. 4. There are concerned when girls leave for school and when they go for out with friends.	1. Needs strong rules and regulations during the construction. Need to hire people from within the country for the works but issues with wage rate.
Women (Above 18 years)	Tareythang	02/09/24	F	9	1. When go out alone, its risky to girls and women due to presence of foreign workers. 2. Feeling insecure that foreign labors may rape the girls and women 3. Concern about traffic accidents	1. Take care of girl children, advise them about the safety.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					4. Girls drop out the school because of poor financial background, poor academic performances, to run business. Boys drop out the school because of poor financial background, poor academic performances 5. Health concerns: risk of HIV, risk of cervical cancer, risk during delivery. 6. They concern about their daughters regarding unwanted pregnancy, rape and murder, and scared of wild animals. 7. Women are restricted not to play the games that is generally being played by men.	
Girls (15-18 years)	Tareythang	02/09/24	F	8	1. Feel unsafe, fear, uncomfortable about men from outside your village being hired on these construction sites. This can lead to eve teasing, privacy intervention, potential rape, extra marital affairs and lead to more divorce cases. 2. Fear of wild animals when collecting water 3. Scared of snakes near sanitation facilities Girls drop out the school because of poor academic performance, and lack of interest. 4. Parents have concerns for their daughter regarding sexual harassment, murder, encounter with wild animals, and accidents. 5. Concerns about rape and murder, attack by wild animals, sexual harassment, trafficking near jungle, and Indian border areas.	1. Go out in groups, go with brothers, CCTV surveillance

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
Men and Boys (Above 18 years)	Tareythang	02/09/24	M	6	1. Concerns include risks to girls and women, such as rape, drug abuse, kidnapping, trafficking, privacy violations (digital recording), sexual harassment, and increased chances of teenage or unwanted pregnancies due to outsiders hired at construction sites. 2. Parents are concerned about their sons potentially engaging in substance abuse, involvement in rape or murder cases, gambling, and gang violence. 3. The reasons for girls dropping out of school include inability to qualify for higher studies, peer pressure, substance abuse, lack of parental guidance, and family issues such as having separated or single parents. Boys drop out of school due to the same factors: inability to qualify for higher studies, peer pressure, substance abuse, lack of parental guidance, and family instability.	1. Strict health screening for various diseases before hiring labors, proper guidance from parents, strengthening security surveillance since current security is not able to respond promptly, create awareness on safety measures.
Women (Above 18 years)	Umling	02/09/24	F	6	1. Boys and girls complete Class 10 and 12 generally. 2. Girls generally drop out of school due to a lack of interest in studies, medical issues, lack of parental support, early marriage, and teenage pregnancy. Boys drop out due to substance abuse, conflicts with teachers, or academic incompetence. 3. Wild-life problems	N/A

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					4. Health issues such as pressure and diabetes due to old age... ulcer, womb cancer but rarely 5. Sometimes, there is problem of having to go fetch water around 1 km far because of water shortage or blockage in summer and winter and sometimes due to elephants breaking the pipes	
Girls (15-18 years)	Umling	02/09/24	F	6	1. Concerned that their safety will be at risk 2. Some drop out of school because of teachers (they hit the students) 3. There are safety concerns when going out alone, because there are people such as laymonks, working in gyalsuungs, dropouts (men) in general 4. The riversides are considered unsafe because girls came across different people and animals.	The community should be informed about construction sites and workers and should hire those who aren't into substance abuse.
Men and Boys (Above 18 years)	Umling	02/09/24	M	5	1. Most Indians were seen to be hired on such construction sites and rare to see Bhutanese workers. There haven't been any cases of harm caused or harassment issues regarding women and girls so far. 2. Men are worried for their daughter's safety in case they are exploited by strangers (rape or harassed). Locations such as Tareythang area is kind of unsafe because it is said to be a place where one could meet ghosts/spirits or generally in shops, it is unsafe in case they meet alcoholics. 3. There are few cases whereby due to alcohol addiction or under the influence of alcohol, family members have created problems.	Raising awareness, and stricter law and order. Parents guidance is required.

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
Total				120		

Group Discussion with organizations Venue: Date:

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
Consultation group: Dechen - farmer	Chhuzagang	02/09/24			1. Water level goes down during winter	1. need for stronger rules and awareness to the community for female safety.
Consultation group: Tshering Dendup, Pelrithang Khamed,	Gelephu	31/08/24	M	5	1. Have land but unable to engage in cultivation due to lack of irrigation 2. Concerns: rape cases, drugs abuse, alcohol usage, gang fight. Parents have concern for their daughter about teenage pregnancy, rape case.	1. Parents need guide their daughters (pick and drop to school), timely advise, select the friends carefully, while going out from house monitor timely.
Consultation Group: Tshering Kuendrup - Tshering Kuendrup (also doing construction business since 1991) Kumar Pradhan - Vice president of BCCI. Rusn small farm at Samtenling Sonam Dorji - Bricks manufacturing business Tashi Tobgay - network service provider dealing	Gelephu Thromde	01/09/24	M	4	1. Reduced movement because of covid has affected businesses but improving. Now there's more people again there's more competition, making it difficult to get jobs. 2. Unemployment issues 3. Concerns about not having enough biological corridors 4. Migration has happened before covid, but after covid, Gelephu economic situation has reduced and so, migration has reduced. People are migrating for better	N/A

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
with wifi connection services, tv cable services, and surveillance camera services					opportunities. One thing is that survival has become a matter of choice, and the economic situation of the country is not that good 5. Recent increase in substance abuse and decrease in education quality 6. Unemployment issues as youth expect high income for moderate work 7. Business owners are most vulnerable to being poor since covid 8. Suggest opportunities should be given to Bhutanese workers instead of foreign workers.	
Consultation Group	Tareythang	02/09/24	2M 2F	4	1. Human- wildlife conflicts discourage agriculture 2. Older- illiterate, MID- 80% literate and has studied till class 10, Younger- all educated	N/A
Consultation Group • Tshering Dorji- land user	Umling	02/09/24	3M 2F	5	1. Health issues like diabetes being prevalent in the older people and a bit of lack of health services in the area.	1. There could be better health services, e.g., bigger hospitals would be better

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
• Pema Drakpa-landuser • Sangay-Cultivator/Land user • Dorji Singye (Farmer) • Tshering Bidha: Businesswoman					2. There's a water shortage issue when the force of the river blocks the passage or breaks the pipe during monsoon season and during winter 3. Unemployment 4. As for human-human conflict-there was a language barrier in the past but now, there isn't a huge issue related to it 5. Cultivate paddy mostly but now, cannot work due to water shortage in the area 6. The human- wildlife conflicts mainly arise due to sightings of elephants and wild boars 7. There are safety concerns such as daughter getting pregnant early (teenage pregnancy) 8. There is a rock near one house in Sangay that is inhabited by deity (lug) 9. There are safety concerns for women, including the risk of extramarital affairs, elopement, rape, exploitation, divorce, and other vulnerabilities	2. To ensure safety, there should be establishment of women self-help groups, strengthened security as well as stricter law and order

Name	Gewog / Thromde	Date	Gender (F/M)	Total	Issues/concerned	Outcome
					10. Literacy level is about the same for both genders	
Total						

APPENDIX O CONSULTATIONS ON DRAFT ESIA

Consultation Meetings with Communities – ACCESS Project

Public consultation meetings were held covering all the project Gewogs under the Sarpang Dzongkhag, The Meeting was attended by a total of **305 participants**, of which **49% were females**. Among the participants, **81% were adults** (25-59 years), 17% were elderly (60 years and above), and 2% were youth (13-24 years). A detailed list of participants is presented below as Annex tables below.

Public Consultation Meetings summary of participants

	Gewogs/Thromde	Venue	Date of Meeting	Nos of Participants		
				Male	Female	Total
1	Chhuzanggang	Gup Office, Chhuzagang	03 December 2024	13	15	28
2	Sherzhong, Samteling, and Gelephu	Gelephu Meeting Hall	03 December 2024	48	50	98
3	Tareythang	Gewog Meeting Hall	02 December 2024	34	30	64
4	Umling	Gewog RNR Meeting Hall	02 December 2024	15	31	46
5	Gelephu Thromde	Thromde Meeting Room	04 December 2024	46	23	69
	Total			**156**	**143**	**305**
	Percentage			51	49	100

Age	Number of participants	Percentage
Youth (13- 24 yrs)	7	2
Adult (25- 59 yrs)	247	81
Elderly 60 yrs and above	51	17

ANNEX 1 A. List of Participants: Meeting with Communities of Chhuzanggang Gewog

Venue: Gewog Meeting Hall

Date: 03 December 2024 Time 9:30 am

SL/No	Name	Age	Gender	Occupation	Organization	Chiwog/Demkhong
1	Cheda	73	Male	Farmer	Private	Barthang
2	Yingjung Lhamo	50	Female	Business	Private	Barthang
3	Nima Tshering	36	Male	Farmer	Private	Barthang

SL/No	Name	Age	Gender	Occupation	Organization	Chiwog/Demkhong
4	Dechen Wangmo	61	Female	Farmer	Private	Barthang
5	Ngawang Choden	60	Female	Farmer	Private	Barthang
6	Yamuna Devi	35	Female	Farmer	Private	Barthang
7	Norbu Wangdi	62	Male	Farmer	Private	Barthang
8	Rinchen Dorji	42	Male	Farmer	private	Chaskhar
9	Damber Bdr Kararia	42	Male	Farmer	private	Chaskhar
10	Migma Tshering	50	Male	Shopkeeper	private	Chaskhar
11	Kinley Gyeltshen	42	Male	Farmer	private	Barthang
12	Lok Bdr	59	Male	Business	private	Barthang
13	Hasta Bdr Biswa	53	Male	Framer	private	Barthang
14	Pema Tshechi	50	Male	Farmer	private	Chaskhar
15	Rinchen Yangzom	45	Female	Business	private	Barthang
16	Lhaden	49	Female	Business	private	Shawapong
17	Akbar Rai	51	Male	Farmer	private	Yueling
18	Tshering Namgyel	58	Male	Farmer	private	Barthang
19	Pema Lhamo	50	Female	Farmer	private	Shawapong
20	Yeshi Wangmo	66	Female	Farmer	private	Shawapong
21	Tenzin Wangmo	28	Female	Nun	Sherab Choling Ani dratshang	Chaskhar
22	Thubten	32	Female	Nun	Sherabcholing Ani dratshang	Chaskhar
23	Narayan Gautam	38	Male	ADM	Chuzagang Hospital	Yueling
24	Sonam Pelden	32	Female	Teacher	Chuzagang Primary School	Nimaling
25	Deki Yangzom	28	Female	Teacher	Chuzagang Primary School	Nimaling
26	Sonam Tobgay	35	Female	Farmer	Private	Chaskhar
27	Karma Tshering	43	Male	Gup	Chuzagang Gewog	Barthang
28	Jigme Dorji	32	Male	Mangmi	Chuzagang Gewog	Barthang

ANNEX 1 B. List of Participants: Meeting with Communities of Gelephu, Samtenling and Shershong Gewogs

Venue: Glephu Gewog Meeting Hall

Date: 03 December 2024 Time 1:45pm

SL/No	Name	Age	Gender	Occupation	Organization	Chiwog/Demkhong
1	Dorji Tamang	46	Male	Farmer	Private	Lekithang
2	Bir Bdr Subba	24	Male	Farmer	Private	Lekithang
3	Norbu Wangmo	61	Female	Farmer	Private	Lekithang
4	Nagal	62	Female	Farmer	Private	Lekithang
5	Thinley Wangdi	57	Male	Monk	Religious	Lekithang
6	Nima Lhamo Sherpa	59	Female	Farmer	Private	Lekithang
7	Ugyen Tshering	48	Male	Tshogpa	LG member	Lekithang
8	Pabi Maya Mongar	42	Female	Housewife	unemployed	Pemathang
9	Keshara Devi Nepal	58	Female	Housewife	unemployed	Pemathang
10	Tandin Dema	36	Female	Civil servant	Admin Gelephu	Gelephu
11	Prem Prasad	38	Male	Gup	Gewog	Gelephu
12	KN Khatiwara	66	Male	Tshogpa	Gewog	Pelrithang Khatoed
13	Dena Nath Nepal	42	Male	Tshogpa	Gewog	Pelrithang Khatoed
14	Rinzin Lhamo	37	Female	Tshogpa	Gewog	Pelrithang Khatoed
15	Deki	39	Female	Business	Private	Pelrithang Khatoed
16	Tashi	72	Male	Farmer	Private	Pelrithang Khatoed
17	Doley Bdr	57	Male	Farmer	Private	Pelrithang Khatoed
18	N. Nandi Guriji	32	Male	Pandit	Religious	Pelrithang Khatoed
19	Chandra Bdr Rai	61	Male	Farmer	Private	Pelrithang Khatoed
20	Devi Charam	59	Male	Farmer	Private	Pelrithang Khatoed
21	Tandin Tshewang	46	Female	Farmer	Private	Pelrithang Khatoed
22	Beli Raj Gurung	47	Male	Business	Private	Pelrithang Khatoed
23	Mongal Singh Rai	37	Male	Business	Private	Pelrithang Khatoed
24	Yamuna Adhikari	33	Female	Housewife	unemployed	Pelrithang Khatoed
25	Laxmi Phuyel	35	Female	Housewife	unemployed	Pelrithang Khatoed
26	Rinchen Lhamo	36	Female	Housewife	unemployed	Pelrithang Khatoed

27	Devi Charan Katel	61	Male	Farmer	Private	Pelrithang Khatoed
28	Yuwa Raj Kumal	35	Male	Carpenter	H.B furniture house	Dzomlingthang
29	Mohan Singh Newar	40	Male	Shopkeeper	Newar Tshongkhang	Dzomlingthang
30	Reta Mongar	45	Female	Shopkeeper	Reta Tshongkhang	Dzomlingthang
31	Kul Bdr Tamang	63	Male	Farmer	Private	Dzomlingthang
32	Dika Darnal	25	Female	Shopkeeper	Tandin General store	Dzomlingthang
33	Tshewang Palden	28	Female	Housewife	unemployed	Dzomlingthang
34	Mon Maya Rai	41	Female	Housewife	unemployed	Dzomlingthang
35	Lal Bdr Pradhan	62	Male	Farmer	Private	Dzomlingthang
36	Tek Nath Bdr Bhandari	68	Male	Farmer	Private	Dzomlingthang
37	Ajay Kr. Monger	29	Male	Tshogpa	G/phu Gewog	Dzomlingthang
38	Geeta Monger	33	Female	CSE	Gewog Admin	Gelephu
39	Kaushila Tamang	51	Female	Business	Private	Lekithang
40	Karma Dema	52	Female	Business	Private	Lekithang
41	Choki	38	Female	Business	Private	Lekithang
42	Karma Euden	43	Female	Business	Private	Lekithang
43	Tulasi Pradhan	49	Female	Business	Private	Lekithang
44	Choden	26	Female	Business	Private	Lekithang
45	Sangay Dema	24	Female	Business	Private	Lekithang
46	Melam Zangmo	23	Female	Farmer	Private	Pelrithang Khatoed
47	Phurba Wangdi		Male	Farmer	Private	Pelrithang Khatoed
48	Tenzin Dema	58	Female	Farmer	Private	Pelrithang Khatoed
49	K.N Khatiwara	68	Male	Farmer	Private	Pelrithang Khatoed
50	Yogya Nanda Sharma	60	Male	Ex-Govt Servant	unemployed	Pelrithang Khatoed
51	Oma Kanta Sharma	61	Male	Ex-Govt Servant	unemployed	Pelrithang Khatoed
52	Tsheten Lhendup	57	Male	Farmer	Private	Pelrithang Khatoed
53	Radhika Khatiwara	58	Female	Farmer	Private	Pelrithang Khatoed
54	Chandra Maya Phuyel	30	Female	Farmer	Private	Pelrithang Khatoed

55	Pabitra Khatiwara	43	Female	Farmer	Private	Pelrithang Khatoed
56	Ugyen Tshering	63	Male	Farmer	Private	Pelrithang Khatoed
57	Puspa	49	Female	Farmer	Private	Pelrithang Khatoed
58	Hari Pradhan	41	Male	Religious Person	Mandir	Pelrithang Khatoed
59	Tshewang Yeshi	35	Male	Shopkeeper	Private	Dechenpelri
60	Tashi Tshering	57	Male	Shopkeeper	Private	Dechenpelri
61	Dorji Zangmo	28	Female	Shopkeeper	Private	Dechenpelri
62	Pema Tshomo	38	Female	Shopkeeper	Private	Dechenpelri
63	Kaushila Bhujel	60	Female	Shopkeeper	Private	Dechenpelri
64	Dawa Dorji Tamang	34	Male	Business	Private	Samtenling
65	Bal Krishna	46	Male	Mangmi	Gewog	Samtenling
66	Bena Rai	35	Female	Business	Private	Samtenling
67	Devika Rai	49	Female	Shopkeeper	Private	Samtenling
68	Bidhya Monger	30	Female	Shopkeeper	Private	Samtenling
69	Samita Maya Monger	26	Female	Shopkeeper	Private	Samtenling
70	Mongali Maya Tamang	40	Female	Shopkeeper	Private	Samtenling
71	Subash Chettri	45	Male	Shopkeeper	Private	Samtenling
72	Dawa Tshering Tamang	37	Male	Tshogpa	Gewog	Samtenling
73	Namgay Wangchuk	56	Male	Business	Private	Samtenling
74	Nar Maya Khatiwara	37	Female	Shopkeeper	Private	Samtenling
75	Keshar Man Rai	49	Male	Business	Private	Samtenling
76	Anil Chettri	41	Male	Shopkeeper	Private	Samtenling
77	Herka Bdr Kharka	41	Male	Shopkeeper	Private	Samtenling
78	Jit Bdr Sarki	45	Male	Shopkeeper	Private	Samtenling
79	Baily Rasaily	52	Female	Shopkeeper	Private	Samtenling
80	Leela Kumari Ghalley	46	Female	Shopkeeper	Private	Samtenling
81	Dhan Maya Rai	41	Female	Shopkeeper	Private	Samtenling
82	Sonam Dorji Tamang	63	Male	Farmer	Private	Khampa gang
83	Singh Bdr Tamang	41	Male	Farmer	Private	Khampagang
84	Dil Bdr Rai	47	Male	Farmer	Private	Khampagang

85	Guman Singh Ghalley	54	Male	Farmer	Private	
86	Mangal Dhoj Tamang	69	Male	Farmer	Private	Samtenling
87	Dawa Dorji Tamang		Male	Shopkeeper	Private	Samtenling
88	Leela Kumari Ghalley	46	Female	Shopkeeper	Private	Samtenling
89	Ambika Monger	28	Female	Business	Private	Chokharling
90	Tek Bdr Layo	66	Male	Farmer	Private	Chokharling
91	Kencho Dema	50	Female	Housewife	unemployed	Chokharling
92	Sonam Choden	50	Female	Housewife	unemployed	Chokharling
93	Karma Jurme	54	Male	Farmer	Private	Samtenling
94	Padam Lal Monger	64	Male	Farmer	Private	Samtenling
95	Sonam Lhaki	47	Female	Farmer	Private	Samtenling
96	Tshering Lhadon	44	Female	Farmer	Private	Samtenling
97	Namgay Wangchuk	56	Male	Farmer	Private	Samtenling
98	Pema Namgay	35	Male	Farmer	Private	Shershong

ANNEX 1 C. List of Participants: Meeting with Communities of Tareythang Gewog

Venue: Gewog Meeting Hall

Date: 02 December 2024 Time 9:00 am

SL/NO	Name	Age	Gender	Occupation	Organization	Chiwog/Demkhong
1	Bir Man Rai	55	Male	Farmer	Private	Dorjitshe
2	Suk Raj Rai	32	Male	Farmer	Private	Dorjitshe
3	Purna Bdr Rai	47	Male	Farmer	Private	Dorjitshe
4	Honi Lall Rai	44	Male	Farmer	Private	Dorjitshe
5	Makar Dhoj Rai	63	Male	Farmer	Private	Dorjitshe
6	Lalita Rai	34	Female	Farmer	Private	Dorjitshe
7	Hari Rai	42	Male	Tshogpa	Gewog	Dorjitshe
8	Bhakta Bdr Rai	56	Male	Farmer	Private	Dorjitshe

9	Dhan Man Gurung	35	Male	Gup	Gewog	Pemacholing
10	Ugyen Tshewang	30	Male	Mangmi	Gewog	Pemacholing
11	Pema Wangmo		Female	Farmer	Private	Pemacholing
12	Cheku		Male	Business	Private	Pemacholing
13	Cheki Lhamo		Female	Business	Private	Pemacholing
14	Tshewang Norbu		Male	Farmer	Private	Pemacholing
15	Ngaden Dema		Female	Farmer	Private	Pemacholing
16	Nim Dorji		Male	Farmer	Private	Pemacholing
17	Ngawang Gyeltshen		Male	Farmer	Private	Pemacholing
18	Pema Dema		Female	Farmer	Private	Pemacholing
19	Karma Wangzom		Female	Farmer	Private	Pemacholing
20	Kota		Male	Farmer	Private	Pemacholing
21	Norzin Lhamo		Female	Driver	Private	Pemacholing
22	Dhan Maya Gurung		Female	Farmer	Private	Pemacholing
23	Jigme Wangdi		Male	Farmer	Private	Pemacholing
24	Champhel		Male	Tsampa	Religious	Pemacholing
25	Bhagi Maya Rai	34	Female	Housewife	unemployed	Woong Chilo
26	Garja Man Rai	79	Male	Farmer	Private	Woongchilo
27	Gopi Maya Rai	54	Female	Farmer	Private	Woongchilo
28	Pema Cheki	26	Female	Farmer	Private	Woongchilo
29	Shari Maya Rai	54	Female	Farmer	Private	Woongchilo
30	Devika Homagai	35	Female	Farmer	Private	Woongchilo
31	Pushpa Dhungana	40	Female	Tshogpa	Gewog	Woongchilo
32	Rinchen Dema	35	Female	Farmer	Private	Tashicholing
33	Phurpa Wangzom	33	Female	Farmer	Private	Tashicholing
34	Kelzang Lhamo	48	Female	Farmer	Private	Tashicholing
35	Jungkiri Tirwa	59	Female	Farmer	Private	Tashicholing
36	Chophel	59	Male	Farmer	Private	Tashicholing
37	Suk Man Kami	35	Male	Farmer	Private	Tashicholing
38	Chador Thinley	60	Male	Farmer	Private	Tashicholing

39	Lhari Zangmo	49	Female	Farmer	Private	Tashicholing
40	Chezom		Female	Farmer	Private	Tashicholing
41	Pem Chezom	33	Female	Farmer	Private	Tashicholing
42	Pem Dema		Female	Farmer	Private	Tashicholing
43	Sonam Lhamo	28	Female	Farmer	Private	Tashicholing
44	Choney Dema	41	Female	Farmer	Private	Tashicholing
45	Kinzang Dorji	19	Male	Student	Student	Tashicholing
46	Tshering Dorji	39	Male	Farmer	Private	Tashicholing
47	Pema Dorji	52	Male	Tsampa	Religious	Pemacholing
48	Sonam Yangdey	55	Female	Driver	Private	Pemacholing
49	Karma	59	Female	Farmer	Private	Pemacholing
50	Sonam Dema	56	Female	Farmer	Private	Yoezergang
51	Drupchu Zangmo	36	Female	Farmer	Private	Yoezergang
52	Ugyen Tshewang	20	Male	Student	Private	Yoezergang
53	Sengda	60	Male	Driver	Private	Yoezergang
54	Keku Dorji	55	Male	Farmer	Private	Yoezergang
55	Lobzang Dorji	40	Male	Farmer	Private	Yoezergang
56	Tshering Tenzom	38	Female	Tshogpa	Gewog	Yoezergang
57	Druji Tshering	48	Male	Farmer	Private	Yoezergang
58	Sonam Tashi	54	Male	Business	Private	Yoezergang
59	Tobgay	38	Male	Farmer	Private	Yoezergang
60	Rinchen Tshering	33	Male	Tsampa	Religious	Yoezergang
61	Kezang Dema	60	Female	Farmer	private	Yoezergang
62	Jigme Dorji	38	Male	Driver	private	Yoezergang
63	Pema Khandu	31	Male	Driver	private	Yoezergang

ANNEX 1 D. List of Participants: Meeting with Communities of Umling

Venue: Umling RNR Hall

Date: 02 December 2024 Time 2:30 am

SL/No	Name	Age	Gender	Occupation	Organization	Chiwog/ Demkhong
1	Leki Selden	31	Female	Farmer	Private	Gaden
2	Pemo	65	Female	Farmer	Private	Gaden
3	Cheten Zangmo	52	Female	Farmer	Private	Gaden
4	Pema	74	Male	Farmer	Private	Gaden
5	Tshewang Darjey	45	Male	Farmer	Private	Gaden
6	Yoezer Dema	40	Female	Sr. Teacher	MOE, Govt	Gaden
7	Yangchen Dema	42	Female	Farmer	Private	Gaden
8	Yeshi Pelden	38	Female	Farmer	Private	Gaden
9	Dechen Tshomo	39	Female	Farmer	Private	Gaden
10	Kuenzang Choden	41	Female	Farmer	Private	Gaden
11	Tshering	25	Male	unemployed	unemployed	Gaden
12	Sonam Dema	64	Female	Farmer	Private	Gaden
13	Damber Bdr Adhikari	73	Male	Farmer	Private	Gaden
14	Pema Lhamo	69	Female	Farmer	Private	Gaden
15	Rinzin Lhamo	49	Female	Farmer	Private	Gaden
16	Pema Dema	30	Female	Farmer	Private	Gaden
17	Rinchen Pelden	41	Female	Farmer	Private	Gaden
18	Tangpo	59	Male	Farmer	Private	Gaden
19	Tshering Dorji	71	Male	Farmer	Private	Gaden
20	Phurpa Lhamo	39	Female	Farmer	Private	Gaden
21	Sangay Tshomo	39	Female	Farmer	Private	Gaden
22	Sonam Tshomo	40	Female	Farmer	Private	Gaden
23	Lhamo (A)	37	Female	Farmer	Private	Gaden
24	Lhamo (B)	33	Female	Farmer	Private	Gaden
25	Tshering Choki	25	Female	Farmer	Private	Gaden
26	Sangay Tenzin	37	Male	Gup	Gewog Admin	Gaden

27	Pema Phelay	36	Male	Tshogpa	Gewog	Gaden
28	Sangay Zangmo	38	Female	Farmer	Private	Gaden
29	Tshedon	57	Female	Farmer	Private	Gaden
30	Passang Lhamo	38	Female	Farmer	Private	Gaden
31	Nyomba	62	Male	Farmer	Private	Gaden
32	Dorji Wangmo	27	Female	Farmer	Private	Gaden
33	Tshering Choden	47	Female	Farmer	Private	Gaden
34	Selden	52	Female	Farmer	Private	Gaden
35	Tshering Dorji	71	Male	Farmer	Private	Gaden
36	Dawa Zangmo	56	Female	Farmer	Private	Gaden
37	Zangmo	60	Female	Farmer	Private	Gaden
38	Yoezer Dema	42	Female	Civil Servant	Govt	Gaden
39	Sangay Lhaden	44	Female	Farmer	Private	Gaden
40	Wangdi	60	Male	Farmer	Private	Gaden
41	Nima Selden	49	Female	Farmer	Private	Gaden
42	Karma Yangden	35	Male	Tshogpa	Gewog	Dungmin
43	Ugyen Dorji	39	Male	Tshogpa	Gewog	Rijoog
44	Leki Dema	53	Female	Tshogpa	Gewog	Tashithang
45	Pema Phelay	36	Male	Tshogpa	Gewog	Gaden
46	Thinley Wangchuk	33	Male	Mangmi	Gewog	Dungmin

ANNEX 1 E. List of Participants: Meeting with Communities of Gelephu Thromde

Venue: Thromde Conference Hall

Date: 04 December 2024 Time 9:30 am

SL/No	Name	Age	Gender	Occupation	Organization	Chiwog/Demkhong
1	Dorji Wangchuk	53	Male	Forest	Royal Manas National Park	Tashiling
2	Maya Giri	51	Female	Business	Private	Namkhaling

3	Pema Choden	50	Female	Housewife	unemployed	Namkhaling
4	Karuna Pradhan	23	Female	Business	Private	Namkhaling
5	Tshering Norbu	44	Male	Principal School	GHSS (Govt)	Tashiling
6	Shiva Norayan Pradhan	67	Male	Ex-gov servant	Private	Sonamgatshel
7	Col Chogyel Drukpa	48	Male	SSP	RBP	-
8	Yechuri Prasad Gajmer	39	Male	Business	Private	Namkhaling
9	Amrat Gajmer	29	Male	Fo	BTFEC (GMC)	Namkhaling
10	Kaushila	63	Female	Housewife	unemployed	Namkhaling
11	Ganga Maya Pradhan	40	Female	Housewife	unemployed	Rabdeyling
12	Wangmo	41	Female	Housewife	unemployed	Namkhaling
13	Mon Maya	63	Female	Housewife	unemployed	Namkhaling
14	Sunil Ghalley	26	Male	Cooperate Employee	BHSL	Namkhaling
15	Madani Prasad Oli	54	Male	Business	Oli Enterprise	Namkhaling
16	Birkha Bdr Ghalley	48	Male	Business	Season Botique	Namkhaling
17	CM Pradhan	69	Male	Farmer	Private	Namkhaling
18	Renuka Gurung	28	Female	Housewife	unemployed	Namkhaling
19	Sheela Mongar	35	Female	Business	Sheela Mongar Restaurant	Namkhaling
20	Bishnu Maya Gurung	39	Female	Housewife	unemployed	Namkhaling
21	Sudha Jain	23	Female	Student	Thimphu	Namkhaling
22	Drukpola	38	Male	CS	Gelephu	Jampeling
23	Karma Wangdi	53	Male	BBS Reporter	Gelephu	Tashiling
24	Tashi Wangmo	34	Female	Housewife	Gelephu	Namkhaling
25	Nar Bdr Adhikari	58	Male	Program Director ARDC	ARDC	Gelephu
26	Pema Sherab	53	Male	PD.N pi DC	Jampeling	Gelephu Thromde
27	Gagan Bdr Ghalley	57	Male	Business	General Market	Namkhaling
28	Bikash Giri	35	Male	ICT	Sarpang	Samdrupling
29	Yeshey Rangdrol	42	Male	Land	Sarpang	Samdrupling
30	Karma Tshering	53	Male	Principal	Gelephu MSS	Samdrupling

31	Hari Prasal Powdel	49	Male	Principal	Gelephu LSS	Sonamgatshel
32	Om Maya Pradhan	52	Female	Housewife	unemployed	Rabdeyling
33	Deo Kumar Gurung	51	Male	PLO	NPDC	Sarpang
34	Sonam Bumthap	53	Male	RD	ROICE	Gelephu
35	Pema Dorji Tamang	26	Male	DBO	Dzongkhag Admin, Sarpang	Sarpang
36	Bhim Bdr Mongar	50	Male	Farmer	Private	Namkhaling
37	Passang Tamang	47	Male	Business	Private	Namkhaling
38	Tshering Drukpa	64	Male	Business	Private	Namkhaling
39	Karma Dorji	62	Male	Business	Private	Namkhaling
40	Amber Bdr. Sapkota	58	Male	Resident	Private	Namkhaling
41	Mon Bdr. Ghalley	63	Male	Resident	Private	Namkhaling
42	LN Pradhan	55	Male	Resident	Private	Namkhaling
43	Pema Thinley	56	Male	PDEO	Education	Dzongkhag
44	Dr. Choeda Gyeltshen	47	Male	M.S	CRRM	Thromde
45	Monorath Bhattarai	71	Male	Retired	Private	Namkhaling
46	Karma Wangdi	47	female			
47	Tul Bdr. Pithakotay	46	Male	Business	Private	Namkhaling
48	Indra Maya Ghalley	70	Female	Housewife	unemployed	Namkhaling
49	Ran Bdr. Bhattarai	57	Male	Farmer	Private	Namkhaling
50	Chunu Rai	49	Female	Housewife	unemployed	Namkhaling
51	Mani Ghalley	56	Male	ex-Teacher	Private	Namkhaling
52	Kezang Tshomo	36	Female	Business	Private	Namkhaling
53	Sonam Tshering	60	Male	Farmer	Private	Namkhaling
54	Mani Ram Baraily	60	Male	Farmer	Private	Namkhaling
55	Bhim Bdr Gurung	27	Male	Business	Private	Namkhaling
56	LB Thapa	80	Male	Farmer	Private	Namkhaling
57	Tshering Norbu	42	Male	Thrompoen	Thromde	Namkhaling
58	Bal Bdr Bista	60	Male	Farmer	Private	Namkhaling
59	Dawa Zangmo	37	Female	Business	Private	Rabdeyling
60	Barat Rai	60	Male	Disabled	Unemployed	Rabdeyling

61	Phomo	63	Female	Disabled	Unemployed	Rabdeyling
62	Indra Lal Kafley	71	Male	Disabled	Unemployed	Namkhaling
63	Phool Maya Ghalley	57	Female	Housewife	Unemployed	Namkhaling
64	Darman Pradhan	33	Male	Tourism	Private	Namkhaling
65	Chimmi Dema	55	Female	Women's Group	Private	Tashiling
66	Januka Sharma	55	Female	Housewife	Unemployed	Rabdeyling
67	Krishna Prasad Sharma	31	Male	Disabled	Unemployed	Rabdeyling
68	Nishal Giri	25	Male	Disabled	Unemployed	Jigmeling
69	Mon Bdr Rai	35	Male	Disabled	Unemployed	Rabdeyling

Public Consultation Meetings Photo

FIGURE 1 MEETING WITH THE COMMUNITIES AND LG OF GELEPHU, SAMTENLING AND SERSHONG GEWOGS

FIGURE 2 MEETING WITH THE COMMUNITIES AND LG OF GELEPHU, SAMTENLING AND SERSHONG GEWOGS

FIGURE 3 MEETING WITH THE COMMUNITIES LG OF UMLING GEWOG

FIGURE 4 MEETING WITH THE COMMUNITIES AND LG OF UMLING GEWOG

FIGURE 5 MEETING WITH THE COMMUNITIES AND LG OF CHUZAGANG

FIGURE 6 MEETING WITH THE COMMUNITIES AND LG OF CHUZAGANG

FIGURE 7 MEETING WITH THROMDE LG AND REGIONAL HEADS AND SECTOR DZONGKHAG HEADS

FIGURE 8 MEETING WITH THROMDE LG AND REGIONAL HEADS AND SECTOR DZONGKHAG HEADS

FIGURE 9 MEETING WITH THE COMMUNITIES AND LG OF TAREYTHANG GEWOG

APPENDIX P LABOR MANAGEMENT PROCEDURES