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

Gelephu-Tareythang Road

Environment and Social Impact Assessment (ESIA)

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

DATE

March 2025

(Revised)

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

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ACRONYMS AND ABBREVIATIONS

Acronym	Description
ACCESS	Accelerating Transport and Trade Connectivity in Eastern South Asia
ARUP	ARUP International Projects Limited (ARUP)
ASEAN	The Association of Southeast Asian Nations
AZE	Alliance for Zero Extinction site
BBMP	Bhutan Bird Monitoring Protocol
BLSS	Bhutan Living Standard Survey
BMG	Biodiversity Monitoring Grids
BMP	Biodiversity Management Plan
CCRA	Climate Change Risk Assessment
CF	Community Forest
CHA	Critical Habitat Assessment

Acronym	Description
CIA	Cumulative Impact Assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CR	Critically Endangered
dB	Decibels
DBH	Diameter at Breast Height
DDM	Department of Disaster Management
DO	Dissolved Oxygen
DoECC	Department of Environment and Climate Change
DED	Detailed Engineering Design
DIA	Directly Impacted Area
DID	Department of Infrastructure Development
DoC	Department of Culture
DoCDD	Department of Culture and Dzongkha Development
DoEE	Department of Employment and Entrepreneurship
DoFPS	Department of Forests and Park Services
DoI	Department of Labor (DoI-Department of Immigration, DoL- Department of Labour)
DoST	Department of Surface Transport under the Ministry of Infrastructure and Transport
DoW	Department of Water
DT	Dzongkhag Tshogdu
AoA	Critical Habitat Area(s) of Analyses
EBA	Endemic Bird Area
EC	Electrical Conductivity
E&S	Environmental and Social
EAAB	Environmental Assessment Act of Bhutan
ECP	Environmental Codes of Practice
EHS	Environmental, Health and Safety guidelines.
EIA	Environmental Impact Assessment
EN	Endangered
EOO	Extent of Occurrence
EPC	Engineering, Procurement, and Construction
ERM	ERM Siam
ES	Environmental Standards
ESS	Environmental and Social Standard
ESF	Environmental and Social Framework
ESHMP	Environmental, Social, and Health Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environment and Social Management Plan
ESS	Environmental and Social Standards (“”) of the and associated
FGD	Focus Group Discussion
FMPB	Flora Monitoring Protocol of Bhutan
FNCA	Forest and Nature Conservation Act
FNCRR	The Forest and Nature Conservation Rules and Regulation
km	kilometers
GBIF	Global Biodiversity Information Facility
GLOF	Glacial Lake Outburst Flood
GMC	Gelephu Mindfulness City
GNH	Gross National Happiness
GPN	Good Practice Notes
GRM	Grievance Redress Mechanism
GVW	Gross Vehicle Weight
GT	Gewog Tshogde

Acronym	Description
HH	Higher Himalaya
HSU	Hatridge Smoke Unit
IBA	Important Bird Area
IBAT	Integrated Biodiversity Assessment Tool
IFC	International Finance Cooperation
IPF	Investment Project Financing
IUCN	International Union for Conservation of Nature
KBA	Key Biodiversity Area
KIIs	Key Informant Interviews
KW	Kilowatts
LC	Least Concern
LH	Lesser Himalaya
m	Meters
MBT	Main Boundary Thrust
MCT	Main Central Thrust
MFT	Main Frontal Thrust
MEA	Multilateral Environmental Agreement
MoAL	Ministry of Agriculture and Livestock
MoEA	Mines and Minerals Act
MoICE	Ministry of Industry, Commerce and Employment
MoIT	Ministry of Infrastructure and Transport
MoU	Memorandum of Understanding
NBC	National Biodiversity Center
NCA	National Conservation Area
NCHM	National Centre for Hydrology and Meteorology
NDMA	National Disaster Management Authority
NEC	National Environment Commission
NFE	Non-Formal Education
NGO	Non-Governmental Organization
NIOSH	National Institute of Occupational Safety and Health
NIWRMP	National Integrated Water Resources Management Plan
NLC	National Land Commission
NLCS	National Land Commission Secretariat
NLUZ	National Land Use Zoning
NT	Near Threatened
NWFP	Non-wood forest products
OHS	Occupational Health and Safety
PA	Protected Area
PM	Particulate matter
ppb	Parts per billion
ppm	Parts per million
PS	Performance Standards
PT	Public Transport
RBMP	River Basin Management Plan
RDC	Reverse Circulation Drilling
RECOP	Regulations for Environmental Compliance of Project
RENEW	Respect, Educate, Nurture, Empower Women
RGoB	Royal Government of Bhutan
RMNP	Royal Manas National Park
ROW	Right-Of-Way
RPF	Resettlement Policy Framework
SACEP	South Asia Co-operative Environment Programme

Acronym	Description
SAR	Special Administrative Region
SEA/SH	Sexual Exploitation and Abuse and Sexual Harassment
SEP	Stakeholder Engagement Plan
SIA	Social Impact Assessment
SLCPs	Short-lived climate pollutants
SOGI	Sexual Orientation and Gender Identity
SPP	Superintendent of Police
STP	Sewage treatment plant
SW	Siwalik
TCU	Truce Color Unit
TDS	Total Dissolved Solids
TIA	Traffic Impact Assessment
TraMCA	Transboundary Manas Conservation Area
TSP	Total Suspended Particulate Matter
TSS	Tethyan Sedimentary Series
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
USEPA	United States Environmental Protection Agency
VECs	Valued Environmental Components
VU	Vulnerable
WB	World Bank
WBG	World Bank Group
WHO	World Health Organization

1. INTRODUCTION

1.1 OVERVIEW

Bhutan, a small landlocked country between India and China, faces significant challenges in regional trade and connectivity due to its limited transport infrastructure and high costs of connectivity. To address these issues, the Royal Government of Bhutan, with World Bank support, has initiated a multi-phase project called the Accelerating Transport and Trade Connectivity in Eastern South Asia Project - Bhutan (ACCESS – Bhutan), which aims to increase the efficiency and resilience of trade and transport along selected corridors in Bhutan. The ACCESS is expected to reduce trade and transport costs through (i) an increase in throughput at priority border points; (ii) a reduction in average travel time for vehicles along selected regional corridors, (iii) a reduction in annual fatalities on program corridors; and (iv) increase the number of people provided with improved climate resilient road access along regional corridors. The ACCESS Bhutan has the following 3 components:

Component 1 - Digital Systems for Trade (Estimated cost of $42m): This component will enhance trade efficiency and resilience by strengthening digital infrastructure and connecitivity, and improving cybersecurity and disaster recovery capabilities. It will support (i) the implementation of the National Single Window for trade bringing all export, import and transit trade related services under one digital platform; (ii) strengthening digital enablers, supporting digitalization of electronic transactions and services and promote trusted data sharing; (iii) enhancing cybersecurity; and (iv) improving digital connectivity and data infrastructure resilience.

Component 2 – Green and Resilient Transport and Trade Infrastructure (Estimated cost of $232m): This component will enhance regional corridors and trade gateways that are the backbone of the physical and economic integration of the region. It includes the following subcomponents:

Subcomponent 2.1 Developing Green, Resilient, and Safe Road Connectivity (US$218 million): This subcomponent will construct Gelephu – Tareythang Road, a climate-resilient greenfield road segment with four major bridges along the Southern East-West Highway (SEWH). It replaces a vulnerable 45-kilometer road regularly damaged by flooding and landslides, reducing travel distance while enhancing safety. Road designs incorporate a strong emphasis on biodiversity protection for the Asian Elephant and Gee's Golden Langur. A Biodiversity Management Plan (BMP) and net gain strategy will guide the measures to mitigate project impacts, habitat enrichment, community protection from potential human wildlife conflict, elephant corridor development, and wildlife monitoring and capacity building. The subcomponent also funds feasibility studies, design work, and environmental assessments for the follow-on 60-kilometer missing link between Tareythang and Panbang and a full-scale Cumulative Impact Assessment (CIA) building on the preliminary CIA done during project preparation.

Subcomponent 2.2: Strengthening Road Asset Management and Maintenance ($11 million). This activity will strengthen data-driven road maintenance by upgrading the Road Asset Management System (RAMS) and introducing a five-year Performance-Based Maintenance contract, ensuring climate resilience through targeted nature-based solutions.

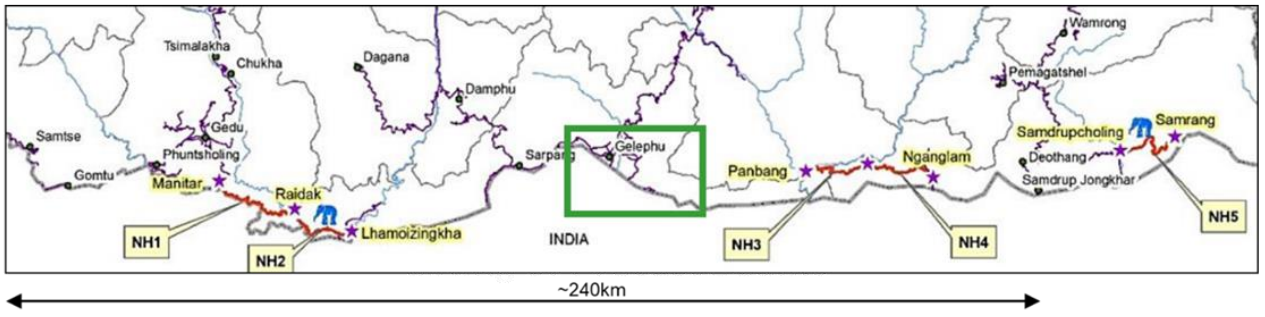
Subcomponent 2.3: Improving Multimodal Connectivity ($3 million): This subcomponent will support pre-feasibility and feasibility studies for inland water transport (IWT) and rail, updating dry port assessments, and promoting climate-resilient logistics and private sector investments.

Component 3 – Institutional and Policy Strengthening for Transport and Trade ($26m): This component will provide (i) project implementation support to implementing agencies and capacity building, (ii) policy and regulatory support for cross-border digital trade and transport facilitation; and (iii) support for resilient and sustainable infrastructure planning for regional trade through feasibility studies including E&S studies and future trade project assessments.

Construction of the proposed 14-km long Gelephu-Tareythang Road (G-T Road) in the Gelephu area in Sarpang district is the only major physical activity involving civil works in the ACCESS – Bhutan and is categorized as a high-risk activity from an environmental and social (E&S) perspective and a full environmental and social assessment is required. Hence, a comprehensive E&S assessment has been conducted for the Gelephu – Tareythang Road (herein after referred to as the "G-T Road"), and this report l presents the environmental and social impact assessment (ESIA) for the G-T Road. A Biodiversity Management Plan (BMP), a Stakeholder Engagement plan (SEP) and a Resettlement Action Plan (RAP) have also been prepared for the G-T Road and presented as standalone reports.

The proposed Gelephu-Tareythang Road is a part of the road link along the southern east-west highway (SEWH) running from east to west of the country (approximately 240 km in straight-line distance) as described in ***Figure 1.1***.

FIGURE 1.1 SOUTHERN EAST-WEST HIGHWAY FROM SAMTSE TO SAMDRUP JONGKHAR



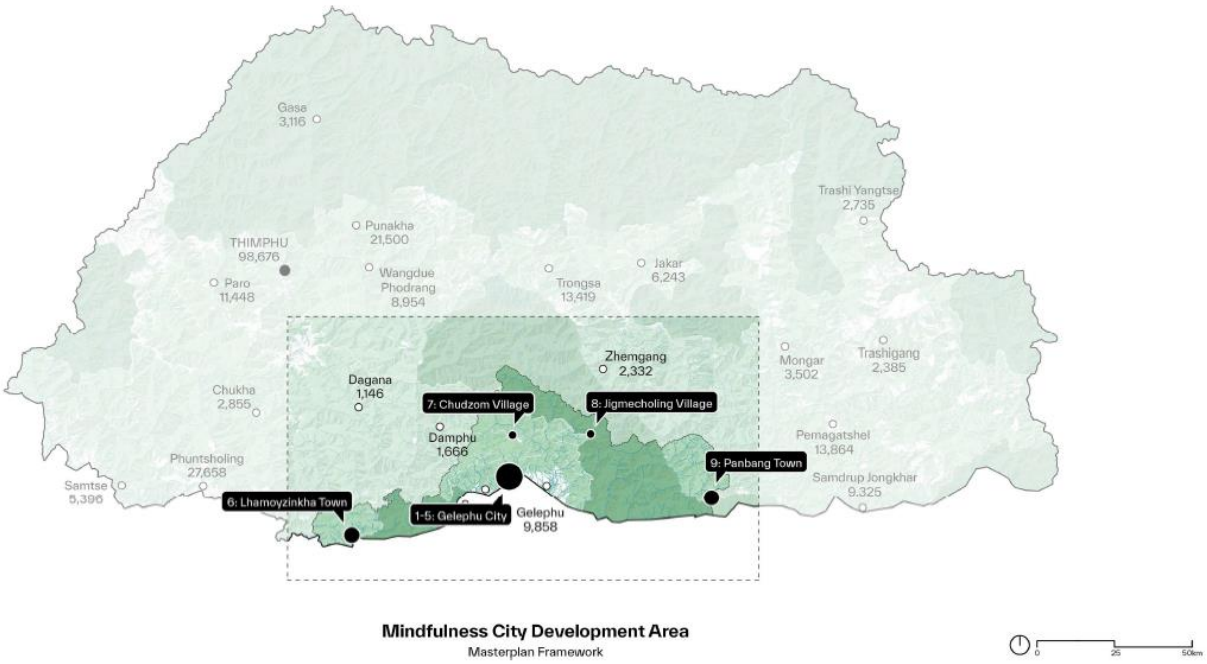
Southern East-West Highway from Samtse to Samdrupjongkhar		
0743906 Gelephu-Tareythang Road Project		ERM
Photo Credit: Bhutan Highways Masterplan to 2040-Stratgic Environmental Assessment Scoping Report	Date: 2024	

1.1 BACKGROUND

The proposed G-T Road is located within the master-plan boundary of the Gelephu Mindfulness City (GMC) Special Administrative Region (SAR) masterplan. The GMC masterplan is designed in accordance with the nine domains of happiness that are used as a reference to direct and evaluate development in Bhutan to align with Bhutan's Buddhist principles.

The site-wide master plan boundary covers an area of 2,500 sq. km in and around Gelephu in the Sarpang district in the Kingdom of Bhutan, located on the southern end of the nation near the border with India, as shown in ***Figure 1.2***.

FIGURE 1.2 MINDFULNESS CITY DEVELOPMENT AREA



Located strategically at the intersection of South Asia, ASEAN, and China, GMC will capitalize on Bhutan's commitment to sustainable development, its rich cultural heritage, and its strong governance framework. The aspiration for GMC is to develop a "15-minute" city with walkable neighborhoods, well-connected public transport, and low usage of private cars. This strategy requires improved public transport connectivity between Gelephu and Tareythang.

1.2 NAME OF PROJECT PROPONENT AND CONSULTANTS

The Department of Surface Transport (DoST) of the Ministry of Infrastructure and Transport (MoIT) is the "Project Proponent" for the development of Gelephu-Tareythang Road on Southern East-West Highway, Sarpang, Bhutan. The details of the project description are outlined in ***Table 1.1***.

ERM Siam ("ERM") has been engaged as the environmental and social (E&S) consultant in preparing this ESIA.

TABLE 1.1 DETAILS OF THE PROJECT PROPONENT

Project Proponent	Detail
Name of Project Proponent	The Department of Surface Transport, Ministry of Infrastructure and Transport
Mailing Address	Department of Surface Transport, Ministry of Infrastructure and Transport. Drentoen Lam, Thimphu, Bhutan. Post Box: 791
Name and Contact of the Environmental Focal	Director General Department of Surface Transport, Ministry of Infrastructure and Transport. Tel: +975-2-327998/322182/327451

Specialists involved in preparing the ESIA are listed below:

- **Environment** - Daniela Viveash, Thailand, +25 years' experience in Environmental Management and Environmental Impact Assessment
- **Air Quality** - Christie Hazell Marshall, United Kingdom, 25+ years in air quality impact and management
- **Noise** - Michael Fraser, United Kingdom, 30+ years in acoustics/noise impact and management
- **Water Resources, Hydrology, surface water, groundwater and soil quality** - Venkat S. Kolluru, United States, 33+ years in water impact assessment and water resource management
- **Traffic -** Ben Sussman, United States, 25+ years in public infrastructure
- **Biodiversity** - Arun Venkataraman, India, 30+ years in ecology and biodiversity conservation
- **Social** - Sabrina Genter, Australia, 15+ years in social impact, risks and management
- **Cultura Heritage** – Chris Morley, United Kingdom, 20+ years in cultural heritage impact and management

The ESIA has been independently reviewed by international environmental, biodiversity and cumulative impact assessments consultants and a national social consultant engaged by the DoST and World Bank, Venkata Nukala, Andrew Cauldwell, Miles Scott-Brown and Pema Cheizom.

1.3 PURPOSE AND SCOPE OF THE ESIA

The Project Proponent is seeking Project Financing from the World Bank ("WB"). Therefore, an Environmental and Social Impact Assessment (ESIA) Study for the Project is required to comply

with the World Bank Group's Environmental and Social Standards ("ESS") of the World Bank Environmental and Social Framework ("WB ESF") and associated Environmental, Health and Safety guidelines ("EHSG"). The Project, therefore, needs to document conformance with the lender's respective environmental and social policies.

The purpose of the ESIA is to assess the potential impacts of the Project activities on the surroundings (including biological, physical, and socio-economic resources). Where applicable, mitigation or enhancement measures will be developed to avoid, reduce, or remediate negative impacts on the environment or people to support the application for Project financing from international lenders. The specific purpose of this ESIA report is as follows:

- Introduce the Project and provide an opportunity for stakeholders to provide suggestions and identify concerns about the Project;
- Facilitate an understanding of the elements of the existing baseline conditions that are relevant to resources/receptors that could be potentially impacted by the Project;
- Identify the aspects of the Project that could potentially result in significant environmental and social impacts on resources/receptors;
- Document how stakeholders have been engaged during the ESIA Process, and how stakeholder feedback has been considered in the ESIA study;
- Predict and evaluate the significance of the potential environmental and social impacts of the Project;
- Identify the aspects of the Project that need to be managed, and recommend appropriate and justified mitigation and enhancement measures;
- Determine the significance of residual impacts, considering the implementation of mitigation measures; and
- Generate plans for the management and monitoring of impacts, including plans for ongoing stakeholder engagement.

The scope of this ESIA includes the entire Gelephu-Tareythang Road under consideration for financing by the World Bank, including the following activities:

- Road - total of 13.6 km, with dual 2-Lane Highway for 3.8 km with a 40 m wide Right-of-Way (ROW) and single carriageway for 9.8 km with 30 m wide ROW
- Bridges - Mau River: 1,000 m length, Jengkhurung & Taklai Rivers: 780 m length, Langer River: 400 m length and Singye River: 400 m length including some minor culverts and bridges.
- Interchanges – A T-junction will be installed in Gelephu, and only two (02) stub ends will be left for future interchanges.
- Ancillary facilities: Temporary and permanent ancillary facilities required to construct and operate the project components listed above, including haul roads for material transport, local quarry sites and borrow pits, on-site crushing and batching plants for concrete production, designated work areas for storage and contractor offices, worker camps and designated disposal areas for excavation activities.

Associated Facilities: These include facilities or activities that are not funded by the World Bank but are directly and significantly related to the Project; carried out or planned to be carried out contemporaneously with the Project; and necessary for the Project to be viable and would not have been constructed, expanded, or conducted if the Project did not exist (World Bank 2017).

The WB ESF requires associated facilities to meet the requirements of the Environmental and Social Standards (ESSs). For this project, no associated facilities are identified as per the definition. (see ***Section 2.4.7***)

1.4 LIMITATION OF THE STUDY

The ESIA was prepared by ERM in parallel with the project Feasibility Study by the Engineering Consultant, ARUP. This concurrent approach allowed for early identification of potential environmental and social risks, enabling proactive integration of E&S considerations into project planning and design. However, some project component details were still being finalized as part of the detailed Feasibility Study.

This report is based upon the application of scientific principles and professional judgment to certain facts with resultant subjective interpretations. Professional judgments expressed herein are based on the currently available facts within the limits of the existing data, scope of work, budget, and schedule.

The information provided in this report is not to be constructed as legal advice. Any specific limitations and assumptions utilized for the assessments are included in the respective chapters.

1.5 ESIA REPORT STRUCTURE

The ESIA structure and contents are detailed in ***Table 1.2***.

TABLE 1.1.2 REPORT STRUCTURE

Section	Contents
Chapter 1	**Introduction** - Contains an overview and Project background, objective of the study, limitations, and outline of the report structure
Chapter 2	**Project Description** - Presents a detailed description of the Project, including Project design, its components, ancillary facilities, resources, Project activities, and Project schedule.
Chapter 3	**Legal and Institutional Framework** - Contains applicable national policy, laws, regulations, and standards, and applicable Environmental and Social Standards (ESSs) of the World Bank's Environmental and Social Framework (ESF)
Chapter 4	**Project Alternatives and Environmental and Social Considerations** - Presents an analysis of different alignment alternatives to the Project in terms of environmental and social perspectives.
Chapter 5 (***Appendix B***)	**Methodology and Scoping -** Presents the impact assessment process, baseline data collection, stakeholder engagement, project impact area, screening and scoping and Institutional Capacity Assessment and Strengthening
Chapter 6	**Physical Environmental Baseline -** Describes the existing physical environment.
Chapter 7	**Biodiversity Baseline -** Describes the existing biological environment.
Chapter 8	**Socio-Economic Baseline Data** - Describes the existing socio-economic conditions which are considered as the receiving baseline environment.
Chapter 9	**Impacts on Physical Environment –** Describes the potential impacts on the physical environment generated by the Project's activities including traffic, unplanned events, climate risks and GHG, embedded controls, significance of impacts, additional mitigation management and monitoring procedures.
Chapter 10	**Impacts to Biological Environment –** Describes the potential impacts on the biological Environment generated by the Project's activities, embedded controls, significance of impacts, additional mitigation management and monitoring procedures.
Chapter 11	**Social Environment Risks, Impacts, and Mitigation –** Describes the potential social impacts likely generated by the Project's activities, embedded controls, significance of impacts, additional mitigation management and monitoring procedures
Chapter 12	**Cumulative Impact Assessment –** Defines cumulative impacts as those resulting from the interaction of the Project's impacts with the impact of other activities.
Chapter 13	**Environment and Social Management Plan –** Describes material measures and actions for the Project to meet the ESSs over a specified time.
Chapter 14	**Stakeholder Engagement Plan** – A summary of the project stakeholders, stakeholder consultation and disclosure.

2. PROJECT DESCRIPTION

2.1 PROJECT LOCATION

The Project is situated in Sarpang District (Dzongkhag), centrally located in southern Bhutan, with elevations ranging from 200 to 3,600 m above sea level. Sarpang borders the Indian state of Assam and serves as one of the three gateways to Bhutan from India via Gelephu. It is also one of Bhutan's emerging socio-economic zones. The alignment crosses the lower-lying natural terrain of Sarpang, mainly comprising floodplains and plains of agricultural land and forest.

The Project would connect the western part of Gelephu Town (Thromde)[1] and the eastern part of the area in Tareythang that was being developed as Tareythang Gyalsung[2] (***Table 2.1***). It passes through parts of Gelephu Thromde and partly through three (03) Gewogs [3] : Chhuzanggang Gewog, Umling Gewog and Tareythang Gewog.

TABLE 2.1.1 GEOGRAPHICAL COORDINATES

	Start	**End**
Geographical Coordinates	26° 51′ 54″ N, 90° 29′ 05″ E	26° 48′ 26″ N, 90° 35′ 16″ E

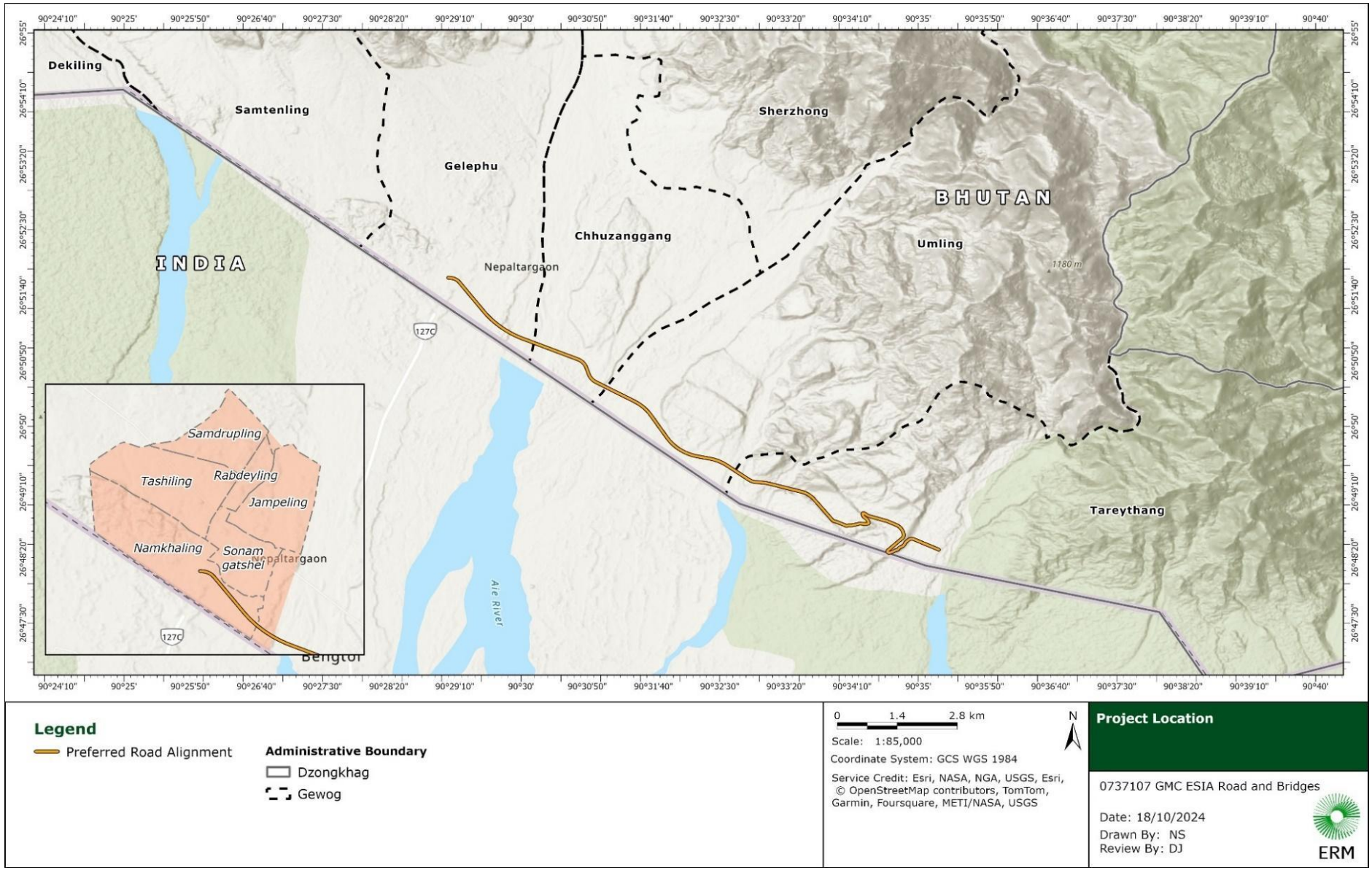
The overall Project location can be seen in ***Figure 2.1***.

[1] A Thromde is a second-level administrative division in Bhutan.

[2] A Gyalsung is envisioned as a one-year integrated training program mandatory for all youths attaining the age of 18 in Bhutan

[3] A is an administrative division comprising a group of villages in Bhutan.

FIGURE 2.1 OVERALL PROJECT LOCATION



2.2 SALIENT FEATURES

The key salient features of the Project are detailed in ***Table 2.2***.

TABLE 2.2 PROJECT SALIENT FEATURES

Item	Preferred Alignment	
Total Length	13.6 km	
Road Specifications	Dual 2-Lane Highway for 3.8 km with a 40 m wide Right-of-Way (ROW) and single carriageway for 9.8 km with 30 m wide ROW	
Widened Length	3.4 km of the single carriageway	
Bridge Lengths / River Widths Crossed (Bridge designs incorporate elephant crossings)	Mau River	1000 m / 480 m
	Jengkhurung & Taklai Rivers	780 m / 110 m + 220 m
	Langer River	400 m / 190 m
	Singye River	400 m / 20 m
Other Bridges	One 80 m long bridge to span a small stream	
Bridges Length Totals/River Widths Crossed	2,660 m / 1,020 m	
Gradients	900 m length at 5.5% gradient (Segment 9).	
Design Speed		
Culverts (Culverts to facilitate the movement of small mammals and reptiles etc. Will also be included)	Culvert internal dimensions 2.5 m x 2.5 m x 0.4 m thick slabs and walls.	
River training works	Mau River - Western	500 m upstream and 250 m downstream
	Mau River - Eastern	300 m upstream and 100 m downstream
	Jengkhurung & Taklai River	400 m upstream and 100 m downstream
Slope Stability	Significant slope cutting, stabilization works, and retaining walls will be required to widen the road segment to Tareythang.	
Interchanges	T – junction in Gelephu and two stub ends for two future interchanges.	

2.3 ROAD ALIGNMENT

The preferred highway alignment based on the findings from the feasibility study consists of 10.2 km of new highway and 3.4 km of widening to the existing highway (***Figure 2.2***). The alternative alignment options are explained in detail in ***Chapter 4***.

Segment 1 – At the west end of the Project, the proposed new road will connect to the existing north-south road, S Ngedrup Zhung Lam, through Gelephu, at a location approximately 700 m north of the Indian border. It traverses the Namkhaling Municipality, south of the existing road, Gatshel Lam SE, which leads to the Sewerage Treatment Plant.

Segment 2 – The proposed alignment passes to the south of the Sewerage Treatment Plant, approximately 280 m from the Indian border.

Segment 3 – The proposed road will cross the Mau River approximately perpendicular to the flow direction to minimize the length of the bridge structure. The normal river channels are around 500 m wide at this location, but under flood conditions, the west bank becomes part of the river flows.

Segment 4 – In Chhuzanggang Gewog, the proposed alignment skirts around the southern edge of the higher ground, following the contours and minimizing level differences as much as possible.

Segment 5 – The proposed alignment is straight across both the Jengkhurung River and Taklai River, crossing them each approximately perpendicular to their flows. The bridge crossing here will be continuous over both rivers as the area between the reivers is subject to flooding. The alignment location is chosen to cross at the narrowest point from the west bank of the Jengkhurung River to the east bank of the Taklai River.

Segment 6 – In Umling Gewog, the proposed alignment skirts around the southern edge of the higher ground, following the contours and minimizing level differences as much as possible.

Segment 7 – Langer River is proposed to be crossed slightly to the south of its narrowest point to avoid the steep bank on the east side of the river. The alignment climbs up on the east side to meet the higher ground level.

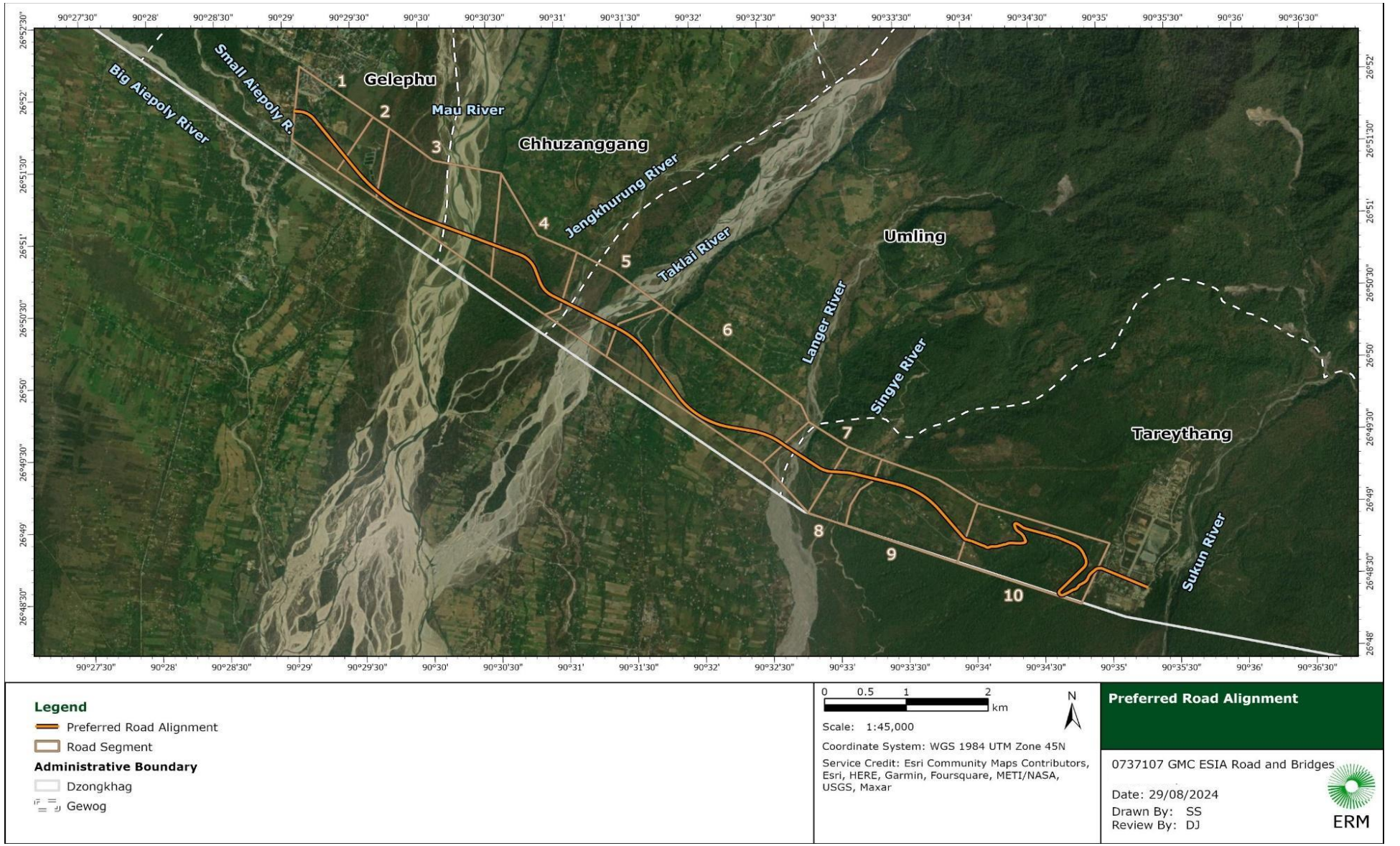
Segment 8 – Although Singye River is typically a narrow channel, the ground levels to each side climb quite steeply, so a 382.5 m long bridge is proposed to cross from the west bank to the east bank.

Segment 9 – The portion of the alignment in the western part of Tareythang Gewog, the proposed road will follow a shallow valley, north of the existing Gewog center. The alignment climbs steeply at first and then very gently to join to the existing road.

Segment 10 – In the eastern part of Tareythang Gewog, the proposed alignment merges with and follows the routing of the existing road, which will be widened.

After segment 10, the highway merges into the existing roadway in Tareythang.

FIGURE 2.2 OVERALL PLAN OF PREFERRED ALIGNMENT



2.4 PROJECT COMPONENTS

The Project comprises at-grade roads, interchanges, and bridge crossings. In low-lying areas and at the approaches to bridge crossings and required changes in elevation, at-grade roads will be located on top of embankments. Other civil works required include retaining walls and drainage provisions.

2.4.1 NEW ROAD

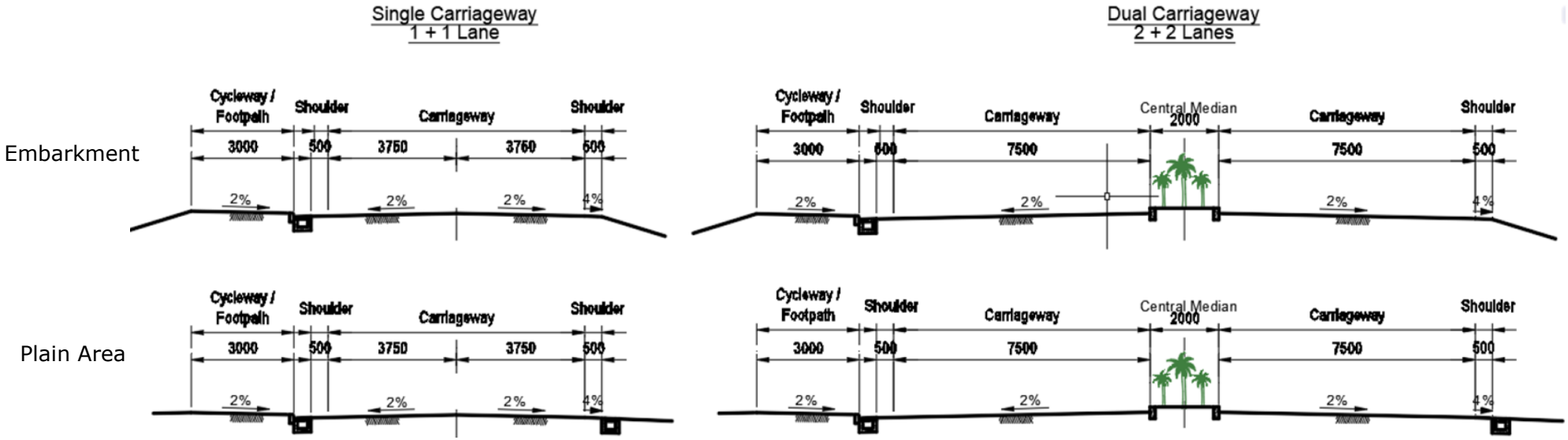
About 3.8 km of the proposed new road will be a dual 2-lane highway based on the project traffic demand and 9.8 km will be a single carriageway highway with one lane in each direction, with the suitable geometry to be classified as a Primary National Highway. The proposed highway geometry along the alignment for the embarkment and plan area is shown in ***Figure 2.3***. The dual carriageway will typically incorporate a wide central median to allow for landscaping works. The utility details are not available. The road geometry for the hilly area is not available.

The Right-of-Way (ROW) corridor will be wider than the civil works for the highway to allow a buffer zone at both sides, with the potential for future expansion. The typical dual carriageway portions with 2 lanes in each direction will have a 40 m wide ROW. The typical single carriageway portions will have a 30 m wide ROW.

The highway alignment corridors were refined further and developed into specific 3D geometry for various options. Road design follows the Bhutan Standard "ICS:93.080.10, Draft Bhutan Standard on Road Geometric Design and Alignment Requirements, Bhutan Standards Bureau", with enhancements based on international standards to improve safety.

The improved safety standards included a shared-use footpath/cycle path added along northern edge; Open drainage channels to have precast concrete covers, and will have a design speed of 60 kph to suit Level (L) terrain proposed. Design Speed (Based on Bhutan Standard ICS:93.080.10) for the different terrain types is detailed in ***Table 2.2***.

FIGURE 2.3 PROPOSED HIGHWAY GEOMETRY



2.4.2 INTERCHANGES

At the western end of the Project, a simple T-junction is planned for the connection at S Ngedrup Zhung Lam in Gelephu. Traffic on the highway will give way to traffic on the S Ngedrup Zhung Lam. Consideration will be given to modifying this junction and altering the traffic priorities once the planning for the continuation of the highway west of S Ngedrup Zhung Lam is completed.

In the center of Tareythang Gewog, the new highway will merge with the existing road in Tareythang, which will be widened. This through route will (become the priority). The existing Tareythang road to the west will become a give-way T-junction.

For the future interchanges, provisions of stub ends only within the road ROW are included, these stub ends can be easily connected to by the future interchanges to GMC developments at Chhuzanggang Gewog and Umling Gewog.

2.4.3 ROAD WIDENING

Towards Tareythang, approximately 3.4 km of the existing road is proposed to be widened to comply with Primary National Highway standard. This will involve widening the existing carriageway from about 5.5 m wide to 7.5 m wide. Most of the widening works are relatively straightforward except for the widening of the final descending section is more challenging, due to the steep slope above the road on the western side and below the road on the eastern side. The widening will require slope cutting, stabilization works, and retaining walls are required to facilitate widening of the road in this section.

2.4.4 RIVER TRAINING WORKS

The hydrology of the project area is complex, with very large catchment areas encompassing Himalayan mountains up to 2,000 m tall. The rivers in the project area mainly braided rivers with shifting channels and sand/boulder deposits 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, which can lead to potential riverbank erosion.

In order to minimize impacts of river flows, the number of bridge piers in the rivers and flood plains is minimized, and the piers should be aligned with the flow direction as closely as possible.

At Detailed Design stage, a detailed hydrological and hydraulic study will be required to determine the required engineering measures at each bridge location to ensure robust climate-resilience.

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 as shown in ***Figure 2.4***. The length of proposed river training works is summarized in ***Table 2.3***.

TABLE 2.3 RIVER TRAINING WORKS SUMMARY

S.No.	River	Length of River Training Works
1	Mau River - Western	500 m upstream and 250 m downstream
2	Mau River - Eastern	300 m upstream and 100 m downstream
3	Jengkhurung & Taklai River	400 m upstream and 100 m downstream

The typical design solutions for these works include use of gabion baskets to form river walls, as shown in ***Figure 2.5***.

FIGURE 2.4 LOCATION OF THE PROPOSED RIVER TRAINING WORKS

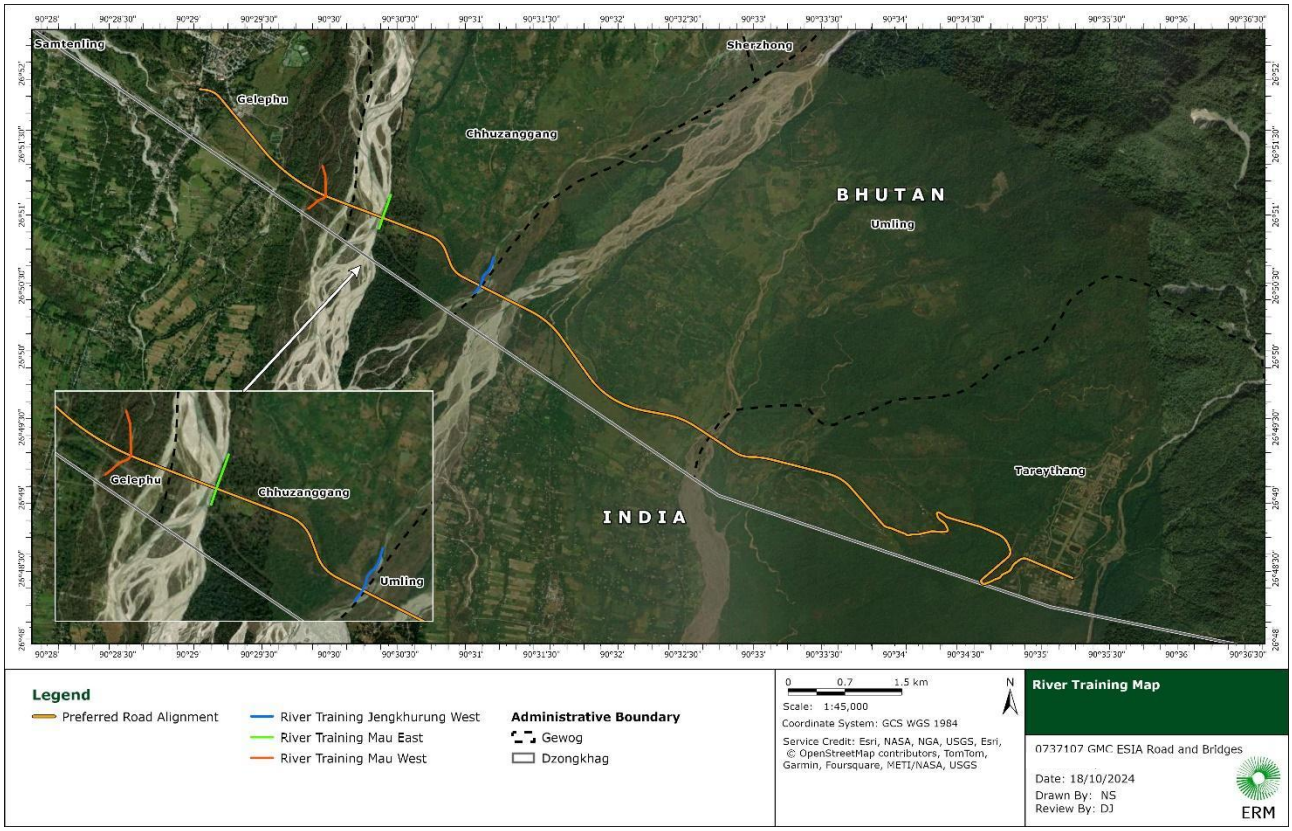
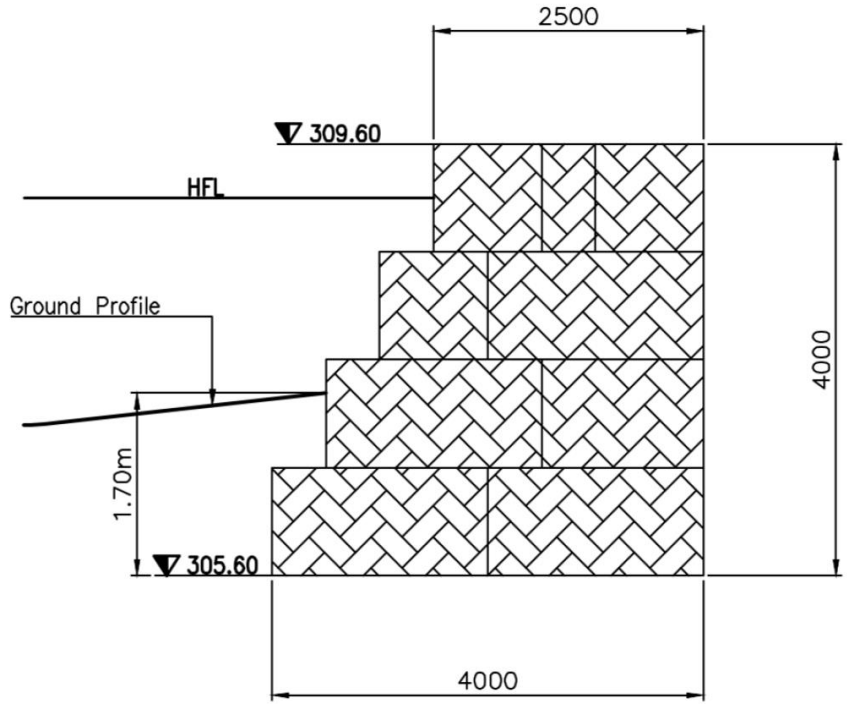


FIGURE 2.5 TYPICAL RIVER TRAINING MEASURES – GABION WALLS



2.4.5 SLOPE STABILITY WORKS

The preliminary site formation design for the proposed at-grade road, which includes solutions for fill and cut slopes is summarized below. The preliminary design should undergo additional review, and the stability of the wall, fill slopes, and cut slope schemes should be reassessed at the next stage of the project.

2.4.5.1 FILLED SLOPES

Fill slopes are preferred when the proposed road level is higher than the existing ground, as they are generally more cost-effective than retaining walls. The maximum slope height is 5m, while higher slopes (>5m) may require a combined solution of L-shaped reinforced concrete wall with a 1:2 fill slope above. Drainage layers and weepholes are necessary to prevent pore water pressure buildup. Surface drainage and erosion protection (hydroseeding, erosion mats, or stone pitching in flood zones) are mandatory.

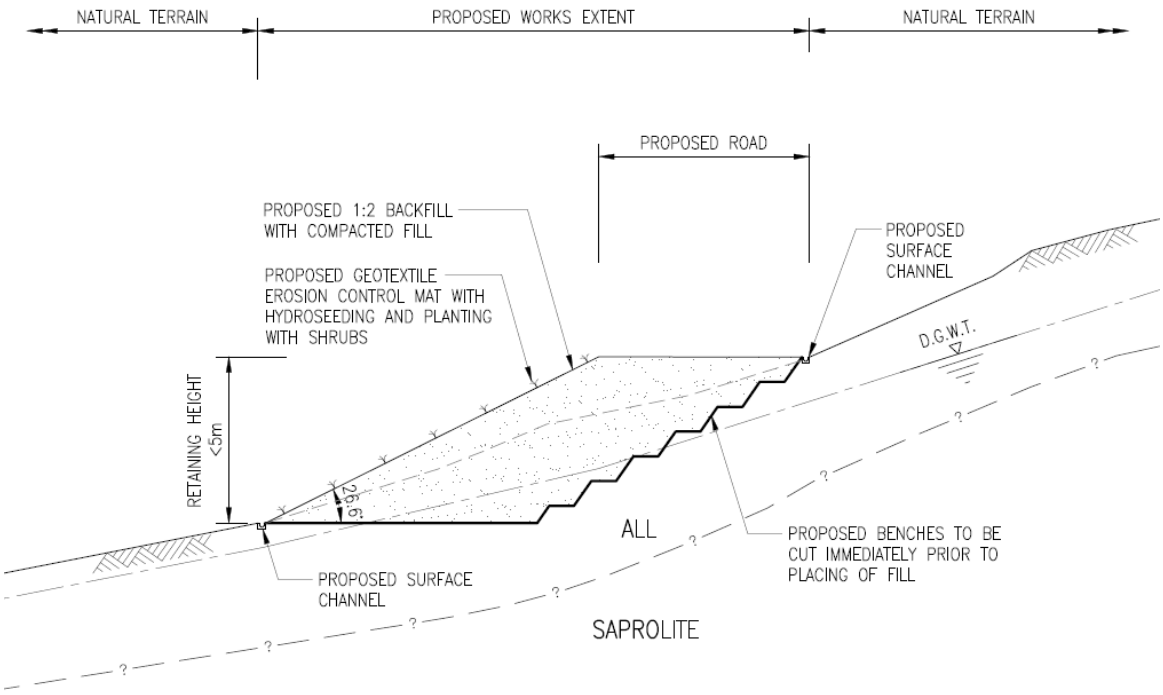
However, filled slopes are not feasible when the existing gradient is 1:2 or flatter, leading to infinite slope extents. Or they block existing streams or potential landslide flow lines and when the ground is too soft to support the embankment.

For basic site formation scheme, the following configuration is to be used for soil fill slope:

- Granular material is assumed as backfilling material.
- Maximum fill slope gradient at 1:2 (~26.6° from horizontal).
- Each batter of slope shall be at a maximum 7.5 m in height.
- A 1.5 m wide footpath / maintenance access shall be provided at 7.5 m vertical interval.

- Slope drainage (u-channel) shall be provided along all footpath.
- Slope surface protection such as hydroseeding, erosion control mat etc shall be provided.
- Slope surface protection using stone pitching within the predicted flood zone.

An illustration of fill slope is shown below.



SITE FORMATION SCHEME F1: PROPOSED BACKFILL TO 26.6° SLOPE
RETAINING HEIGHT: <5m
SCALE 1:200

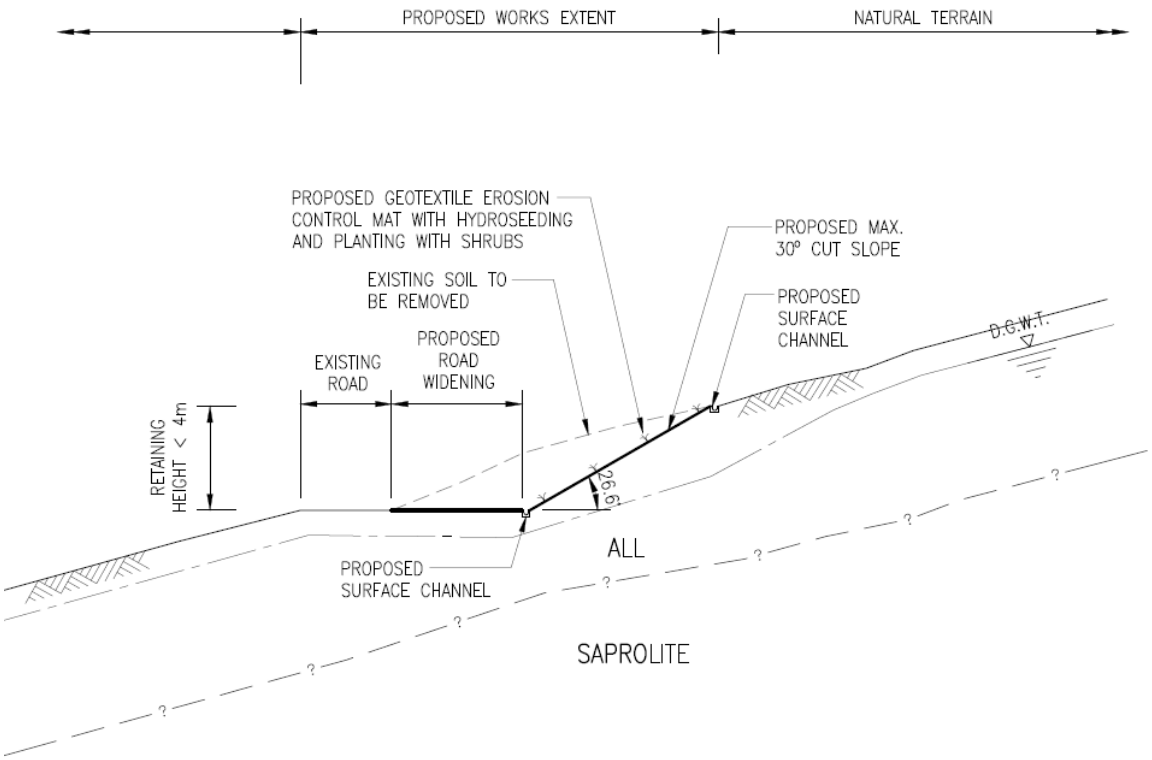
2.4.5.2 CUT SLOPES

Cut slopes are designed to ensure stability where the road encroaches into the existing ground level, with soil nails being the preferred solution due to cost efficiency and environmental considerations. Depending on slope height and material, gradients range from 26.6° to 70°, with steeper slopes stabilized using soil nails or, in some cases, concrete buttress walls. Drainage systems, hydroseeding, and erosion control mats are integral to prevent erosion and minimize pore water pressure. Soil nailing is particularly advantageous, allowing steeper angles, reducing excavation, and maintaining project timelines. Design refinements will follow geotechnical investigations and topographic surveys.

For basic site formation scheme, the following configuration is to be used for the soil cut slope:

- Maximum cut slope gradient at 26.6° to 70° depending on the material and the presence of soil nail.
- Each batter of slope shall be at a maximum 7.5 m in height.
- A 1.5 m wide footpath / maintenance access with handrailing shall be provided at 7.5 m vertical interval.
- Slope drainage (u-channel) shall be provided along all footpath.
- Slope surface protection such as hydroseeding, erosion control mat etc shall be provided.
- A row of raking drain near the toe of the lowest batter.

An illustration of cut slope is shown below.

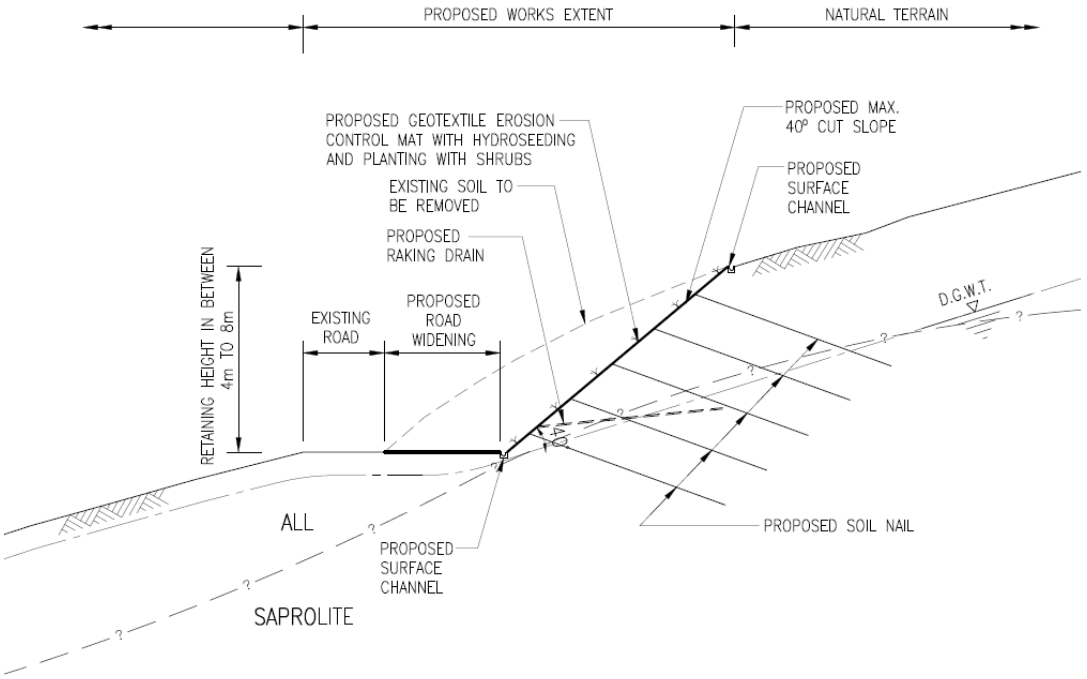


SITE FORMATION SCHEME C1: PROPOSED 26.6° OPEN CUT
RETAINING HEIGHT: <4m
SCALE 1:200

2.4.5.3 SOIL NAILS

Soil nailing, though not widely used in Bhutan, has proven effective in projects like the Telegangchu bridge for landslide mitigation. This technique offers significant advantages, including adaptability to varied geological conditions, steeper slope angles, reduced excavation, and minimal environmental disturbance. It is also cost-effective, quick to install, and requires less intrusive equipment. For enhanced slope protection, erosion control mats and hydroseeding are recommended, ensuring stability, longevity, and environmental integration. Implementation would require experienced international contractors for soil nail and tie-back wall installations.

An illustration of soil nails application is shown below.



SITE FORMATION SCHEME C2: PROPOSED 40° CUT SLOPE WITH SOIL NAILS
RETAINING HEIGHT: 4m–8m
SCALE 1:200

2.4.6 BRIDGES

2.4.6.1 OVERVIEW

A total of approximately 2.6 km of bridge structures are required along the alignment to enable the highway to span over obstacles and deal with changes in level. The alignment will require four major bridges to cross large rivers and associated floodplains, including the Mau River Bridge, Jengkhurung & Taklai Bridge, Langer Bridge, and Singye Bridge. The length and the height of the opening under the bridges are summarized in ***Table 2.4***.

TABLE 2.4 BRIDGE DESIGN SUMMARY

S.N.	Bridge	Length of Bridge	Height of Bridge
1	Mau River	1,005 m	8 – 10 m
2	Jengkhurung River and Taklai River	780 m	8 – 10 m
3	Langer River	390 m	10 – 15 m
4	Singye River	382.5 m	5 – 10 m

2.4.6.2 FOUNDATION AND SUB-STRUCTURE

The foundation and sub-structure will comprise single or twin column integral pile cap on pile group. The piles will be cast in-situ reinforced concrete bored piles. The pier columns will be either solid or hollow rectangular cast in-situ reinforced concrete.

2.4.6.3 EMBANKMENTS (WITH BOX CULVERTS)

Embankments will be used to transition from the at-grade road to the bridge structures. 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.

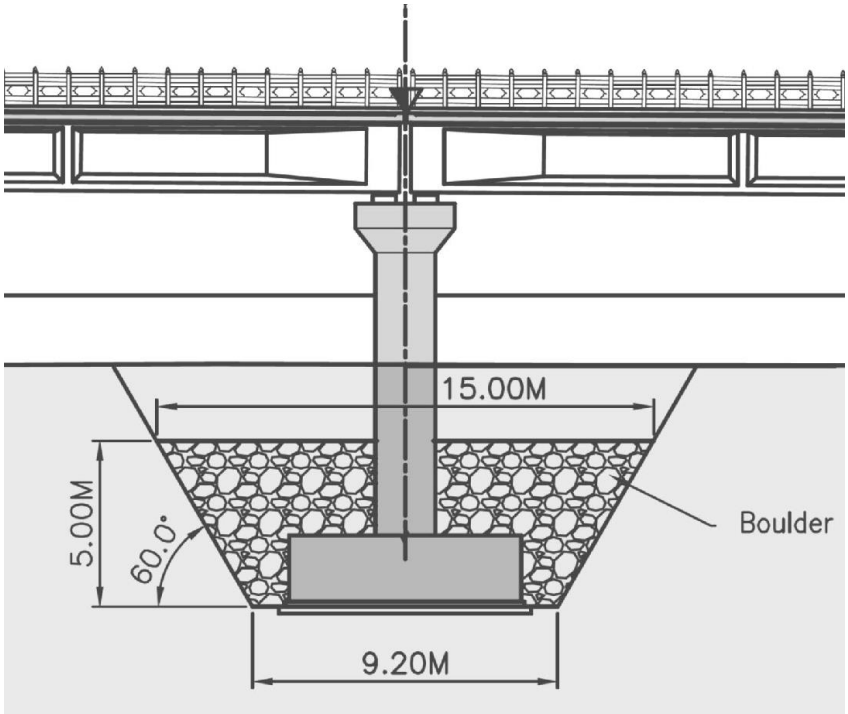
2.4.6.4 RETAINING STRUCTURES

Reinforced concrete retaining walls are adopted to minimize the extent of slope works and width of embankment construction as the height of the embankment increases, or the terrain is unfavorable for embankment construction.

2.4.6.5 SCOUR PROTECTION

Given the fast flows in the rivers, design to prevent scour will be critical to ensure the robustness of the bridges. The 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 as shown in ***Figure 2.6***.

FIGURE 2.6 TYPICAL PAD FOUNDATION WITH SCOUR PROTECTION



2.4.6.6 BRIDGE DESIGN

Mau River

In addition to crossing the flood plain west of the river and the river itself, the bridge is extended on the eastern side to allow for passage of elephants underneath. The total length is 1,005 m. The bridge will carry 2 lanes of traffic in each direction with provision for pedestrians on one side. The proposed form will utilize a traditional concrete box girder deck, with 80 m spans over the river and typically 50 m spans on each side . The deck varies in depth over the longer spans from 2.5 m to 4.9 m and the deck is a constant 2.5 m deep in the shorter spans as shown in ***Figure 2.7***.

The length of the bridge required is determined by the flood plain on the western side and the requirement for adequate clearance for elephant movements along the eastern riverbank.

The extent of the flood plain on the western side is proposed to be limited with the use of river training measures; here, river training is assumed to be required for 500 m upstream and 250 m downstream of the bridge. River training is also required along the eastern edge of the river to control ongoing erosion. Here, river training is assumed to be required for 300 m upstream and 100 m downstream of the bridge. At the Detailed Design stage, a detailed hydrological and hydraulic study will be required to determine the required engineering measures at each bridge location to ensure robust climate-resilience.

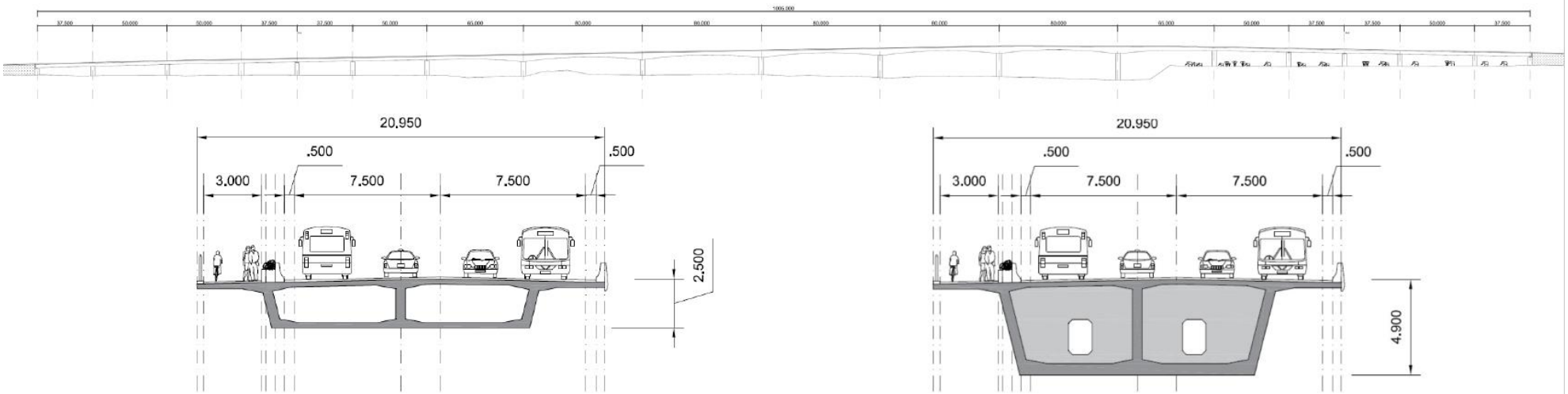
Based on the results from the GMC ecological study, the elephants use the riverways for passage, therefore to maintain this passage during the wet season, the initial design has incorporated a minimum of 250 m wide elephant corridor on the eastern riverbank, with an average vertical clearance of 8.15 m, and a minimum clearance of 5.80 m at the East abutment in line with Good International Industry Practice (GIIP).

The majority of the corridor is elevated and remains dry throughout the year, including during the wet season. Based on the results of the flooding risk with a 100-year return period, a minor portion of the corridor may be flooded.[1] However, given the permeability of the soil in the area, the flooding events are expected to be short-term (a few hours to a few days) and do not impede the overall movement of the elephants.[4]

The cross-section and vertical alignment are shown in ***Figure 2.7***.

[4] CDR, 2024 Hydrological Assessment and Management Principles for Masterplan Area

FIGURE 2.7 MAU RIVER BRIDGE



Jengkhurung River and Taklai River Bridge

Due to the flood plain between the Jengkhurung and Taklai Rivers, a combined bridge is proposed as any at-grade road or embankment in between the rivers would have a severe impact on the hydrology of the area.

This combined bridge crosses both rivers as the area between the two rivers is subject to flooding, and water flow across the whole area needs to be permitted. The total length is 780 m. The bridge will carry one lane of traffic in each direction, with provisions for pedestrians on one side. The proposed form of this bridge is a concrete box girder with typical spans of 60 m in length. The depth of the bridge deck will be constant at 3.0 m. No additional elephant crossing was included due to the shorter span of the bridge and the height of between 8 – 10m, which is deemed sufficient to allow the passage of elephants. Only an extreme flood event would prevent the movement of elephants under the bridge, which is a short-term and irregular event.

The river training is estimated to be required 400 m upstream and 100 m downstream from the selected bridge location.

Langer River Bridge

The proposed bridge will be 390 m long to cross the river. The bridge will carry one lane of traffic in each direction, with provisions for pedestrians on one side. The proposed form of this bridge is a concrete box girder with typical spans of 60 m in length. The depth of the bridge deck will be constant at 3.0 m. No additional elephant crossing was included due to the shorter span of the bridge and the height of 10 - 15 m, which is deemed sufficient to allow the passage of elephants. Only an extreme flood event would prevent the movement of elephants under the bridge which is a short-term and irregular event.

Singye River Bridge

The proposed bridge will be 382.5 m long to cross from the west bank of the valley over the river and climb up to meet the higher ground on the east side. The bridge will carry one lane of traffic in each direction with provision for pedestrians on one side. The proposed form of this bridge is a concrete box girder with typical spans of 60 m in length. The depth of the bridge deck will be constant at 3.0 m.

No additional elephant crossing was included due to the shorter span of the bridge and the height of 5 - 10 m, which is deemed sufficient to allow the passage of elephants. Only an extreme flood event would prevent movement of elephants under the bridge which is a short term and irregular event.

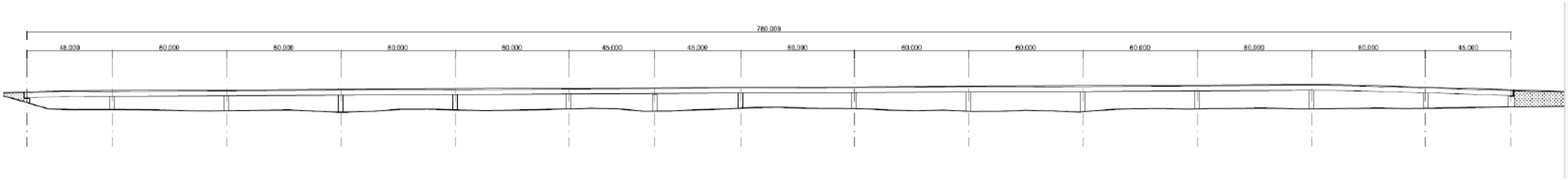
Other Minor Bridges and Culverts

For the small streams and dips in the ground level some minor bridges and culverts will be required. This includes an 80 m long bridge to span the streams and existing access track to the east of the Gelephu Sewerage Treatment Works. The proposed form of these minor bridges will be concrete beam and slab with typical spans of up to 40 m in length. The beams will be up to 2.2 m deep supporting the deck slab which is typically 250 mm thick.

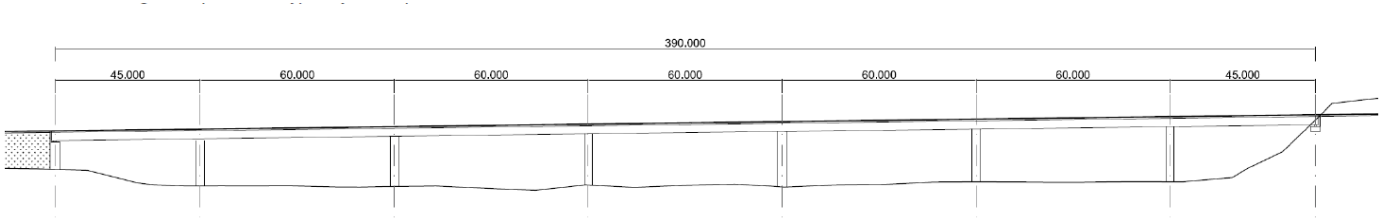
The cross section and vertical alignment for the three bridges are shown in ***Figure 2.8***, while the cross section of the bridge with the elephant corridor is attached in ***Appendix A***.

FIGURE 2.8 VERTICAL ALIGNMENTS OF REMAINING CONCRETE BOX GIRDER WITH TYPICAL 60 M SPAN BRIDGES

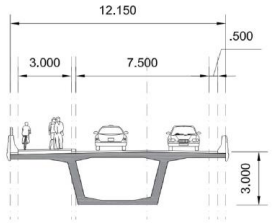
Jengkhurung and Taklai Rivers Bridge



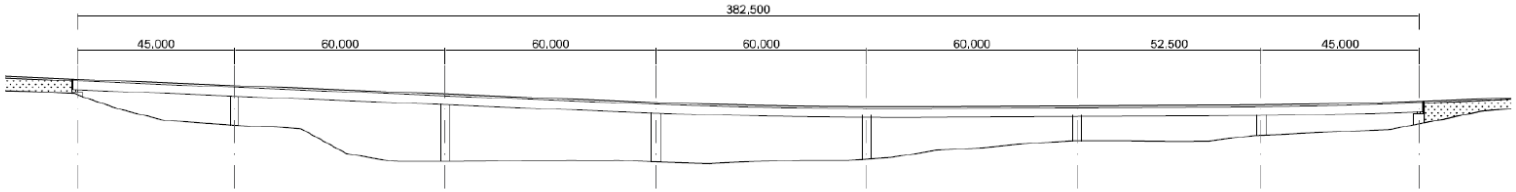
Langer River Bridge



Cross Section



Singye River Bridge



2.4.7 WILDLIFE CROSSINGS

The design of the Gelephu-Tareythang Road has embedded provisions for the passage of elephants. Based on the information on elephant movement and topography, it was identified that the riverbeds would be the most suitable locations for crossings. Therefore, the clearance height of each bridge was designed to be in compliance with the Asian Elephant Transport Working Group guideline[5] and other international good practices (refer to the Biodiversity Management Plan for detailed guidelines followed for the design of these crossings).

Considerations for the bridges are as follows:

- Mau River Bridge: The current bridge design incorporates an elephant corridor on the east bank of the Mau River. This corridor is approximately 500 m wide, with a bridge clearance height of 8–10 m, providing sufficient space for elephants to move along the river and access foraging areas north of Gelephu town.
- Jengkhurung River and Taklai River Bridge: The current bridge design includes a clearance height of 8–10 m to accommodate elephant passage.
- Langer River bridge: The bridge design includes a clearance height of 10–15 m, facilitating safe movement of elephants underneath.
- Singye River bridge: The design incorporates a clearance height of 5–10 m for elephant passage.

For smaller animals a number of culverts are also integrated in the road design. 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. Culvert internal dimensions are 2.5 m x 2.5 m x 0.4 m thick slabs and walls.

The design of the culverts is in compliance with the Asian Development Bank Guidelines[6] and will allow the passage of small sized animals.

The recommended spacing for the culverts by the Asian Development Bank Guidelines is 1.4 km based on an estimated home range of small mammals of 2 km^2.

Therefore, considering that small animals can also use the bridge crossings, it is estimated that three culvers should be sufficient: one culvert between Gelephu and Mau River, one between Taklai River and Langer River and one between Singye River and Tareythang.

2.4.8 ANCILLARY FACILITIES

Construction of the Gelephu-Tareythang Road will require several ancillary support facilities, as described in **Table 2.5**.

[5] Dodd, N., Butynski, M., Ament, R., Chen, S., Jayasinghe, N., Lim, J.C., Saaban, S., Tiwari, S. K., van der Ree, R., Wang, Y., & Wong, E. P. (2024). Handbook to Mitigate the Impacts of Roads and Railways on Asian Elephants. AsETWG (Asian Elephant Transport Working Group); IUCN WCPA Connectivity Conservation Specialist Group/IUCN SSC Asian Elephant Specialist Group. https://doi.org/10.53847/PZNC3560

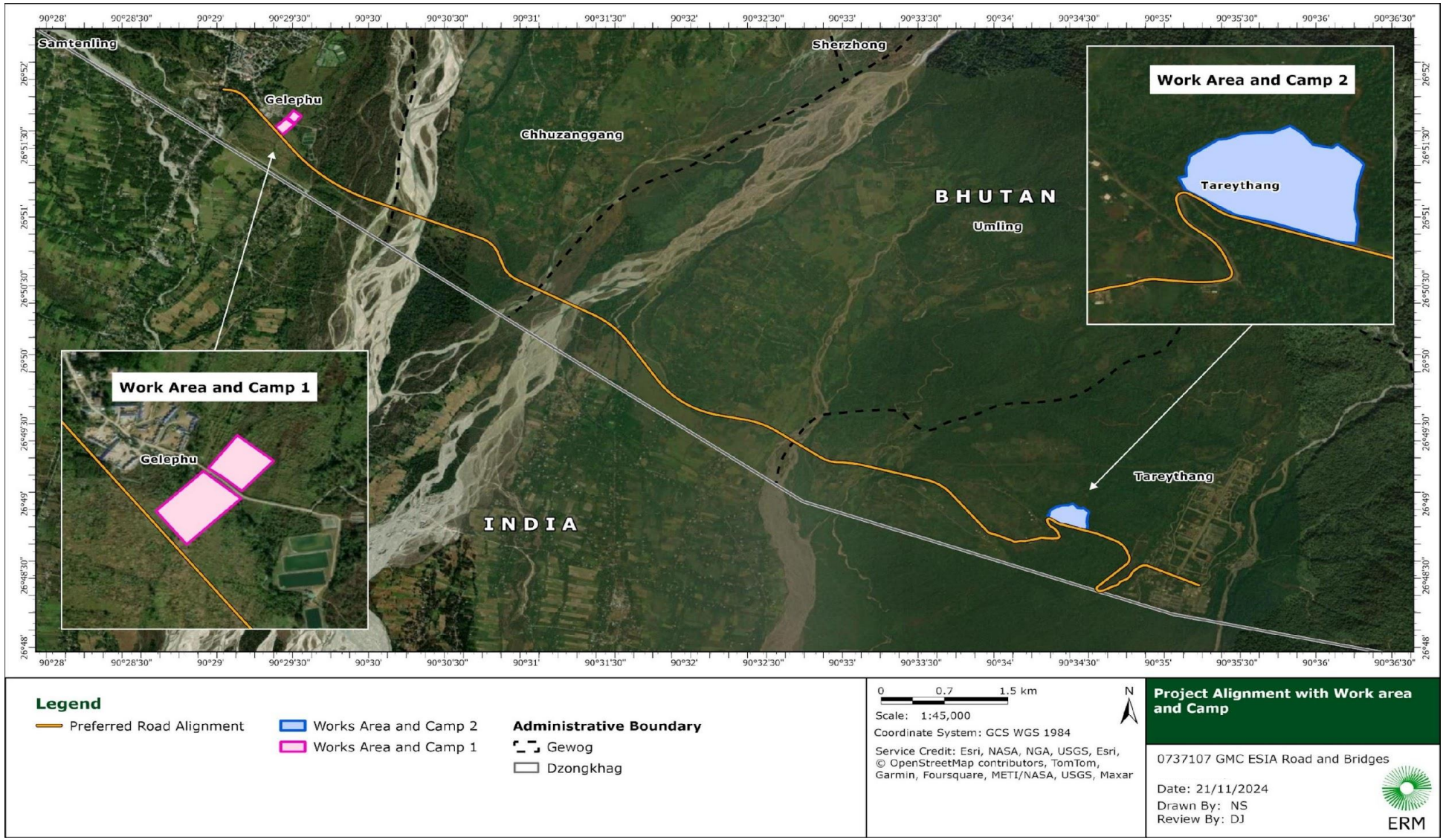
[6] Asian Development Bank, 2019. Green Infrastructure Design for Transport Projects A Road Map to Protecting Asia's Wildlife Biodiversity. ISBN 978-92-9261-991-6 (print), 978-92-9261-992-3 (electronic). DOI: http://dx.doi.org/10.22617/TCS189222

The final location and layout of construction ancillary facilities, including crushing and batching plants, will need to be confirmed and updated as part of detailed construction planning following the engagement of the design and construction contractor.

TABLE 2.5 BRIDGE DESIGN SUMMARY

No.	Type of Facilities	Details
1.	Haul Road	Haul road(s) to and from the construction sites and in particular the works area(s), and/or precasting yard will be required. The haul road for the construction will start at either end of the road alignment run within the ROW of the highway for material and equipment transport.
2.	Quarry Sites & Borrow Pits	Government approved borrow and quarry sites with licensed crushing operators are available in and around Gelephu along the existing Sarpang – Gelephu Highway and Gelephu – Tareythang Road. Source of these sites are given in Section 2.5. These materials are usually excavated from sand/sediment deposits in the river, with no excavation occurring within the active river channels. The borrow pits can be established from the road ROW if required.
3.	Batching Plants	Concrete will be batched on site to reduce transportation time from off-site facilities, ensure continuous supply of concrete and improve quality control. The batching plants will be located along the highway ROW and in the proposed work areas shown in ***Figure 2.9***.
5.	Work Areas	The work areas will be utilized for storage of materials, workshops and other construction support. The proposed work areas are shown in ***Figure 2.9***. The contractor(s) will use the work areas for Contractor's offices, supervision staff offices, equipment storage yard, machine storage and repair workshop. The storage yard will be used for machine storage and repair workshop. It is anticipated that there will be two work areas considering the geographical extent of the Project.
6.	Worker Camps	The worker camps will be constructed in compliance with the minimum standards in the WBG ESS-2. The proposed camp areas as of the preparation of this report are shown in ***Figure 2.9***.
7.	Disposal Areas (Solid waste, Liquid waste)	There will be many excavation activities, such as excavation of soft materials for at-grade road construction, and foundation works for bridges. The dumping / storage areas for material that need to be dumped will be identified located within the ROW of the highway. Liquid waste from the camps will be treated by an onsite wastewater treatment plant. For domestic wastes, the area has one lined landfill management by the Gelephu Environmental Division. This landfill can accept general domestic waste, but not hazardous waste. Hazardous waste to be stored and managed safely ensuring compliance with environmental regulations .

FIGURE 2.9 PROPOSED LOCATIONS OF THE LAYDOWN/WORK AREAS AND THE CAMPS



2.4.9 ASSOCIATED FACILITIES

Associated facilities are defined in the World Bank ESF as meaning "facilities or activities that are not funded as part of the project and, in the judgement of the Bank, are: (a) directly and significantly related to the project; and (b) carried out, or planned to be carried out, contemporaneously with the project; and (c) necessary for the project to be viable and would not have been constructed, expanded or conducted if the project did not exist." To be considered an associated facility, the facility or activity must meet all three of these criteria.

There are no associated facilities required for the Gelephu-Tareythang Road project as it is part of the existing Southern East-West Highway. The project is independent of any new developments, and no contemporaneous facilities or activities meeting the criteria of associated facilities under the ESF are necessary for its viability.

2.5 CONSTRUCTION MATERIALS, EQUIPMENT, AND SOURCES OF MATERIALS

The construction materials, such as cement, asphalt, aggregates, and other required materials, will be prioritized to source locally from government-recognized cement manufacturing, and quarry/crushing plants located near the project area.

1.1.1 BORROW AND QUARRY MATERIALS AND SOURCES

The rivers near Gelephu provide abundant construction materials such as stone, sand, and fill. Steep gradients and seasonal changes create a braided channel system with coarse alluvium deposits in these rivers. Heavy monsoon rains from June to August cause high-energy flows transporting large volumes of materials, while the dry season reveals extensive gravel, sand, and stone deposits due to reduced flow. During peak monsoon flows, sediment is eroded from upstream slopes and carried downstream; once river velocities drop, coarse materials settle out, forming gravel bars and alluvial deposits. Over repeated annual cycles, this process perpetually replenishes deposits of boulders, cobbles, gravel, and sands. The combination of steep slopes, fast flows, and seasonal high discharge fosters continual scouring and redistribution of bed material, creating expansive depositional zones where resources can be efficiently extracted.

Several government-approved crushing sites have been established to harness these deposits for construction purposes, particularly for road-building activities with established guidelines. Under these guidelines, extraction is conducted from the deposited materials outside the actively flowing channels, ensuring that natural river flows remain unobstructed and environmental impacts are minimized. This approach allows for the utilization of a high-quality, renewable source of fill material, aggregates, and other construction inputs without compromising the river's natural dynamics. The government-approved borrow and quarry sites, along with licensed operators near the G-T Road, are listed below. Some of these sites will be utilized by the project's contractor, with their specific locations to be finalized during project implementation.

TABLE 2.6 LOCATIONS OF BORROW AND QUARRY MATERIALS

Licensed Crusher No.	Place/River Name	Latitude	Longitude	Distance from Road Alignment	Remarks
1	Mau	26.914	90.515	8 km	Located along the existing Gelephu - Tareythang Road
2	Mau	26.925	90.513	7 km	-do-
3	Mau	26.869	90.502	2 km	Located close to the proposed road alignment
4	Shetikheri	26.908	90.474	5 km	Located within Gelephu
5	Big Aielpoly	26.885	90.455	6	Located along existing Sarpang – Gelephu Highway
6	Paitha	26.905	90.439	6.5	-do-
7	Bhur	26.904	90.420	8	-do-
8	Bhur	26.911	90.416	8.5	-do-
9	Bhur	26.914	90.412	9	-do-

1.1.2 MATERIALS AND SOURCE

The construction materials and equipment that will be used for the Project are presented in ***Table 2.7***.

TABLE 2.7 LIST OF THE RAW MATERIALS

List of Raw Materials	Quantity			Unit	Source	Storage
	-30%	Base	+40%			
General Fill	36,760	52,510	73,510	m^3	Approved borrow locations and licensed operators.	Covered
Boulders / Rock Fill	10,420	14,880	20,840	m^3	Licensed crushing operators in Gelephu	Open
Bitumen	280	400	560	m^3	Local	Open
Cement	9,840	14,060	19,680	tonnes	Local	Covered
Sand	17,920	25,600	35,830	tonnes	Approved borrow locations and licensed operators.	Covered
Aggregates	97,700	139,570	195,400	tonnes	Licensed crushing operators in Gelephu	Open
Steel Reinforcement	6,540	9,350	13,080	tonnes	India	Above ground and covered
Prestressing Steel	960	1,370	1,920	tonnes	India	Above ground and covered

List of Raw Materials	Quantity			Unit	Source	Storage
	-30%	Base	+40%			
Steel Wire	180	260	360	tonnes	India	Above ground and covered

Source: ARUP Revised Draft Preliminary Design Report (9 December 2024)

2.5.1 SITE CLEARANCE AND CONSTRUCTION EQUIPMENT

2.5.1.1 ROAD CONSTRUCTION EQUIPMENT

New at-grade roads will require site formation for construction, which will require the removal of vegetation, debris, structures, etc., from the site area. The site will then be excavated to the required formation level to create a stable base, followed by the installation of drainage and the subsequent layering of sub-base, base course and compaction work.

2.5.1.2 ROAD WIDENING

The road widening is required along the road segment towards Tareythang. Rock cutting is required to facilitate the road widening in this area. In addition to the typical equipment required for road construction as shown above, some mechanical breaking tools such as hydraulic breakers will be required to break the rock. Use of explosives is not anticipated.

2.5.1.3 RIVER TRAINING CONSTRUCTION

River training in the form of gabion walls will be required along the abutment area of the river bridges. The gabion walls comprise rock boulders, which can be sources from dredging nearby site and filled into the steel gabion cases. Typical excavators mounted with buckets and lifting equipment will be used for construction of the gabion walls.

2.5.1.4 BRIDGE CONSTRUCTION EQUIPMENT

Access

Access for bridge construction would be by temporary steel trestle or temporary rubble embankment to provide a level and stable platform for delivery of construction materials, equipment and personnel. Temporary steel trestle would consist of steel piles and prefabricated steel deck. Rubble embankment would comprise graded rubble sourced locally and formed into an embankment.

Foundations

The foundation for the bridges will be reinforced concrete bored piles. These piles are constructed by rotary boring machines to form the excavation before placing steel reinforcement and in-situ concreting to form the pile. Typical construction methods for this pile type include the Reverse Circulation Drilling (RCD) and Kelly Method.

Substructure

The substructure will adopt typical reinforced concrete construction using formwork and falsework and in-situ concreting for casting the pile caps and columns.

Superstructure

- ***Mau River Bridge, and Jengkhurung and Taklai River Bridge***

Longer span box girder bridges of up to 80 m in length are proposed for these river crossings. For this span length, balanced cantilever construction is the only practical construction method for the superstructure construction. Segments will be cast in-situ working outwards from both sides of each pier location.

- ***Langer River and Singye River Bridges***

  Shorter span beam and slab bridges up to 40 m in length are proposed for these river crossings. Typically, beams are precast, and the slab is cast in-situ. Due to the relatively short length of bridge adopting this form, it would be economical for the beams to be cast on-site rather than at an off-site casting yard facility.

  The summary of Major Plant and Construction Equipment is as follows (***Table 2.8***):

TABLE 2.8 SUMMARY OF PLANT AND CONSTRUCTION EQUIPMENT

Construction Work	Construction Activity	Construction Plant	No. per work front
Road Construction			
	Site Clearance & ROW	Crane, mobile (diesel)	1
		Excavator / loader, wheeled / tracked	1
		Lorry	1
	Roadworks, Pavement, Drainage and Utilities (inc. haul roads and at-grade roads)	Air compressor, air flow > 10m3/min and <= 30m3/min	2
		Asphalt paver	2
		Crane, mobile (diesel)	2
		Dump truck	2
		Excavator/loader, wheeled/tracked	2
		Generator, silenced, 75 dB(A) at 7 m	2
		Lorry	2
		Paint line marker	2
		Roller, vibratory	2
		Water pump, submersible (electric)	2
	Culverts	Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1
		Lorry	1
		Concrete lorry mixer	1
		Bar bender and cutter (electric)	1

Construction Work	Construction Activity	Construction Plant	No. per work front
		Poker, vibratory, hand-held	2
		Generator, silenced, 75 dB(A) at 7 m	1
		Saw, circular, wood	1
	Slope Works(for road widening)	Breaker, hand-held	4
		Breaker, excavator mounted (hydraulic)	1
		Compactor, vibratory	1
		Drilling rig	1
		Excavator/loader, wheeled/tracked	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Grout mixer	1
		Grout pump	1
		Lorry	1
Bridge Construction			
	Piling Works	Air compressor, air flow > 10m3/min and <= 30m3/min	1
		Breaker, hand-held, mass <= 10kg	1
		Concrete lorry mixer	1
		Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Lorry	1
		Piling, large diameter bored, grab and chisel	1
		Water pump, submersible (electric)	1
	Construction of Pile Caps and Piers	Air compressor, air flow > 10m3/min and <= 30m3/min	1
		Bar bender and cutter (electric)	1
		Breaker, hand-held, mass <= 10kg	1
		Concrete lorry mixer	1
		Concrete pump, lorry mounted	1

Construction Work	Construction Activity	Construction Plant	No. per work front
		Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1
		Lorry	1
		Poker, vibratory, hand-held	2
		Generator, silenced, 75 dB(A) at 7 m	1
		Saw, circular, wood	2
	Construction of Superstructures	Bar bender and cutter (electric)	1
		Concrete lorry mixer	1
		Concrete mixer (petrol)	1
		Concrete pump, lorry mounted	1
		Crane, mobile (diesel)	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Lorry	1
		Poker, vibratory, hand-held	2
		Saw, circular, wood	2
		Travelling formwork / falsework (for in-situ box only)	2
Miscellaneous			
	River Training Works	Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Lorry	1
	Landscape Works	Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Lorry	1
	Tree Felling / Transplanting Works	Breaker, hand-held	1
		Crane, mobile (diesel)	1
		Excavator/loader, wheeled/tracked	1

Construction Work	Construction Activity	Construction Plant	No. per work front
		Lorry	1
		Saw, circular, wood	1
	Construction of Concrete Batching Plant	Air compressor, air flow > 10m3/min and <= 30m3/min	1
		Breaker, hand-held	1
		Concrete lorry mixer	1
		Crane, mobile (diesel)	1
		Dump truck	1
		Excavator/loader, wheeled/tracked	1
		Generator, silenced, 75 dB(A) at 7 m	1
		Poker, vibratory, hand-held	1

2.6 LABOUR REQUIREMENT

The tentative estimate for the manpower required during the construction phase of the Project peaks at 2,000-2,500 number of workers. This comprises:

- 600-750 skilled laborers; and
- 1,400–1,750 unskilled laborers.

Both national and foreign workers will likely be involved. The construction contractor and subcontractors will be encouraged to prioritize the use of local workers and prioritizing employment of women who live in the project area.

The exact number of foreign and local workers or expected ratio of female workers is not available at the time of the report preparation.

2.7 UTILITY REQUIREMENTS

The Project will require the use of power, potable water and treatment of wastewater at the camps. Power supply will mostly come from the local grid with the use of a sub-station to convert the power and potentially a booster along the length of the alignment. However, the power supply will need to be confirmed during detailed design. Some generators may also be required during the construction phase, but this will be limited to any areas where power supply cannot be provided.

Potable water will be sourced from the local municipality or purchased from a supplier.

Wastewater will be treated at the camp site as per the local and national requirements.

2.8 PROJECT ACTIVITIES

2.8.1 PRE-CONSTRUCTION PHASE

The pre-construction phase will involve hiring consultants, undertaking planning and design works, obtaining the required permits and licenses, including environmental clearance and land

acquisition for right-of-way (ROW), preparation of bidding documents, bidding process for selection of contractors, and mobilizing for construction. Additionally, the baseline surveys such as topographic, geotechnical, and environmental surveys associated with road and bridges construction work will be carried out to assess the baseline conditions such as rock, soil, soil stability, water flow, flora and fauna species, etc. The procured engineering consulting firm will assist in developing detailed engineering designs, preparation of environmental compliance documents, and providing Project management expertise for efficient implementation and successful delivery.

2.8.2 CONSTRUCTION PHASE

The construction phase will include civil works on road, bridges and their ancillary facilities. Some of the major construction activities which are to be implemented are as follows:

- Construction staking;
- Site clearance along the road alignment such as a forest;
- Excavation and filling along the proposed alignment;
- Construction of retaining walls structures;
- Construction of side drains and other water management structures;
- Construction of site formation;
- Construction of river training works;
- Construction of bridges, including foundations, piers / abutments, and superstructures;
- Construction of culverts;
- Gravelling and blacktopping works;
- Installation of road safety infrastructure such as traffic signs and lighting; and
- Landscaping.

After completion of the construction, demobilization activities will be conducted in the areas of temporary ancillary facilities. This will involve dismantling temporary accommodations, facilities, and structures, as well as retrieving all equipment. The construction areas will be cleared and cleaned to remove any debris or waste. All demobilization and restoration efforts will be carried out with the procedures and standards specified in the approved civil works contract, in accordance with DoST guidelines.

2.8.3 OPERATION AND MAINTENANCE PHASE

The proposed road will be maintained by DoST. Routine maintenance refers to activities such as grading, grass cutting, drain clearing and pothole patching. Periodic maintenance activities are typically scheduled over periods of several years and include resurfacing.

Other maintenance activities considered to be periodic include seasonal maintenance if required, such as flood repairs, emergency maintenance to reinstate roads after major failures, and the regular upkeep of safety features and road signs.

2.9 PROJECT TIMELINE

The detailed engineering design of the project will start in the first quarter of 2025. The construction works are expected to begin in the first quarter of 2026, with construction expected to take approximately 5 years, concluding by the fourth quarter of 2029.

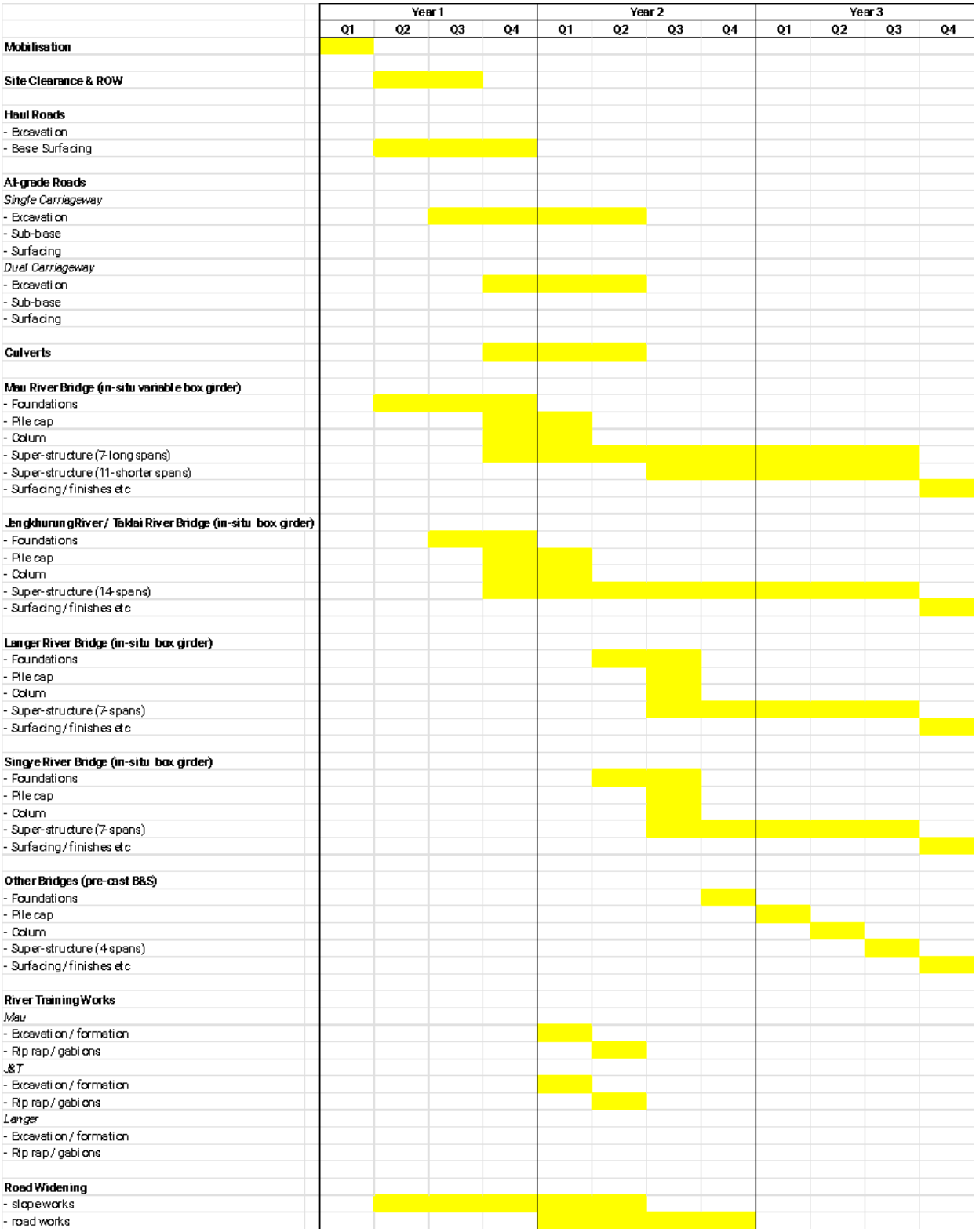
The detailed construction schedule is shown in ***Figure 2.10***.

Long-term performance-based maintenance is scheduled to take place over the life of the asset in operations.

2.10 PROJECT COST

The total cost to construct the 13.6 km of the Gelephu-Tareythang Highway is estimated at about USD 150 Million – 200 Million. The Project is funded by the RGoB and the World Bank.

FIGURE 2.10 DETAILED PROJECT SCHEDULE



3. LEGAL AND INSTITUTIONAL FRAMEWORK

This chapter presents a review of the legislative and administrative framework related to the environmental and social requirements of the Gelephu - Tareythang Road Project, including the relevant national laws and policies and the applicable World Bank's Environmental and Social Standards (ESS).

3.1 BHUTAN LEGAL AND INSTITUTIONAL FRAMEWORK / BHUTAN'S LAWS AND REGULATIONS

This section describes Bhutan's national policies, laws and regulations applicable to the development of the Project. ***Table 3.1*** summarizes the key regulations, laws and policies and ***Table 3.2*** summarizes the relevant standards, codes and guidelines.

TABLE 3.1 BHUTAN'S KEY POLICIES, LAWS AND REGULATIONS

No.	Policy/Acts/Rules	Responsible Government Agency	Key Provision and Purposes	Applicability/Relevance to the Project	Type of Permit and Timeline
A.	Regulation related to Environmental Assessment and Management				
1.	Environment Assessment Act 2000	Department of Environment and Climate Change (DoECC)	This act mandates Environmental Impact Assessments (EIAs) for strategic plans, policies, programs, and projects which may have an impact on the environment, are used to identify potential environmental impacts and develop mitigation measures. It introduces the concept of Environmental Clearance as a mandatory requirement for obtaining development permits and outlines the EIA process.	Relevant to the Project. Preparation of Environmental Impact Assessment for National Highways for EC as a red list project.	Environmental Clearance before construction.
2.	Regulation for Environmental Clearance of Projects 2016	Department of Environment and Climate Change (DoECC)	This act outlines the responsibilities and procedures for implementing environmental clearance processes, including issuance and enforcement. The National Environmental Commission serves as the primary authority for administering and granting Environmental Clearances.	Relevant to the Project Proponent. Obtaining the environmental clearance for the Project. The designated category is red based on Annexure I as it involves the construction of National Highways.	Environmental Clearance before construction.
3.	National Environment Protection Act 2007	Department of Environment and Climate Change (DoECC)	This act establishes the foundation for Bhutan's environmental protection policies and regulations. It empowers the National Environment Commission (NEC) as the primary environmental authority and outlines its responsibilities.	Relevant to the Project. Implementation of the Project in alignment with the Act.	No permit. General compliance before and during construction.
4.	Mines and Minerals Act 1995, Mines and Minerals Bill of Bhutan 2020, Mines	Department of Geology and Mines (DGM)	This act and establishes a framework for mineral resource exploration within the country. To ensure environmental protection, it	Relevant to activities under the Project.	Quarrying License Before construction.

	and Minerals Management Regulations 2022		complements the EA Act of 2000 by mandating site clearance for sand and stone quarrying operations required for road construction.	Exploration and extraction of resources required for road construction.	
5.	Waste Prevention and Management Act of Bhutan 2009	Department of Environment and Climate Change (DoECC)	This act aims to protect and sustain human health through protection of the environment by: Reducing the generation of waste at source; • Promoting the segregation, reuse and recycling of wastes; • Disposal of waste in an environmentally sound manner; and • Effective functioning and coordination among implementing agencies.	Relevant to the activities under the Project. Management of waste including construction materials, hazardous waste, and non-hazardous waste generated from road construction.	No permit. General compliance during construction.
6.	The Water Act of Bhutan 2011	Department of Environment and Climate Change (DoECC) Department of Water (DoW) National Centre for Hydrology and Meteorology (NCHM)	This act aims to safeguard, conserve, and efficiently manage Bhutan's water resources while prioritizing environmental sustainability. It establishes the National Environmental Authority as the governing body responsible for implementing these objectives and mandates the formation of River Basin Committees. The Act also outlines contingency plans for water emergencies such as droughts and floods.	Relevant to the Project. Management of use of water resources for construction phase and impact on water resources during construction and operation phases.	Water Abstraction Permit before and during construction.
7.	Waste Prevention and Management Regulation 2012 and 2016 (amendment)	Department of Environment and Climate Change (DECC)	This regulation identifies the roles and requirements of the Implementing Agencies for the purpose of establishing a sound waste management system including monitoring procedures at every organization level, it also assigns costs in proportion to the waste volume generated from the point source or by degree of their hazardousness by levying fees, charges and fines for non-compliance and	Relevant to the Project. Management of waste including construction materials, hazardous waste, and non-hazardous waste generated from road construction.	No permit. General compliance during construction.

			control and prohibit illegal dumping or releasing of waste into the environment. In addition, the amendment establishes key provisions to promote waste reduction and management.		
8.	The Water Regulation of Bhutan 2014	Department of Environment and Climate Change (DECC) Department of Water (DoW) National Centre for Hydrology and Meteorology (NCHM)	This regulation aims to operationalize the Water Act of 2011 by defining roles, responsibilities, and procedures. It outlines the framework for developing and implementing the National Integrated Water Resources Management Plan (NIWRMP) and River Basin Management Plans (RBMP).	Relevant to the Project. Obtaining water abstraction permits and complying with water quality standards.	Water Quality Compliance Certificate / Water Use Permit before construction.
9.	Regulation for Environmental Clearance of Projects (RECOP) 2016	Department of Environment and Climate Change (DoECC)	This regulation applies to all Projects that require an environmental assessment. It outlines the responsibilities and procedures for the implementation of the Environmental Assessment Act (EAA), 2000 concerning the environmental assessment process for Projects.	Relevant to the Project and Project Proponent. Obtaining the environmental clearance for the Project.	Environmental Clearance before construction.
B.	Biological				
1.	Forest and Nature Conservation Act 2023	Department of Forests and Park Services (DoFPS) National Biodiversity Center (NBC) Department of Environment and Climate Change (DoECC)	This act protects and ensures the sustainable use of forests, wildlife, and related resources of Bhutan for the benefit of present and future generations. Forest clearing, tree felling and constructing or placing any permanent or temporary structure, fence, marker, or other device are prohibited in Government Reserved Forests.	Relevant to the activities under the Project. Vegetation clearance and minimization use of forest land.	Vegetation clearance before construction.

2.	Biological Corridor Rules 2007	Department of Forests and Park Services (DoFPS)	These rules protect wildlife by maintaining the continuity of forest areas and prohibiting activities that disturb wildlife.	Relevant to the Project. Management of Project associated impacts on wildlife.	Permission for Use of Biological Corridor Areas before construction (if applicable).
3.	Forest and Nature Conservation Rules and Regulations of Bhutan 2023	Department of Forests and Park Services (DoFPS) National Biodiversity Center (NBC) Department of Environment and Climate Change (DoECC)	This regulation establishes the role of the Department of Forests and Park Services in creating and implementing forest management plans. The involvement of local communities in forest management is emphasized through the formation of Forest Management Committees and the recognition of community forest rights. Additionally, it includes guideline for (i) highway expansion within forested areas undergoing a thorough environmental clearance process, (ii) measures to manage the impact on protected areas, (iii) the use of community forest, and (iv) the implementation of invasive species management plan and (v) invasive management.	Relevant to the Project.	Timber Extraction Permit (if applicable) before construction.
4.	Biodiversity Act of Bhutan 2022	Department of Forests and Park Services (DoFPS)	The act aims to protect Bhutan's biological resources and associated traditional knowledge. It seeks to regulate access to these resources, ensure fair benefit sharing, and recognize the rights of farmers and breeders. The Act also establishes a legal framework for protecting plant varieties not covered by international patent laws.	Relevant to the Project. Management of Project associated impact on biological environment.	Access and Benefit Sharing Permit (if applicable) before construction.
C.	Social				
1.	The Local Government Act of Bhutan 2009	Local Governments	This act empowers communities to actively participate in and manage their own social, economic, and environmental development	Relevant to the Project. Community participation and stakeholder engagement.	Local government approval before construction.

			through the decentralization of power and authority.		
2.	The Movable Cultural Property Act of Bhutan 2015	Department of Culture and Dzongkha Development (DoCDD)	This act to conserve and protect Bhutan's movable cultural property by establishing rules and procedures governing the sale or export of non-valuable cultural properties.	Relevant to the Project.	Approval for Handling Cultural Property (if applicable) during project activities.
3.	Land Act 1979 (amended 2007)	National Land Commission Secretariat (NLCS)	The act mandates that all land acquisitions, whether public or private, adhere to established procedures. For private land acquisitions, a comprehensive assessment of affected families is required to develop resettlement and compensation plans. Notably, the Act prioritizes land substitution over cash compensation, stipulating that replacement land must be within the same district.	Relevant to the Project.	Land Lease/Ownership Transfer Approval/ Acquisition Permit before construction.
4.	Rules and Regulations for Lease of Government Reserved Forest Land & Government Land 2018	National Land Commission Secretariat (NLCS)	The regulations incorporate changes to align with various updated sectoral policies, rules and regulations, including updating the eligibility criteria for leasing land, monitoring and management, ensuring sustainable and optimum use of limited land resources.	Relevant to the Project.	Government Land Lease Approval before construction.
5.	Land Exchange Rules and Regulations 2022	National Land Commission Secretariat (NLCS)	The regulations set out the procedure, including eligibility and scope of land exchanges in Bhutan required as a result of natural calamities, land plots falling within the Critical Watershed area and Wetland, and scattered private registered plot(s) located within State forests.	Relevant to the Project.	Land Exchange Approval before construction.
6.	Labor and Employment Act of Bhutan 2007	Department of Labor (DoL)	The act establishes fundamental labor rights, including child labor prohibition, anti-discrimination policies, and equal pay. It	Relevant to the Project.	Labor Registration Permit throughout the Project.

			prioritizes workplace safety by mandating occupational health and safety measures and holding employers accountable for work-related injuries and diseases. The act also prohibits sexual harassment.	Employment of a large workforce during construction.	
7.	Revised National Work Force Wage Rate 2015	Department of Labor (DoL)	It provides a workforce wage rate for Bhutanese employed by government agencies for works executed directly by the agencies.	Relevant to the Project. Employment of a large workforce during construction.	No permit. General compliance throughout the Project.
8.	Cultural Heritage Bill of Bhutan 2016	Department of Culture and Dzongkha Development (DoCDD)	This bill aims to sustain cultural heritage and the cultural landscape of Bhutan for the present and future generations. By defining the scope of cultural heritage, establishing regulatory bodies, and outlining procedures for conservation and management, the bill seeks to ensure the sustainable development and utilization of Bhutan's cultural resources.	Indirectly relevant to the Project.	No permit. General compliance throughout the Project.
9.	Regulations on Working Conditions 2022	Department of Labor (DoL)	This regulation establishes uniform standards and procedures in accordance with the Act and ensure fair working conditions in the workplace. It also looks into appropriate and safe conditions at the workplace.	Relevant to the Project. Support working conditions of workers including special terms and conditions to avoid negative social impacts due to foreign influx management	No permit. General compliance throughout the Project.
10.	Regulation on Foreign Workers Management 2022		This regulation establishes standards and procedures in accordance with the Labor and Employment act of Bhutan, 2007 and ensure just and fair recruitment process, management, deployment, repatriation, and working conditions at the workplace.	Relevant to the Project. Employment of a large workforce likely including foreign workers during construction.	Foreign Worker Permit before workforce deployment.
11.	Land Acquisition and Compensation Rules and Regulations 2022	National Land Commission Secretariat (NLCS)	This regulation establishes a clear and fair process for the government's acquisition of private land for public interest Projects. It	Relevant to the Project. Land acquisition process.	Land Acquisition Approval before construction.

			outlines the procedures, compensation mechanisms, and the roles of different government entities involved in the land acquisition process.		
12.	Land Compensation Rates 2022		It provides land compensation rates for Kamzhing, Chhuzhing, Orchard land of different Gewog and Thromdes in Bhutan	Relevant to the Project Proponent. Land acquisition process.	No permit. General compliance before land acquisition.
13.	National Gender Equality Policy (NGEP) 2020	National Commission for Women and Children (NCWC)	This policy aims to ensure equal rights, opportunities, and benefits for all people, regardless of gender. The policy seeks to address gender-based violence (GBV), gender gaps, and other issues in social, economic, political, health and education domains. NCWC is responsible for protection and promotion of rights of women and children through advocacy, legislations and policy, monitoring, and resource mobilization. The NCWC is responsible for promoting gender equality and women's empowerment in collaboration with relevant government and non-government agencies.	Relevant to the Project. Promoting inclusion and addressing SEA/SH (a form of GBV)	No permit. General compliance throughout the Project.
14.	The Domestic Violence Prevention Act of Bhutan 2013	National Commission for Women and Children (NCWC)	This act represents Bhutan's commitment to addressing domestic violence, promoting safety, and fostering respect within families. It provides a legal structure for protecting individuals from abuse while emphasizing preventive measures and victim support.	Relevant to the Project.	No permit. General compliance throughout the Project.
15.	Child Care and Protection Act of Bhutan 2011		This act provides comprehensive legal protection for children and establishes mechanisms for addressing child abuse, exploitation and neglect. It mandates the establishment of child protection services and rehabilitation facilities.	Relevant to the Project.	No permit. General compliance throughout the Project.

16.	Narcotic Drugs, Psychotropic Substances and Substance Abuse Act of Bhutan 2018	Drug Regulatory Authority (DRA)	This act criminalizes the production, trafficking and abuse of narcotic drugs and psychotropic substances. It provides guidelines for treatment, rehabilitation, and reintegration of individuals with substance use disorders.	Relevant to the Project.	No permit. General compliance throughout the Project.
17.	Tobacco Control Act of Bhutan 2021	Bhutan Food and Drug Authority (BFDA)	This act regulates the production, sale, and use of tobacco products and aims to reduce substance abuse related to tobacco.	Relevant to the Project.	No permit. General compliance throughout the Project.
D.	Occupational Health and Safety (OHS)				
1.	General Rules and Regulations on Occupational Health and Safety (OHS) in Construction, Manufacturing, Mining and Service Industries 2006	Department of Labor (DoL)	This regulation assures safe and healthful working conditions for working men and women as well as other persons present at workplaces from work related risks to their health, safety, and well-being.	Relevant to the activities under the Project. Employment of a large workforce during construction, required to comply with occupational safety and health regulations to mitigate the risks associated with hazardous working conditions.	No permit. General compliance throughout the Project.
2.	Regulation on Occupational Health and Safety for Construction Industry 2022	Department of Labor (DoL)	This regulation adopts the international best practice principles as defined in relevant international labor standards. It emphasizes promotion of a healthy and safe workplace for the development of a sustainable safety culture within enterprises and beyond.	Relevant to the activities under the Project. Employment of a large workforce during construction, required to comply with occupational safety and health regulations to mitigate the risks associated with hazardous working conditions.	No permit. General compliance throughout the Project.
3.	Rules and Regulations on Occupational Health, Safety, and Welfare 2022	Department of Labor (DoL)	This regulation includes provisions for addressing workplace harassment and ensuring a safe environment for all employees.	Relevant to the Project.	No permit. General compliance throughout the Project.

E.	Management				
1.	Disaster Management Act of Bhutan 2013	Department of Local Governance & Disaster Management (DLGDM)	This act aims to establish a robust disaster management framework, prioritizing community involvement and risk reduction. It creates the National Disaster Management Authority as the governing body and mandates the development of comprehensive disaster contingency plans at both national and district levels.	Relevant to the Project's planning, design, operation and maintenance stages.	No permit. General compliance throughout the Project.
2.	Disaster Management Rules and Regulations 2014		This rule and regulation outline the operational framework for implementing the Disaster Management Act of Bhutan. It establishes the roles and responsibilities of government agencies, private sector, and civil society in disaster management. The regulations also mandate the formation of disaster management committees at the district level, the establishment of emergency operation centers, and the development of early warning systems. Additionally, it provides guidelines for classifying disasters and outlines procedures for relief and recovery efforts.	Relevant to the Project's planning, design, operation and maintenance stages.	No permit. General compliance throughout the Project.
F.	Road				
1.	The Road Act of Bhutan 2013	Department of Surface Transport (DoST)	This act establishes a road management system. It focuses on: • Developing a safe and efficient road network to support economic growth; • Creating a coordinated management structure for roads; • Empowering relevant government agencies to manage roads effectively;	Relevant to the Project's planning, design, operation and maintenance stages.	Road Construction Permit / Access Permit for Road Usage before and during construction.

			• Promoting public-private partnerships for road development and maintenance; and • Protecting road infrastructure and ensuring responsible use of road reserves.		
2.	Road Rules and Regulations of The Kingdom of Bhutan 2016		This regulation establishes a standardized framework for road construction, maintenance, and management in the country. It outlines the roles and responsibilities of government agencies and road users.	Relevant to the Project Proponent.	Permit for Road Closure or Diversion before and during construction.
3.	Road Safety and Transport Regulation 2021	Bhutan Construction and Transport Authority (BCTA)	This Act and regulation establish a system to provide for the safe, reliable, efficient, inclusive and environment friendly road transport system in the Kingdom of Bhutan and to ensure the highest standard of safety of passenger transport. It also provides a framework for registration and renewal of motor vehicles, licensing of drivers, emission testing, vehicle roadworthiness, vehicle ownership transfer, and/or any other services associated or incidental to the motor vehicle and its drivers.	Relevant to the Project's planning, design, operation and maintenance stages.	No project-specific permit. Drivers in the Project shall have a valid vehicle/driver license during project activities.
4.	Road Safety and Transport Act 1999	Bhutan Construction and Transport Authority (BCTA)	This Act establishes the framework for road safety, vehicle registration, and driver licensing.		
G.	Immigration				
1.	Immigration Act of the Kingdom of Bhutan, 2007	Department of Immigration (DoI)	Department of Immigration (DoI)	Department of Immigration (DoI)	Department of Immigration (DoI)

TABLE 3.2 BHUTAN'S STANDARDS, CODES, GUIDELINES AND NON-POLICY DOCUMENTS

No.	Policy/Acts/Rules	Responsible Government Agency	Key Provision and Purposes	Applicability/Relevance to the Project
A.	Regulation related to Environmental Assessment and Management			
1.	Environmental Codes of Practice (ECP) (Highways and Roads) 2000	Department of Environment and Climate Change (DoECC)	The ECP provides a summarized environmental management plan for road Projects. This management plan can be used as an Environmental Manual. The Project stages covered are: • Planning, studying and surveying; • Design; • Tender documents; • Construction and supervision; and • Operation and maintenance.	Relevant to the Project. Preparation of environmental management plan for addressing the potential environmental impacts from road construction during different Project stages.
2.	Strategy for Air Quality Assessment and Management in Bhutan 2010	Department of Environment and Climate Change (DoECC)	The Strategy guides the strategy for air quality impact and required standards to reduce the impact on the environment and public health.	Relevant to the activities under the Project. Management of impact on air quality associated with construction activities, including operation of machinery and equipment use.
3.	Environmental Assessment Guideline for Roads and Highways 2012	Department of Environment and Climate Change (DoECC)	The guideline provides guidance and assistance to various stakeholders involved in the EA process. In addition, this guideline also provides the step in the EIA process, good practices in EIA, TOR for road/highway Projects, impact assessment method, and mitigation measures and EMP for road/highway Projects.	Relevant to the Project. Impact assessment process and preparation of environmental and social impact assessment with mitigation measures for road/highway Project.
4.	National Waste Management Strategy 2019	Department of Environment and Climate Change (DoECC)	This management strategy aims to significantly reduce greenhouse gas emissions, including those from short-lived climate pollutants (SLCPs), originating from the waste sector.	Irrelevant to the Project.

5.	Environmental Standards, 2020		This regulation provides the environmental criteria, and standards including ambient water quality criteria, industrial effluent discharge standard, sewage treatment plant (STP) discharge standards, ambient air quality criteria, industry emission standards (maximum limit for pollutants), industrial emission standards for aluminum smelting unit, workplace emission standards, vehicular emission and noise limit standards, noise level limits, incineration emission standards, waste incinerator ash disposal/utilization standards.	Relevant to the Project. Threshold values for environmental parameters monitored in environmental baseline surveys.
B.	Biological			
1.	Bhutan's National Biodiversity Strategy and Action Plan 2014	Department of Forests and Park Services (DoFPS) National Biodiversity Centre (NBC) Department of Environment and Climate Change (DoECC)	The National Biodiversity Strategies and Action Plan aims to conserve Bhutan's biodiversity while ensuring its sustainable use for the benefit of current and future generations. It focuses on: Biodiversity valuation and monitoring; Sustainable resource management; Climate change adaptation; Ecosystem conservation; and Food security.	Indirectly relevant to the Project.
2.	Biodiversity Monitoring and Social Survey Protocol of Bhutan 2020		To create a standardized system for tracking biodiversity and understanding its impact on people. By monitoring biodiversity and conducting social surveys, the program aims to: Build a comprehensive dataset on Bhutan's biodiversity; Track changes in species distribution and habitat use over time; Assess the socioeconomic conditions of communities reliant on biodiversity; and Understand local perspectives on environmental changes and conservation efforts.	Relevant to the Project. Baseline data collection for biodiversity and social baseline surveys.

3.	Protected Area Zonation Guidelines of Bhutan 2020		This guideline classifies a PA into different zones as per the functions of the area and accordingly prescribe regulations and management interventions for the purpose of; Ensuring conservation of threatened endemic and keystone species and its habitat; Enhancing social and community services through legal and traditional resource use rights; and Strengthening effective management of the area through objective driven management interventions and resource allocations.	Irrelevant to the Project.
4.	Guidelines for Wildlife Habitat Management 2021		This guideline provides concepts, processes, and techniques for wildlife managers and biologists on how to effectively manage and improve wildlife habitats in Bhutan. At a broader scale, it is developed with an intention to maintain and improve the wildlife habitats in Bhutan at an optimum level in the face of changing land use practices and climate change for the persistence of wildlife in its natural habitat.	Relevant to the Project. Management of Project associated impact on natural habitat.
5.	Elephant Conservation Action Plan for Bhutan 2018-2028	Department of Forests and Park Services (DoFPS)	The Action Plan provides an overview of elephant population and occurrence within the Bhutan landscape and aims to summarize the key threats to the species' survival, as well as opportunities and actions which can be taken to reduce threats and increase conservation efforts, including addressing human-wildlife conflict and maintenance of elephant corridors. A summary of the action plan has been included in Section 7.6.1.	Relevant to the Project. Management of Project associated impact on biological environment.
C.	Social			

1.	Gender Responsive Planning and Budgeting (GRPB)	National Commission for Women and Children (NCWC)	It is strategy to accelerate investment in gender equality and women's empowerment interventions. The RGoB began piloting GRPB in three sectors (education, health, and agriculture) in 2014. A strategic framework for gender mainstreaming and GRPB was prepared in 2013 to provide an overall framework for the RGoB and to enhance coordinated efforts across sectors. The MoF was identified as the lead agency for implementing GRPB supported by the NCWC as well as a steering committee and a working-level committee.	Relevant to the Project.
2.	National Plan of Action for Gender Equality 2019-2023	National Commission for Women and Children (NCWC)	The Action Plan presents a holistic approach to achieving gender equality by addressing the gaps and challenges identified, and by taking into consideration new and emerging issues. It outlines key gender equality targets and interventions across 10 critical areas of good governance; education and training; health; ageing, mental health, and disabilities; violence against women; stereotypes and prejudices; economic development; women and poverty; sports; and climate change and poverty.	Relevant to the Project.
3.	The National Youth Policy	Department of Youth and Sports (DYS)	It sets out goals to provide youth proper education and training opportunities, provide access to information in respect of employment opportunities and to other services, including entrepreneurial guidance, financial credit and strengthening of private sector to promote a strong and vibrant Bhutanese society.	Relevant to the Project.
4.	Penal Code of Bhutan 2021	Office of the Attorney General	This code criminalizes sexual harassment, including in workplace settings. It defines sexual harassment and outlines penalties. This code criminalizes drug-related offenses, including trafficking and possession of illegal substance.	Relevant to the Project.

5.	National Policy and Strategic Framework to Reduce Harmful Use of Alcohol 2015	Department of Public Health	This act outlines measures to prevent and reduce alcohol-related harm in Bhutan.	Relevant to the Project.
6.	National Policy for Persons with Disabilities 2019	Office of the Prime Minister and Cabinet	This act promotes rights and inclusion of persons with disabilities to ensure them to be fully participate in social, economic, political, and cultural life, in line with Bhutan's commitments under the United Nations Convention on the Rights of Persons with Disabilities (CRPD), which Bhutan ratified in 2016.	Relevant to the Project.
D.	Road			
1.	Urban Roads Standard 2002	Bhutan Standards Bureau (BSB)	Provide a guide for the design and construction of urban roads. It establishes essential standards to be followed and provides references to additional resources for detailed specifications. It emphasizes the critical role of quality control in ensuring the construction of safe and durable roads.	Relevant to the Project's planning, design, operation and maintenance stages.

3.1.1 RELEVANT ENVIRONMENTAL STANDARDS

According to Bhutan's Environmental Standards (ES) (2020), the criteria and standards have been specified for environmental and occupational health and safety parameters, including ambient air quality, noise, surface water, groundwater, and workplace emission.

In addition to the local ES, the WBG EHS Guidelines apply their own set of standards for specific effluents, emissions, and discharges. Application of these guidelines requires that when host country regulations differ from the levels and measures presented in the WBG EHS Guidelines, Projects are required to achieve whichever is the more stringent.

In comparison of Bhutan and WBG EHS standards, the most stringent standard will be applied for ease of reference for ESIA assessment. The following section lists the standards as defined by local and WBG EHS guidelines.

3.1.1.1 AMBIENT AIR QUALITY CRITERIA

The Project shall comply with Bhutan's environmental, social, health and safety laws and international good practice standards, notably the WBG EHS Guidelines. The ambient air quality standards applied for the Project are presented in ***Table 3.3***, based on the most stringent standards between Bhutan Ambient Air Quality Standards and WBG EHS Guidelines.

TABLE 3.3 PROJECT AMBIENT AIR QUALITY STANDARDS

		Bhutan National Criteria (µg/m³) [a]			**WBG EHS Guidelines (µg/m³) [b,c]**
Parameter		Industrial area	Mixed Area [d]	Sensitive Area [e]	
Total Suspended Particulate Matter (TSP)	24-hour average	500	200	100	-
	Yearly average	360	140	70	-
Particulate < 2.5 µm (PM2.5)	24-hour average	60	60	60	5
	Yearly average	40	40	40	15
Particulate < 10 µm (PM10)	24-hour average	200	100	75	15
	Yearly average	120	60	50	45
Sulfur Dioxide (SO_2)	10-minute	-	-	-	500
	24-hour average	120	80	30	40
	Yearly average	80	60	15	-
Nitrogen Oxides (NO_x)	24-hour average	120	80	30	-
	Yearly average	80	60	15	-
Nitrogen Dioxide (NO_2)	24-hour average	-	-	-	10
	Yearly average	-	-	-	25
Carbon Monoxide (CO)	24-hour average	-	-	-	4,000
	8-hour average	5,000	2,000	1,000	-
	1-hour average	10,000	4,000	2,000	-
Ozone	8-hour average	100	100	100	100
	1-hour average	180	180	180	60

Note:

a National Environment Commission Royal Government of Bhutan, June 2020

b WBG EHS Guideline adopts WHO Ambient Air Quality Guidelines.

c World Health Organization. (2021). WHO global air quality guidelines. https://apps.who.int/iris/handle/10665/345329. License: CC BY-NC-SA 3.0 IGO

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

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

- means there is no standard for this parameter

3.1.1.2 WORKPLACE EMISSION STANDARDS

The WBG EHS guidelines do not establish specific standards for workplace emission standards. Instead, the Project will comply with the workplace emission standards regulated under the National Environment Commission Royal Government of Bhutan, June 2020. These standards are designed to protect workers from exposure to air pollution. The standards applied for the Project are presented in ***Table 3.4***.

TABLE 3.4 WORKPLACE EMISSION STANDARDS

Parameter		Unit	Standards
TSPM	8-hour average	mg/m^3	10
RSPM (PM10)	8-hour average	mg/m^3	5
PM2.5 [1]	24-hour average	mg/m^3	25
	1-year average	mg/m^3	10
Sulfur dioxides	8-hour average	mg/m^3	1
Nitrogen oxides	8-hour average	mg/m^3	1
Carbon monoxide	8-hour average	mg/m^3	5
Pb [2]	1-hour average	mg/m^3	0.0005
Ozone [3]	8-hour average	ppm	0.08

Source: National Environment Commission Royal Government of Bhutan, June 2020

Note:

[1] Gravimetric/light-scattering/ beta attenuation-based instruments

[2] National Institute of Occupational Safety and Health (NIOSH) Method 7303

[3] UV Photometric/ Chemiluminescence/ Chemical method

3.1.1.3 VEHICULAR EMISSION AND NOISE LIMIT STANDARDS

The WBG EHS guidelines do not establish specific standards for vehicular emission and noise limit standards. Instead, the Project will comply with the vehicular emission and noise limit standards regulated under the National Environment Commission Royal Government of Bhutan, June 2020. These standards provide vehicle emissions and vehicular noise level limits, including limits for different fuel types.

The standards applied for the Project are presented in ***Table 3.5*** and ***Table 3.6***.

TABLE 3.5 VEHICLE EMISSION STANDARDS

Fuel Type	Vehicles registered prior 01/2005	Vehicles registered after 01/2005	Vehicles registered prior 01/2021	Vehicles registered after 01/2021 [Approval type: Euro 6/BS VI]
Petrol/ Gasoline (%CO)	4.5 %	4.0 %	4.0 %	0.5%
Diesel (%HSU)	75%	70%	70%	50%

Source: National Environment Commission Royal Government of Bhutan, June 2020

TABLE 3.6 VEHICULAR NOISE LEVEL LIMITS

No.	Type of Vehicle	Noise Limits dB(A)
Two wheeler		
1.1	Displacement up to 80 cc	75
1.2	Displacement more than 80 cc but up to 175 cc	77
1.3	Displacement more than 175 cc	80
2	Vehicles used for carriage of passengers and capable of having not more than nine seats, including the driver's seat	74
Vehicles used for carriage of passengers having more than nine seats, including the driver's seat, and a maximum gross Vehicle Weight (GVW) of more than 3.5 tonnes		
3.1	With an engine power less than150 KW	78
3.2	With an engine power of 150 KW or above	80
Vehicles used for carriage of passengers having more than nine seats, including the driver's seat: Vehicles used for carriage goods		
4.1	With maximum GVW not exceeding 2 tonnes	76
4.2	With maximum GVW greater than 3 tonnes but not exceeding 3.5 tonnes	77
Vehicles used for transport of goods with a maximum GVW exceeding 3.5 tonnes		
5.1	With an engine power less than 75 KW	77
5.2	With an engine power of 75 KW or above but less than 150 KW	78

Source: National Environment Commission Royal Government of Bhutan, June 2020

3.1.1.4 NOISE LEVEL STANDARDS

The Project shall comply with Bhutan environmental, social, health and safety laws and associated WBG (which includes IFC PS) EHS Guidelines. Thresholds are presented in

Table 3.7, based on the most stringent standards between National Environment Commission Royal Government of Bhutan, June 2020, which provides noise level standards of industrial area, mixed area, and sensitive area standards and WBG EHS Guidelines.

TABLE 3.7 NOISE LEVEL LIMITS

Receptor	**Bhutan National Criteria** Maximum Value dB(A) [3]		**WBG EHS Guidelines** One Hour L_{Aeq} (dBA) [1, 2]	
	Daytime [4] (06:00 – 22:00)	**Nighttime [5] (22:00 – 06:00)**	**Daytime (07:00 – 22:00)**	**Nighttime (22:00 – 07:00)**
Industrial area	75	65	-	-
Mixed area	65	55	-	-
Sensitive area	55	45	-	-
Residential; institutional; educational	-	-	≤ 55	≤ 45
Industrial; commercial	-	-	≤ 70	≤ 70
Occupational Health & Safety (exposure limits)	-	-	LAeq, 8h (dB(A))	Max LAmax, fast (dB(A))
	-	-	85 (heavy industry)	110 (heavy industry)
	-	-	50-65 (light industry)	110 (light industry)
	-	-	45-50 (open offices)	-
	-	-	40-45 (closed offices)	-

Note:
[1] WBG EHS noise level guidelines, noise impacts should not exceed the levels presented in the above table or result in a maximum increase in background levels of 3 dB at the nearest receptor location off-site.
[2] WBG General EHS Guidelines (2007), Noise Level Guidelines
[3] National Environment Commission Royal Government of Bhutan, June 2020
[4] Day time is from 6:00 hours to 22:00 hours (human activities)
[5] Nighttime is from 22:00 hours to 6:00 hours (limited human activities) Maximum value allowed in workplace at any point of time is 75 dB(A)
- means there is no standard for this parameter

3.1.1.5 AMBIENT WATER QUALITY CRITERIA

The WBG EHS guidelines do not establish specific standards for surface water quality. Instead, the Project will comply with the national water quality standards regulated under the National Environment Commission Royal Government of Bhutan, June 2020.

Table 3.8 provides ambient water quality criteria, which are only applicable for surface water quality. The table below shows the acceptable ranges for each parameter according to water quality classification.

TABLE 3.8 AMBIENT WATER QUALITY CRITERIA

		Bhutan's ES Standards			International Guidelines [1]
Parameter	**Unit**	**Very good (A)**	**Good (B)**	**Moderate (C)**	**WHO Drinking Water**
pH	pH scale	6.5-8.5	6.0-9.0	6.0-9.0	- [2]
Color	Hz	5	50	-	< 15 True color unit (TCU)
TSS	mg/L	25	100	-	-
Conductivity	µS/cm	800	1,000	2,000	-
Odor		Unobjectionable	Unobjectionable	-	Should not be detectable
Mineral oil		No film	No film	-	-
Nitrate	mg/L	10	50	-	50
Fluoride	mg/L	1	2.0	-	1.5
Sulphates	mg/L	25	100	-	- [2]
Chloride	mg/L	50	200	-	- [2]
Surfactants	mg/L	0.1	0.2	-	-
Phosphates	mg/L	0.5	<0.1	-	-
DO	mg/L	6	4	-	-
BOD	mg/L	2	5	50	-
TKN	mg/L	0.5	2.0	-	-
Ammonia	mg/L	0.05	0.5	-	-
T. coliform*	CFU/ 100mL	50	5,000	10,000	Should not be detectable in any 100 mL sample
F. coliform*	CFU/ 100mL	20	2,000	5,000	
F. Streptocoppi	CFU/ 100mL	20	1,000	1,000	
Dissolved Iron	mg/L	0.2	0.5	-	- [2]
Copper	mg/L	0.05	0.1	-	2
Zinc	mg/L	0.2	0.5	-	- [2]
Arsenic	mg/L	0.01	0.05	-	0.01
Cadmium	mg/L	0.003	0.003	-	0.003
Total chromium	mg/L	0.05	0.05	-	0.05
Lead	mg/L	0.02	0.02	-	0.01
Selenium	mg/L	0.01	0.01	-	0.04
Mercury	mg/L	0.0005	0.0005	-	0.006
Phenols	mg/L	0.001	0.002	-	0.2
Cyanides	mg/L	0.05	0.05	-	- [2]
PAH	mg/L	0.0002	0.0002	0.001	0.0007
Total	mg/L	0.0005	0.0005	0.001	-

		Bhutan's ES Standards			International Guidelines [1]
pesticides					
PCB	mg/L	0.0002	0.0002	-	-
Boron	mg/L	-	-	1	2.4
Floating materials-wood, plastic, rubber etc.		Absent	Absent	-	-
Anionic Detergents[7]	mg/L	0.2	1	-	-
Manganese	mg/L	0.4	-	-	- [2]
Sodium Absorption ratio[8]	Max	-	-	26	- [2]
Barium[9]	mg/l	0.7	-	-	1.3
Calcium hardness[10]	mg/l	200	-	-	- [2]
COD*[11]	mg/l	5	-	-	-
Magnesium hardness[12]	mg/l	200	-	-	- [2]
Total Dissolved Solids (TDS)[13]	mg/l	500	1500	2100	- [2]
Turbidity	NTU	5	-	-	-

Source: National Environment Commission Royal Government of Bhutan, June 2020
[1] WHO Guidelines Drinking-water Quality 4th edition
[2] Parameter has no guideline value as it is not of health concern at levels found in drinking-water

Note:
*[a] * Applicable only to Surface water quality*
[b] Very good (A) means Drinking water source without conventional treatment, but after disinfection whenever necessary
[c] Good (B) means Drinking water source with conventional treatment
[d] Moderate (C) Moderate means Used for irrigation, industrial cooling, etc.

To achieve the drinking quality standard, disinfection/boiling of the water is recommended. The total coliform may be high due to their contribution from natural sources like soil, litter etc., which does not relate to pathogen. If MPN of total coliform is noticed to be more than the limit suggested, then regular tests should be carried out. The criteria would be satisfying if during a period not more than 5% of samples showed greater than the prescribed limit.

3.1.2 INTERNATIONAL CONVENTIONS AND TREATIES

Bhutan is a signatory and party to Multilateral Environmental Agreements (MEAs) governing climate change, ozone depletion, biodiversity conservation, cultural heritage,

[7] Annex K of IS 13428
[8] American Public Health Association (APHA)
[9] Annex F of IS 13428* or IS 15302
[10] IS 3025 (Part 21)
[11] IS 3025 (Part 21)
[12] IS 3025 (Part 46)
[13] IS 3025 (Part 16)

human rights, and hazardous waste management.[14] The key international conventions relevant to the Project are included in ***Table 3.9***.

Bhutan and India have a strong bilateral relationship that extends to cooperation in the field of biodiversity and environmental conservation. The key aspects of the Bhutan-India cooperation on biodiversity include the following:

- Memorandums of Understanding (MoU) 0n the Field of Forestry and Biodiversity
- MoU for Conservation of the Manas Tiger Reserve
- South Asia Co-operative Environment Programme (SACEP), established on 25 February 1981 in Sri Lanka.
- Transboundary Manas Conservation Area (TraMCA), formally established in 2011, it is an initiative for collaboration between India and Bhutan to manage and conserve the contiguous protected areas cross the shared border. This collaboration is currently suspended.

TABLE 3.9 INTERNATIONAL CONVENTIONS RELEVANT TO THE PROJECT

Conventions	Ratified/Acceded/ Adherence/Signed	Applicability/Relevance to the Project
Environment, Agriculture and Forestry		
Convention on Biological Diversity, Rio de Janeiro, 05 June 1992, signed on 11 June 1992	25 August 1995 [a]	Relevant to the Project, related to ESS-1 and ESS-6. Management of Project associated impacts on wildlife and biological environment.
United Nations Framework Convention on Climate Change (UNFCCC), New York, 9 May 1992, signed on 11 June 1992	25 August 1995 [a]	Relevant to the Project, related to ESS-1, ESS-3 and ESS-6. Implementation of the Project in alignment with convention objectives.
Kyoto Protocol to the United Nations Framework Convention on Climate Change, Kyoto 11 December 1997	26 August 2002 [b]	Relevant to the Project, related to ESS-1 and ESS-3. Implementation of the Project in alignment with convention objectives.
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and	26 August 2002 [b]	Relevant to the Project, related to ESS-1, ESS-3 and ESS-6. Management of waste including construction materials, hazardous

[14] National Implementation Plan for the System of Environmental-Economic Accounting in Bhutan (2024-2029). Available from: https://www.nsb.gov.bt/wp-content/uploads/dlm_uploads/2023/10/SEEA-National-Implementation-Plan.pdf

their Disposal, Basel, 22 March 1989		waste, and non-hazardous waste generated from road construction.
Vienna Convention for the Protection of the Ozone Layer, Vienna, 22 March 1985	23 August 2004 [b]	Relevant to the Project, related to ESS-3. Implementation of the Project in alignment with convention objectives.
Montreal Protocol on Substances that Deplete the Ozone Layer, Montreal, 16 September 1987	23 August 2004 [b]	Relevant to the Project, related to ESS-3. Implementation of the Project in alignment with convention objectives.
International Plant Protection Convention, Italy, 6 December 1951	20 June 1994 [c]	Relevant to the Project, related to ESS-1 and ESS-6. Implementation of the Project in alignment with convention objectives.
Human Rights		
International Convention on the Elimination of All Forms of Racial Discrimination, New York, 07 March 1966	26 March 1973 [d]	Relevant to the Project, related to ESS-2 and ESS-7.
Convention on the Elimination of All Forms of Discrimination against Women, New York, 18 December 1979	17 July 1980 [d] 31 August 1981 [b]	Relevant to the Project, related to ESS-2 and ESS-7.
UN Convention on the Rights of the Child, 20 November 1959	4 June 1980 [d] 1 August 1990 [a]	Relevant to the Project, related to ESS-2 and ESS-7.
Cultural Heritage		
Constitution of UNESCO, England, 16 November 1945	Acceptance 13 April 1982	Relevant to the Project, related to ESS-8.

UNESCO Convention on the Means of Prohibiting and Preventing the Illicit Import, Export and Transfer of ownership of Cultural Property, France, 14 November 1970	26 September 2002 [a]	Relevant to the Project, related to ESS-8.
Convention on the Safeguarding of the Intangible Cultural Heritage, France, 17 October 2003	12 October 2005 [a]	Relevant to the Project, related to ESS-8.

Source: United Nations Treaty Collection
Note: [a] Ratified, [b] Acceded, [c] Adherence, [d] Signed

3.2 WORLD BANK STANDARDS AND GUIDELINES/ WORLD BANK FRAMEWORKS, POLICIES, AND STANDARDS

All new WB funded Investment Project Financing (IPF) are required to apply the Environmental and Social Framework (ESF) established by the World Bank in 2018. The ESF is a set of policies and standards established by the World Bank to address environmental and social risks and impacts associated with Projects financed by the Bank aiming to protect people and the environment from potential adverse impacts that could arise from World Bank-financed Projects. The ESSs set out the requirements for Borrowers relating to the identification, assessment, and mitigation of environmental and social (E&S) risks and impacts associated with Projects financed by the Bank. The ten (10) ESSs are described in ***Table 3.10***.

The ESF particularly applies to all types of IPF including road construction, maintenance, or improvement Projects. The ESF requires the Borrowers to comply with the ESSs throughout the life of the Project, which includes addressing direct and indirect linkages to climate change-related risks. The ESF also mandates the Borrowers to assess and manage environmental and social risks and impacts arising from road Projects, including potential adverse impacts on communities from Project-related activities. Additionally, the ESF requires the Borrowers to engage in meaningful consultation with stakeholders, identify appropriate methods and tools to assess and manage potential environmental and social risks, and monitor the environmental and social performance of road Projects in accordance with the ESSs.

Due to the extensive extraction of construction materials from riverbeds, the EHS guidelines for Construction Material Extraction are highly relevant to this project. It is important to incorporate and consider these guidelines to ensure the project aligns with World Bank requirements.

3.2.1 ENVIRONMENTAL AND SOCIAL FRAMEWORK (ESF) / WB ESF

FRAMEWORKS AND RELEVANT ESS

Each of the ten standards (ESS-1 to ESS-10) and associated Directive and their requirements are tabulated in ***Table 3.10***. Additionally, it also indicates the relevance and requirements relating to other guidance notes of WB. The more stringent requirements will apply while having differentiating between Bhutan's regulations and WB's ESSs.

TABLE 3.10 WORLD BANK ESF FRAMEWORKS AND RELEVANT ESS

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
ESS-1 Assessment and Management of Environmental and Social Risks and Impacts	• Identify, evaluate, and manage environment and social risks and impacts in a manner consistent with the ESSs; • Adopt a mitigation hierarchy; • Anticipate and avoid risks and impacts; • Where avoidance is not possible, minimize or reduce risks and impacts to acceptable levels; • Once risks and impacts have been minimized or reduced, mitigate and; • Where significant residual impacts remain, compensate for or offset them, where technically and financially feasible; • Adopt differentiated measures so that adverse impacts do not fall disproportionately on the disadvantaged or vulnerable, and they are not disadvantaged in sharing development benefits and opportunities; • Utilize national environmental and social institutions, systems, laws, regulations and procedures where appropriate; • Promote improved environmental and social performance, in ways	Environmental and social risks from civil works activities during construction phase such as occupational and community health and safety, landslides and erosion from terrace cutting and earth excavation, siltation of rivers, vegetation loss from forest clearance, disturbance land acquisition and potential physical displacement, permanent or temporary impact on livelihoods of the affected people, labor influx, inclusion issues for vulnerable groups (women, children, persons with disabilities, LGBTI+ etc.) and GBV and SEA/SH risks are expected. An Environmental and Social Impact Assessment (ESIA) will be required with measures to be included in, Environment and Social Management Plan (ESMP).	ESIA report including the following: • Introduction, project description, administrative framework, impact assessment methodology, alternative analysis • Environmental and social baseline studies • Environmental Impact assessment including air quality, noise impact, water & hydrology, general physical environment and biodiversity • Traffic Impact Assessment (TIA) • Climate Change Risk Assessment (CCRA) • Greenhouse Gas Emission Calculation • Critical Habitat Assessment (CHA) • Social Impact Assessment (SIA) • Cultural Impact Assessment • Cumulative Impact Assessment (CIA) • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP) Environmental and Social Management Plan (ESMP) including the following: • Biodiversity Management Plan (BMP) • Invasive Species Management Plan

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	which recognize and enhance Government capacity.		• Workers Accommodation Management Plan • Influx Management Framework • Gender Action Plan • SEA/SH Action Plan will contain measures to mitigate SEA//SH risks related to labor influx and working conditions. • Grievance Redress Mechanism (GRM)
ESS-2 Labor and Working Conditions	a) Promote safety and health at work; b) Promote the fair treatment, non-discrimination, and equal opportunity of Project workers; c) Protect Project workers, with particular emphasis on vulnerable workers; d) Prevent the use of all forms of forced labor and child labor; e) Support the principles of freedom of association and collective bargaining of Project workers in a manner consistent with national law; and f) Provide Project workers with accessible means to raise workplace concerns.	In Bhutan's current practice, a significant portion of construction workers, including direct, contracted, and primary supply workers with civil works contractors, are often hired from abroad, particularly from neighboring countries like India l. This raises concerns about an influx of external labor and related social risks including the use of vulnerable workers and child labor. Additionally, there may be safety risks for workers during the construction phase. As the project is located in a hot climate, proper working/housing conditions are required to avoid heat stroke. Heavy rainfall and flash floods are common risks in this region. Prevent SEA/SH and ensure mechanisms exist to respond to SEA/SH incidents	ESIA report including the following: • Social baseline studies • Critical Habitat Assessment (CHA) • Social Impact Assessment (SIA) • Cultural Impact Assessment • Cumulative Impact Assessment (CIA) • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP) Environmental and Social Management Plan (ESMP) including the following: • Workers Accommodation Management Plan • Influx Management Framework • Gender Action Plan • SEA/SH Action Plan will contain measures to mitigate SEA//SH risks related to labor influx and working conditions.

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
			• Grievance Redress Mechanism (GRM)
ESS-3 Resource Efficiency and Pollution Prevention and Management	a) Promote the sustainable use of resources, including energy, water, and raw materials; b) Avoid or minimize adverse impacts on human health and the environment caused by pollution from Project activities; and c) Avoid or minimize Project-related emissions of short and long-lived climate pollutants; d) Avoid or minimize generation of hazardous and non-hazardous waste; and e) Minimize and manage the risks and impacts associated with pesticide use.	The civil works during construction will consume raw materials likely to be extracted from Bhutan's natural resources. A number of risks and impacts of pollution from potential sources such as dust and emission from operation of hot-mix and batching plants, crushers, construction, and haulage vehicles, material, and spoil stockpile; effluents and wastewater from worker camps, construction camp; spillage or leakage during handling of chemical admixtures, hazardous materials like bitumen, high strength diesel, used oil, battery wastes etc.; and disposal of non-hazardous wastes (municipal wastes) generated during construction are expected.	ESIA report including the following: • Environmental Impact assessment including air quality, noise impact, water & hydrology, general physical environment and biodiversity • Traffic Impact Assessment (TIA) • Climate Change Risk Assessment (CCRA) • Greenhouse Gas Emission Calculation
ESS-4 Community Health and Safety	a) Anticipate or avoid adverse impacts on the health and safety of Project-affected communities during Project life-cycle from routine and non-routine circumstances; b) Promote quality, safety, and climate change considerations in infrastructure design and construction, including dams; c) Avoid or minimize community exposure to Project related traffic and	During construction, civil works and vehicles passing through urban areas could expose communities to health & safety risks. Dust and noise arising from the construction may affect the community, crops and livestock. The Project will be developed on hilly terrains. The civil works will affect the local communities living and working in the vicinity of the sites.	ESIA report including the following: • Climate Change Risk Assessment (CCRA) • Greenhouse Gas Emission Calculation • Social Impact Assessment (SIA) • Cultural Impact Assessment • Cumulative Impact Assessment (CIA) • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP)

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	road safety risks, diseases and hazardous materials; d) Have in place effective measures to address emergency events; e) Ensure that safeguarding of personnel and property is carried out in a manner that avoids or minimizes risks to the Project-affected communities.	In addition, potential impacts from labor influx to the existing communities are expected. It is important to highlight the potential risks on women resulting from the large influx of external workers and due to the availability of alcohol, which may lead to disruptive behavior by migrant workers. The available healthcare facility shall be reviewed as the demand may increase due to the influx of workers. Due to the dry winter season, water shortages may occur and may compromise the health and sanitation of the community and project workers. During operation, however, road safety and community health and safety are anticipated to significantly improve with the installation of safety features on widened roads.	Environmental and Social Management Plan (ESMP) including the following: • Workers Accommodation Management Plan • Influx Management Framework • Gender Action Plan • SEA/SH Action Plan • Grievance Redress Mechanism (GRM)
ESS-5 Land Acquisition, Restrictions on Land Use and Involuntary Resettlement	a) Protect and conserve biodiversity and habitats b) Apply the mitigation hierarchy and the precautionary approach in the design and implementation of Projects that could have an impact on biodiversity c) Promote the sustainable management of living natural resources	The physical activities to be implemented under the Project are expected to require land acquisition and population displacement on a limited scale, although the part of the proposed route are the existing roads owned by the RGOB. The impacts on communities, businesses and common property, livelihood activities, and issues related to hindering access to neighboring	ESIA report including the following: • Environmental Impact assessment including air quality, noise impact, water & hydrology, general physical environment and biodiversity • Critical Habitat Assessment (CHA) • Climate Change Risk Assessment (CCRA) • Greenhouse Gas Emission Calculation

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	d) Support livelihoods of local communities, including indigenous peoples, and inclusive economic development, through the adoption of practices that integrate conservation needs and development priorities	settlements are expected. Appropriate compensation arrangements will be made to the affected households/individuals including replacement land at par in terms of quality and suitability. However, hill cutting at some sections through settlements may pose threat of displacement of housing from potential risks of landslide and vibration effects. Accordingly, the ESS-5 is applicable to the Project.	• Social Impact Assessment (SIA) • Cultural Impact Assessment • Cumulative Impact Assessment (CIA) • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP) Environmental and Social Management Plan (ESMP) including the following: • Biodiversity Management Plan (BMP) • Invasive Species Management Plan • Grievance Redress Mechanism (GRM) • Worker Accommodation Management Plan
ESS-6 Biodiversity Conservation and Sustainable Management of Living Natural Resources	a) protect and conserve biodiversity and habitats; b) apply the mitigation hierarchy and the precautionary approach in the design and implementation of Projects that could have an impact on biodiversity; c) promote the sustainable management of living natural resources, and; d) support livelihoods of local communities, including indigenous peoples, and inclusive economic development, through the adoption of	Based on the secondary desktop review, stakeholder consultations and primary baseline survey, the project footprint and its vicinity provide movement pathways and are critical habitat for Asian Elephant and the Gee's Golden Langur. Land clearing activities for acquiring the right of way of the Road will result in some habitat loss and increased habitat fragmentation. River training works are also expected to result in increased erosion and sedimentation, which would subsequently decrease	ESIA report including the following: • Biodiversity impact assessment • Critical Habitat Assessment (CHA) • Cumulative Impact Assessment (CIA) Environmental and Social Management Plan (ESMP) including the following: • Biodiversity Management Plan (BMP) • Invasive Species Management Plan

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	practices that integrate conservation needs and development priorities.	aquatic habitat quality downstream of the Project.	
ESS-7 Indigenous-Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities	a) Ensure that the development process fosters full respect for affected parties' human rights, dignity, aspirations, identity, culture, and natural resource-based livelihoods; b) Promote sustainable development benefits and opportunities in a manner that is accessible, culturally appropriate, and inclusive; c) Improve Project design and promote local support by establishing and maintaining an ongoing relationship based on meaningful consultation with affected parties; d) Obtain the Free, Prior, and Informed Consent (FPIC) of affected parties in three circumstances. Recognize, respect, and preserve the culture, knowledge, and practices of Indigenous Peoples, and to provide them with an opportunity to adapt to changing conditions in a manner and in a timeframe acceptable to them.	The validation and performing of meaningful consultations with informed consent approach will be required if the situation warrants.	ESIA report including the following: • Social Impact Assessment (SIA) • Cultural Impact Assessment • Cumulative Impact Assessment (CIA) • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP) Environmental and Social Management Plan (ESMP) including the following: • Cultural Heritage Management Plan • Grievance Redress Mechanism (GRM) • Worker Accommodation Management Plan • Community Development Framework
ESS-8 Cultural Heritage	a) Protect cultural heritage from the adverse impacts of Project activities and support its preservation;	Bhutan defines tangible and intangible cultural heritage. Tangible cultural heritage includes movable cultural heritage (paintings, sculptures, coins, manuscripts, etc.), immovable cultural	ESIA report including the following: • Cultural Impact Assessment • Stakeholder Engagement Plan (SEP)

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	b) Address cultural heritage as an integral aspect of sustainable development; c) Promote meaningful consultation with stakeholders regarding cultural heritage; d) Promote the equitable sharing of benefits from the use of cultural heritage.	heritage (monuments, archaeological sites, and so on), and underwater cultural heritage (shipwrecks, underwater ruins and cities and so on). Intangible cultural heritage includes oral traditions, performing arts, rituals, and so on. Bhutan has a rich cultural heritage (including extant cultural characteristics and traditions), well-preserved. The locations of the cultural heritage (tangible and intangible) sites should be identified within the Project area. The ESS-8 is applicable to the Project.	Environmental and Social Management Plan (ESMP) including the following: • Cultural Heritage Management Plan • Grievance Redress Mechanism (GRM)
ESS-9 Financial Intermediaries	a) Sets out how Financial Intermediaries (FI) will assess and manage environmental and social risks and impacts associated with the sub-Projects it finances; b) Promote good environmental and social management practices in the sub-Projects of the FI finance. Promote good environmental and sound human resources management within the FI.	The ESS-9 is not applicable to the Project.	NA
ESS-10 Stakeholder Engagement and Information Disclosure	a) Establish a systematic approach to stakeholder engagement that will help Borrowers identify stakeholders and build and maintain a constructive	The Project will involve a wide variety of stakeholders during its Project cycle that are associated with activities under other components of the Project such as Road Safety.	ESIA report including the following: • Stakeholder Engagement Plan (SEP) • Resettlement Action Plan (RAP)

WB ESF's ESS	Objectives	Requirements and Applicability to the Project	Deliverables / Assessments
	relationship with them, in particular Project-affected parties; b) Assess the level of stakeholder interest and support for the Project and to enable stakeholders' views to be considered in Project design and environmental and social performance; c) Promote and provide means for effective and inclusive engagement with Project-affected parties throughout the Project life cycle on issues that could potentially affect them; d) Ensure that appropriate Project information on environmental and social risks and impacts is disclosed to stakeholders in a timely, understandable, accessible and appropriate manner and format, and; e) Provide Project-affected parties with accessible and inclusive means to raise issues and grievances and allow Borrowers to respond to and manage such grievances.	Key stakeholders will be identified, and a Stakeholder Engagement Plan will be drawn up to involve them during the Project implementation. Project information on environmental and social risks and impacts will be disclosed to the stakeholders.	Environmental and Social Management Plan (ESMP) including the following: • Cultural Heritage Management Plan • Grievance Redress Mechanism (GRM) • GRM responsive to SEA/SH Resettlement Plan

3.2.2 WORLD BANK GOOD PRACTICE NOTES, TEMPLATES, AND CHECKLISTS

To guide clients in their use of the ESF, the WB is developing additional resources, including Good Practice Notes, Templates and Checklists. However, these are not WB policies, and their use is not mandatory.

3.2.2.1 GOOD PRACTICE NOTES

The World Bank's Good Practice Notes (GPNs) are designed to assist staff and borrowers in implementing the Environmental and Social Framework (ESF). These guidelines offer practical advice but are not mandatory. The GPNs that related to the Project include[15]:

- Water use;
- Third party monitoring;
- Road safety;
- Non-Discrimination: Sexual Orientation and Gender Identity (SOGI);
- Non-Discrimination and Disability;
- Gender;
- Assessing and Managing the Risks of Adverse Impacts on Communities from Project-Related Labor Influx;
- Assessing and Managing the Risks and Impacts of the Use of Security Personnel;
- Addressing Sexual Exploitation and Abuse and Sexual Harassment in IPF involving Major Civil Works; and
- Addressing Sexual Exploitation and Abuse and Sexual Harassment (SEA/SH) in Human Development Operations.

3.2.2.2 TEMPLATES AND CHECKLISTS

Templates and Checklists are essential resources for ensuring consistent and efficient implementation of Projects.

Templates, and checklists have been produced by the World Bank to guide their clients and staff in the use of the Environmental and Social Framework. Those templates, and checklists most relevant to the Project are identified below:

- Environmental and Social Commitment Plan;
- Labor Management Procedures Template; and
- Stakeholder Engagement Plan.

3.2.3 EHS GUIDELINES/ WBG'S GENERAL EHS GUIDELINES

The WBG EHS Guidelines are technical reference documents with examples of Good International Industry Practice (GIIP). The guidelines provide the general approach to the management of EHS issues at Project level on Environmental, Occupational Health and Safety, Community Health and Safety, and Construction and Decommissioning.

Among them, WBG General EHS Guidelines on Construction and Decommissioning relevant to the Project are noise control strategies, reduction measures for disturbance to water bodies, safety measures for site hazards, etc. The applicability of the guidelines should be adjusted to

[15] Good Practice Notes. World Bank Group. https://www.worldbank.org/en/projects

fit the Project's hazards and risks, determined during the assessment process. When host country regulations contrast from the levels and measures presented in the guidelines, the Project is expected to utilize whichever is more stringent.

3.2.4 WBG'S EHS GUIDELINES FOR TOLL ROADS (2007)

The WBG's EHS Guidelines for Toll Roads include information relevant to construction, operation and maintenance of large, sealed road Projects including associated bridges and overpasses. The elements of this Guideline document apply to smaller scale and / or unsealed road Projects[16].

These guidelines prioritize minimizing environmental impacts by recommending careful selection of alignment, eco-friendly design, and construction practices that address air and noise pollution, stormwater management, and soil erosion control. Biodiversity conservation is a key focus, with guidelines advocating for thorough environmental impact assessments to understand and mitigate potential effects on local ecosystems and wildlife habitats. Measures for controlling air emissions, noise pollution, and water contamination are integral to the framework. The guidelines also highlight the importance of effective waste management, and robust health and safety plans, including traffic management and emergency response strategies. Ongoing monitoring, active stakeholder engagement, and strict adherence to local and international regulations are emphasized to ensure both environmental and social sustainability throughout the lifecycle of toll road Projects.

3.2.5 GOOD PRACTICE HANDBOOK ON CUMULATIVE IMPACT ASSESSMENT AND MANAGEMENT

The Good Practice Handbook on CIA and Management provides guidance for assessing and managing cumulative impacts in project development, especially in environmentally sensitive areas. It outlines methods for identifying the combined effects of multiple activities, considering both direct and indirect impacts on ecosystems, communities, and resources. The handbook helps organizations develop strategies to mitigate these impacts, ensuring sustainable development and environmental stewardship, particularly in sectors like infrastructure, mining, and energy. It promotes good practices to improve decision-making and reduce negative long-term consequences.

CIA should be conducted when there is concern that a project or activity may contribute to cumulative impacts on one or more valued environmental components (VECs). CIA is also relevant when a development is expected to cause significant or irreversible effects on the future condition of one or more VECs, particularly when those VECs are or will be impacted by other ongoing or future developments. Therefore, it is applicable to the Project as it helps to identify the combined effects of different developments over time, assess potential significant or irreversible impacts, and propose mitigation strategies to manage these cumulative effects. The ultimate goal is to inform decision-making processes, ensuring that development occurs sustainably while minimizing negative long-term consequences on ecosystems, communities, and resources.

[16] World Bank Group (2007), Environmental, Health, and Safety Guidelines for Toll Roads. Available from: https://www.ifc.org/content/dam/ifc/doc/2000/2007-toll-roads-ehs-guidelines-en.pdf

3.2.6 GAPS BETWEEN NATIONAL LEGISLATION AND WORLD BANK'S ESF

The gaps between Bhutan's environmental /social framework and ESS standards are summarized in ***Table 3.11***.

TABLE 3.11 GAPS BETWEEN NATIONAL LEGISLATION AND ESS

ESS	Bhutan Key Legislation and Subsidiary Rules [b]	Gaps between ESSs and Bhutan's regulatory requirements	Gap-bridging measures
ESS-1 Assessment and Management of Environmental and Social Risks and Impacts	Environmental Assessment Act 2000 Regulation for Environmental Clearance of Projects 2006 National Environment Protection Act 2007 Environmental Assessment Guideline for Roads and Highways 2012 Environmental Standards, 2020	The national law of Bhutan does not have clear guidelines for developing EIAs. The scope of an EIA may not cover all the aspects required in WB ESS, and especially lacks guidance on social impact assessment including labor issues, vulnerable groups etc. The national law of Bhutan does not emphasize a hierarchy of measures in environmental and social risk management.	The ESIA will assess the proposed project plans and technical assistance activities to meet both government and World Bank standards. Social impacts will be addressed comprehensively in several deliverables and management plans. The proposed mitigation measures will follow a hierarchical approach. The key mitigation measures start with road alignment and facilities location to avoid sensitive habitats. The ESMP is developed in accordance with Environmental, Social, Health, and Safety Guidelines (ESHG) and Good International Industry Practices (GIIPs).
ESS-2 Labor and Working Conditions	Labor and Employment Act of Bhutan 2007 Regulations on Working Conditions 2022 Regulation on Foreign Workers Management 2022	There are gaps and inadequacies, particularly in gender-based violence (GBV/SEA/SH), gender equality and equal pay for equal work.	There are gaps in enforcement and comprehensive safeguards for vulnerable workers, especially migrants. The gaps will be addressed in ESMP, Influx Management Plan and Worker Accommodation Management Plan.

	General Rules and Regulations on Occupational Health and Safety (OHS) in Construction, Manufacturing, Mining and Service Industries 2006		Stakeholder Engagement Plan (SEP) and Grievance Redress Mechanism (GRM); GRM responsive to SEA/SH Gender Action Plan will also be prepared.
ESS-3 Resource Efficiency and Pollution Prevention and Management	Environmental Codes of Practice (ECP) (Highways and Roads) 2000 Waste Prevention and Management Act of Bhutan 2009, 2012, 2016	Bhutan lacks comprehensive regulations on resource efficiency, GHG emission reduction and water use. Bhutan lacks detailed, enforceable regulations for specific pollutants, particularly in relation to hazardous waste management, chemical pollution, and soil contamination. However, resources should be used efficiently, minimizing pollution and managing hazardous waste according to best practices.	The project will comply with WBG EHS and Bhutan national standards, depending on which is more stringent for pollution prevention and resource efficiency. Resource efficiency and GHG emissions related to project activities are addressed in the ESIA and ESMP.
ESS-4 Community Health and Safety	General Rules and Regulations on Occupational Health and Safety (OHS) in Construction, Manufacturing, Mining and Service Industries 2006 Disaster Management Act of Bhutan 2013 Disaster Management Rules and Regulations 2014	National legislation focuses on natural hazards and emergency response while ESS-4 requires projects to integrate preparedness for both natural and man-made risks. ESS-4 requires detailed plans to prevent public exposure of harmful exposure as well as manage waste and pollution from construction and operation activities.	Unplanned events are included as part of ESS-4. The road design has incorporated geophysical and climate-change risks. The project's ESMP will address all community health and safety issues identified. Stakeholder Engagement Plan (SEP) and Grievance Redress Mechanism (GRM); GRM responsive to SEA/SH A Gender Action Plan will also be prepared.
ESS-5 Land Acquisition, Restrictions on Land Use	Land Act 1979 (amended 2007)	The Land Act 1979 requires resettling assessment yet a generic Resettlement Policy Framework is lacking, which leads to limitations on the attention to livelihood restoration, vulnerable groups, consultation, and grievance mechanisms.	The gap-bridging will be completed with the Resettlement Action Plan (RAP).

and Involuntary Resettlement	Land Acquisition and Compensation Rules and Regulations 2022		
ESS-6 Biodiversity Conservation and Sustainable Management of Living Natural Resources	Forest and Nature Conservation Act (FNCA) 1995 Forest and Nature Conservation Rules 2006 Biological Corridor Rules 2007 Elephant Conservation Action Plan for Bhutan 2018-2028 Biodiversity Monitoring and Social Survey Protocol of Bhutan 2020 Guidelines for Wildlife Habitat Management 2021 Biodiversity Act of Bhutan 2022	National legislation generally aligns with ESS-6, strengthening the management of wildlife habitats, the sustainable use of natural resources with international standards, the control of invasive species, and the adoption of biodiversity offsets for residual impacts. Critical Habitat Assessment is not required under national regulation.	As part of biodiversity impact assessment, the habitat category of the area in accordance with ESS6's definition of modified habitat, natural habitat, and critical natural habitat are assessed. Biodiversity Management Plan and Invasive species Management Plan are included as part of ESMP.
ESS-7 Indigenous-Peoples/Sub-Saharan African Historically Underserved Traditional Local Communities	-	ESS-7 focuses on protecting and fostering the rights, culture, identity, and livelihoods of Indigenous Peoples (IPs) and other underserved traditional local communities impacted by development projects. It aims to ensure that projects respect Indigenous Peoples' dignity, human rights, and cultural identity, and that they benefit from development projects while avoiding or minimizing negative impacts.	As part of the ESIA & ESMP, the following are included to bridge the gap: 4. Social Impact Assessment (SIA) 5. Cultural Impact Assessment 6. SEP & GRM
ESS-8 Cultural Heritage	The Movable Cultural Property Act of Bhutan 2015	The local act conserves Bhutan's movable cultural property by regulating the sale and export of non-valuable items. ESS-8 focuses on protecting cultural heritage that may be impacted by the project. The objective is to ensure that development projects respect and preserve cultural heritage, avoid its destruction or damage, and involve local communities in its protection.	As part of the ESIA & ESMP, cultural heritage assessment is included to bridge the gap.

ESS-9 Financial Intermediaries	Not applicable.		
ESS-10 Stakeholder Engagement and Information Disclosure	-	There are no national regulations on the process or requirements on stakeholder engagement. Stakeholder engagement including grievance mechanism and proactive information disclosure. SEP & GRM are required under ESS-10.	As part of the ESIA & ESMP, Stakeholder Engagement Plan (SEP) and Grievance Redress Mechanism (GRM); GRM responsive to SEA/SH

Note:

[a] Based on BHUTAN: OVERVIEW ASSESSMENT OF COUNTRY'S FRAMEWORK FOR ASSESSING AND MANAGING ENVIRONMENTAL AND SOCIAL RISKS AND IMPACTS OF DEVELOPMENT PROJECTS, World Bank Group

[b] Refer to *Table 3.1* and *Table 3.2* for detail.

4. ANALYSIS OF ALTERNATIVES/ PROJECT ALTERNATIVES AND ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

An alternatives analysis is a fundamental component of the mitigation hierarchy and its objective of avoiding and minimizing environmental and social impacts. Consideration of alternatives is also a key component of documenting why the proposed design is the preferred option for achieving the project purpose, taking into consideration and balancing environmental, social, engineering and cost considerations. Alternatives analysis is also an essential component of the ESIA that takes into consideration the valid concerns of project-affected people, adjusting the project design accordingly.

The WB ESS-1 requires a systematic comparison of feasible alternatives to the proposed site/location, design/technology, and operation, as well as consideration of the "without project" situation – in terms of their potential environmental and social impacts (WB, 2018). It is a critical ESIA component, especially for projects deemed by the WB to be of substantial or high risk.

The importance of alternatives is also reflected in the Bhutan EIA regulations, which require consideration of alternatives. The national Environmental Assessment Guideline for Roads and Highways (2012) recommends considering site alternatives and design alternatives with justification chosen for the preferred alignment.

The alternative analysis will focus on the alignment/site alternatives considering from design and environmental and social risks and impacts perspectives.

4.1 WITHOUT PROJECT ALTERNATIVE

The "Without Project Alternative" means that the Gelephu – Tareythang Road Project would not be developed and would not be available for increased connectivity and transport between the two cities.

The current travel distance on the existing roads between Gelephu and Tareythang is approximately 45 km (***Figure 4.1***) and the journey typically takes 1 hour 20 minutes. The narrow roads are single carriageways with one lane in each direction, and wind their way through steep terrain. This routing crosses various rivers on narrow bridges which only permit one-way traffic, located a considerable distance north of the direct line from Gelephu to Tareythang. Some areas of the existing road connection are vulnerable to landslides, which cause blockages and cut off the connection between the two (02) cities. The section of road on the west bank of the River Mau, approximately 1.2 km before the bridge crossing to Serzhong Gewog is especially vulnerable to severe damage from landslides.

At the Langer River, Taklai River and Jengkhurung River suspension bridges for pedestrian crossing are located to the south. Small vehicular bridges are located north along the existing road Gelephu to Tareythang shown in ***Figure 4.1***. It is noted that across these three (03) rivers, traffic also crosses by driving across the riverbed close to the pedestrian crossings. In the wet season, this riverbed crossing can become impassable due to flowing water, severing the connection and forcing all traffic onto the road to the north.

It is considered that the existing roads will not be able to provide safe and efficient access to the new GMC.

The Gelephu – Tareythang Road construction was also part of the overall masterplan to support the GMC. The plan is for the new city in Gelephu to establish an economic hub for Bhutan with efficient and reliable connectivity noted as one of three immediate priority areas. The objective of the Project is to increase the efficiency and resilience of trade and transport along the corridor from Gelephu to Tareythang, parallel with the border with India. It is part of a wider plan to improve east-west connectivity across the whole of southern Bhutan through the long-term development of the Southern East-West Highway from Samtse in the west to Samdrupjongkhar in the east.

Table 4.1 details the key environmental and social impacts of the "Without Project" alternative against the potential impacts of the Project.

TABLE 4.1 POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS OF THE "WITHOUT PROJECT" ALTERNATIVE COMPARED TO THE PROJECT IMPACTS

	Potential Project Impacts	Without Project Alternative
Physical Components	• Potential negative impacts to ambient air quality, ambient noise, surface water quality & hydrology, groundwater quality and soils during construction and operation. • Impacts to be mitigated through embedded mitigation, avoidance and minimization measures and best practices during construction and operation.	• No changes to physical environmental components due to the Project, however, physical components would continue to be affected by other activities, interactions or drivers (human or natural) in the area.
Biological Components	• Degradation of habitat, wildlife conflict and impacts to ecosystem services. • Impacts to be mitigated through embedded mitigation, avoidance and minimization measures and best practices during construction and operation.	• No change to biological components due to the Project, however, biological components would continue to be affected by other activities, interactions, or drivers (human or natural) in the area.
Social Components	• Physical displacement during construction. • Long-term positive impact on the efficiency and resilience of trade and transport in the region, with positive impact on communities and socio-economics. • Increased road safety on program corridors.	• No physical displacement compared to the Project. • No positive impacts to trade and transport in the region. • No improvement to road and travel safety. • No facilitation of the GMC objectives.

It is noted that the "Without Project Alternative" would avoid the environmental and social risks and impacts associated with construction and operation of the Proposed Project.

However, not constructing the Project would not address the needs of the country to increase the efficiency and resilience of Bhutan's trade and transport in the south of Bhutan. The project is designed to strengthen trade connectivity with India and to form a key link within the Southern East-West Highway planned for the longer-term, and support the GMC development.

A number of enabling conditions need to be met in order to foster the establishment of core and non-core economic clusters at the GMC. Success factors noted in the economic framework for the GMC are the quality and availability of infrastructure and connectivity and accessibility. The Project will provide quality infrastructure to enable trade and will provide accessibility and

connectivity to enable key future projects of the GMC. This includes the potential Tareythang Education and Business Retreat Centre which will rely on the express road to Tareythang.

The Project is expected to reduce costs of trade and transport through the high-capacity direct road connection between Gelephu and Tareythang. The Project will achieve enhanced connectivity by increasing throughput at priority border points and reducing average travel time for vehicles along selected regional corridors.

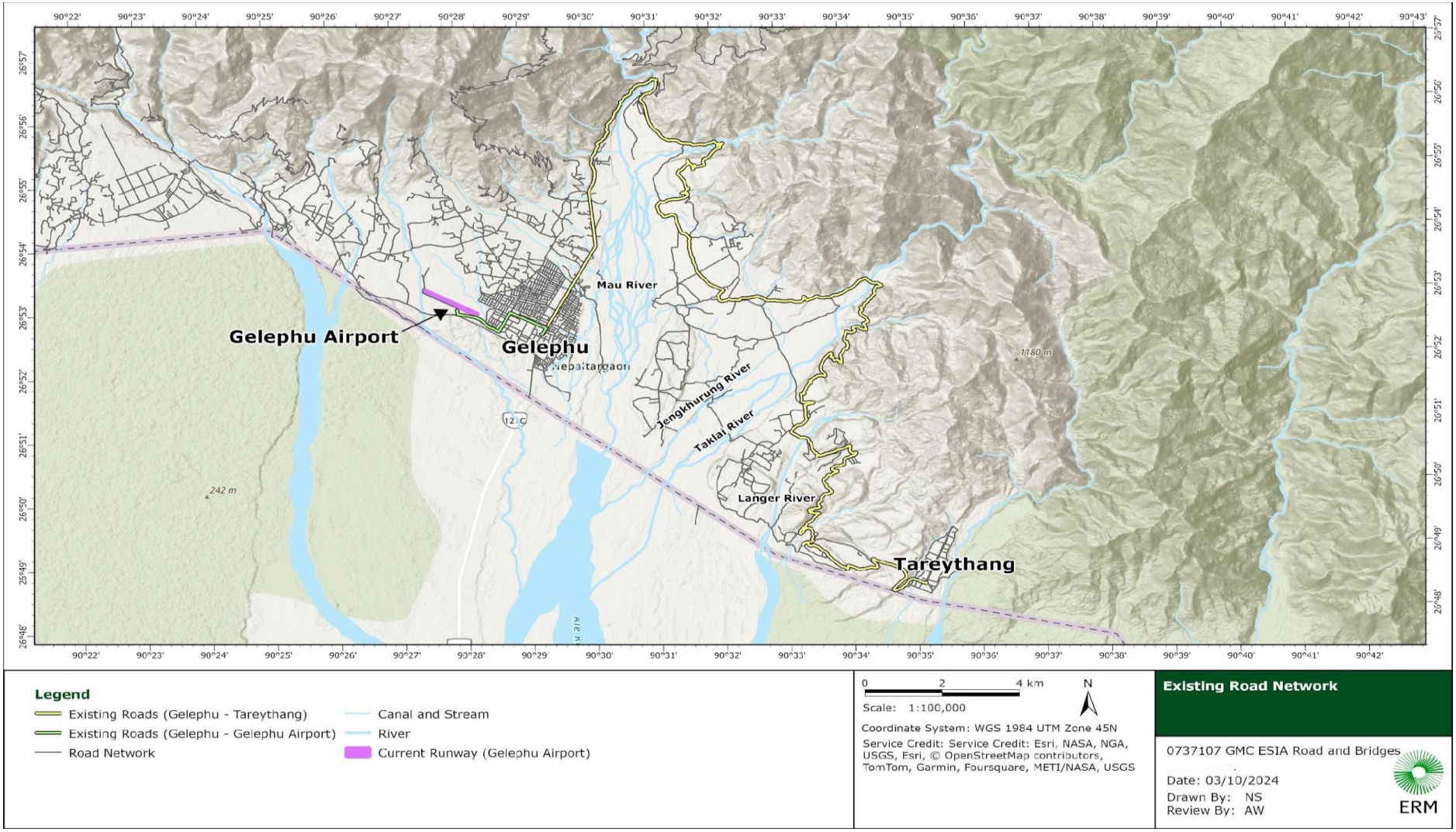
The road will be designed to National Highway standard and will ensure a reduction in annual fatalities on program corridors as a result of appropriate design and construction to address the risks of land slides and flooding in the area. It will increase the number of people provided with resilient road access along regional corridors.

The new road link will:

- Provide a direct high quality road link between Gelephu and Tareythang;
- Facilitate the international airport, dry port and multi-modal transport hub planned for Gelephu;
- Provide connectivity between the various phases of the GMC developments, currently under planning;
- Overcome existing difficulties of narrow and winding roads which are vulnerable to landslides; and
- Provide resilient crossings of the rivers in the area so that mobility is not hindered by flooding.

In summary, the "Do Nothing" Alternative would not take advantage of a unique and well-structured highway which would enhance the Bhutan trade and transport strategic plan and facilitate the safe access to the new GMC. For these reasons, the Without Project Alternative is not the preferred alternative.

FIGURE 4.1 EXISTING ROADS CONNECTING GELEPHU CITY AND AIRPORT AND TAREYTHANG



4.2 SITE/LOCATION ALTERNATIVES - ALTERNATIVE ALIGNMENTS

4.2.1 OVERVIEW

The proposed highway needs to be located within an approximately 1 km wide area between the Indian border to the south and the steeper mountain slopes to the north. Routes further north into the foothills would require more land disturbance and be more prone to landslides, so were not considered further. Three basic alignments were developed.

- Northern Alternative - which is further away from the Indian border than the Central Alternative and closer to the foothills;
- Central Alternative – which is parallel to and approximately 600 m from the Indian border and is the most direct alignment; and
- Southern Alternative - which is closer to the Indian border than the Central Alternative.

The segments for each of these three alternatives are summarized below in **Table 4.2** and shown in ***Figure 4.2***. In some cases, combinations of these three alternatives were considered by road segment.

The entire southern region of Bhutan is recognized as an essential elephant corridor, playing a crucial role in the movement and migration of these species. The project area, in particular, is situated within this corridor and is considered a critical habitat for elephants. This region supports key ecological functions for the species, including feeding, breeding, and migration routes. Given the importance of this area, there are no feasible alternatives that would completely avoid impacts on the elephant corridor. Any alternative location or approach would still result in some form of disruption to this critical habitat.

FIGURE 4.2 ALIGNMENT ALTERNATIVES

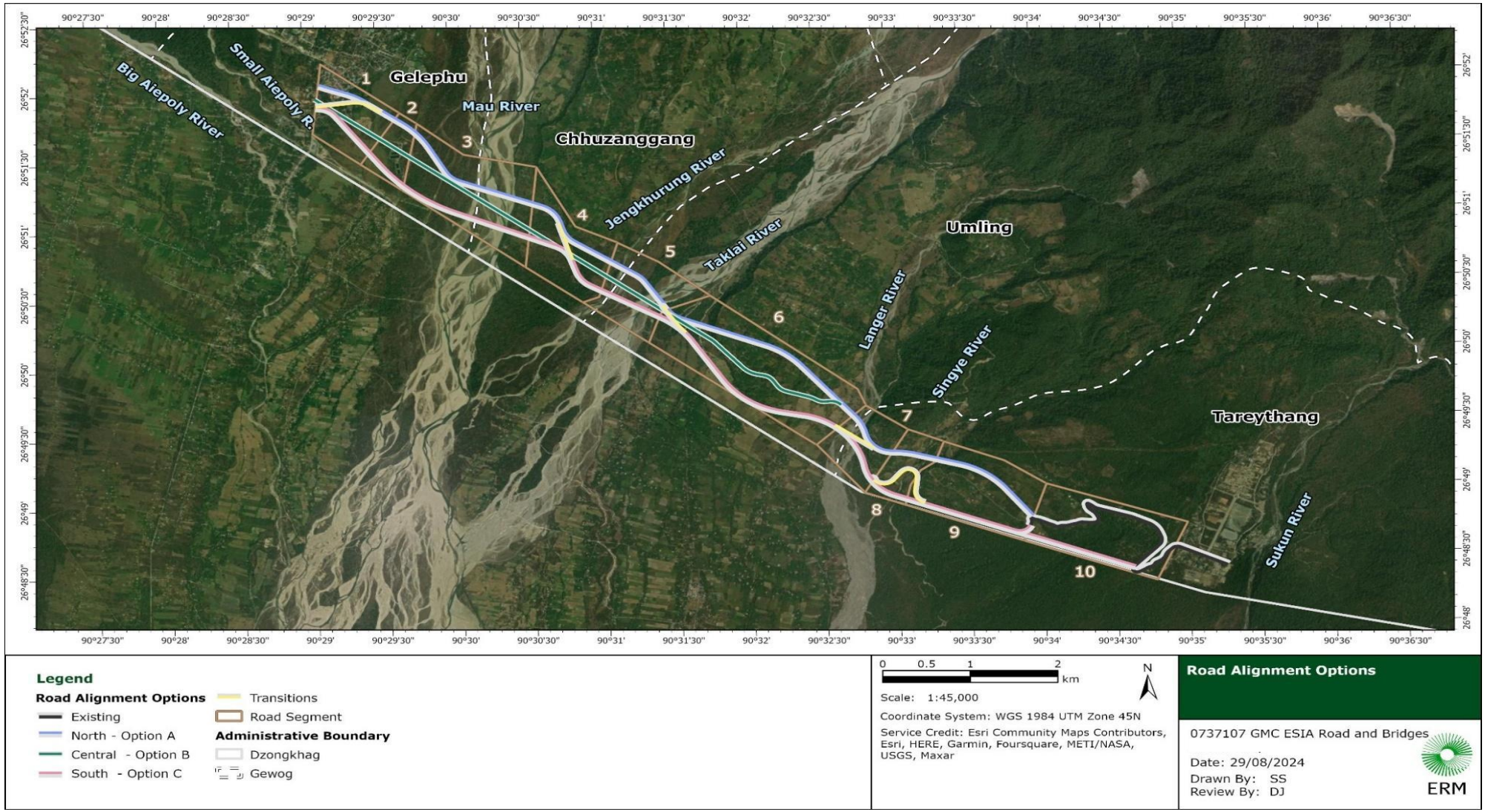


TABLE 4.2 ALIGNMENT ALTERNATIVES SEGMENT SUMMARY

	Northern Alternative	Central Alternative	Southern Alternative	Transitions
Segment 1	In Gelephu, the alignment uses the first part of the existing road, Gatshel Lam SE, and then continues east where the existing road turns south.	The alignment connects to the existing north-south road, S Ngedrup Zhung Lam, through Gelephu, at a location approximately 700 m north of the Indian border. It traverses the Namkhaling Municipality and merges to align with the existing Gatshel Lam SE, which would need to be realigned if it is retained.	At the west end of the Project, the proposed new road will connect to the existing north-south road, S Ngedrup Zhung Lam, through Gelephu, at a location approximately 700 m north of the Indian border. It traverses the Namkhaling Municipality, south of the existing road, Gatshel Lam SE, which leads to the Sewerage Treatment Plant.	**Transition 01** The starting point is the same as the proposed alignment avoiding impact to Gatshel Lam SE. The alignment then deviates north, crossing over Gatshel Lam SE, the access road to the Sewerage Treatment Plant, necessitating a bridge to prevent any impact on the road.
Segment 2	The alignment passes to the north of the existing Sewerage Treatment Plant rather than to the south.	The alignment continues straight and passes through the location of the Sewerage Treatment Plant which needs to be relocated.	The proposed alignment passes to the south of the Sewerage Treatment Plant, approximately 280 m from the Indian border.	-
Segment 3	The alignment crosses the Mau River approximately perpendicular to the flow direction to minimize the length of bridge structure. The location of the Mau River bridge crossing is approximately 400 m north of the proposed alignment.	The alignment continues straight and passes over the Mau River at an angle approximately 15° skewed related to a perpendicular crossing.	The proposed road will cross the Mau River approximately perpendicular to the flow direction to minimize the length of bridge structure. The normal river channels are around 500 m wide at this location, but under flood conditions the west bank becomes part of the river flows.	-

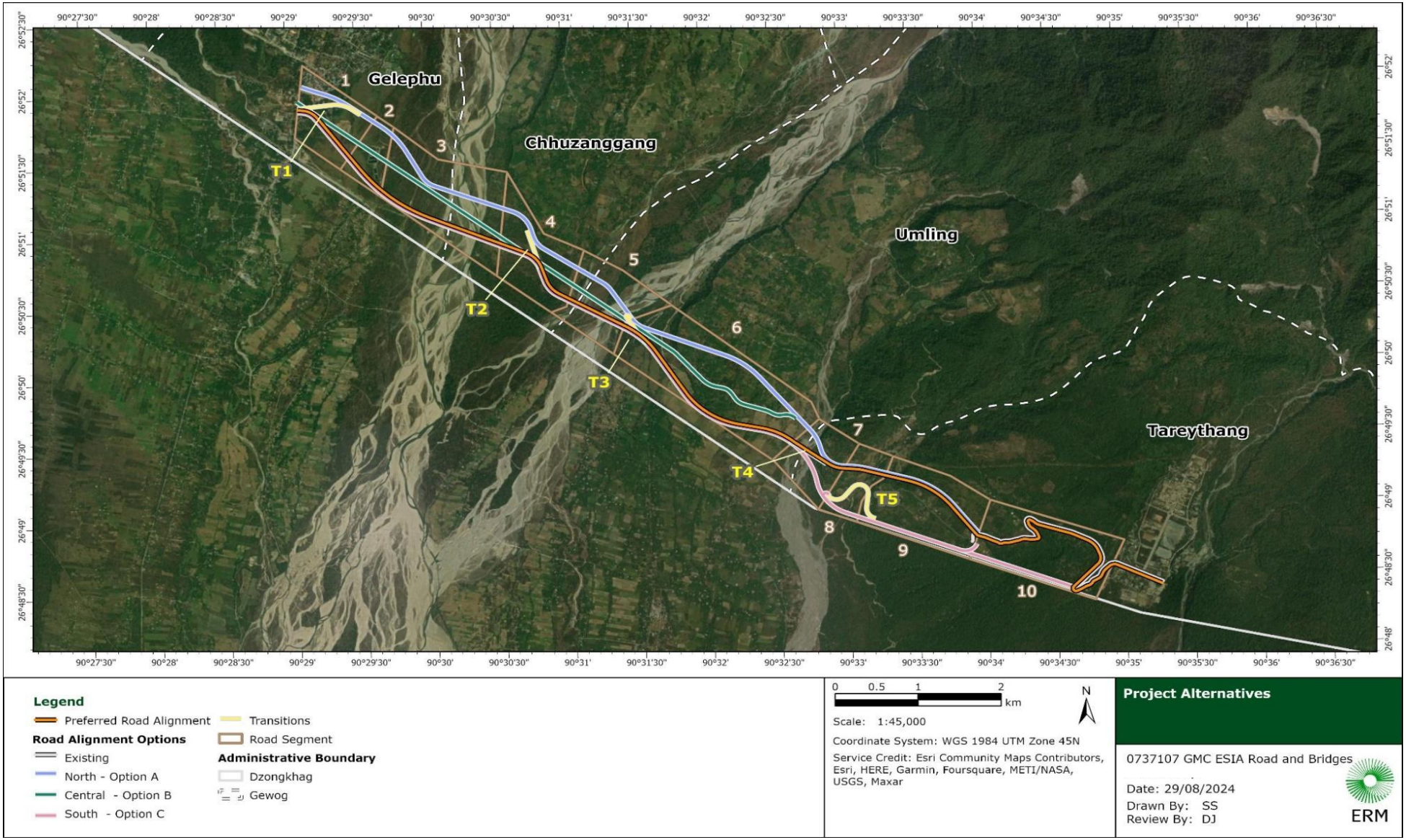
	Northern Alternative	Central Alternative	Southern Alternative	Transitions
Segment 4	In Chhuzanggang Gewog, this alignment deviates slightly south, to avoid the areas of higher ground, but remains north of the proposed alignment.	The alignment continues straight, rising up slightly in the west of Chhuzanggang Gewog to match existing ground levels, and then falling again in the east of Chhuzanggang Gewog.	In Chhuzanggang Gewog, the proposed alignment skirts around the southern edge of the higher ground, following the contours and minimizing level differences as much as possible.	**Transition 02** Connects the northern alignment to the southern alignment in the middle of segment 4 to avoid the higher ground level to the north.
Segment 5	The alternative alignment crosses the Jengkhurung River and Taklai River at different orientations, with the change in angle approximately halfway between the rivers.	The alignment continues straight and crosses the Jengkhurung and Taklai Rivers slightly north of the narrowest crossing point.	The proposed alignment is straight across both the Jengkhurung River and Taklai River, crossing them each approximately perpendicular to their flows. The bridge crossing here will be continuous over both rivers as the area between the reivers is subject to flooding. The alignment location is chosen to cross at the narrowest point from the west bank of the Jengkhurung River to the east bank of the Taklai River.	-
Segment 6	In Umling Gewog, the alignment climbs on structure to meet the top of a ridgeline. The routing remains at the higher level, before starting to descend steeply on the other side down towards the Langer River.	The alignment deviates slightly as it climbs to skirt around the lower portion of the higher ground in Umling Gewog.	In Umling Gewog, the proposed alignment skirts around the southern edge of the higher ground, following the contours and minimizing level differences as much as possible.	**Transition 03** Facilitates the connection of the northern alignment to the southern alignment just east of the Taklai River to avoid the higher ground level to the north.
Segment 7	The more northern routing allows the Langer River to be crossed at a narrower point, but on the east side, the alignment has to skirt around the edge and climb a steep slope.	Same as Northern Alternative.	Langer River is proposed to be crossed slightly to the south of its narrowest point, to avoid the steep bank on the east side of the river. The alignment climbs up on the east side to meet the higher ground level.	**Transition 04** Connects the southern alignment to the northern alignment allowing for the alignment to deviate north and cross Singye River at a narrower point.

	Northern Alternative	Central Alternative	Southern Alternative	Transitions
Segment 8	Although Singye River is typically a narrow channel, the ground levels to each side climb quite steeply, so a 400 m long bridge is proposed to cross from the west bank to the east bank.	Same as Northern Alternative.	The alignment is to the south, close to the Indian border. One option is to bridge over the Singye River valley, which requires a structure approximately 400 m long. An alternative is TS05 described below in ***Section 4.2.2***.	**Alternative Routing in Segment 8 – T5** To limit the extent of bridge structure required, an alternative way to cross the Singye River is to loop the alignment north, following the ground profile down to near the bottom of the valley, adding approximately 350 m to the length of the road.
Segment 9	The portion of the alignment in the western part of Tareythang Gewog, the proposed road will follow a shallow valley, north of the existing Gewog center. The alignment climbs steeply at first and then very gently to join to the existing road.	Same as Northern Alternative.	In the western part of Tareythang Gewog, the alignment runs approximately parallel to, and approximately 120 m from, the Indian border. Within this segment, this alignment climbs steeply from around +200 m at the edge of the Singye River to around +285m at the connection to the existing road.	-
Segment 10	In the eastern part of Tareythang Gewog, the proposed alignment merges with and follows the routing of the existing road, which will be widened.	Same as Northern Alternative.	In the eastern part of Tareythang Gewog, the alignment continues approximately parallel to, and approximately 120 m from, the Indian border.	-

4.2.1 PROPOSED PREFERRED ALIGNMENT

The preferred alignment (***Figure 4.3***) consists of the southern alignment from Segment 1 to 7 and then uses the Transition 04 in Segment 7 to connect to the northern alignment allowing for the alignment to deviate north and cross Singye River at a narrower point and then continues along the Northern route from Segments 8 and 9 and then connects to the existing roadway in Segment 10.

FIGURE 4.3 PREFERRED ALIGNMENT COMPARED WITH ALTERNATIVES



4.2.3 ANALYSIS OF ALTERNATIVE ALIGNMENT

The potential environmental and social risks and impacts associated with the three optional alignments (***Figure 4.2***) are screened using the criteria set out in ***Table 4.3.*** The key findings for each segment are discussed in this section.

It is noted that while the preferred alignment may not have the best outcome for each individual assessment, these have been weighed up together to ensure the least amount of negative impact overall.

In the table below ESS-1 and ESS-3 are excluded for physical environment. This is due to the geographical proximity of all options, which therefore mean they have a very similar risk of natural and geological hazards (such as Flooding and landslides, etc.), potential to generate air and noise emissions, waste generation and effect on local water bodies including water pollution and sediment runoff.

TABLE 4.3 KEY PRINCIPLES/CRITERIA FOR ROAD ALIGNMENTS

Aspects	Relevant WB's ESS	Key Principles/Criteria
Engineering	-	Overall Length
	-	Channel Crossings
Biodiversity	ESS-6	Effect on wildlife connectivity
	ESS-6	Coverage of natural habitat or forest area
Social	ESS-5	Extent of physically and/or economically displacement
	ESS-8	Impacts sites of cultural heritage value

Overall, the land cover for all options have similar land types as follows:

From Segments 1-2 The land cover in the area is transitioning from fallow agriculture land (i.e. modified habitat) to forest (i.e. Natural Habitat). Each option overlaps approximately 50% with Natural Habitat. There is no significant difference between options.

From Segments 3-5 - The land cover in the area is mostly forest (i.e. Natural Habitat). All options overlap with Natural Habitat for the majority of their extent. There is no significant difference between options.

From Segments 6-7 - The land cover in the area is mostly agriculture land and plantations of areca nut (i.e. modified habitat).

From Segments 8-10 – The widening of the existing road will significantly reduce the amount of forest clearance compared to a new road crossing the existing forest.

TABLE 4.4 SUMMARY OF ALTERNATIVE ANALYSIS

Item	Northern Route		Central Route		Southern Route		Preferred	
Overview	The northern route for the initial segments would require additional physical displacement and has greater river channel lengths to cross.		The central route crosses through the existing town and through the sewerage treatment plant. It also has longer river channel crossings		The southern route is very near to the Indian border from segment 7-10 and would impact a cultural heritage area.		The preferred route is a combination of the southern route until segment 7 and then transitions to the northern route to fit into the existing road. This combined route has the shortest river channel crossing distances resulting in shorter bridges and by using Transition 5 it limits the extent of bridge structure required compared to the southern route only. By deviating to the north it avoids cultural heritage areas and provides additional distance from the India border avoiding elephant natural habitat areas.	
Length	13.8 km		13.6 km		12.6 km		13.6 km	
River Channel Crossing	Mau River	500 m	Mau River	540 m	Mau River	490 m	Mau River	490 m
	Jengkhurung River to the Taklai River	750 m	Jengkhurung River to the Taklai River	650 m	Jengkhurung River to the Taklai River	590 m	Jengkhurung River to the Taklai River	590 m
	Langer River	190 m with T4 is only 180m	Langer River	190 m	Langer River	270 m	Langer River	T4 is 180m
	Singye River	30 m	Singye River	30 m	Singye River	30 m but with the Transition 05 is 40 m	Singye River	30 m
Cost	Total bridge length 3,410 m, with a very long bridge crossing (1,400 m) at		Longest total bridge length, 3,640 m.		Shortest total bridge length, 2,970 m. Benefiting from the alignment in Segments 5, 7 and 8 with the shortest		Lowest cost in construction as had the Shortest crossing of the Jengkhurung and Taklai Rivers.	

Item	Northern Route	Central Route	Southern Route	Preferred
	Jengkhurung & Taklai Rivers (Segment 5). Moderate construction cost.	Highest construction cost due to length of bridge structures required.	crossings of the Jengkhurung and Taklai Rivers, Langer River, and Singye River. High construction cost due to additional bridges required in Segment 10.	Avoids need for a 400 m long bridge across the valley in Segment 10 near the Indian border.
Biodiversity	The northern option results in a habitat loss of 20.3 ha for the entire length. From an elephant movement perspective, the Northern option would allow for a 500 m corridor for longitudinal movement along all segments.	The central option results in a habitat loss of 23.18 ha. From an elephant movement perspective, the Central option would allow for a 500 m corridor for longitudinal movement along all segments.	The southern option results in a habitat loss of 19.61 ha. From an elephant movement perspective, all options from Segment 1 to 7 allow the creation of a corridor for longitudinal movement with variations of width based on the alignment, which will be lower than 500 m in some sections. Sections 2, 3, and 6 of the alignment will require the corridor's width to be reduced to 250 meters. This is due to the proximity to the Indian border in these locations. However, there are currently no physical barriers along the Bhutan-India border, meaning that the corridor's width is defined by administrative boundaries rather than physical demarcations. Segment 8 to 10 in the southern option is the least preferred alignment as it is the closest to the forest at the Indian border. This may increase the risk of vehicle collisions with wildlife emerging from the forest.	The preferred options result in a habitat loss of 19 ha. The calculations for the habitat loss assumes that the current right of way of the existing road is 7.5 m, while the new road is considered to be 14m with a right of way of 30-40 mm. Therefore, vegetation clearance is still required when transitioning onto the existing road alignment. This alignment will allow for the creation of an approximately 500 m corridor for longitudinal movement of elephants which allows for wildlife conductivity and will avoid wildlife displacement. The widening of the existing roadway in Segment 10 will significantly reduce the amount of forest clearance compared to a new road crossing in the existing forest. The use of the existing road will have a lower impact on biodiversity overall, compared to opening up a new road through mature woodland and increasing fragmentation.

Item	Northern Route	Central Route	Southern Route	Preferred
			At Segment 10 it would require the opening of a new road crossing a dense patch of forest, clearing a significant higher amount of Natural Habitat and introducing a novel barrier for the movement of wildlife	
Social	The northern route would affect 195 land plots. This route avoids the existing sewage treatment plant, however, the Northern route in segment 1 crosses more of the existing town and would result in increased social disturbance and physical displacement. In the latter segments it has been designed to avoid physical displacement. The northern route is close to but avoids the Kuengachhoeling Lhakhang cultural heritage landmark.	The central route would affect 190 land plots. The central route would cross the existing town and existing sewage plant, of which the decommission date is currently unknown. It would also result in legacy issues such as potential land contamination resulting from the demolition of the sewage treatment plant.	The southern route would affect 184 land plots. The southern route avoids the existing town and covers fewer households as compared to the Northern and Central routes. The southern route would require Transition 5, which would cross very near to the Jangchub Chorten cultural heritage landmark.	The preferred route would affect 190 land plots. The preferred route crosses a moderate amount of land plots. However, it has been designed to have a minimal amount of physical displacement. The exact number of physical displacements is to be finalized following a census survey and asset inventory. The preferred route does not affect the existing Sewage Treatment Works and also avoids direct impact to cultural heritage areas.

4.3 TECHNOLOGIES AND DESIGN ALTERNATIVES

4.3.1 ROAD GEOMETRY

4.3.1.1 OVERVIEW

The aspiration for GMC is to develop a "15-minute" city with walkable neighborhoods and low usage of private cars. This strategy requires connectivity between Gelephu and Umling.

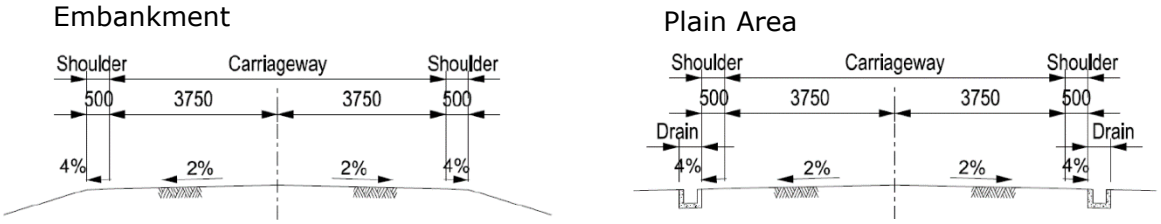
The GMC is to be developed over time and it was considered that the implementation of the dedicated Public Transport corridor will add significant cost at this early stage. Therefore, a phased approach is desirable, with Public Transport sharing the roadway initially, and a dedicated Public Transport corridor implemented later as a separate project.

4.3.1.2 DEVELOPMENT OF ROAD GEOMETRY

The Gelephu-Tareythang Road is planned as a Primary National Highway, being of strategic importance and carrying high traffic volume.

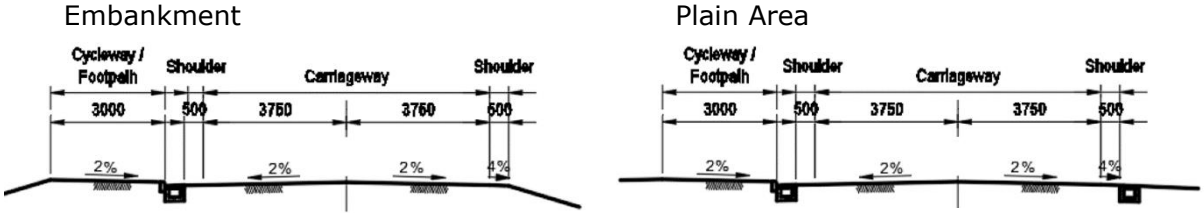
Road design follows the Bhutan Standard "ICS:93.080.10, Draft Bhutan Standard on Road Geometric Design and Alignment Requirements, Bhutan Standards Bureau", with enhancements based on international standards to improve safety. The highway alignment corridors were refined and developed into specific 3D geometry for various options (***Figure 4.4***).

FIGURE 4.4 EXAMPLE SINGLE CARRIAGEWAY ROAD GEOMETRY BASED ON BHUTAN STANDARDS



Further development of the road geometry was undertaken to incorporate the design objectives and aspirations of the GMC (***Figure 4.5***), particularly the inclusion of a shared use footpath and cycle path. In addition, precast concrete covers were added to open drainage.

FIGURE 4.5 EXAMPLE PROPOSED SINGLE CARRIAGEWAY ROAD GEOMETRY



4.3.2 BRIDGE FORMS

4.3.2.1 MAU RIVER CROSSING

For the Mau River Bridge the length of the bridge required is determined by the flood plain on the western side and the requirement for adequate clearance for elephant movements along the eastern riverbank. The extent of the flood plain on the western side is proposed to be limited with the use of river training measures. River training is also required along the eastern edge of the river to control ongoing erosion. A 250 m wide elephant corridor on eastern riverbank has been incorporated into the Project and therefore the vertical alignment is governed by this elephant corridor on the eastern side and the ground levels beyond the flood plain to the west.

The Mau River is strongly connected with the GMC development and therefore aligning the Mao River Bridge design with GMC values will significantly improve the pedestrian experience and demonstrate how infrastructure can create a greatest positive impact. One of the main strategies is the integration of vegetation to enhance biodiversity and provide the necessary separation between pedestrian and vehicular mobility.

For the longer crossings two options were considered for design development; the Concrete Box Girder and the Steel Struss bridges. The comparison of the alternatives is detailed in ***Table 4.5***.

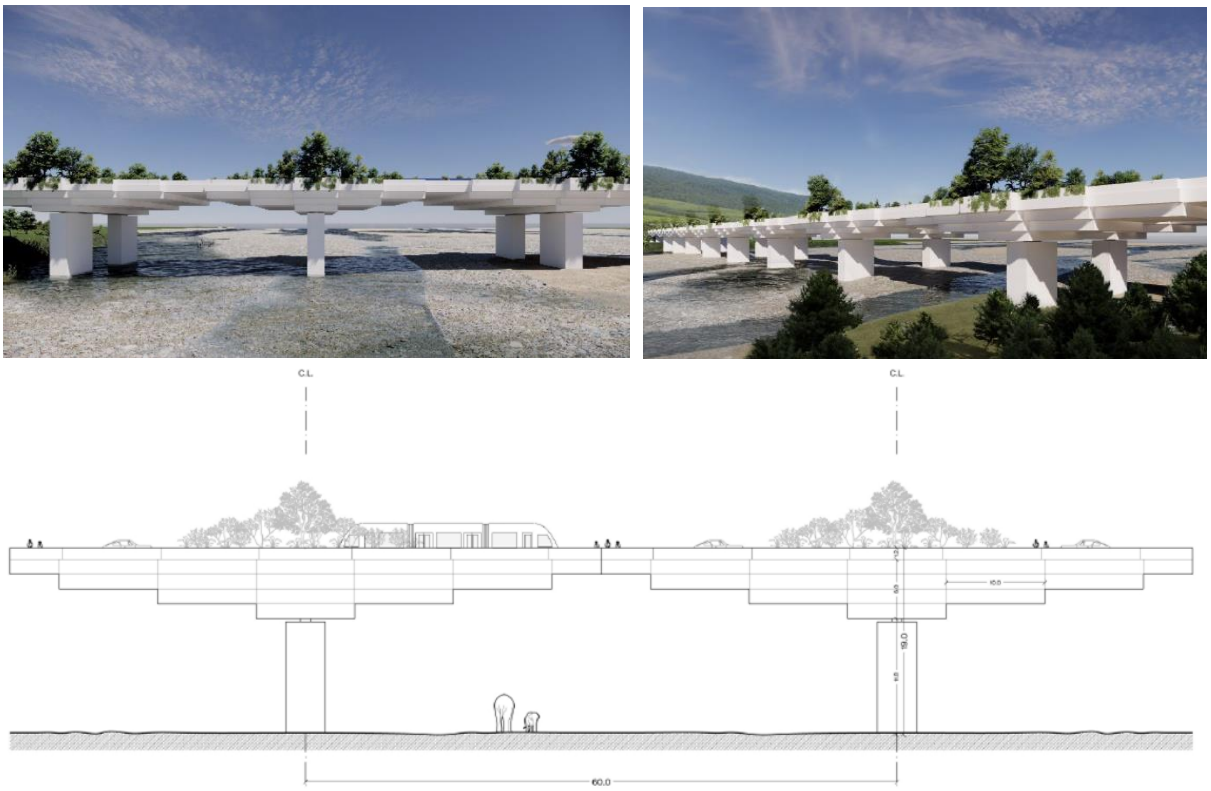
Concrete Box Girder

The concrete box girder bridge (***Figure 4.6***) uses the natural riverbed's sand and stone as a locally sourced construction material. The bridge is designed as a single level with horizontal mobility separation. The bridge has an optimal span for piers between 40-80 m with a clearance between 7-10 m providing sufficient clearance for the existing elephant corridor. A bridge structure with modest spans reduces the overall construction complexity and embodied carbon, however, will require additional piers within the riverbed; with 80 m spans between the piers there would be 6 piers in the river and an additional 3 piers in the floodplain.

The geometry of the concrete box girder bridge is composed of hollow structural sections that step outward to provide space for planted zones above the structural piers. The integrated planting aligns with the GMC principles of expanding ecologies, increasing biodiversity and reducing the bridge's carbon footprint with sequestration. Vegetation slows water runoff and improves heat island effect by shading the roadway during hot summer months. In addition, the structural piers created a geometry that references the profiles of traditional Bhutanese patterns, motifs and columns found in architecture throughout the country.

The planting and design of the piers will improve the pedestrian and vehicular experience, reduce the visual impact on the natural setting of Gelephu and evokes the long rich history of structures in Bhutan.

FIGURE 4.6 EXAMPLE DESIGN FOR A CONCRETE BOX GIRDER BRIDGE OVER THE MAU RIVER

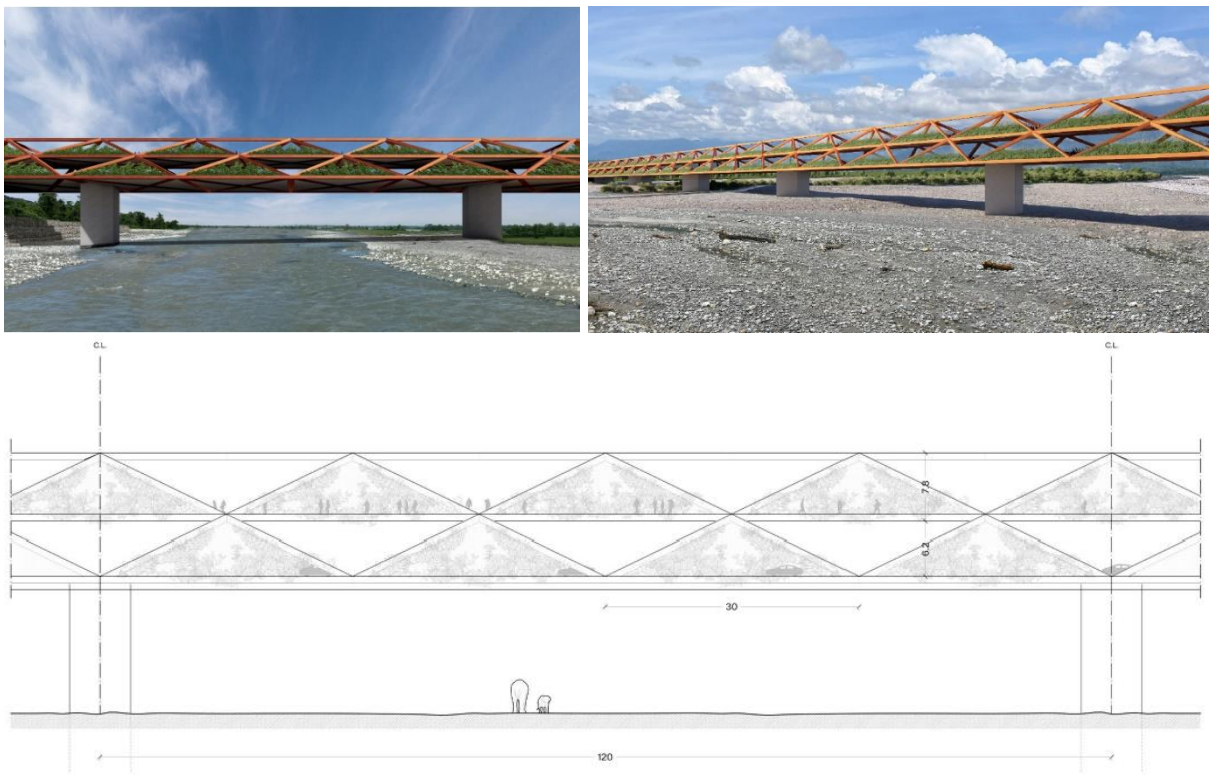


Steel Truss

The two-level triangle truss design (***Figure 4.7***) would be composed of prefabricated steel elements that allow for quick assembly on site. The overall bridge design allows for efficient use of material and structure by accommodating the full GMC mobility requirements within one structure and the additional structural height of the truss lowers its steel tonnage and embodied carbon. The steel truss allows for longer spanning structure between 100-150 m to reduce the number of piers within the riverbed; with 120 m spans there would be 4 piers in the river and an additional pier in the floodplain. A height clearance of 7 m and a width clearance of 250 m is provided to allow sufficient space for elephants to migrate.

The two-level triangle-diamond truss design allows pedestrian and cycle mobility to be vertically separated from vehicular lanes. The separation also improves pedestrian experience and provides a safer journey for all mobility types. The design allows for the integration of low and climber plantings to shade roadways and increase biodiversity. The triangle-diamond truss design also references local Bhutanese patterns and geometries.

FIGURE 4.7 EXAMPLE DESIGN FOR A STEEL TRUSS BRIDGE OVER THE MAU RIVER



Analysis of the Alternative Bridge Options for the Mau River Crossing

A comparison of the concrete box girder and steel truss options for crossing the Mau River is provided in ***Table 4.5***. In determining preferred option, engineering feasibility, environmental issues and cost are all considered.

TABLE 4.5 LONGER CHANNEL BRIDGE ALTERNATIVE ANALYSIS

Concrete Box Girder	Steel Truss
Option aligns with the GMC principles in providing mobility requirements and incorporating ecology enhancements. The option also references Bhutanese heritage in its geometries.	Option aligns with the GMC principles in providing mobility requirements and incorporating ecology enhancements. The option also references Bhutanese heritage in its geometries.
Use of local material (riverbed's sand and stone) for construction with reduced energy and resource consumption. The reduction in the need for imported materials means a lower carbon solution.	Prefabricated steel structure would need to be produced and imported to site; however, the height of the trusses lowers its steel tonnage and embodied carbon. Overall, higher embodied carbon than the concrete box girder design.
Integrated plantings and trees can expand ecologies, increasing biodiversity and reducing the bridge's carbon footprint with sequestration. Vegetation also slows water runoff and improves heat island effect by shading the roadway during hot summer months. A greater variety of vegetation types and therefore increased biodiversity compared to the steel truss option.	Integrated vegetation improves the heat island effect at the upper deck and the upper deck shades the lower deck. Vegetation is more limited to climbing plants and low level shrubs, compared to the concrete box girder which allows for a greater variety and incorporates tree planting.

Concrete Box Girder	Steel Truss
The mobility separation is less ideal than the steel truss option. Pedestrian mobility is separated from vehicles via vegetation.	Ideal mobility separation. The top truss structure allows for separated pedestrian and cycle mobility. The elevated deck makes use of the truss structure to improve pedestrian experience and safety.
This option has more structural piers within the riverbed and will cause increased disturbance and hydraulic impact. Given the fast flows in the rivers, design to prevent scour will be critical to ensure the robustness of the bridges and to prevent further deterioration of the riverbed ecosystem around the piers.	The steel truss option has a reduced number of piers compared to the concrete box design. The reduced number of structural piers will cause less impact to the riverbed and natural ecosystem.
Potential for phasing construction if the single level bridge is divided into two separate bridging structures, one for vehicular traffic and a second for pedestrian, cycle and public transport. While this scenario has an advantage for phasing the construction, it will increase structural piers within the riverbed.	The pedestrian deck could potentially be phased and built at a later date.
Reduced construction complexity and slightly reduced cost compared to the steel truss design.	Increase construction complexity and increased costs compared to the concrete box girder design.

Following comparison of the engineering, environmental and monetary aspects of the two options for the Mau River bridge, the concrete box girder design was taken forward as the preferred option due to the greater use of local materials, and therefore reduced need for imported material with associated traffic, noise and GHG emission impacts, and due to the slightly lower construction complexity and cost overall.

4.3.2.2 JENGKHURUNG, TAKLAI, LANGER AND SINGYE RIVERS

The bridges crossing the Jengkhurung, Taklai, Langer, and Singye Rivers are of a smaller scale than the Mau River Bridge. The number of traffic lanes and layout of the public transport network are subject to review, but the current expectation is each bridge will have the following functional requirements:

- Jengkhurung River and Taklai River crossings – one (01) traffic lane in each direction, public transport corridor, cyclists and pedestrians; and
- Langer River and Singye River crossings – one (01) traffic lane in each direction, pedestrians.

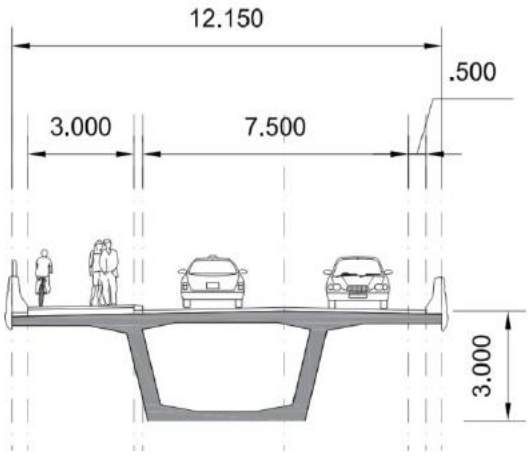
The designs for these bridge crossings will be developed based on the following criteria:

- Robustness and resilience to natural disasters;
- Cost-effective;
- Use of local materials; and
- Bridge forms capable of being constructed by Bhutanese contractors.

Two options have been considered for the shorter channel bridge crossings; a concrete box girder with typically 60m spans (***Figure 4.8a***), and a concrete beam and slab design with 40m spans (***Figure 4.8b***). The comparison of alternatives is ***Table 4.6***.

FIGURE 4.8 EXAMPLE BOX GIRDER AND CONCRETE BEAM AND SLAB BRIDGE CROSS SECTIONS

a. Concrete box girder



b. Concrete beam and slab

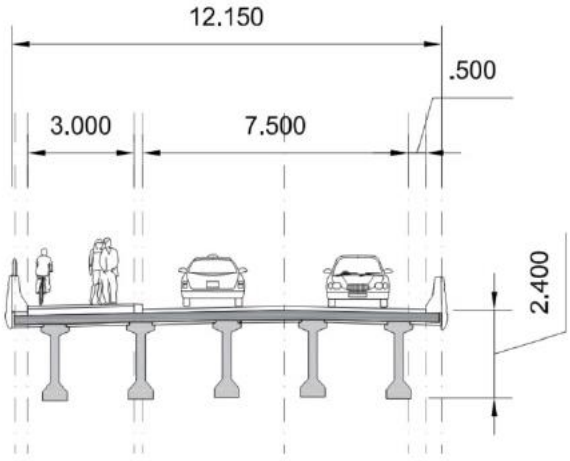


TABLE 4.6 SHORTER CHANNEL BRIDGE ALTERNATIVE ANALYSIS

TABLE 4.6 SHORTER CHANNEL BRIDGE ALTERNATIVE ANALYSIS

	Alternatives	
Jengkhurung River and Taklai River Crossing	Option 1 - Variable depth concrete box girder, with spans up to 60 m	Option 2 - Constant depth beam and slab bridges, with spans up to 40 m
Langer River Crossing		
Singye River Crossing		
Alternative Analysis	Fewer piers than Option 2 and therefore less disturbance to riverbeds, water flows, and natural ecosystems .	More piers than Option 1 and therefore increased riverbed disturbance and disruption to water flows.
	The monolithic piers of the box girder make it more robust under extreme seismic or flood events and is therefore more likely to withstand seismic hazards, landslides, and debris flow.	The beam design of Option 2 is more vulnerable to natural disasters than Option 1.
	The structure is relatively simple to build, and local contractors could be engaged.	The structure is relatively simple to build, and local contractors could be engaged. However, the erection of the beams for both the Langer and Singye bridge is considered slightly more challenging at their respective locations.
	The reduced number of bearings and movement joints make the box girder an easier asset to maintain.	The increased number of bearings and movement joints make the beam and slab design a harder asset to maintain.

	Alternatives	
	The box girder design requires increased energy and resources to build and therefore is more costly than the beam and slab solution.	The beam and slab solution is more economical and cost-effective.

The preferred alternative for the shorter channel bridge crossings is the box girder construction due to reduced hydraulic impact, greater robustness, and easier maintenance.

4.3.3 RIVER TRAINING

Options for bioengineering solutions compared to the proposed gabion baskets for the river training works are presented in ***Table 4.7***.

TABLE 4.7 RIVER TRAINING ALTERNATIVE ANALYSIS

	Gabion Baskets	Vegetated Retaining Walls	Soil Bioengineered Retaining Walls
Materials	Wire cages filled with stones	Soil, plants, and engineered systems	Soil, plants, and natural materials
Cost	Moderate initial cost	Higher initial cost due to planting	Variable cost depending on materials used
Installation	Quick installation in a variety of terrains	Requires careful planning and maintenance	Relatively simple, but needs expertise
Maintenance	Low maintenance, occasional check required	Moderate maintenance (watering, pruning)	High maintenance; depends on plant health
Environmental Impact	Minimal provision of habitat	Provides habitat, improves biodiversity	Enhances biodiversity and soil health
Load Bearing Capacity	High; suitable for heavier loads	Moderate; depends on design and vegetation	Moderate to high, depending on engineering

Gabion baskets have high load bearing capacity, low maintenance and quick installation however they provide minimal habitat improvement. Currently, the feasibility study is based on utilizing gabion baskets. However, during the DED bioengineering design including vegetated Retaining Walls are to be considered.

4.4 CONCLUSIONS

The preferred route has the shortest channel crossing and shortest bridge distances out of the options, thereby reducing impact on the riverbed and its natural ecology. By using Transition 5, the preferred alignment limits the extent of bridge structure required compared to the southern route only, and by deviating to the north it avoids cultural heritage areas and provides additional distance from the India border for the elephant natural habitat areas. By deviating north, the

preferred route will use the existing road, which will be widened, therefore significantly reducing the amount of forest clearance compared to a new road crossing the existing forest.

For bridge forms, the Mau River Crossing will be a modified prestressed concrete box girder. This option is the preferred option due to the use of local resources, greater integrated planting and reduced complexity and cost. For the Jengkhurung River, Taklai River, Langer River and Singye River Crossings prestressed concrete box girder is the preferred option due to the reduced riverbed disturbance and hydraulic impact, the robustness to seismic and flooding hazards and the easier maintenance. However, the beam and slab bridge alternative may be adopted for any small scale or minor crossings as this is the most economical superstructure form for the shorter span lengths required.

5. METHODOLOGY AND SCOPING

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 scope of area of analysis to be studied for the baseline data collection and E&S assessment has been defined as follows i:

- **Direct Impact**: An impact that is caused by the Project and occurs contemporaneously within the Project footprint or area of disturbance ;
- **Indirect Impac**t: An impact that is caused by the Project but occurs later in time or at a greater distance than a direct impact. It remains reasonably foreseeable and includes changes in social dynamics, hydrology, and biodiversity but does not include induced impacts; and
- Cumulative Impact: The incremental impact of the Project when added to impacts from other relevant past, present, and reasonably foreseeable developments. This also includes unplanned but predictable activities enabled by the Project that may occur later or at a different location.

The detailed ESIA methodology and project scoping has been detailed in ***Appendix B***.

1.2 PROJECT AREA OF INFLUENCE

The Project Area of Influence or the Project Impact Area is defined as the geographical area that may be affected by the Project's direct, indirect, and cumulative impacts during both construction and operational phases.. This is described in ***Table 5.1*** below.

Direct Area of Influence or Direct Impact Area (DIA) – includes all areas where the Project is expected to have a direct impact, such as: (i) The Project footprint and area of disturbance, including construction and operational zones, (ii) Villages and households directly affected by the Project's construction and operation activities, and (iii) Areas where ecosystem services could be directly impacted by the Project. Project DIA is shown in ***Table 5.1*** and ***Figure 5.1***.

Indirect Impact Area –includes the areas where indirect but reasonably foreseeable effects may occur due to the Project. These areas extend beyond the direct impact areas and cover broader environmental and social changes, including one Thromde and three Gewogs: Gelephu Thromde (Area affected: Namkhaling Demkhong), Umling Gewog, Chhuzanggang Gewog, and Tareythang Gewog. This area covers approximately 31.41 km^2. These areas will have indirect impacts related to the projects from the ongoing construction and the operations of the project that could extend outside the direct impact areas. The indirect impacts expected are mostly related to the changes in social dynamic, changes to hydrology and biodiversity. The Indirect Impact Area is shown in ***Figure 5.2***.

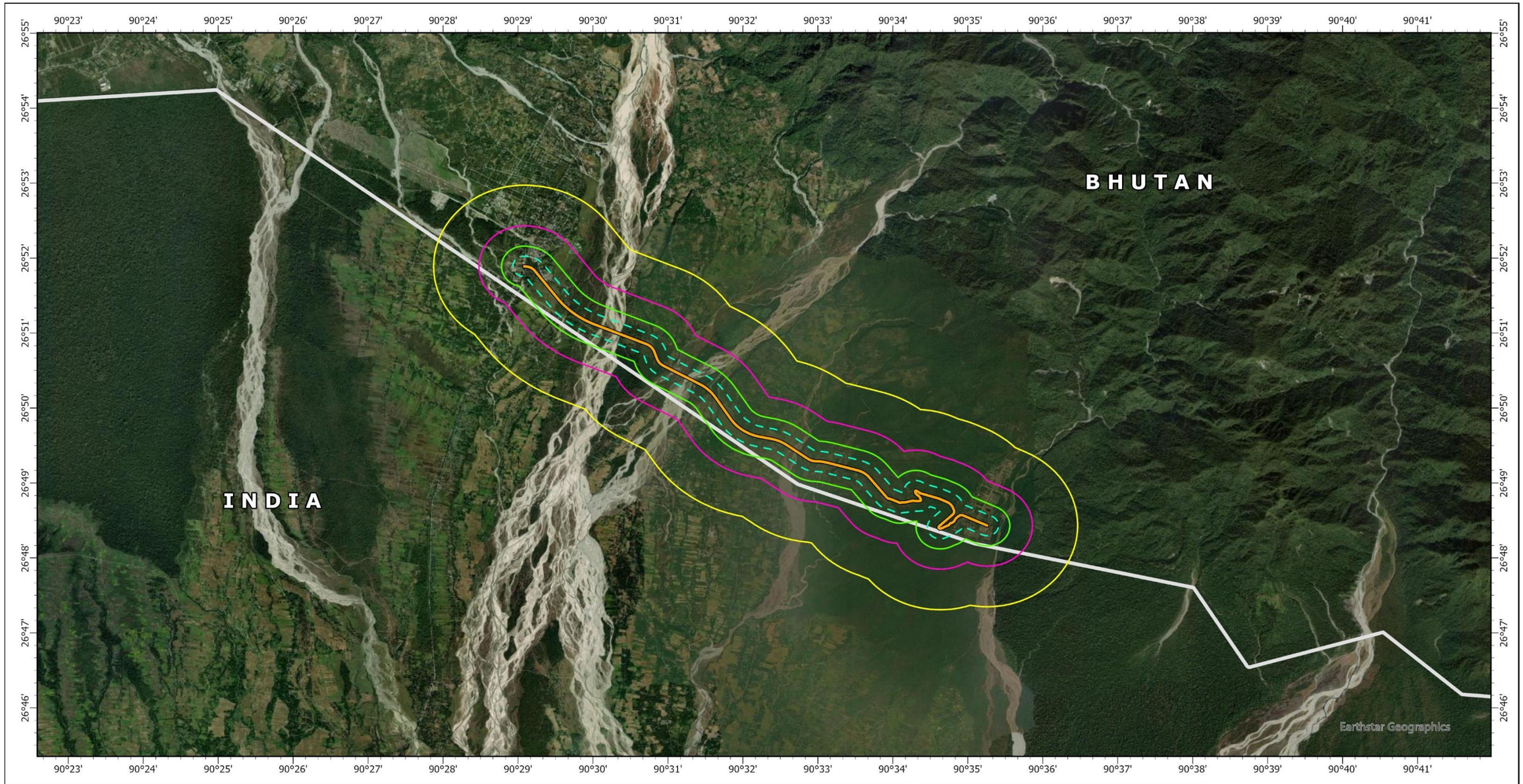
Cumulative Impact Assessment Area – includes the area to be directly affected by the Project activities (the DIA) and the wider area within which the Valued Environmental and Social Components (VECs) may be indirectly affected. The CIA Area is detailed in ***Chapter 15***.

TABLE 5.1 PROJECT IMPACT AREA

Project activities	Source of Impact	Direct Impact Area
Site preparation/Land clearing & Earthworks (Cutting and Filling)	Air emission including dust and gaseous exhausts	Within 250 m from the Project's boundary
	Topsoil removal	Within the Project footprint
	Surface runoff	Within 1 km from the Project's boundary
	Generation of noise from equipment and machinery	Within 500 m from the Project's boundary
	Vibration from construction	Within 250 m from the Project's boundary
	Loss of terrestrial habitat and species	Within the Project's footprint
	Increased number of vehicles on roadways	Transportation roadways
Construction of temporary ancillary facilities, Road and Bridge Construction (including river training, retaining walls, culverts / drainage and foundations)	Air emission including dust and gaseous exhausts	Within 250 m from the Project's boundary
	Vibration from construction	Within 250 m from the Project's boundary
	Surface runoff	Within 1 km from the Project's boundary
	Generation of noise from equipment and machinery	Within 500 m from the Project's boundary
Procurement of material and operation of borrow pits	Air emission including dust and gaseous exhausts	Within 250 m from the access roads and existing roads
	Increased number of vehicles on roadways	Transportation roadways
	Accidental introduction of invasive species	Within the Project's boundary[17]
Wastewater and solid waste generation	Generation of construction and domestic wastewater and solid waste	Within 1 km from the Project's boundary
Worker Influx, Activities, and Management and Operations	Social	Within 2 km from the Project's boundary
Road Operation and Maintenance	Air Emissions	Within 250 m from the Project's boundary
	Noise Emissions	Within 500 m from the Project's boundary

[17] Initially, but if established may spread to a wider area.

FIGURE 5.1 DIRECT IMPACT AREA



Legend

- Preferred Road Alignment
- 2 km Radius (Social)
- 1 km Radius (Surface Runoff, Wastewater and Solid Waste)
- 500 m Radius (Noise)
- 250 m Radius (Air & Vibration)

Administrative Boundary

- Country

0 1.6 3.2 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

Project Direct Impact Area

0737107 GMC ESIA Road and Bridges

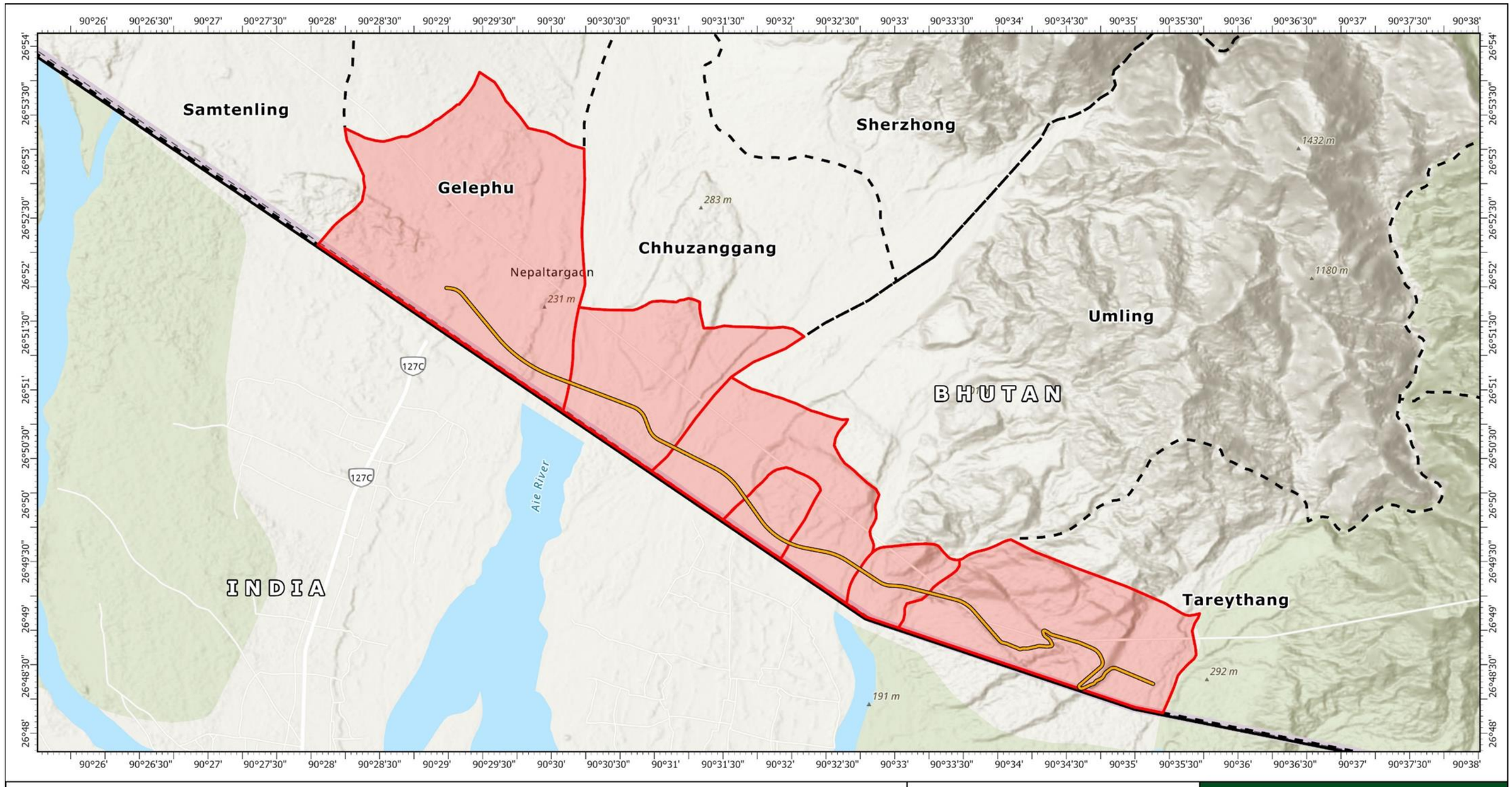
Date: 18/10/2024

Drawn By: NS

Review By: DJ

ERM

FIGURE 5.2 INDIRECT IMPACT AREA



Legend

- Preferred Road Alignment
- Project Indirect Impact Area

Administrative Boundary

- Gewog
- Country

0 1.1 2.1 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

Project Indirect Impact Area

0737107 GMC ESIA Road and Bridges

Date: 25/11/2024

Drawn By: NS

Review By: DJ

ERM

6. PHYSICAL ENVIRONMENTAL BASELINE CONDITIONS

This chapter provides a baseline understanding of the physical environment prior to the Project's initiation. This information acts as a reference point for evaluating the potential interactions of the Project on these conditions.

The primary baseline environmental quality in the locality of the Project has been collected through field studies, providing firsthand data on key local environmental attributes. The secondary data was collected from secondary sources for macro-environmental settings , including climate (temperature, rainfall, humidity, and wind speed), physiography, geology etc. The planned Gelephu Mindfulness City (GMC) masterplan development has had several recent studies conducted with relevant baseline data for the Project area, these have been referenced as applicable.

The Primary environmental surveys were conducted including surface water, groundwater and soil samples. Air and noise monitoring were conducted at several locations. Refer to ***Appendix C*** for the methodology of baseline data collection.

6.1 PHYSICAL ENVIRONMENT

6.1.1 TOPOGRAPHY

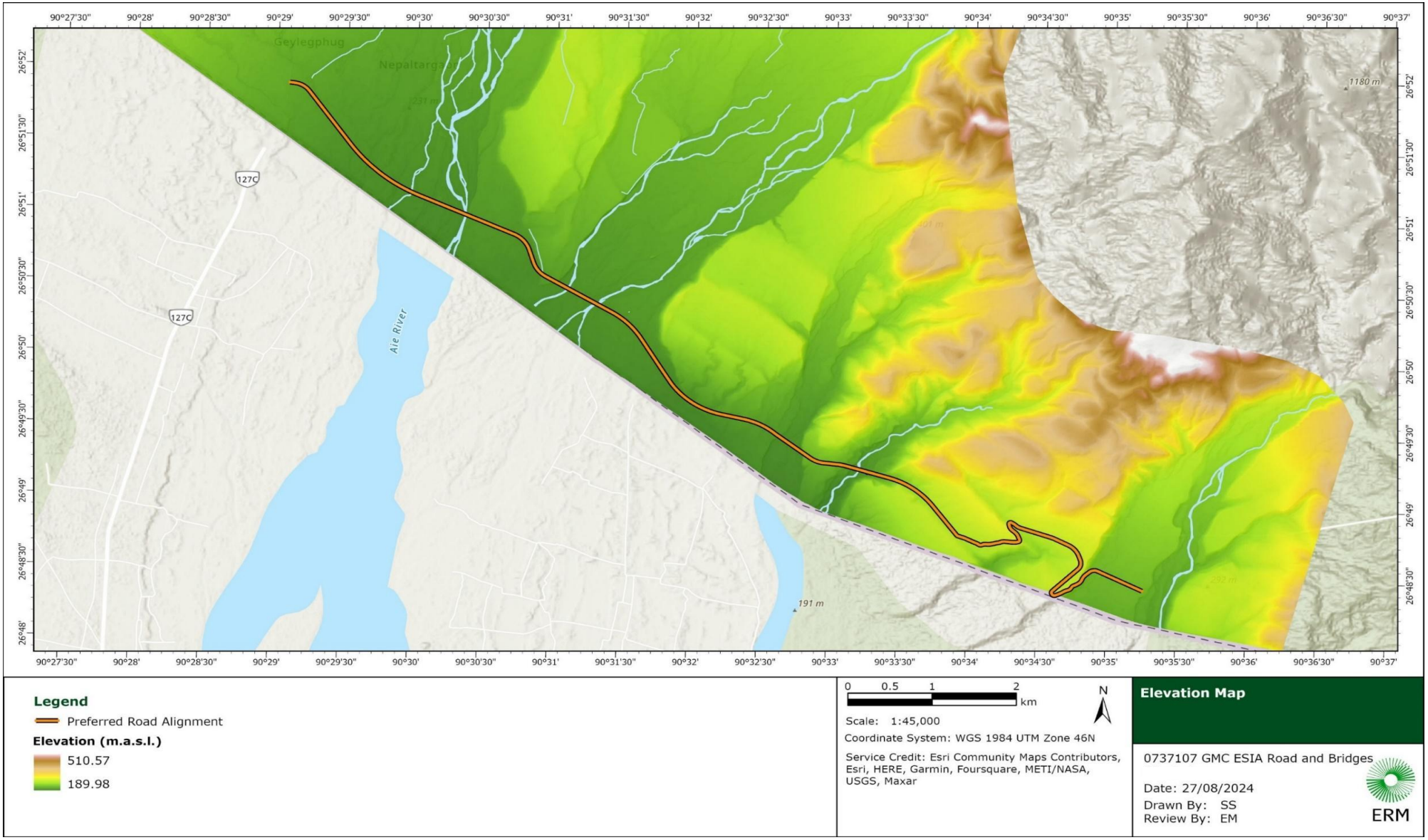
The Lesser Himalayas is located at the central and southern part of Bhutan. These mountains range from 1,500 to 4,500 m with heavy forested areas. This subtropical region is characterized by rolling hills, deep river valleys, and broad floodplains with elevations ranging from 150 to 1,500 m above sea level (masl).[18]

Gelephu is located in the Sarpang District of Southern Bhutan, which lies in the subtropical foothills and shares the border with India. The project area is situated within a floodplain and pass through several rivers, including the Mau, Jengkhurung, Taklai, Langer, and Singye. It is positioned on a river terrace and the surrounding peripheral piedmont, with altitudes around 200 masl in the plain and 400 masl at the summit of the hill. The Mau River is very flat and prone to flooding. Chhuzanggang Gewog, situated east of the Mau River near the Indian border, has ground levels between 210 m and 230 m, rising to 260 m in the north. The west bank of the Jengkhurung River is steep, whereas the area between the Jengkhurung and Taklai rivers is flat. East of the Taklai River, the ground rises steeply from 220 m to 280 m with a 45% slope. Near the Indian border, the land is flatter, with a 6% slope (north-south) from the border to Umling Gewog. The Langer River is located in a flat, wide area. The Singye River flows through a valley with a gently sloping west bank and a floodplain to the east, followed by a steep slope to existing buildings. East of the Singye River, ground levels rise through Tareythang before descending steeply to the Sukun River. In Tareythang, the terrain is characterized by a steep ridge with elevations decreasing from around 280 m to 230 m.

In summary, Gelephu's topography is characterized by its low-lying plains, fertile soil, closeness to rivers, and location at the base of the Himalayan foothills.

[18] National Soil Services Centre (NSSC). (2024). Soil Atlas of Bhutan.

FIGURE 6.1 TOPOGRAPHIC MAP OF PROJECT AREA



6.1.2 GEOLOGY

Bhutan's geology is profoundly shaped by its position in the eastern Himalayas, one of the most geologically dynamic and active regions on Earth. Bhutan is situated in the Himalayan belt, where the Eurasian and Indian tectonic plates collide. This tectonic compression has led to folding, faulting, and frequent seismic activity, resulting in a rugged, fragile, and complex topography.

Bhutan is classified into several geological zones: the Tethyan Himalayan Zone at Northern Bhutan, Higher Himalayan Zone at Central Bhutan, Lesser Himalayan Zone and Sub-Himalaya (Siwalik Group) at Southern Bhutan. The geological map of Bhutan is shown in ***Figure 6.2***.

The Tethyan Himalayan Zone consists primarily of sedimentary rocks including limestone, shale, sandstone and slate. Central Bhutan consists of high-grade metamorphic rocks including gneiss, schists, quartzite and marble. These rocks were originally sedimentary or igneous rocks that were deeply buried and subjected to extreme heat and pressure, transforming them into their present forms. The Lesser Himalayan formations along the southern border comprise a diverse range of sedimentary and low-grade metamorphic rocks, including argillites, metargillites, sandstones, quartzites, limestone, dolomite, and gypsum. These rocks are highly susceptible to erosion. Southern Bhutan features significant deposits of unconsolidated sediments from environments such as braided streams, alluvial fans, and floodplains, as well as undifferentiated sediments from the Tibetan Plateau.

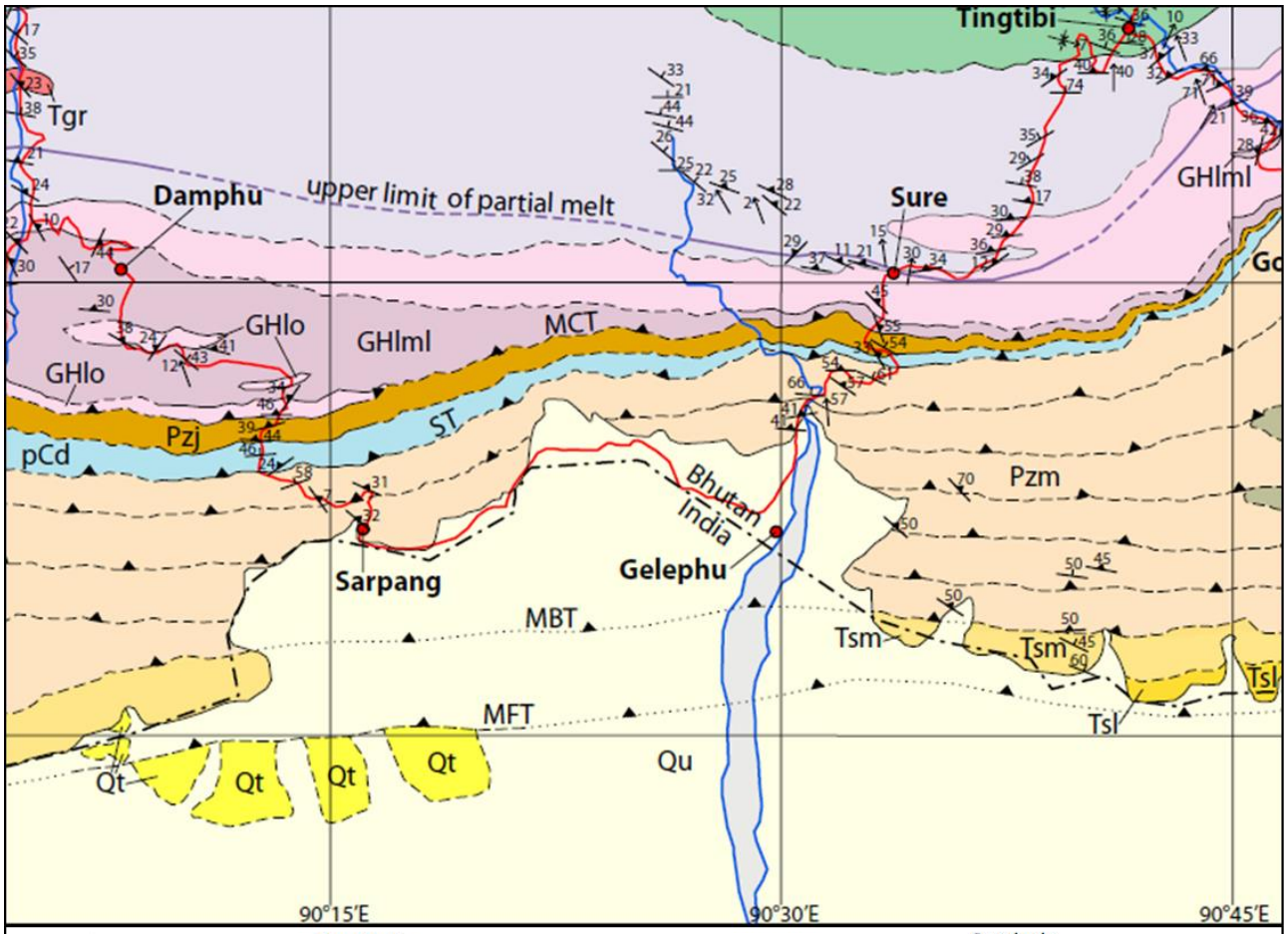
The Project is located in the Quaternary sediment zone, a typical landform of southern Bhutan's fringe, characterized by river terraces and Quaternary unconsolidated, predominantly coarse fan alluvium derived from the Lesser Himalayan Formation in the northern foothills. Key geological formations in the Project Area include alluvial deposits and sandstone, siltstone, clay deposits with alluvial deposits and the area surrounding by the Manas Formation and some Middle members, composed of tan to gray, medium- to coarse-grained sandstone[19]. The Manas Formation consists of light grey dolomite, limestone, and grey and carbonaceous phyllite, found along the southern border.[20]

In summary, Gelephu's geology is defined by its rich alluvial plains, subtropical climate, and proximity to the Himalayan foothills.

[19] Long et al. (2011). Geologic Map of Bhutan. Available from: https://sites.pitt.edu/~nmcq/Long_etal_2011_JOM_Bhutan_Map_1-500k.pdf

[20] Infrastructure Planning and Flood Adaptation Division (IPFAD). (n.d.). Feasibility study for meandering the Big Aiepoly Stream in Gelephu.

FIGURE 6.2 GEOLOGICAL MAP OF BHUTAN



Map Units

Quaternary sediment
- Qt River terraces
- Qu Undifferentiated

Subhimalayan Zone
Siwalik Group (Miocene-Plioce
- Tsu Upper member
- Tsm Middle member
- Tsl Lower member

Lesser Himalayan Zone
- Pzg Gondwana succession
- Pzd Diuri Formation
- Pzj Jaishidanda Formation

Baxa Group
- Pzph Phuentsholing Formation
- Pzm Manas Formation
- pCp Pangsari Formation

Daling-Shumar Group (Paleoproterozoic)
- pCd Daling Formation
- pCo Orthogneiss
- pCs Shumar Formation

Paro Formation
- Pzpun Undifferentiated
- Pzpu Upper unit
- Pzpm Middle unit
- Pzo Orthogneiss
- Pzpl Lower unit

Greater Himalayan Zone
Structurally-lower Greater Himalayan section
- GHlmu Upper metasedimentary unit
- GHlo Orthogneiss unit
- GHlml Lower metasedimentary unit

Structurally-higher Greater Himalayan section
- Tgr Leucogranite
- GHhu Undifferentiated
- GHhm Metasedimentary rocks

Tethyan Himalayan Zone
- THu Undifferentiated
- Ku Cretaceous, undifferentiated
- Tr-Jru Triassic-Jurassic, undifferentiated
- Pzu Paleozoic, undifferentiated
- Pzm Maneting Formation
- Pzc Chekha Formation

Structures
- STDh structurally-higher South Tibetan detachment
- KT Kakhtang thrust
- STDl structurally-lower South Tibetan detachment
- MCT Main Central thrust
- ST Shumar thrust
- MBT Main Boundary thrust
- MFT Main Frontal thrust

Symbols
- stratigraphic contact
- thrust fault (teeth on upper plate)
- detachment fault (ticks on upper plate)
- normal fault (ball on down-thrown side)
- anticline
- syncline
- strike and dip of bedding and foliation
- structural data from Gansser (1983)
- vertical bedding and foliation
- horizontal bedding
- mineral stretching lineation
- crenulation axial plane
- town
- peak
- pass (La)
- road
- river ('chu' or 'ri')
- highest occurrence of partial melt textures in structurally-lower GH section in central Bhutan**

Scale: 1:500,000
Geographic coordinate system: WGS 1984
Datum: WGS 1984

Geologic Map of Bhutan

0750493 Gelephu-Tareythang Road Project	
Figure Source: Long et al. (2011)	Date: September 2024

ERM

6.1.3 SEISMICITY

Bhutan is part of the Himalayan orogeny, formed by the collision of the Indian and Eurasian Plates, resulting in a series of folding, faulting, and frequent seismic activities. Bhutan Himalaya can be divided into Siwalik (SW), Lesser Himalaya (LH), Higher Himalaya (HH), and Tethyan Sedimentary Series (TSS) tectonics regions. This tectonic activity has created a complex system of overthrusts and fault lines, including the Main Frontal Thrust (MFT), Main Boundary Thrust (MBT), and Main Central Thrust (MCT) and Kakhthang Thrust (KT), ordered from south to north.

The thrust fault along the Bhutan-India border generally aligns with the MFT, except in the Sarpang-Gelephu area, where a 10 km wide re-entrant feature juxtaposes Lesser Himalayan formations with Quaternary alluvium. The MBT is currently the primary center of seismic activity[21]. The primary tectonic feature in around Sarpang is the MCT**.** The eastern part of the Project Area (i.e. Umling and Tareythang) crosses several active fault systems[22], as shown in ***Figure 6.2***.

6.1.4 CLIMATE

Bhutan's climate is primarily influenced by the southwestern monsoon originating from the Bay of Bengal. The monsoon season typically begins in June and continues until September, bringing heavy rainfall especially in the southern regions. Post-monsoon rains can occur in October and November, sometimes with severe intensity. The period from November to March is usually dry, though occasional showers may happen due to westerly winds that bring winter rains to the Himalayan foothills. The pre-monsoon period in April and May features light showers, hailstorms, and thunderstorms.

There are four seasons in Bhutan: winter, spring, summer and autumn. The southern edge of Bhutan is characterized by a warm, humid (tropical) climate different from most of the country. Bhutan receives about 70% of the precipitation during monsoons, while pre-monsoon rainfall accounts for 20%. The annual precipitation ranges widely across the country[23].

6.1.4.1 TEMPERATURE

The Report for Gelephu Flood Protection[24] studied temperature data for the period 1996-2017 from three meteorological stations at Sarpang, Bhur, and Jigmecholing. The results show that the mean maximum temperature during the months of June to August ranges from 28°C to 32°C, while the mean minimum temperature during December to January ranges from 18°C to 24°C.

The annual average, minimum and maximum temperatures at Bhur, Sarpang[25] from 1996 – 2023 is plotted in ***Figure 6.3***. The average annual temperature ranges from 20°C to 25°C. The

[21] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

[22] Greenwood, L., Argles, T., Parrish, R., Harris, N., & Warren, C. (2016). The geology and tectonics of central Bhutan. Journal of the Geological Society, 173(2), 201-214. https://doi.org/10.1144/jgs2015-031

[23] National Center for Hydrology and Meteorology. (2018). Climate Data Book of Bhutan 2018

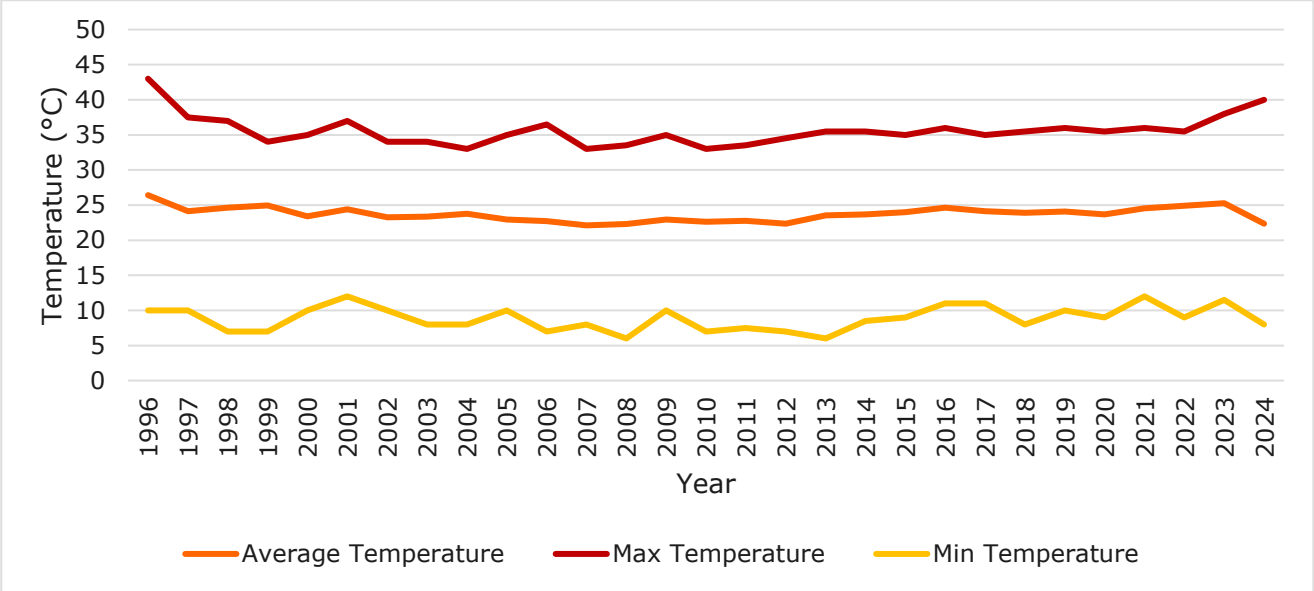
[24] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

[25] The station located at 27°54’25.16” N and 90°25’51.89” E where approximately 7 kilometers from the Project

maximum temperature was recorded at 43°C in 1996 while the minimum was recorded at 6°C in 2008.

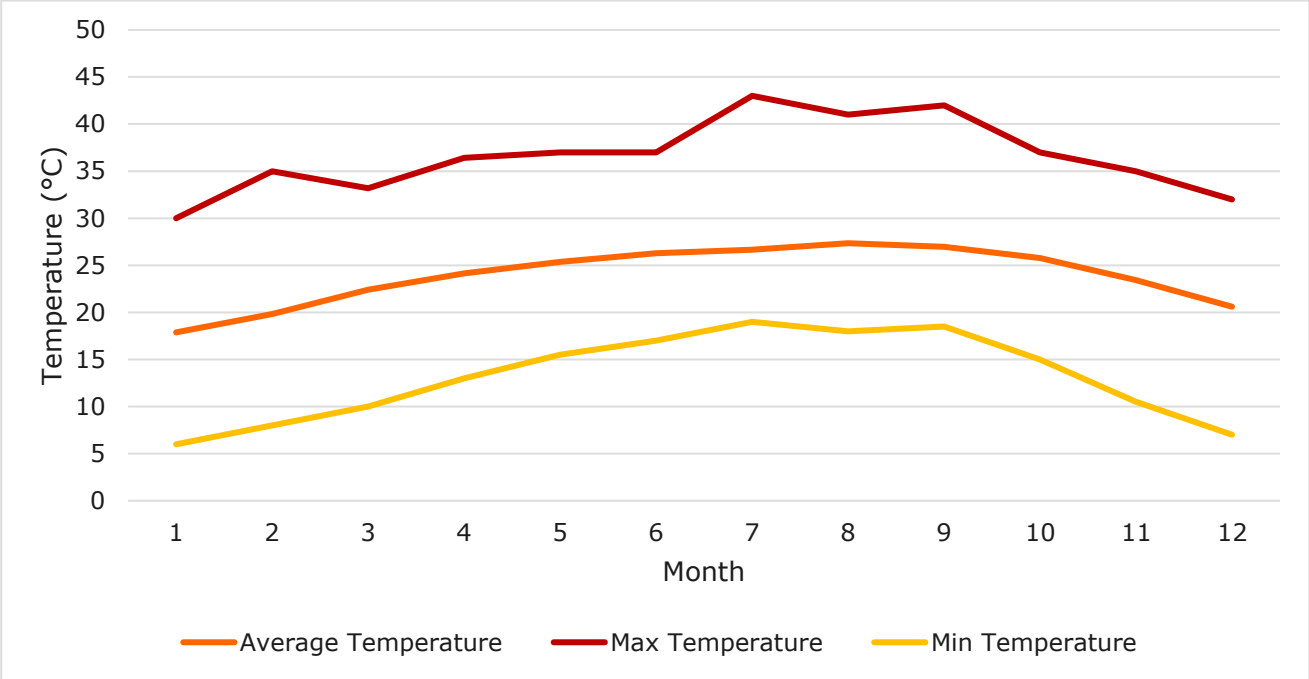
The monthly average, minimum and maximum temperature at Bhur, Sarpang from 1996 – 2023 is plotted in ***Figure 6.4***. The coldest month is January while the highest monthly temperature was found in July.

FIGURE 6.3 ANNUAL AVERAGE MINIMUM AND MAXIMUM TEMPERATURE AT BHUR (1996 - 2023)



Source: Bhur Meteorological Station, 2023

FIGURE 6.4 MONTHLY AVERAGE MINIMUM AND MAXIMUM TEMPERATURE AT BHUR (1996 - 2023)



Source: Bhur Meteorological Station, 2023

6.1.4.2 RAINFALL

The rainfall patterns of Bhutan are determined by the Southwest monsoon circulation, which dominates the Indian subcontinent during the summer period. Due to this, there is a seasonal cycle that results in wet summers that extend from June to September for the majority of the country. The southern regions are the most at risk for drought and dry spells brought on by the unpredictable monsoon rainfall. In total 72% of the total annual rainfall in Bhutan comes from the Southwest or Summer Monsoon (June - September), the highest rainfall amount can be recorded in July and August. The spring (March - May) and autumn (October - November) rainfalls contribute around 22% of the total annual rainfall[26].

Depending on latitude, Bhutan's climate varies widely both within and between its valleys. Due to rain shadow effects, these characteristics also cause significant shifts in rainfall over short distances. Based on historical data, the average yearly precipitation in the southern foothills ranges between 2,500 and 5,500 mm, in the inner valleys between 1,000 and 2,500 mm, and in the northern region between 500 mm and 1,000 mm.

To quantify the rainfall at Gelephu, the precipitation measurements at the Bhur station[27] is used[28]. The monthly rainfall statistics at Bhur station in 2023 were compared with the average rainfall from 1996 to 2022, as shown in ***Figure 6.5***[29]. The monthly rainfall in the Project Area follows the typical pattern of southern Bhutan, with rainfall concentrated between the months of June and September and accounts for more than half of the total annual rainfall.

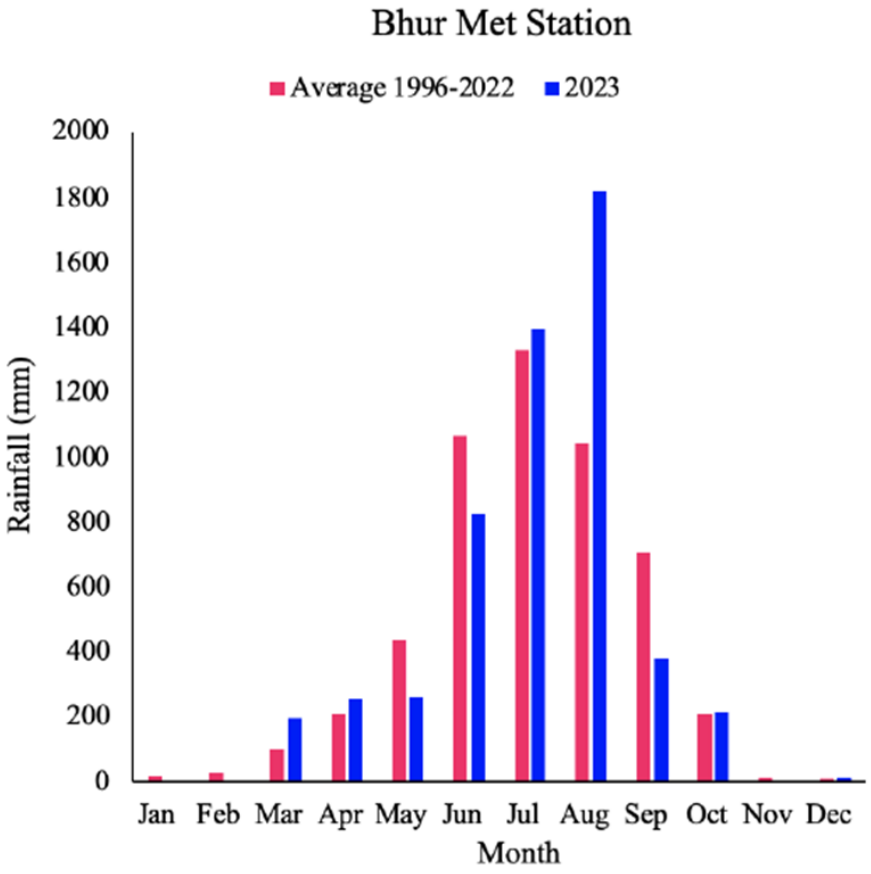
[26] Dorji, T. and Tamang, T.B., 2019, Analysis of Historical Climate and Climate Projection for Bhutan, National Center for Hydrology and Meteorology Royal Government of Bhutan, P.2.

[27] The station located at 27°54’25.16” N and 90°25’51.89” E where approximately 7 kilometers from the Project

[28] CDR, 2024, Hydrological Development of the Gelephu Mindfulness City Project, Bhutan.

[29] Phuntsho, T., Chimi, N., Monju, S., 2024, Bhutan State of the Climate 2023, National Center for Hydrology and Meteorology (NCHM).

FIGURE 6.5 MONTHLY RAINFALL IN 2023 COMPARED TO LONG-TERM AVERAGE



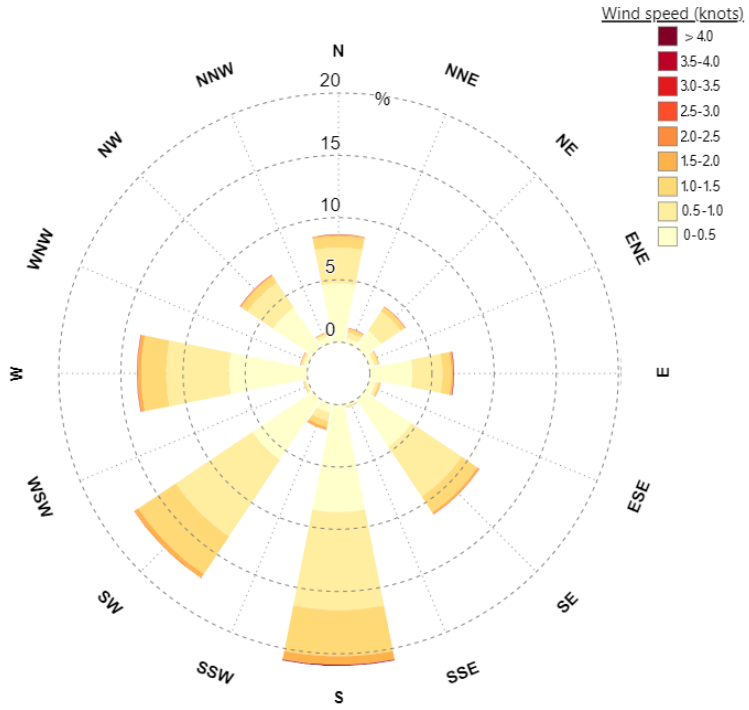
Monthly Rainfall in 2023 compared to Long-term Average Rainfall	
0750493 Gelephu-Tareythang Road Project	
Figure Source: NCHM (2024)	Date: September 2024

6.1.4.3 WIND SPEED AND DIRECTION

Wind speed data from the Bhur Meteorological Station from 1996 to 2023 shown in ***Figure 6.6*** indicates that winds predominantly originated from the south and the southwest, with occurrences of approximately 20% and 15% respectively. Wind speeds below 1 knot were the most common throughout the period, while speeds under 2 knots accounted for over 99% of the recorded observations. The average wind speed during this time was 0.32 knots.

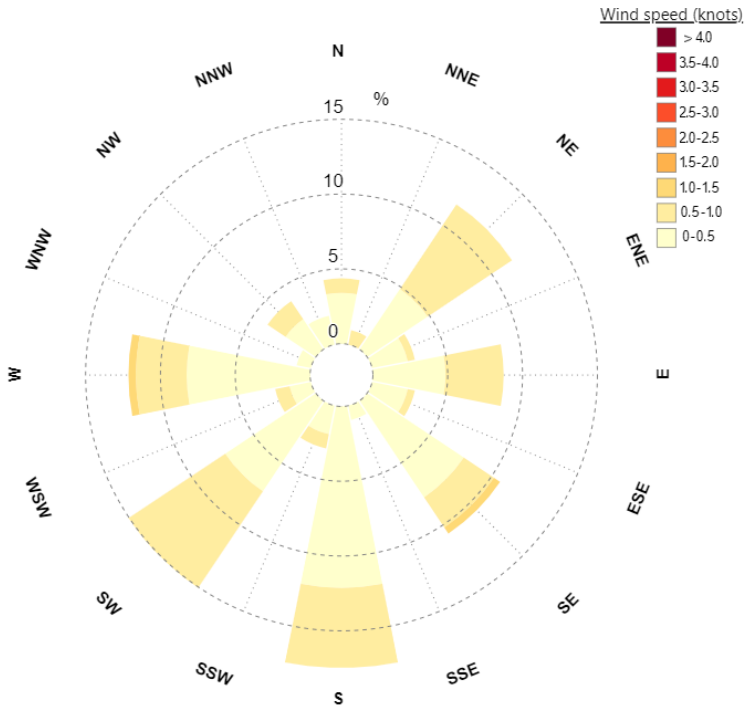
Data from January to July 2024 shown in ***Figure 6.7***, illustrates a similar trend to the long-term wind speed and direction patterns. Wind speeds were predominantly below 1.5 knots, with the majority coming from the south, followed by the southwest direction. The average wind speed was 0.23 knots.

FIGURE 6.6 WIND ROSE AT BHUR STATION (1996 – 2023)



Source: Bhur Meteorological Station, 2023

FIGURE 6.7 WIND ROSE AT BHUR STATION (2024)



Source: Bhur Meteorological Station, 2024

Note: Data available from January to July 2024

6.1.5 LAND USE AND LAND COVER

6.1.5.1 LAND USE ZONING

The Baseline Report on National Land Use Zoning of Bhutan (2023) was conducted by the National Land Commission in collaboration with relevant sectors to create a unified National Land Use Zoning (NLUZ) framework.

Table 6.1 presents the land use zone areas for four (04) Gewogs including Gelephu , Chhuzanggang, Umling, and Tareythang. ***Figure 6.8*** illustrates the preferred road alignment alongside the land use zoning for each Gewog. The starting point of the preferred road alignment is located in Gelephu Thromde, an area designated as urban and continues through land predominantly classified as agricultural in Chhuzanggang, Umling, and Tareythang.

TABLE 6.1 LAND USE ZONING – GEWOGS

	Gewog / Area (in Acres)			
Zone	**Chhuzanggang**	**Gelephu**	**Tareythang**	**Umling**
Agriculture	2,399.34	1,381.65	490.2	1,811.67
Cultural Heritage	16.2	4.9	1.28	3.2
Industrial	1.75	3.61	0.1	0
Nature Conservation Area (NCA)	0	2,160.45	22,908.51	16,397.8
Rangeland	0	0	0	0
Rural Settlement	206.13	523.16	1,847.41	189.96
Sustainable Forest Management Area (SFMA)	746.07	304.82	493.91	1,841.91
Urban	0	2,638.7	0	0

Source: National Land Use Zoning – A Baseline Report, 2023.

FIGURE 6.8 LAND USE ZONING MAP

6.1.6 NATURAL HAZARDS

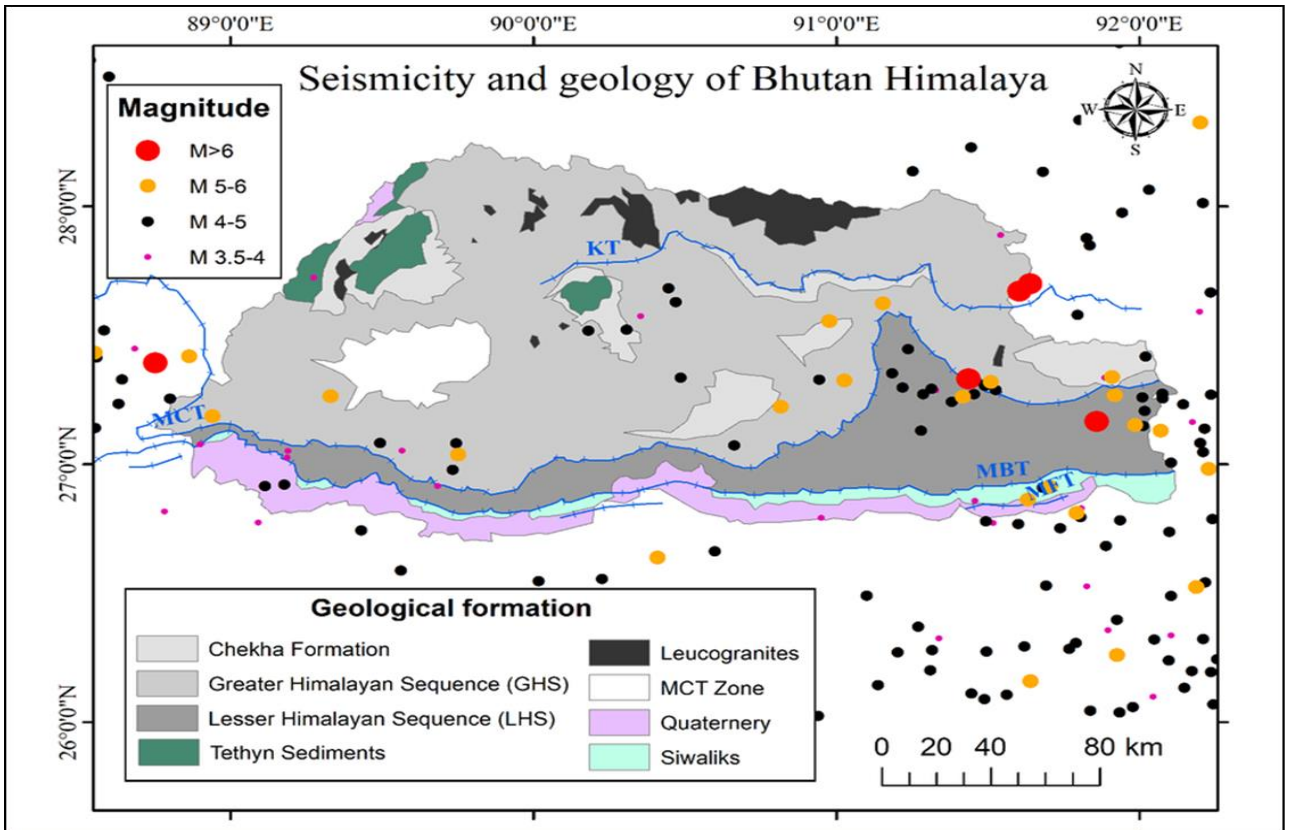
Bhutan is susceptible to a range of geohazards due to its geologically active environment, steep terrain, and heavy monsoon rains. The main geohazards in Bhutan include earthquakes, droughts, flooding, mass movements (debris flows, avalanches, rock fall and landslides), Glacial Lake Outburst Floods (GLOFs) and wildfires. Bhutan is vulnerable to a range of natural hazards as a country surrounded by Himalayas, the country is vulnerable to frequent hydro-meteorological disasters such as floods and landslides.

6.1.6.1 SEISMIC HAZARDS

As discussed in the geology sub-section above, the location of Bhutan is where the Eurasian and Indian tectonic plates collide, in which governs the entire seismicity in the region. The geographical positioning of Bhutan makes the country susceptible to seismic hazards. Bhutan has experienced several large/great damaging earthquakes in the past. Most notably the earthquake in 2003, registering a magnitude of 6.1, caused severe damages to infrastructure and loss of life. ***Figure 6.9*** below showed the historical distribution and magnitude of the earthquakes in Bhutan. Severe earthquakes with magnitude higher than 6 are typically found in the Eastern Bhutan while smaller earthquakes typically occur around the central and southern parts of the country[30].

[30] Debunking seismic vulnerability of Bhutanese buildings (Gautam et.al, 2022)

FIGURE 6.9 SEISMICITY OF BHUTAN HIMALAYA



Seismicity Map of Bhutan Himalaya		
0750493 Gelephu-Tareythang Road Project		ERM
Figure Source: Gautam et.al, 2022	Date: September 2024	

6.1.6.2 LANDSLIDES

Landslides in Bhutan are frequent due to the country's mountainous topography, heavy rainfall, soil conditions, and land-use patterns. Reports from the Department of Disaster Management (DDM) in 2015 and 2016 highlighted that landslide in Bhutan are mainly triggered by heavy rainfall and earthquakes, with intense rainfall being the primary factor. Landslides are particularly prevalent in southern regions like Samtse, Chukha, Samdrup Jongkhar, and Sarpang, where the fragile geology, steep slopes, and heavy rainfall combine to create high landslide risk. Human activities, including road construction, infrastructure development, and slope alterations, further exacerbate the risk by destabilizing the terrain.

The ground conditions in Gelephu area (GMC) can be very simply divided into steeper regions (red & yellow) where bedrock can be found at the surface and flatter regions (pale blue), where typically looser soils and gravels are found (***Figure 6.10***).

According to a quantitative debris-flow hazard assessment carried out for the GMC, the main hazards from heavy precipitation include floods, landslides, and debris flows. Landslide susceptibility was mapped using five key parameters: slope angle, geology, precipitation, proximity to streams, and land use/land cover. The results indicate that the Project Area has mostly very low to low susceptibility to landslides, as shown in ***Figure 6.11***.

In July 2016, heavy rainfall across 20 Dzongkhags caused significant flooding, with the hardest-hit areas being Sarpang, Chukha, and Samtse Dzongkhags. Major damage occurred to highways, bridges, houses, and agricultural lands. Notably, the entire town of Sarpang was washed away[31]. In southern Sarpang, the flatter areas mostly comprise geologically young sediments which comprise of alluvial fan deposits (river transported and slope transported loosely consolidated sediments) as shown in ***Figure 6.10***. Generally, these deposits occupy the lower elevation and low slope gradient areas. The slopes in the alluvial material are susceptible to slope failure during static conditions (without seismic loading or saturation, both of which are relevant in this setting). The rock slopes are also highly susceptible to slope failure under the same static conditions. This means the areas are highly susceptible to large landslides and debris flows as well as smaller slope failures in soils of embankments etc. (***Figure 6.11***).

Analysis of historical satellite images of the Mau River shows the occurrence of landslides in the upper parts of the basin. These slides generate huge amounts of sediment that reach the river and are subsequently transported downstream fine sediments, such as silt and fine sand, are transported downstream in a relatively short time. The coarse sediment, and in particular the gravels and cobbles, create shoals and move downstream with big floods. The shoals move like a sediment wave, raising and lowering the riverbeds along its passage. The passage of these sediment waves creates the braiding nature of Mau River, causing flooding and erosion in the Gelephu area[32].

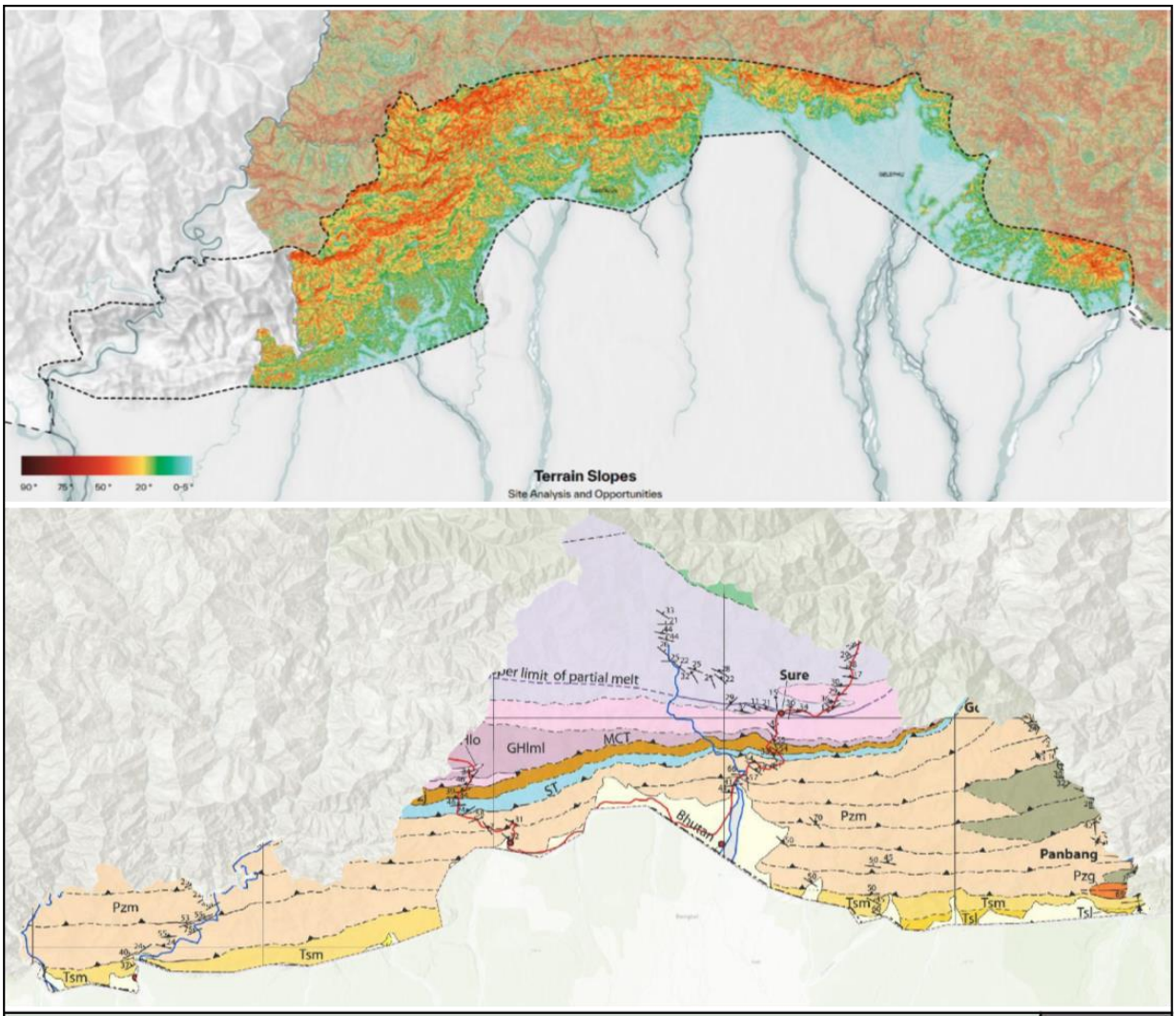
The Mau River and many of its tributaries have very relevant sediment sources in the form of landslides of different types, mainly shallow landslides, rockfalls, debris avalanches and debris flow among them. These landslides are often mobilized by rainfall infiltration and input pulses of great volumes of sediment into the fluvial system.

The Project is situated at the foothills of Himalaya, which experiences significant rainfall during monsoon season from June to September. The soil composition within Gelephu is primarily loose sediments and alluvial deposits. The intense rainfall during these months can lead to soil saturation and increase the risks of landslides. Moreover, upon crossing the Langer River, the terrain becomes more rugged, with pronounced slopes that significantly elevate the landslide risk to a high level.

[31] Committee for Development Policy (CDP). (2018). Vulnerability profile of Bhutan (CDP2018/PLEN/6.a). United Nations.

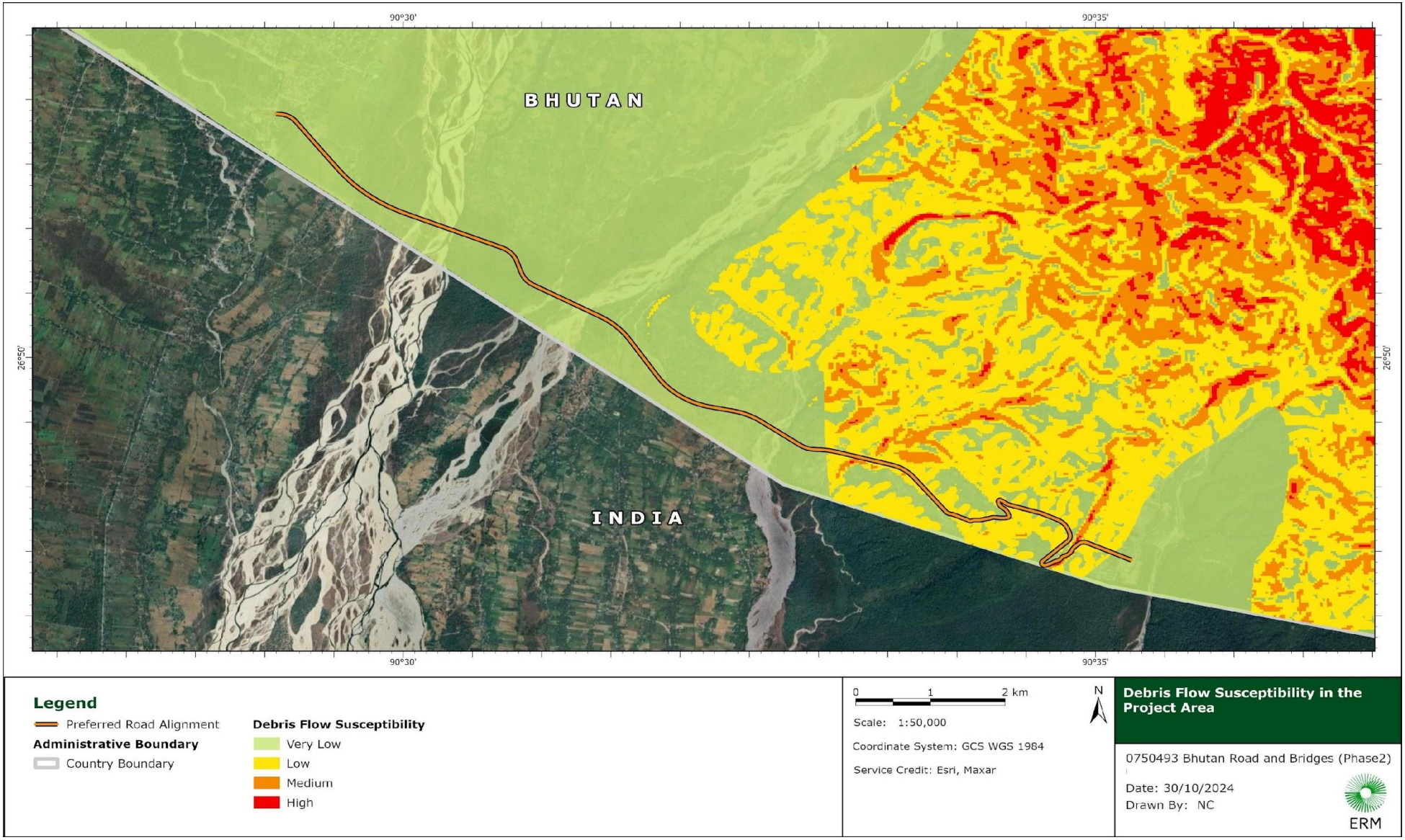
[32] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

FIGURE 6.10 TERRAIN SLOPE ANALYSIS AND GEOLOGICAL MAP OF GMC



Terrain Slope Analysis and Geological Map of GMC		
0743906 Gelephu-Tareythang Road Project		ERM
Photo Credit: BIG and Arup	Date: September 2024	

FIGURE 6.11 DEBRIS FLOW SUSCEPTIBILITY IN THE PROJECT AREA



6.1.6.3 FLOODS

In Bhutan, flooding is a frequent and impactful event, causing significant risks and economic damages due to its seasonal occurrence. The country experiences heavy rainfall, particularly during the monsoon season from June to September.

Significant rivers exist in the Gelephu region, many of which are seasonal. Due to the extreme monsoon rains experienced in the region, both the rivers and flash flooding due surface water runoff from the mountains onto relatively flat ground, are major hazards.

The relatively flat southern border of Bhutan is especially vulnerable to sudden, severe flood events along riverbanks. In the Project Area, the Mau River and its tributaries flood during the rainy season, from June to September, carrying heavy loads of sediment and boulders that alter the river's course and erode riverbanks. These floods often inundate low-lying agricultural lands, depositing infertile sediments that reduce land productivity.[18]

Gelephu faces several critical water-related challenges: elevated water levels cause flooding in agricultural areas and vital infrastructure; bank erosion leads to the loss of agricultural land and threatens infrastructure and sediment deposition at tributary confluences with the Mau River results in high water levels and river channel migration.

Notable historical flooding events occurred in August 2004, June 2015 and July 2019. The cause of these flooding events was mainly heavy rainfall and overflowing of the Mau River. Significant areas of Gelephu were submerged, including roads and public infrastructure.

In summary, Gelephu has a history of significant flooding events, primarily due to heavy monsoon rainfall and its geographical location near river confluences. The impacts of these floods have been substantial, affecting infrastructure, agriculture, and the livelihoods of residents. The Project design has accounted for flood risk and is climate-resilient, including adequate flood mitigation measures through stormwater drainage design.

6.1.6.4 FOREST FIRE

Forest fires are one of the prominent causes of forest degradation in Bhutan, and they can be caused by natural or man-made activities.[33] While most fires in Bhutan are caused by human activities such as the burning of agriculture debris, development of pastures, reckless behaviors of picnickers and smokers, the source of fire is not ascertained in 80% of the incidents .[34] The primary cause of natural forest fires is from lightning strikes during dry seasons from March to May. Forest fire risk is prominent during the dry season, which can create conditions conducive to forest fires. The rugged terrain and mountainous landscapes with dense vegetation contribute to higher fire risk.

The growing incidences of forest fires are recognized as the most pressing threat to forests ecosystem services in Bhutan.[35] In less than a decade, Bhutan recorded a total of 1,403 forest

[33] World Bank. (2019). Bhutan Forest Note: Pathways for Sustainable Forest Management and Socio-equitable Economic Development. World Bank Document

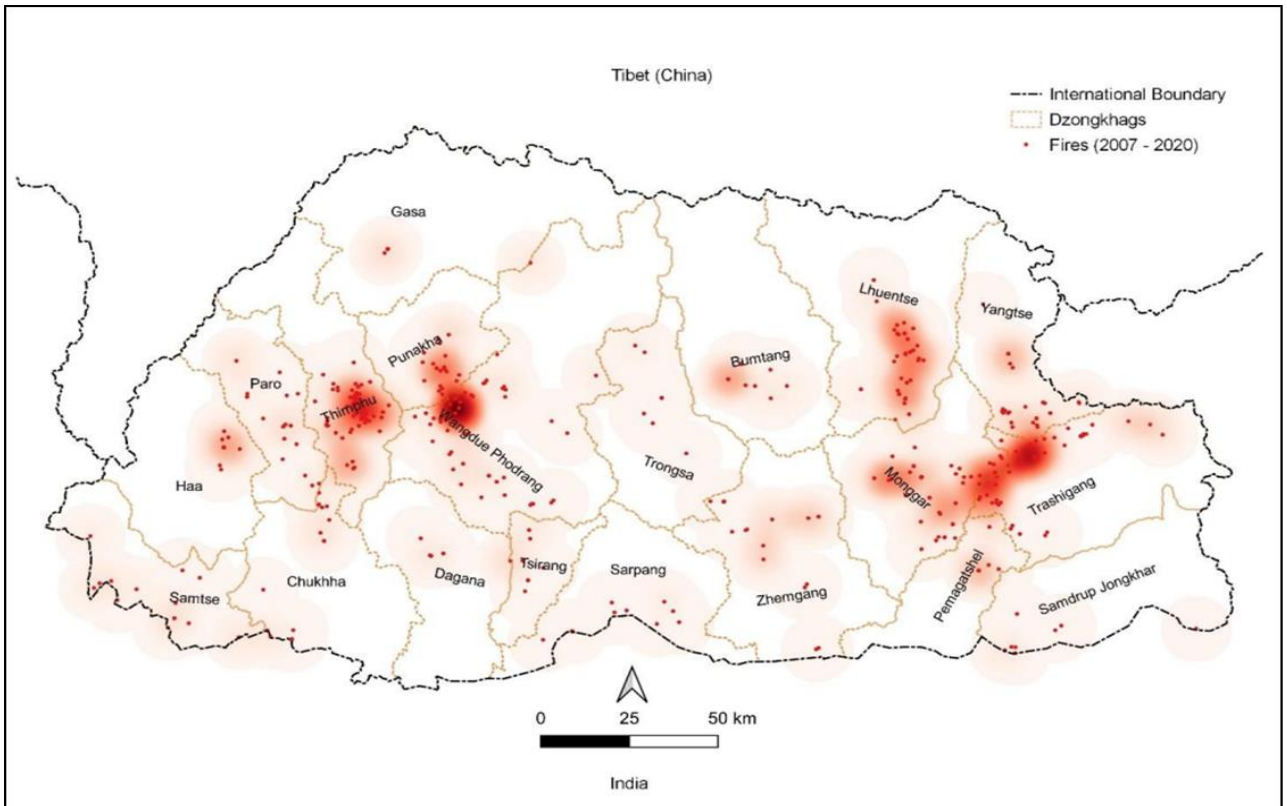
[34] Department of Forest and Park Services. 2019. Forestry Facts and Figures. Pp.10-54.

[35] Sears, R. R., Phuntso, S., Dorji, T., Choden, K., Norbu, N., & Baral, H. (2017). Forest Ecosystem Services and the Pillars of Bhutan's Gross National Happiness. CIFOR Occasional Paper 178, Center for International Forestry Research, Bogor, Indonesia.

fire incidents[36]. On average, forest fire affects an area of approximately 6,260 ha each year[37]. Forest fires are not uniformly spread throughout the country; Dzongkhags like Thimphu, Wangdue Phodrang, Punakha, Mongar, Lhuentse, and Trashigang experience the highest incidence of these fires. The fire occurrence from 2007 to 2020 is shown below in ***Figure 6.12***[38]. The current fires are primarily found in the chir pine and blue pine forest zones, with occasional occurrences in sub-tropical broadleaf forests.

In summary, as Gelephu is situated in the Sarpang and it is a subtropical region characterized by diverse vegetation, including chir pine and broadleaf forests, occasional forest fires are expected. According to Global Forest Watch, Gelephu boasted 2.88 thousand hectares of tree cover in 2010, representing 53% of its total land area. By 2023, it had lost 1 ha of tree cover, which is equivalent to 553 tons of CO_2 emissions.

FIGURE 6.12 FIRE OCCURRENCE LOCATIONS FROM 2007 TO 2020



Fire occurrence locations from 2007 to 2020		
0750493 Gelephu-Tareythang Road Project		ERM
Figure Source: National Adaptation Plan (NAP) 2021	Date: October 2024	

[36] Kuensel. (n.d.). Bhutan's forest coniferous prone to fire. Kuensel Online. Available from: https://kuenselonline.com/bhutans-forest-coniferous-prone-to-fire/ accessed on 28 August 2024.

[37] Ministry of Agriculture and Forests (MoAF). (2017). Drivers of Deforestation and Forest Degradation in Bhutan. Thimphu, Bhutan.

[38] Assessment of climate risks on forests and biodiversity for National Adaptation Plan (NAP) formulation process in Bhutan, 2021

6.2 WATER RESOURCES AND HYDROLOGY

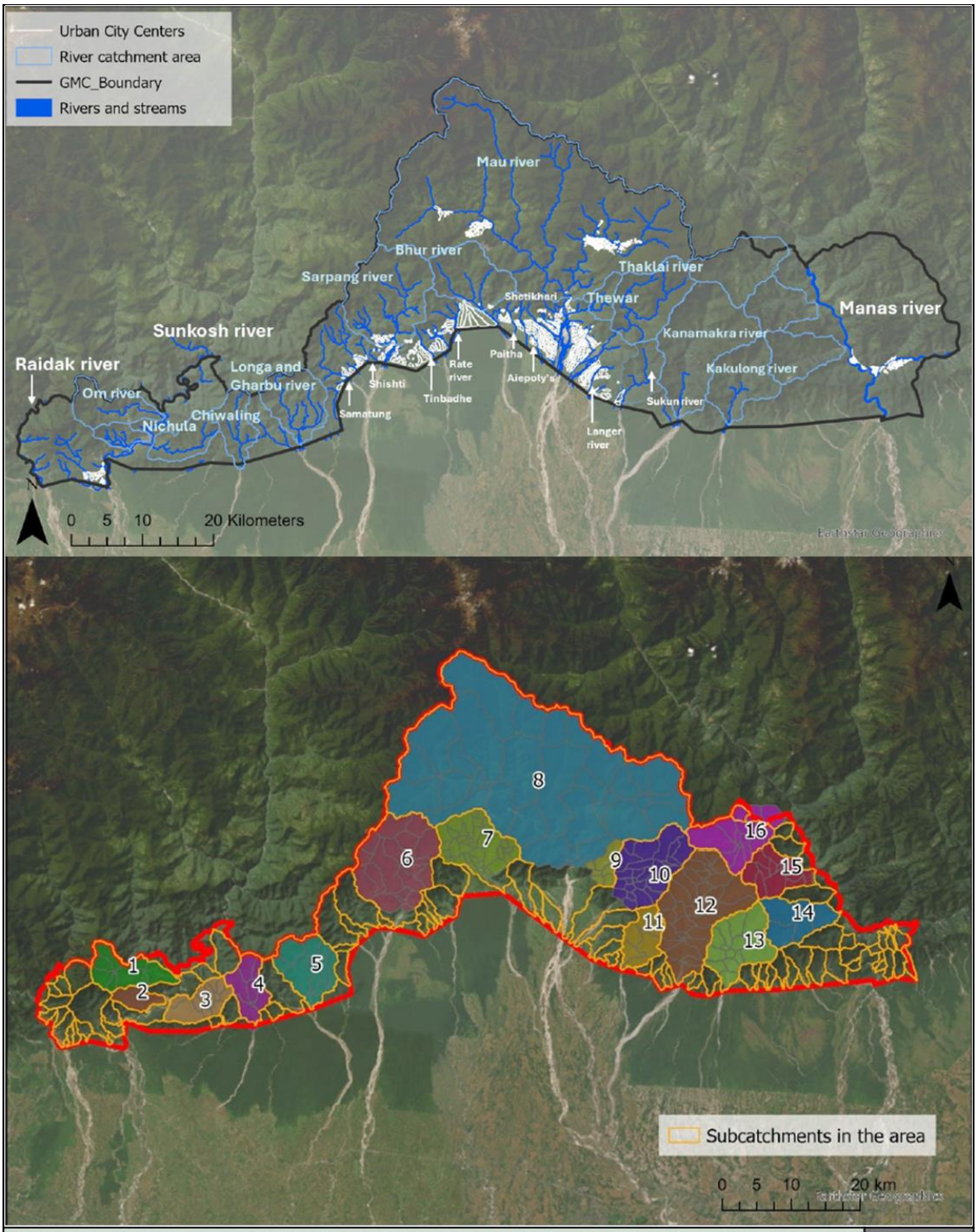
The Gelephu region is primarily influenced by the Manas River system, which flows between Bhutan and India in the Himalayan foothills. It is transboundary and a significant tributary of the Brahmaputra. When the Manas River flows through Bhutan in a south-westerly direction, it comes into India in Assam, which is in the foothills of the Himalayas, in a V-shaped canyon.

The Mau River (also known as the Aie River in India) is a tributary of the Manas River in Assam, India, originating from the Black Mountains in Bhutan. Flowing through the Chirang district of Assam, the Aie River merges with the Manas River at Bangpari in Chirang. It enters India at Agrong village in Assam's Goalpara district after traveling approximately 29 kilometers southwest through Bhutan. From there, the river continues its 75-km journey through Assam toward the Brahmaputra River. The Aie River spans 110 km, beginning at an elevation of around 4,915 m near Bangpari. The Manas River stretches 376 km, of which about 104 km flow through Assam.[39]

The major rivers and the boundary of the catchment areas in the Project area are indicated in ***Figure 6.13***.

[39] Gupta, S., & Singh, A. (2023). Impact of urbanization on water resources: A case study. International Journal of Science and Research (IJSR), 13(3), 154-160. https://www.ijsr.net/archive/v13i3/SR24302124447.pdf

FIGURE 6.13 OVERVIEW MAP WITH MAIN RIVERS, BASINS AND SMALLER STREAMS IN GELEPHU AREA (GMC)



Overview Map with Main Rivers, Basins, Catchment and Smaller Streams in GMC		
0750493 Gelephu-Tareythang Road Project		ERM
Photo Credit: CDR (2024)	Date: October 2024	

The broader Gelephu Mindfulness City Project area covers around 2,500 km^2. Two of the major river basins of Bhutan, the Punatsangchhu and Drangmechhu, borders the Project Area in the west and east respectively.[40]

The Project area is located in the Aiechhu Basin which is a minor basin. The Aiechhu basin has an area of 1,937 km^2 and it is considered part of the Punatsangchhu management basin. According to River basin flows of Bhutan[41], the total annual flow generated in Aiechhu basin is 6,989 million m^3.

Aiechhu river basin originates at an elevation 3,000 m class mountain ridge in South Central Bhutan, and it is a relatively small river basin with a length of approximately 50 km up to the Indian border. Its river slope is 1:40 on average, and its catchment area is 830 km^2 at the Indian border.[42]

The discharge of the Mau River exhibits strong seasonal variability. According to the Gelephu Flood Protection Project report[43], maximum discharges occur during the monsoon period (June-August), with peak average daily discharges ranging from about 1,500 m^3/s (1-year return period) to 3,300 m^3/s (50-year return period). In the dry months, runoff diminishes to a few m^3/s. At the Ai Bridge the estimated yearly average discharge of the Mau River is reported to be between 40 m^3/s and 135 m^3/s. According to data from 2024, the Taklai River in Chhuzanggang has a discharge of 0.839 m^3/s.[44]

6.3 SURFACE WATER, GROUNDWATER AND SOIL QUALITY

The baseline data for ambient surface water, groundwater and soil quality were collected from samples taken on site. Surveys were conducted in both the wet and dry seasons in Bhutan, with wet season sampling on 21-22 August 2024 and dry season sampling on 12-13 November 2024. The surface water and groundwater sampling and soil sites are presented in ***Figure 6.14***.

The surface water, groundwater and soil sampling procedures are described in the ***Appendix C3 & C4***.

[40] CDR. (2024). Hydrological Development of the Gelephu Mindfulness City Project, Bhutan

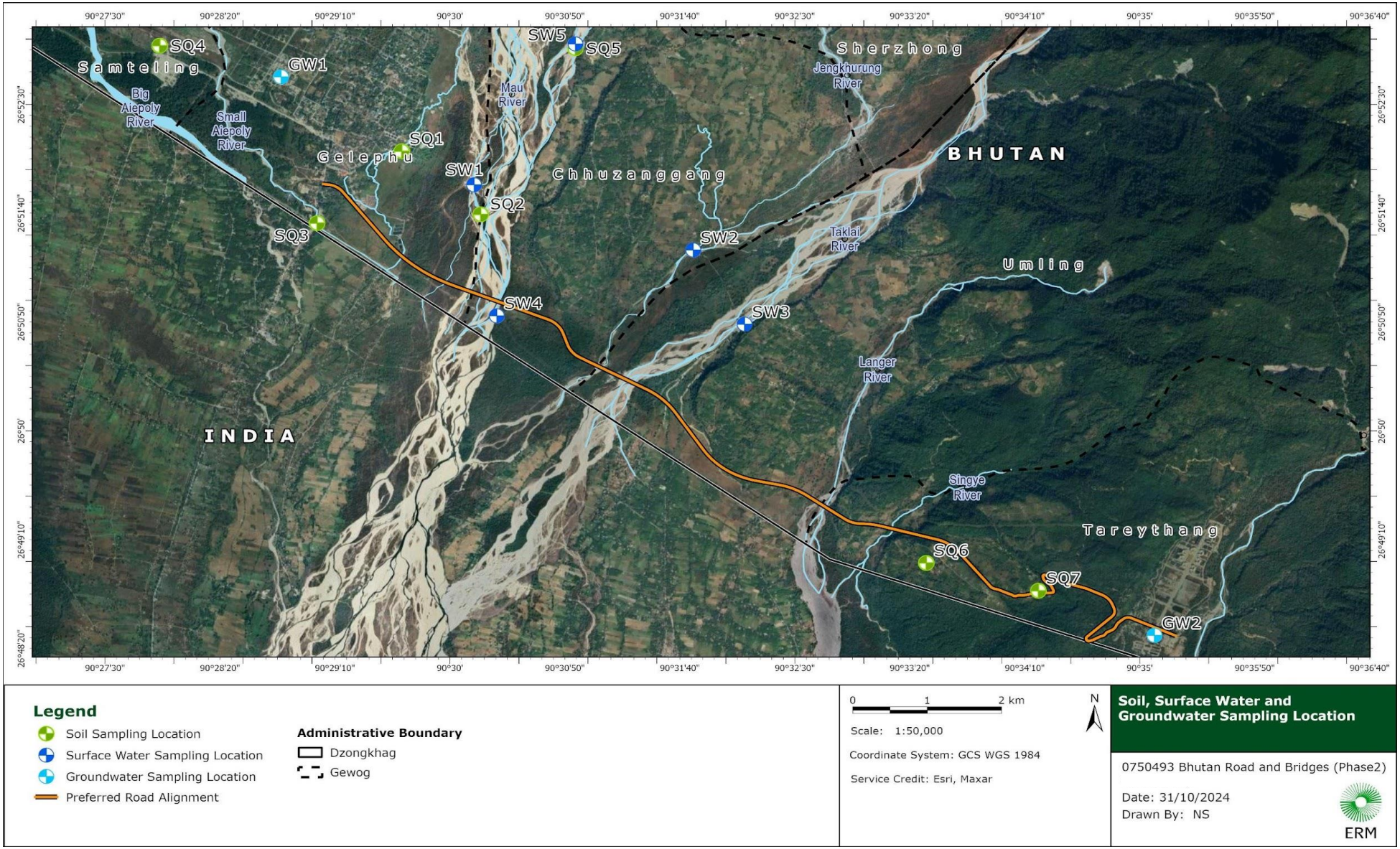
[41] National Environment Commission (NECS), 2016

[42] Japan International Cooperation Agency (JICA), Tokyo Electric Power Company Holdings, Inc. (TEPCO HD), TEPCO Power Grid, Inc. (TEPCO PG), Tokyo Electric Power Services Co., Ltd. (TEPSCO), Nippon Koei Co., Ltd., & International Institute of Electric Power, Ltd. (IIEP). (2019). Project on power system master plan 2040 in Bhutan: Final report. https://openjicareport.jica.go.jp/pdf/12326856_01.pdf

[43] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

[44] Spot Low Flow Discharge Measurements taken in Bhutan

FIGURE 6.14 SOIL, SURFACE WATER AND GROUNDWATER SAMPLING LOCATIONS



6.3.1 SURFACE WATER QUALITY

Environmental water (ambient water) quality refers to the condition of water bodies such as lakes, rivers, and streams. The standards for surface water quality vary widely due to differing environmental conditions. The water condition can impact wildlife that relies on the water for drinking or as a habitat.

A surface water baseline study at the Mau, Phanphaney and Taklai Rivers were conducted in August and November 2024 and measured several water quality parameters, including pH, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and Electrical Conductivity (EC) etc.

The surface water sampling sites are presented in ***Table 6.2***. Samples were collected from the same locations during both seasons.

TABLE 6.2 SURFACE WATER SAMPLING SITES

Monitoring Station [a]	Location	Coordinates
SW1	Midstream of the Mau River at the East of Gelephu City	26.864732°N 90.502926°E
SW2	Phanphaney River	26.856426°N 90.529385°E
SW3	Taklai River	26.84696°N 90.53560°E
SW4	Downstream of the Mau River near the Bhutan - India border	26.848023°N 90.505664°E
SW5	Upstream of the Mau River at the Sherzhong Bridge	26.940902°N 90.518508°E

Notes:

[a] Duplicates were collected at the same location for Quality Control (QC).

6.3.1.1 RESULTS AND DISCUSSION

The results from the collected water samples were compared with Bhutan's national standards and WHO Guidelines for Drinking-Water Quality standards.

Most parameters from the sampled sites adhered to the limits set by the Environmental Standards 2020. However, certain parameters, particularly *Total Coliform levels*, exceeded the "Very Good" (A) conditions but still fell within the "Good" (B) or "Moderate" (C) ranges based on Bhutan's water quality standards. The key findings are listed below.

- All water samples showed pH range of about 7.1-7.3, indicating Very good (A) condition.
- Dissolved oxygen (DO) concentration in freshwater is affected by several factors including water temperature, atmospheric pressure, aeration, and biological/chemical oxygen demand. DO levels were measured between 5.5-6.0 mg/l, indicating conditions that fall within "Good" (B) to "Very Good" (A) conditions.
- The electrical conductivity was low, consistent with the low Total Dissolved Solids (TDS) values. The TDS measured at midstream of Mau River (SW1) is about 10mg/L less than the upstream (SW5) and downstream (SW4) of Mau River.

- Turbidity is a measure of the opaqueness of water, representing an indirect measure of suspended matter. Turbidity measurement of all samples fall within the "Very Good" (A) condition, which was <1 N.T.U.
- The water samples were analyzed for a suite of major ions (e.g. calcium, magnesium, chloride, fluoride, sulphate, sodium), nutrients (e.g., nitrate, phosphate, ammonia), metals (e.g. manganese, copper, zinc, lead, mercury), and metalloids (e.g., arsenic). The analysis indicates that the water quality of the Mau River, Phanphaney River and Taklai River complies with nearly all standards.
- Microbiological analysis showed low levels of faecal streptococci across all sample sites. Total coliform levels at most sites were within "Very Good" (A) conditions, except at Upstream of the Mau River at the Sherzhong Bridge, results fell into "Good" (B) or "Moderate" (C) ranges (over 20 MPN/100 ml but not exceeding 1,000 MPN/100 ml).
- The presence of fecal coliforms, as measured by the number of colonies of the bacterium E. coli per 100 mL of water, is an indication of contamination by humans and/or animal waste. Faecal coliform values at most sites stayed within the "Very Good" (A) condition. However, at upstream of the Mau River near Shershong Check Post (SW5), the values were significantly higher than other sampling sites, exceeding 30 MPN/100 ml.

To compare with WHO Guidelines Drinking-water Quality standards, most of the parameters from the sampled sites adhered to the limits. However, since the surface water samples were collected from rivers where animals are present, the detection of fecal coliform and fecal streptococci is unavoidable.

Table 6.3 presents the baseline surface water quality results.

TABLE 6.3 SURFACE WATER QUALITY RESULT

No.	Parameters	Unit	Result										Bhutan's ES Standards [a]			International Guidelines [b]
			SW1 – Aug 24	SW1 – Oct 24	SW2 – Aug 24	SW2 – Oct 24	SW3 – Aug 24	SW3 – Oct 24	SW4 – Aug 24	SW4 – Oct 24	SW5 – Aug 24	SW5 – Oct 24	Very good (A)	Good (B)	Moderate (C)	
Observations																
1	Odor	None	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Agreeable	Unobjectionable	Unobjectionable	-	-
2	Color	Hazen	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5	50	-	<15 TCU
3	Floating materials	None	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	-	-
In-situ measurements																
1	pH value [c]	None	7.32	7.18	7.26	7.25	7.12	7.21	7.23	7.19	7.29	7.13	6.5-8.5	6.0-9.0	6.0-9.0	-
2	Dissolved Oxygen (DO)	mg/l	5.6	5.7	5.7	5.7	5.6	5.4	5.9	5.6	5.9	5.6	6	4	-	-
3	Total Dissolved Solids (as TDS)	mg/l	76	79	81	74	85	81	87	78	89	75	500	1500	2100	-
4	Temperature	Deg C	24	25	25	25	26	24	26	24	26	24	-	-	-	-
5	Turbidity	N.T.U.	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	5	-	-	-
6	Electrical Conductivity	us/cm	127	134	137	124	140	140	145	130	146	124	800	1,000	2,000	-
7	Flow measurement	m/sec	2.1	-	2.3	-	2.4	-	2.1	-	2.2	2.3	-	-	-	-
Chemical And Physical Analysis Result																
1	Ammonia	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.05	0.5	-	-

No.	Parameters	Unit	Result										Bhutan's ES Standards [a]			International Guidelines [b]
			SW1 – Aug 24	SW1 – Oct 24	SW2 – Aug 24	SW2 – Oct 24	SW3 – Aug 24	SW3 – Oct 24	SW4 – Aug 24	SW4 – Oct 24	SW5 – Aug 24	SW5 – Oct 24	Very good (A)	Good (B)	Moderate (C)	
2	Anionic Detergents (as MBAS)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.2	1	-	-
3	Arsenic (as As)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.05	-	0.01
4	Barium (as Ba)	mg/l	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.7	-	-	1.3
5	Biochemical Oxygen Demand (as BOD)	mg/l	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2	5	50	-
6	Boron (as B)	mg/l	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	1	2.4
7	Cadmium (as Cd)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.003	-	0.003
8	Calcium (as $CaCO_3$)	None	24	17	30	29	32	21	32	48	34	49	200	-	-	-
9	Chemical Oxygen Demand (COD)	mg/l	<4.0	6.1	<4.0	<4.0	<4.0	<4.0	6.1	<4.0	7.1	8.1	5			-
10	Chloride (as Cl)	mg/l	15	21	17	17	21	15	23	19	27	15	50	200	-	-
11	Copper (as Cu)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.1	-	2
12	Cyanide (as Cn)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.05	0.05	-	-
13	Dissolved Iron	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.2	0.5	-	-
14	Fluoride (as F)	mg/l	0.13	0.12	0.12	0.12	0.28	0.29	0.12	0.13	0.21	0.20	1	2	-	1.5
15	Lead (as Pb)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.02	0.02	-	0.01

No.	Parameters	Unit	Result										Bhutan's ES Standards [a]			International Guidelines [b]
			SW1 – Aug 24	SW1 – Oct 24	SW2 – Aug 24	SW2 – Oct 24	SW3 – Aug 24	SW3 – Oct 24	SW4 – Aug 24	SW4 – Oct 24	SW5 – Aug 24	SW5 – Oct 24	Very good (A)	Good (B)	Moderate (C)	
16	Magnesium (as Mg)	mg/l	22	3	28	14	28	8	30	4	30	4	200	-	-	-
17	Manganese (as Mn)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	200	-	-	-
18	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005	0.0005	-	0.006
19	Mineral Oil	mg/l	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	No film	No film	-	-
20	Nitrate (as NO_3)	mg/l	0.81	0.89	0.86	0.7	1.4	1.04	1.1	0.88	1.2	0.98	10	50	-	50
21	Pesticides	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	0.0005	0.001	-
22	Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.002	-	0.2
23	Phosphate (as PO_4)	mg/l	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5	<0.1	-	-
24	Polychlorinated biphenyls (as PCB)	mg/l	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0002	0.0002	-	-
25	Polynuclear Aromatic Hydrocarbons (as PAH)	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0002	0.001	-
26	Selenium (as Se)	mg/l	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	0.01	-	-
27	Sodium (as Na)	mg/l	4.2	2.62	2.2	1.9	2.3	2.83	2.2	2.56	2.7	3.46				-
28	Sodium Adsorption Ration (as SAR)	None	0.27	0.15	0.13	0.12	0.13	0.13	0.12	0.12	0.15	0.19	-	-	26	-

No.	Parameters	Unit	Result										Bhutan's ES Standards [a]			International Guidelines [b]
			SW1 – Aug 24	SW1 – Oct 24	SW2 – Aug 24	SW2 – Oct 24	SW3 – Aug 24	SW3 – Oct 24	SW4 – Aug 24	SW4 – Oct 24	SW5 – Aug 24	SW5 – Oct 24	Very good (A)	Good (B)	Moderate (C)	
29	Sulphate (as SO_4)	mg/l	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	25	100	-	-
30	Surfactants (as LAS)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.1	0.2	-	-
31	Total Chromium (as Cr)	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	0.05	-	0.05
32	Total Kjeldahl Nitrogen	mg/l	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	0.5	2	-	-
33	Total Suspended Solid (as TSS)	mg/l	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	<2.5	25	100	-	-
34	Zinc (as Zn)	mg/l	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.2	0.5	-	-
Microbiological Analysis Result																
1	Faecal coliform	MPN / 100 ml	7.8	<1.8	7.8	13	4.5	<1.8	7.8	<1.8	33	<1.8	50	5,000	10,000	Non-detectable
2	Faecal streptococci	MPN / 100 ml	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	20	2,000	5,000	Non-detectable
3	Total coliform	MPN / 100 ml	13	<1.8	17	22	7.8	17	13	11	79	8	20	1,000	1,000	Non-detectable

Source: Mitra S K Laboratory Analysis Result

Notes:

[a] *Very good (A) means Drinking water source without conventional treatment, but after disinfection whenever necessary*
Good (B) means Drinking water source with conventional treatment
Moderate (C) Moderate means Used for irrigation, industrial cooling, etc.

[b] *Guidelines for Drinking-Water Quality 4th edition*

[c] *at 25 Deg C*

6.3.2 GROUNDWATER QUALITY

The groundwater exploration in Gelephu, Sarpang, indicates that the hydrogeologic features primarily support unconfined aquifers near the surface. High permeability and the proximity to the Seti Stream facilitate direct rainwater infiltration and possible lateral flow as key recharge sources. The water table depth varies between wet and dry seasons, with groundwater flow directed towards the Mau River basin, aided by the region's material composition and inclined topography, resulting in relatively high flow velocity.

Aquifer depths generally range from 40 m to over 100 m, with shallower water tables (40 to 60 m) observed near the road access to Gomtey Dangra.[45] The groundwater table, marking the top of the saturation zone, is influenced by climatic and geological conditions, as well as rainfall intensity and duration. High-intensity rainfall tends to increase runoff, while precipitation on low-permeability soil may lead to runoff or evaporation, depending on slope, vegetation, temperature, and wind speed. In Gelephu, the soil cover in the lower part is alluvial type, which promotes a high rate of infiltration as the material is coarse.

In Bhutan, hot springs are locally referred to as "Tshachu" and mineral water as "Drubchu". Gelephu Tshachu, a prominent hot spring, is located in southern Bhutan, approximately 14 kilometers north of the border town of Gelephu, along the Gelephu-Zhemgang Highway. The Gelephu Tshachu Hotspring is located in Sarpang. Gelephu Tshachu is located about 1.5 km away from the Project. The temperature of Gelephu Tshachu hot spring in Sarpang, Bhutan typically ranges from 40°C to 50°C.

The hot spring sits on an alluvial plain of around 10 acres, near the confluence of the Aie Chhu (Mau River), which originates from the Black Mountain range, and the Ranggang Chhu, which flows from above Samkhara village. Gelephu Tshachu is positioned at 26.947186° N and 90.512262° E, with an elevation of approximately 280 m above mean sea level. The hot spring features an "upwelling" source, with water surfacing at the bottom of the wells in an upward flow, accompanied by visible air bubbles. There are two main water sources.[46] The temperature of the spring water at the original sources, Pond 1 and Pond 2, measured immediately after full drainage and without bathers, is 38.75°C and 41.50°C, respectively, which is 2°C higher than the temperatures measured during normal conditions with bathers. The flow rates of the two sources are comparable, with Source 1 (Pond 1) at 0.475 L/s and Source 2 (Pond 2) at 0.454 L/s. While water samples from most ponds met the specified requirements, nitrite (NO_3) levels in Source 2 (Pond 2) exceeded the specified limits.

The sampling sites are presented in ***Table 6.4***.For the wet season data, the sampling was conducted in August 2024 and for the dry season data, the sampling was conducted in October 2024..

[45] Department of Geology & Mines. (2022). Groundwater Exploration using Electrical Resistivity Tomography Gelephu gewog, Sarpang.

[46] Historical Overview, Cultural Significance and Geochemical Analysis of Gelephu Tshachu, Sarpang. (2024). National Centre for Hydrology and Meteorology (NCHM) and Centre for Bhutan and GNH Studies (CBS)

TABLE 6.4 GROUNDWATER SAMPLING SITES

Monitoring Station	General location	Coordinates
GW1	Gelephu Workshop	26.878515°N 90.479598°E
GW2	Gaylsung Site Tareythang	26.807238°N 90.585114°E

6.3.2.1 RESULTS AND DISCUSSION

The results from the collected water samples were compared with Bhutan's national standards and WHO drinking water standards.

Most parameters from the sampled sites adhered to the limits set by the Environmental Standards 2020. However, certain parameters, particularly *Total Coliform levels*, exceeded the "Very Good" (A) conditions but still fell within the "Good" (B) or "Moderate" (C) ranges based on Bhutan's water quality standards. The key findings are listed below.

- Water samples from all sample sites showed a pH range of about 6.5-7.0, indicating Very good (A) conditions as per Bhutan's water quality standards.
- Dissolved oxygen (DO) levels at the majority of the sample sites ranged from 5.8 to 5.9 mg/l, indicating conditions classified as "Good" (B). One site (GW2A) recorded a DO level of 6.1 mg/l, which falls within the "Very Good" (A) condition based on Bhutan's water quality standards.
- The chemical and physical analysis results indicated low values for all parameters, which are within the standards.
- Microbiological analysis showed low levels of faecal streptococci across all sample sites. Faecal coliform values at most sites stayed within the "Very Good" (A) condition.
- Total coliform levels at most sites were range from around 20-30 MPN/100 ml which indicting within "Good" (B) or "Moderate" (C) conditions (over 20 MPN/100 ml but not exceeding 1,000 MPN/100 ml), except at GW1, where fell into "Very Good" (A) ranges (less than 20 MPN/100 ml but not exceeding 1,000 MPN/100 ml).

To compare with WHO Guidelines Drinking-water Quality 4th edition, most of the parameters from the sampled sites adhered to the limits. However, since the groundwater samples were collected from rivers where animals are present, the detection of fecal coliform and fecal streptococci is unavoidable.

Table 6.5 presents the baseline groundwater quality results.

TABLE 6.5 GROUND WATER QUALITY

Sl. No.	Parameters	Unit	Results				Bhutan's ES Standards [a]			International Guidelines [b]
			GW1 (wet month)	GW1 (dry month)	GW2 (wet month)	GW2B (dry month)	Very good (A)	Good (B)	Moderate (C)	
	Observations									
1	Odor	None	Agreeable	Agreeable	Agreeable	Agreeable	Unobjectionable	Unobjectionable	-	-
2	Color	Hazen	<1.0	<1.0	<1.0	<1.0	5	50	-	<15 TCU
3	Floating materials						Absent	Absent	-	-
	In-situ measurements									
1	pH value [c]	None	6.96	6.92	6.52	6.94	6.5-8.5	6.0-9.0	6.0-9.0	-
2	Dissolved Oxygen (DO)	mg/l	5.8	6.1	6.1	5.9	6	4	-	-
3	Total Dissolved Solids (as TDS)	mg/l	67	32	71	140	500	1500	2100	-
4	Temperature	Deg C	24	25.2	26	25.2				-
5	Turbidity	N.T.U.	<1.0	<1.0	<1.0	<1.0	5	-	-	-
6	Electrical Conductivity	us/cm	113	50	116	220	800	1,000	2,000	-
7	Flow measurement									-
	Chemical And Physical Analysis Result									
1	Ammonia	mg/l	<0.1	<0.1	<0.1	<0.1	0.05	0.5	-	-
2	Anionic Detergents (as MBAS)	mg/l	<0.02	<0.02	<0.02	<0.02	0.2	1	-	-
3	Arsenic (as As)	mg/l	<0.005	<0.005	<0.005	<0.005	0.01	0.05	-	0.01
4	Barium (as Ba)	mg/l	<0.05	<0.05	<0.05	<0.05	0.7	-	-	1.3

Sl. No.	Parameters	Unit	Results				Bhutan's ES Standards [a]			International Guidelines [b]
5	Biochemical Oxygen Demand (as BOD)	mg/l	<2.0	<4.0	<2.0	<2.0	2	5	50	-
6	Boron (as B)	mg/l	<0.5	<0.5	<0.5	<0.5	-	-	1	2.4
7	Cadmium (as Cd)	mg/l	<0.001	<0.001	<0.001	<0.001	0.003	0.003	-	0.003
8	Calcium (as $CaCO_3$)	None	16	3.08	20	43.19	200	-	-	-
9	Chemical Oxygen Demand (COD) [d]	mg/l	<4.0	<4.0	<4.0	<4.0	5			-
10	Chloride (as Cl)	mg/l	17	7.84	23	19.59	50	200	-	-
11	Copper (as Cu)	mg/l	<0.02	<0.02	<0.02	<0.02	0.05	0.1	-	2
12	Cyanide (as Cn)	mg/l	<0.02	<0.02	<0.02	<0.02	0.05	0.05	-	-
13	Dissolved Iron	mg/l	<0.05	<0.05	<0.05	<0.05	0.2	0.5	-	-
14	Fluoride (as F)	mg/l	0.20	0.22	<1.0	<1.0	1	2	-	1.5
15	Lead (as Pb)	mg/l	<0.005	<0.005	<0.005	<0.005	0.02	0.02	-	0.01
16	Magnesium (as CaCo3)	mg/l	16	1.14	18	20.61	200	-	-	-
17	Manganese (as Mn)	mg/l	<0.02	<0.02	<0.02	<0.02	200	-	-	-
18	Mercury (as Hg)	mg/l	<0.001	<0.001	<0.001	<0.001	0.0005	0.0005	-	0.006
19	Mineral Oil	mg/l	<0.1	<0.1	<0.1	<0.1	No film	No film	-	-
20	Nitrate (as NO_3)	mg/l	2.0	1.82	1.2	2.5	10	50	-	50
21	Pesticides	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	0.0005	0.0005	0.001	-
22	Phenol	mg/l	<0.001	<0.001	<0.001	<0.001	0.001	0.002	-	0.2
23	Phosphate (as PO_4)	mg/l	<0.05	<0.05	<0.05	<0.05	0.5	<0.1	-	-
24	Polychlorinated biphenyls (as PCB)	mg/l	<0.0005	<0.0005	<0.0005	<0.0005	0.0002	0.0002	-	-

Sl. No.	Parameters	Unit	Results				Bhutan's ES Standards [a]			International Guidelines [b]
25	Polynuclear Aromatic Hydrocarbons (as PAH)	mg/l	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	0.0002	0.001	-
26	Selenium (as Se)	mg/ l	<0.005	<0.005	<0.005	<0.005	0.01	0.01	-	-
27	Sodium (as Na)	mg/l	3.3	2.8	3.2	4.34				-
28	Sodium Adsorption Ration (as SAR)	None	0.26	0.35	0.23	0.22	-	-	26	-
29	Sulphate (as SO_4)	mg/l	<1.0	<1.0	<1.0	4.8	25	100	-	-
30	Surfactants (as LAS)	mg/l	<0.02	<0.02	<0.02	<0.02	0.1	0.2	-	-
31	Total Chromium (as Cr)	mg/l	<0.01	<0.01	<0.01	<0.01	0.05	0.05	-	0.05
32	Total Kjeldahl Nitrogen	mg/l	<0.3	<0.3	<0.3	<0.3	0.5	2	-	-
33	Total Suspended Solid (as TSS)	mg/l	<2.5	<2.5	<2.5	<2.5	25	100	-	-
34	Zinc (as Zn)	mg/l	<0.02	<0.02	<0.02	<0.02	0.2	0.5	-	-
	Microbiological Analysis Result									
1	Faecal coliform [d]	MPN/ 100ml	4.5	14	7.8	21	50	5,000	10,000	Non-detectable
2	Faecal streptococci [d]	MPN/ 100 ml	<1.8	<1.8	<1.8	<1.8	20	2,000	5,000	Non-detectable
3	Total coliform	MPN/ 100 ml	17	27	22	33	20	1,000	1,000	Non-detectable

Source: Mitra S K Laboratory Analysis Result

Notes:

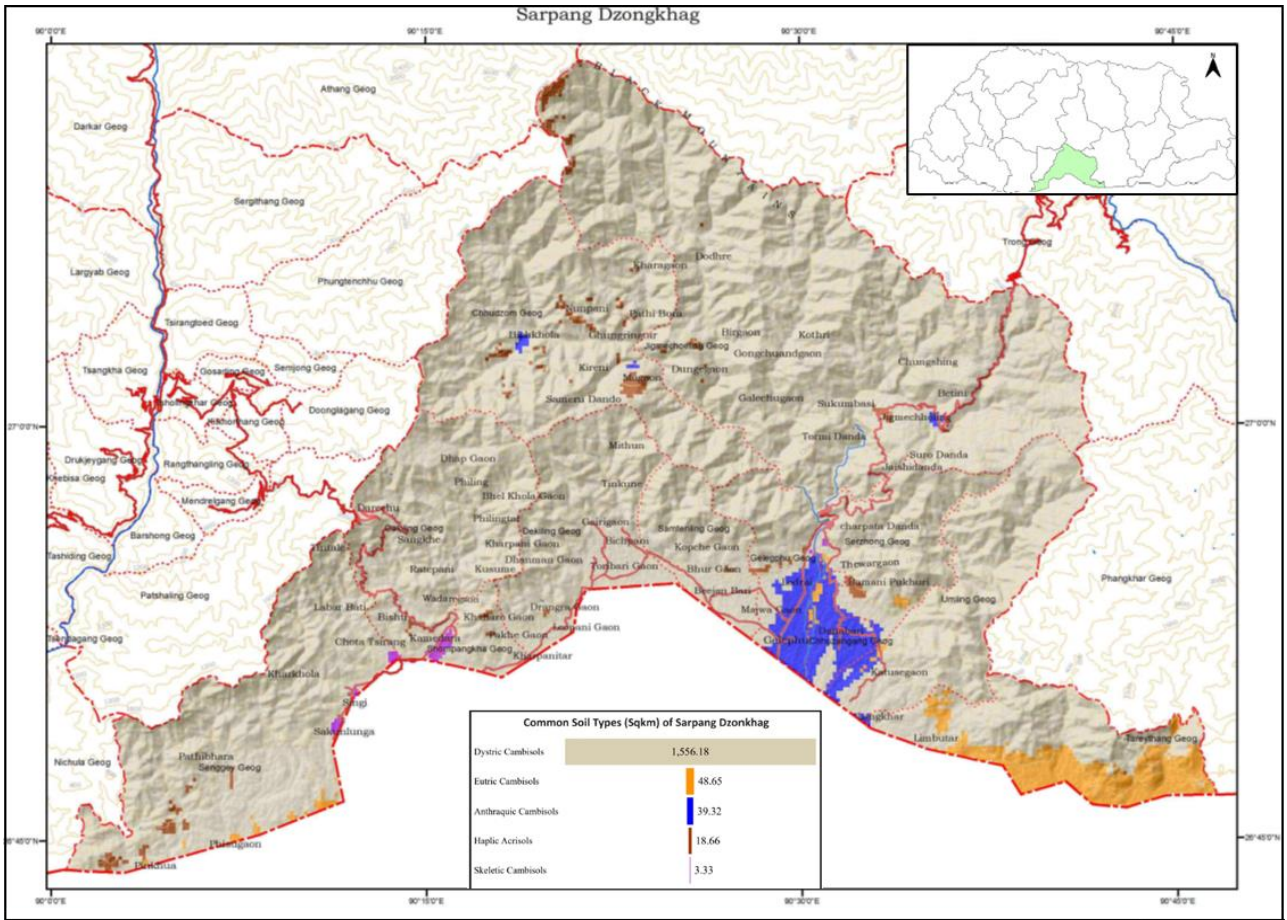
[a] Very good (A) means Drinking water source without conventional treatment, but after disinfection whenever necessary
Good (B) means Drinking water source with conventional treatment
Moderate (C) Moderate means Used for irrigation, industrial cooling, etc.
[b] Guidelines for Drinking-Water Quality 4th edition
[c] at 25 Deg C
[d] According to Environmental Standards 2020, these thresholds are applicable only to surface water quality.

6.3.3 SOIL QUALITY

The soil class map of Bhutan reveals that the country features seven soil types: Dystric Cambisols, Eutric Cambisols, Haplic Lixisols, Haplic Acrisols, Haplic Alisols, Anthraquic Cambisols, and Skeletic Cambisols.

Sarpang features five soil types (***Figure 6.15***). Dystric Cambisols are the most widespread, covering over 90% of the district (and is the most common type in Bhutan). Eutric Cambisols dominate the lower part of Taklai Gewog in the wet-subtropical zone. Anthraquic Cambisols are found along the river terraces and banks of the Mau River in Chhuzanggang and Gelephu Gewogs, where irrigation is prevalent. Haplic Acrisols are present in limited patches on mountain slopes, and Skeletic Cambisols are located in parts of Shompangkha and Hiley Gewogs along the Sarpang River[47].

FIGURE 6.15 THE SOIL MAP OF SARPANG, BHUTAN



Soil of Sarpang	
0743906 Gelephu-Tareythang Road Project	
Figure Source: NSSC (2024)	Date: August 2024

[47] National Soil Services Center. (2024). Soil Atlas of Bhutan

Data from the Gelephu Flood Protection Project indicate that the soil characteristics in the Project Area align with the definition of Fluvisol (FAO/UNESCO 1977). This young soil, commonly found in alluvial deposits, features weakly developed horizons with a distinct topsoil. Analysis on the topsoil (0-20 cm) presented in the report reveals low organic carbon content and poor nutrient levels[48].

According to the Assessment of Flooding and Hazards Development of Climate-Resilient Flood Mitigation Measures in Shetikhari and Aiepoly (Big & Small), in 2019, the laboratory sieve analysis reveals that most soil samples consist of sandy gravels with a very low percentage of fines and a narrow size distribution range.[49] Permeability is generally low with soil classified between Medium Fine-grained Sand and Medium-grained Gravel. Natural Moisture Content ranges measured in the report are found between 7% to 17%.

The soil sampling sites are presented in ***Table 6.6*** and ***Figure 6.14*** Sample were taken as duplicate in the same location at only one depth for quality control purpose.

TABLE 6.6 SOIL SAMPLING SITES

Monitoring Station	General location	Coordinates	Type
SQ1	Land next to National Center for Aquaculture	26.869022°N 90.494182°E	Soil
SQ2	In the river channel of Mau River	26.860965°N 90.503716°E	Sediment
SQ3	Land next to Bhutan – India border checkpoint	26.859849°N 90.483961°E	Soil
SQ4	Land in Gelephu Airport	26.882495°N 90.464943°E	Soil
SQ5	Land in agriculture field in Umling Gewog	26.882714°N 90.515154°E	Sediment
SQ6	Land in agriculture field in Tareythang Gewog	26.816473°N 90.557543°E	Soil
SQ7	Land in agriculture field in Tareythang Gewog	26.812924°N 90.571091°E	Soil

[48] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

[49](2019). Assessment of Flooding and Hazards Development of Climate-Resilient Flood Mitigation Measures in Shetikhari and Aieploy (Big & Small).

6.3.3.1 RESULTS AND DISCUSSION

Various factors such as topography, geology, climate and vegetation types result in variations in soil development and types. The soil samples were tested for texture, fertility, and cation exchange capacity. The results from the collected soil samples were compared with the Dutch standards and USEPA's Eco-SSLs for mammals.

Soil pH is a crucial soil property which measures the acidity or alkalinity of soil by determining the concentration of the hydrogen ions (H+) in the soil solution. It affects the availability of mineral nutrients to plants as well as many soil processes.

Based on the Soil Atlas of Bhutan, the majority of Bhutanese population depend on agriculture as the source of livelihood. Soil supplies vital nutrients and structural support for crops. Soil properties are essential in assessing soil quality and fertility status.

The pH of soils in Bhutan is generally acidic, majority of the area (99.45%) of the soils are within the range of 4.5 to 6.5. The pH values of most soil samples ranged from 4.9 to 5.2. Significantly, sample SQ5 from agriculture field in Umling Gewog recorded a pH of 6.98, whereas sample SQ2 from river channel of Mau River had a pH of 5.64. Extremely acidic and alkaline soils is not found within sampling areas.

Moisture of all soil samples range from 24% (SQ2) to 38% (SQ7). The mineral components of soil, sand, silt and clay determine a soil's texture. Soil texture affects soil behavior, in particular its retention capacity for nutrients and water. Bulk density is defined as the mass of a unit volume of dry soil (105°C). This volume includes both solids and pores and, thus, bulk density reflects the total soil porosity. Low bulk density values (generally below 1.3 kg dm^{-3}) generally indicate a porous soil condition. Bulk density is an important parameter for the description of soil quality and ecosystem function. High bulk density values indicate a poorer environment for root growth, reduced aeration, and undesirable changes in hydrologic function, such as reduced water infiltration.[50]

Pesticides, include Chlorodane, DDT, Dieldrin, Heptachlor, Heptachlor Epoxide, Atrazine, Chlorpyrifos, 2,4-Dichlorophenoxyacetic acid (2,4-D), Glyphosate, Lindane, Paraquat Dichloride and Pentachlorophenol, are BDL(DL:0.1)[51].

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.

The analyzed parameters and their respective outcomes are in ***Table 6.7***.

[50] FAO (2006), Guidelines for soil description, 4th edition

[51] BDL - Below Detection Limit; DL - Detection Limit

TABLE 6.7 SOIL QUALITY RESULT

Parameter	Unit	Sampling Locations							Dutch Standards Target Value, 2000	USEPA Eco-SSLs for mammals
		SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7		
Soil Physical and Chemical Properties										
pH value [a]	None	5.11	5.64	5.21	5.01	6.98	4.91	5.01	6-7	-
Moisture	%	33	24	30	34	26	34	38	-	-
Soil Physical Properties										
Bulk Density	g/cc	1.52	1.67	1.5	1.53	1.66	1.49	1.54	-	-
Silt	%	35	5	37	42	7	44	39	-	-
Sand	%	41	91	46	43	89	37	40	-	-
Clay	%	24	4	17	15	4	19	21	-	-
Heavy metals										
Cadmium (as Cd)	mg/kg	BDL (DL:2.0) [b]	BDL (DL:2.0)	BDL (DL:2.0)	BDL (DL:2.0)	BDL (DL:2.0)	BDL (DL:2.0)	BDL (DL:2.0)	0.8	0.36
Copper (as Cu)	mg/kg	11.9	13.2	9.7	12.4	10.0	22.8	22.2	36	79
Iron (as Fe)	mg/kg	47	16	46	132	7.6	78	74	-	-
Total Lead (as Pb)	mg/kg	8.3	2.7	8.1	8.1	2.1	14.4	15.3	85	56
Zinc (as Zn)	mg/kg	34.1	33.9	35.9	42.6	17.9	48.1	34.8	140	79

Parameter	Unit	Sampling Locations							Dutch Standards Target Value, 2000	USEPA Eco-SSLs for mammals
		SQ1	SQ2	SQ3	SQ4	SQ5	SQ6	SQ7		
Pesticides										
Chlorodane	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.00003	-
DDT	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.01	0.021
Dieldrin	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.0005	0.0049
Heptachlor	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.0007	-
Heptachlor Epoxide	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.0000002	-
Atrazine	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	0.0002	-
Chlorpyrifos	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	-
2,4-D	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	-
Glyphosate	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	-
Lindane	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	-
Paraquat Dichloride	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	-
Pentachlorophenol	mg/kg	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	BDL(DL:0.1)	-	2.8

Source: Mitra S K Laboratory Analysis Result

Notes:
[a] (1:2.5) At 25 deg C
[b] BDL - Below Detection Limit; DL - Detection Limit

6.4 AMBIENT AIR QUALITY

This section describes baseline ambient air quality conditions. Air quality in a geographic area is determined by the type and number of pollutants emitted into the atmosphere, the size and topography of the area, and the prevailing weather and climate conditions. Pollutant concentrations in the atmosphere are typically expressed in units of parts per million (ppm), parts per billion (ppb) or micrograms per cubic meter ($\mu g/m^3$) determined over various periods of time.

The air quality along the Mau River is generally excellent, with some pollution detected in Gelephu Thromde. During the dry season, wind-blown dust from the riverbed can negatively impact air quality. According to 2020 data [52], particulate matter levels are highest near Gelephu Town and Sershong School but remain well below international standards. Monitoring during the monsoon season showed reduced pollutant concentrations due to continuous rainfall. Overall, the air quality in Gelephu is good, with low levels of pollutants like SO_2 and NO_2, primarily generated by vehicle traffic in Gelephu Town.

Bhutan's national limits of ambient air quality criteria and WBG EHS Guidelines are summarized in ***Table 3.2***. The stipulated air quality limits in the WBG EHS Guidelines are generally more stringent.

The baseline data for air quality assessment were collected from monitoring stations on site. The air monitoring stations are presented in ***Figure 6.16***.

The air monitoring procedures are described in the ***Appendix C5***.

[52] CDR International, IHE Delft, & Druk Consult International (DCI). (2023). Gelephu Flood Protection Project: ESIA Report. Invest International Public Programme, Kingdom of Bhutan.

FIGURE 6.16 AIR AND NOISE MONITORING LOCATIONS

6.4.1 RESULTS AND DISCUSSION

PM_{10} and $PM_{2.5}$ Ambient Concentration

The results of the PM monitoring from the Aeroqual for PM_{10} and $PM_{2.5}$ (24 hour) are presented in ***Table 6.8***. Air quality monitoring for PM10 and PM2.5 was undertaken for 23 days in the wet season (August 2024) and 31 days during the dry season (8 Dec 2024 to 7 Jan 2025) at three locations..

TABLE 6.8 PM10 AND PM2.5 AMBIENT CONCENTRATION

Station	Monthly Ambient Concentration (µg/m³)			
	PM_{10}		$PM_{2.5}$	
	Wet month	Dry Month	Wet month	Dry Month
WBG EHS Guidelines (24 hour)	**15**	**15**	**5**	**5**
AQ1	7.4	5.1	9	16.5
AQ2	5	28	5.2	32.8
AQ3	0.011	0.22	0.0057	0.0097
Average	**4.14**	**11.11**	**4.73**	**16.44**

The monitoring data shows that the wet month average concentrations for PM_{10} and $PM_{2.5}$ are 4.14 µg/m³ and 4.73 µg/m³, which are well within the WBG EHS guidelines of 15 µg/m³ and 5 µg/m³ respectively, but the dry data shows higher ambient concentrations than EHS guidelines.

The baseline data shows that the airshed is not degraded as for both $PM_{10,}$ and $PM_{2.5}$ is measured to be less than 50% of the AQS (i.e., the baseline concentration is lower than the national and WBG EHS Guidelines) during the wet season but degraded in terms of PM2.5 values.

NO_x, NO_2, and SO_2 Ambient Concentration

The monitoring for nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and nitrogen oxides (NO_x) during the wet season has been successfully completed. The results of the NO_2, SO_2, and NO_x monitoring are presented in ***Table 6.9***.

TABLE 6.9 NOX, NO2, AND SO2 AMBIENT CONCENTRATION

Station	Monthly Ambient Concentration (µg/m³)		
	NO_2	NO_x	SO_2

	Wet month	Dry month	Wet month	Dry month	Wet month	Dry month
WBG EHS Guidelines (24 hour)	**10**	**10**	**-**		**40**	**40**
AQ1_N	4.75	5.87			0.158	3.08
AQ2_N	2.71	8.70			0.239	6.63
AQ3_N	1.49	2.08			0.240	7.53
AQ4_N	6.92	4.35			0.588	
AQ5_N	1.90	1.19	<1.4	5.2	0.139	
AQ6_N	2.61	3.10	5.4	5.9	0.191	7.71
AQ7_N	2.10				0.138	11.02
Average	**3.21**	**4.21**	**3.4**	**5.55**	**0.242**	**7.19**

The monitoring data shows that monthly average concentrations for NO_x, SO_2 and NO_2 are well below the WBG EHS Guidelines and Bhutan annual AQS at all measured locations. The overall average ambient NO_x, NO_2 and SO_2 is 3.4 µg/m^3, 3.21µg/m^3 and 0.242 µg/m^3 during wet season and 4.21 µg/m^3, 5.55 µg/m^3 and 7.19 µg/m^3 during dry season.

The short-term baseline (1-hour or 24-hour) value can be assumed as being twice the long-term value[53]. On this basis, the short-term baseline concentrations at all locations were well below the 24-hour AQS. The overall average short-term concentration is 6.42 µg/m^3, which is 25.7% of the 24-hour WBG EHS Guidelines.

The baseline study has shown the airshed in the Project area is not degraded for both SO_2, NO_x, NO_2, $PM_{2.5}$ and PM_{10} against both the WBG EHS Guidelines and Bhutan AQ standards. The potential human receptors are of medium sensitivity.

6.5 AMBIENT NOISE CONDITION

This section describes the baseline ambient noise conditions. Ambient noise in a geographic area is affected by the number and intensity of noise emitting sources. Ambient noise levels are typically described by several parameters. The most commonly used parameter to describe noise level is L_{Aeq}, which refers to Equivalent Continuous Sound Pressure Level, is the average noise level over the measurement period. Sound measurement is refined by using an A-weighted scale, which is the range of sound frequencies most audible to the human ear. Unless otherwise noted, all dB measurements presented in this ESIA are A-weighted (dBA) on a logarithmic scale.

Bhutan's national limits of ambient noise and WBG EHS Guidelines (2007) are summarized in ***Table 3.7***. The stipulated noise limits in the Bhutan National Criteria are generally more stringent.

[53] *Air emissions risk assessment for your environmental permit*. (2024, May 21). GOV.UK. https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#calculating-averaging-periods

The baseline data for noise assessment were collected from monitoring stations on site. The noise monitoring stations are presented in ***Figure 6.16***.

The noise monitoring procedures are described in the ***Appendix C6***.

6.5.1 RESULTS AND DISCUSSION

The results from the noise monitoring were compared with Bhutan's national standards and WBG EHS Guidelines and are summarized in ***Table 6.10***.

TABLE 6.10 BASELINE AMBIENT NOISE MONITORING RESULTS

Monitoring Station	**Monitoring Location**	**Bhutan Maximum Noise Level Limits dB(A)**		**WBG EHS One Hour L_{Aeq} (dBA)**		**L_{Aeq}, dB(A)**	
		Daytime [a]	Nighttime [b]	Daytime [a]	Nighttime [b]	Daytime [a]	Nighttime [b]
AQ1	Gelephu Workshop	75	65	70	70	52	50
AQ2	Gelephu Airport Runway	75	65	70	70	61	67
AQ3	Tareythang Weather Station	75	65	70	70	-	-
AQ4	Gelephu Town Park	65	55	55	45	-	-
AQ5	Residence close to road alignments in Umling Gewog	55	45	55	45	55	45
AQ6	Tareythang Gewog Center	55	45	55	45	-	-
AQ7	Residence close to road alignments in Tareythang Gewog	55	45	55	45	53	42

Note:

[a] 06:00–22:00 hours
[b] 22:00–06:00 hours

Measurements at positions AQ3, AQ4 and AQ6 were contaminated by adverse weather conditions and atypical noise events (i.e., loud street parties and extended periods of heavy rainfall). As such, the affected measurement results have been excluded from the analysis as they do not represent the baseline noise levels at these locations. Further noise monitoring will be carried in due course to inform the final ESIA submission.

For the noise baseline, the measurement results from Positions AQ5 and AQ7 are considered representative of the baseline noise levels at residential receptor within city/town outskirts and rural locations. Measurement Positions AQ1 and AQ2 are regarded as being within the "industrial" category (refer to ***Table 3.7***, from the Legal and Institutional Framework chapter) and therefore a higher threshold applies that for residential. On this basis, baseline noise levels across all locations are within Bhutan's national standards and WBG EHS Guidelines.

6.6 TRAFFIC AND TRANSPORT

6.6.1 EXISTING CONDITIONS

6.6.1.1 CURRENT ROAD INFRASTRUCTURE CONDITION

Bhutan has approximately 18,270 km of roads, including 4,864 km of paved roads (26 percent of the total). Approximately 16 percent of the road system is part of the Asian Highway, Expressway, or National Roads, 11 percent are district (dzongkhag) roads, and the remainder are urban, farm, or access roads. The road network in Sarpang consists of 1,024 km of roads, of which 118 km are national roads, 107 km are dzongkhag roads, 16 km are urban roads and the remainder are farm or access roads. Sarpang Dzongkhag has 33 motor vehicle bridges.[54]

Bhutan's network of National Highways consists primarily of an east-west route crossing central Bhutan from Thimphu to Trashigang with four major north-south links from this route to the south of the country at the Indian border. One of the north-south links of the National Highway connects the town of Trongsa, within the Thromde municipality in central Bhutan's Trongsa District, to the border with India, south of Gelephu in Sarpang District.

South of Gelephu, the National Highway (S Ngedrup Zhung Lam) has a two-lane, 5 to 7 m wide paved carriageway with intermittent lane markings and narrow or no shoulders. S Ngedrup Zhung Lam has multiple intersections with roads within Gelephu, which has an extensive grid network with paved, 2-lane primary roads and unpaved secondary roads. North of Gelephu, the National Highway is a 2-lane, paved road with intermittent lane markings.

East of the Langer River, the Project would join with the existing road (the approach road to Gyalsung center) that winds through an area of steep terrain before descending to Tareythang. This existing road is a two-lane road with approximately 5.5 m of paved width, no shoulders, and intermittent lane markings.

Between Gelephu and Tareythang, the Project would intersect several local roads, especially in the area between the Taklai and Langer Rivers. Detailed information on the number of local road crossings and the nature and condition of the local roads is not available and will be provided in the final ESIA.

6.6.1.2 CURRENT TRAFFIC VOLUMES

Information on current traffic volumes on roads near Gelephu and Tareythang is limited. The Department of Roads collects traffic data twice per year (typically in September and February) at the Aie Bridge, where the Trongsa-Gelephu Highway crosses the Manas River north of Gelephu. ***Table 6.11*** summarizes traffic data collected during daylight hours (06:00h to 20:00h) from 2021 through 2024. Traffic volumes within Gelephu are assumed to be higher than those reported at the Aie Bridge, due to local travel within Gelephu. Nonetheless, the reported traffic volumes are relatively low (the 990 vehicles recorded at the Aie Bridge in February 2023 are equivalent to an average of 70 vehicles per daylight hour, or slightly more than 1 vehicle per minute).

[54] National Statistics Bureau. 2022. Statistical Yearbook of Bhutan, October 2022.

TABLE 6.11 AVERAGE DAILY DAYTIME TRAFFIC COUNTS AIE BRIDGE, 2021 TO 2024

	Heavy Vehicles	Medium Vehicles	Light Vehicles	Two-wheelers	Other	Total [a]
15 to 30 September 2021	171	45	376	29	13	**634**
15 to 28 September 2022	118	67	485	39	3	**711**
15 to 28 February 2023	40	40	886	24	0	**990**
15 to 30 September 2023	41	24	598	31	1	**695**
15 to 28 February 2024	45	29	730	29	5	**833**

Heavy vehicles include all trucks. Medium vehicles include passenger buses and similar vehicles. Light vehicles include all two-axle passenger cars. Other vehicles include tractors and similar equipment.

[a] Totals may not match the sum of addends, due to rounding.

6.6.1.3 ROAD SAFETY CONDITIONS

Bhutan had an estimated 123 road traffic deaths nationwide in 2019.[55] The number of road traffic deaths per 100,000 population increased from an estimated 13.6 in 2009 to 16.2 in 2019.[56] Speed limits in Bhutan are generally low, limited to 30 km/hour on urban roads and 50 km per hour outside of towns and cities. Safety provisions established in Bhutan laws include national seat belt and motorcycle helmet requirements, a minimum driving age of 18, and laws regarding driving under the influence of alcohol or drugs.[57]

Table 6.12 summarizes the number of motor vehicle accidents recorded in Bhutan Royal Police crime statistics for 2022 through August 2024. For the 2024 motor vehicle accidents (January through August), the Gelephu and Sarpang police stations report 61 collisions, 24 single vehicle incidents, 9 hit and run incidents, 5 pedestrian hits, 1 accident involving an animal and two accidents resulting in fatalities. Of the accidents in 2024 for which causes are listed, 37 percent were attributed to driving under the influence of alcohol.[58]

TABLE 6.12 NUMBER OF MOTOR VEHICLE ACCIDENTS INCLUDED IN ROYAL POLICE CRIME STATISTICS

Year	Gelephu Police Station	Sarpang Police Station
2022	22	12
2023	14	14
2024, January - August	81	21

Source: Royal Bhutan Police 2024

[55] WHO (World Health Organization). 2021. Road traffic deaths: Data by country. Last updated: 2021-02-09. Available at: https://apps.who.int/gho/data/view.main.51310?lang=en. Accessed October 2024.

[56] Ibid.

[57] World Bank. 2020. *Guide for Road Safety Opportunities and Challenges: Low- and Middle-Income Country Profiles*. Available at: https://www.aprso.org/sites/default/files/document/2020-10/FINAL_Road%20Safety%20Country%20Profiles_compressed%5B1%5D.pdf. Accessed October 2024.

[58] Royal Bhutan Police. 2024. Meeting between ERM and Royal Bhutan Police, Division 5. 3 September 2024.

The most accident-prone areas are concentrated in the urban parts of Gelephu Thromde, including Namkhaling, Jampelling, and Hospital Junction. Safety challenges that contribute to higher accident incidences in these areas include crossroad junctions, narrow roads, and limited parking areas. Samdrupling Junction (Oka Junction) and Tashiling are also prone to accidents despite being in a less urban setting, due to the complexities of their crossroad layouts. Rural locations such as Sershong (Aie Slip), Norbuling, and Umling experience frequent accidents, primarily due to poor road conditions, sharp turns, and landslides, which make these stretches hazardous.

6.6.1.4 FUTURE DEVELOPMENT

Improved east-west connectivity in the south of the country is a key goal of Bhutan's Comprehensive National Development Plan, which specifically calls for new and improved roads connecting Samtse to Samdrupjongkhar, a straight-line distance of approximately 240 km.[59] The plan identifies Gelephu-Panbang as a missing segment of the southern east-west road network.

The regional plan for the Southern Central Region calls for increased development and industrialization in the area from Sarpang to Gelephu. Gelephu is seen as a focal point of manufacturing, with increased access through the opening of the Gelephu Airport to international travel. Improved roadways and implementation of the east-west road connectivity is noted in the plan as necessary to the increased development.[60]

[59] Ministry of Works and Human Settlement. 2019. *The Project for Formulation of Comprehensive Development Plan for Bhutan 2030: Volume III Comprehensive Development Plan, Final Report June 2019.* Available from: https://www.moit.gov.bt/wp-content/uploads/2022/12/CNDP-Vol3_Comprehensive-Development-Plan.pdf.

[60] Ministry of Infrastructure and Transport (MoIT). 2024. *Project for the Formulation of the Southern Central Regional Plan in the Kingdom of Bhutan. Final Report, April 2024*. Research Institute for Urban & Environmental Development, Japan. Nippon Koei Co., Ltd.

7. BIODIVERSITY BASELINE

This section provides a description of the ecological context for the Project area (road and its Right of Way) and the adjacent areas. The data presented were obtained by the following means:

- Desktop review from widely recognized sources, to support a comprehensive understanding of the biodiversity values that are present in the Project area and its proximity. The main sources include (i) Integrated Biodiversity Assessment Tool (IBAT) for Business, (ii) IUCN Red List for Threatened Species online version, (iii) Global Biodiversity Information Facility (GBIF) and iNaturalist, (iv) Birdlife Data Zone, and (v) ebird.org as described in ***Appendix F1.***
- Stakeholder engagements with 12 key experts in July 2024. The experts are ecologists, forest office working for authorities, national park and Non-Governmental Organization, those are familiar with ecology of Sarpang (***Appendix F2***)*;* and
- Primary field surveys (***Appendix F3***)

    - Terrestrial Surveys during wet season: the terrestrial flora and fauna survey was conducted in the monsoon season from 12 July to 29 August 2024. The surveys adopted the Biodiversity Monitoring Grids (BMG), but converted to a smaller area. The smaller grid ensures that biodiversity monitoring is tailored to the scale of the potential Impact Area and is nested within the country-level 4x4 grid. The terrestrial surveys include Quadrat survey for flora, Transect survey for bird, herpetofauna, mammals. Additionally, there were camera traps set from 13 July – 29 August 2024.

    - Terrestrial Surveys during dry season: Similar to the above surveys during the wet season, transect surveys for birds, herpetofauna, and mammals were carried out during 7 to 30 November 2024. In addition, the camera trap data from 30 Aug to 25 October 2024 was also used.

    - Aquatic survey: The fish sampling and macroinvertebrate sampling were collected following a systematic random sampling technique during 05-08 August 2024 for the wet season data collection, and again during the first week of November 2024.

The detailed Methodology regarding data collection is presented in ***Appendix F.***

This section presents a summary of the key biodiversity receptors identified through desk-based study and the baseline biodiversity field surveys undertaken to inform the Project development and ESIA.

7.1 ECOLOGICAL CONTEXT OF THE PROJECT

A desk-based review of available information on the biodiversity features within the Critical Habitat Area(s) of Analyses ("AoA") (***Section 7.2.2***, ***Section 7.2.3***) and rapid baseline surveys were undertaken. The following are the key findings:

- The project footprint is predominantly covered by agriculture and forests, with other land-use types occupying much smaller portions, i.e., bare ground, built-up, successional rangeland, and riparian rangeland. While the forest vegetation has experienced minor disturbances, it likely continues to support a variety of species:
    - Dominating much of the northern of the project area, sub-tropical forests are found at altitudes ranging from 150 to 398 meters. The sub-tropical forests have dense

canopy covered with a rich diversity of evergreen and deciduous trees, shrubs, and thick undergrowth, including species such as *Chukrasia tabularis, Acrocarpus fraxinifolius, Ailanthus grandis, Bombax ceiba, Duabanga grandiflora, Shorea robusta, Tetrameles nudiflora*. These forests typically occur in warm, humid conditions and support a wide variety of wildlife, including insects, birds, mammals, and reptiles.

- Interspersed within the forests and riverbanks, grasslands are composed primarily of tall grasses, such as *Miscanthus spp, Imperata spp and and Saccharum spp*, which are adapted to periodic disturbances like flooding, grazing, and fires. Grasslands are crucial habitats for herbivores as well as predators.
- Warm broadleaf forests are composed of a mixture of deciduous and evergreen trees, such as *Alangium chinense, Alnus nepalensis, Betula alnoides, Bischofia javanica, Callicarpa arborea, Castanopsis indica, Cordia obliqua, Dendrocalamus hookeri, Dichroa febrifuga, Engelhardia spicata, Entada spp. Helicia nilagirica*. The canopy cover is moderately dense, allowing sufficient light for a diverse understory.

- The project requires developing bridge crossings over the Mau River, Jenkhunrung River, Taklai River, Langer River, and Singye River. Sarpang district has recorded 28 fish species belonging to 11 families. [61] No available research reported the number of macroinvertebrates in Bhutan. There is currently no available research documenting the specific fish species or macroinvertebrates present in the sections of the Mau and Taklai rivers crossed by the project.
- There are five (05) Protected Areas within 50 km radius of the project (***Section 7.3***):
  - Ripu and Chirang Reserve Forests (2 km to the Project),
  - Royal Manas National Park (<1 km to the Project),
  - Manas Wildlife Sanctuary (24 km to the Project),
  - Phipsoo Wildlife Sanctuary (30 km to the Project), and
  - Biological Corridor 3 (9 km to the Project).
- There are five (05) Key Biodiversity Areas within 50 km radius of the Project (***Section 7.3***):
  - Ripu and Chirang Reserve Forests (2 km to the Project),
  - Royal Manas National Park Important Bird Area (<1 km to the Project),
  - Manas National Park Important Bird Area and Alliance for Zero Extinction (24 km to the Project),
  - Phipsoo Wildlife Sanctuary Important Bird Area (30 km to the Project), and
  - Sarpang-Gelephu Foothills Important Bird Area (3 km to the Project).
- The southern habitat of AOI, i.e., sub-tropical forests and warm broadleaf forests is contiguous with the Royal Manas National Park.
- Data extraction using the Integrated Biodiversity Assessment Tool (IBAT) identified 1,687 species as occurring within 50 km of the project area. Of these, there were 17 Critically

[61] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

Endangered (CR), 42 Endangered (EN), 70 Vulnerable (VU), 77 Near Threatened (NT), 1402 Least Concerned (LC), and 79 Data Deficient (DD).

- Consultation with experts in July 2024 suggested that within the AOA there is a high probability of occurrence of 14 species of conservation concern (eight (08) mammals, two (02) reptiles, one (01) bird, one (01) fish, and two (02) plants;

The terrestrial and aquatic baseline (5-8 August 2024 during the wet season and 7 to 30 November 2024 during the dry season) surveys yielded the following findings:

- **Flora:** The flora survey found 127 species of trees and shrubs, 69 species of herbs, 59 species of regenerating plants, and 37 species of epiphytes. There are two (02) species of conservation concern, i.e., Teak (*Tectona grandis*, IUCN EN) and *Aporosa cardiosperma* (IUCN VU). These three (03) species were found in the plot 1 of the Quadrat survey towards Tareythang gewog of the preferred road alignment.[62] Nine (09) plants were identified as invasive species.
- **Birds** (**Wet Season**)**:** The avifauna survey findings suggest that the study area is relatively diverse in terms of bird species, with a total of 158 bird species recorded. Among these, the presence of Great Hornbill (*Buceros bicornis*, FNCRR[63], IUCN VU, CITES I[64]), Wreathed Hornbill (*Rhyticeros undulatus*, IUCN VU), River Lapwing (*Vanellus duvaucelii*, FNCRR[65], IUCN NT) and Peregrine Falcon (*Falco peregrinus*, IUCN LC, CITE I[66]) was recorded.
- **Birds** (**Dry Season**The dry season had a higher species richness than the wet season, though total bird abundance was greater in the wet season. The avifauna survey recorded 184 bird species, and 4,858 individual birds compared to 158 bird species and 6,599 individual birds during the wet season. The observations suggest that more bird species migrate to warmer areas during winter, leading to higher species diversity in the dry season. However, overall bird abundance is greater in the wet season, likely due to increased breeding activity. The species of conservation concern recorded in the dry season are similar to those observed in the wet season.
- **Herpetofauna (Wet Season):** the presence of 12 amphibian species and 39 reptile species was recorded, though four (04) amphibian species and five (05) reptile species could not be identified to the species level. There were 3 species of conservation concern, i.e., Tricarinate Hill Turtle (*Melanochelys tricarinata*, IUCN EN, CITES I[67]), King Cobra (*Ophiophagus hannah*, IUCN VU, CITES II[68]), Burmese Python (*Python bivittatus*, IUCN VU).
- **Herpetofauna (Dry Season):** The dry season surveys also recorded 12 amphibian species and 39 reptile species. The species captured through photographs include: Red

[62] The full detail is presented in the ESIA Chapter 7 Biodiversity Baseline.

[63] The Forest and Nature Conservation Rules and Regulations (FNCRR), 2017 of Bhutan

[64] Appendix I: Includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.

[65] The Forest and Nature Conservation Rules and Regulations (FNCRR), 2017 of Bhutan

[66] Appendix I: Includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.

[67] Appendix I: Includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.

[68] Appendix II: Includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.

neck keelback, Yellow speckled wolf snake, Hylarana sp., Forest skink, Skittering frog, Calotes versicolor, and Bhramy blind snake.

- **Terrestrial mammal** (**Wet Season**)**:** The camera trap survey and transect survey recorded the presence of 13 mammal species with six (06) species only encountered through the camera trap. Among the recorded species, species of conservation significance include:
  - Hog Deer (*Axis porcinus*, IUCN EN),
  - Dhole (Cuon alpinus, IUCN EN),
  - Asian Elephant (*Elephas maximus*, IUCN EN),
  - Bengal Tiger (*Panthera tigris ssp. Tigris*, EN),
  - Gee's Golden Langur (*Trachypithecus geei*, IUCN EN and endemic to Bhutan),
  - Gaur (*Bos gaurus*, IUCN VU),
  - Sambar (*Rusa unicolor*, IUCN VU), and
    - Smooth-coated Otter (*Lutrogale perspicillata*, IUCN VU).
- **Terrestrial mammal** (**Dry Season**)**:** The transect surveys recorded a total of 85 observations across 76 incidents, including 3 direct sightings and 82 instances of indirect evidence. The camera trap surveys recorded were spread across 9 orders, 12 families and 15 species (3 EN, 1 NT, 2 VU, and 9 LC). Among the recorded species, species of conservation significance include:
  - Hog Deer (Axis porcinus, IUCN EN),
  - Dhole (Cuon alpinus, IUCN EN),
  - Asian Elephant (Elephas maximus, IUCN EN),
  - Gee's Golden Langur (Trachypithecus geei, IUCN EN and endemic to Bhutan),
  - Gaur (Bos gaurus, IUCN VU), and
  - Sambar (Rusa unicolor, IUCN VU)

- **Fish (Wet Season – Aug 2024):** Fish diversity recorded a total of 32 species with 29 species in Mau River and 24 species in Taklai river. Two IUCN VU species were found, i.e., Reticulated Loach (*Schistura reticulofasciata*) and Mrigal Carp (*Cirrhinus cirrhosus*) but Mrigal Carp is considered invasive in Bhutan. While the expert consultation (July 2024) suggested the potential presence of Golden Mahseer (*Tor putitora*, IUCN EN), no Golden Mahseer was found during the field survey.
- **Fish (Dry Season – Nov 2024):** Fish diversity recorded a total of 28 species under 9 families. In total, 35 fish species from 14 families were recorded across both seasons of the study The dominant species, during monsoon (wet season) were Garra birostris and Garra annandalei, which accounted for 18.79% and 14.54% of the total fish count, respectively. In contrast, the post-monsoon (dry) season recorded a higher total of 849 fish, representing 28 species under nine families. Garra annandalei emerged as the dominant species in this season, comprising 27.21% of the total samples. IUCN VU species recorded are Assamese kingfish (*Cyprinus semiplotus*) and butte bhitti (D*angila danio*). Golden Mahseer was not found during the field survey. In summary, the surveys during both the seasons found no species classified as critically endangered or endangered by the IUCN Red List, suggesting that the biodiversity of the area, while rich,

is not currently at significant risk of extinction. The dominance of species from the Cyprinidae families highlights the ecological significance of these groups in sustaining local aquatic ecosystems.

- **Macroinvertebrate (Wet Season):** A total of 11 families under nine (09) orders were recorded. Among these, the presence of Mayfly fauna e.g., *Baetis spp.* indicated a clean freshwater condition.
    - **Macroinvertebrate (Dry Season):** There were 14 species of macroinvertebrates recorded from seven orders and 14 families from both the seasons. The Baetidae family, particularly the genus Baetis, was the most abundant, contributing 39.63% to the total abundance.

1.3 CRITICAL HABITAT AREA OF ANALYSIS (AOA)

As per WB ESS-6*, the assessment undertaken by the Borrower will include identification of the types of habitats potentially affected and consideration of potential risks to and impacts on the ecological function of the habitats. The Borrower's assessment will include characterization of baseline conditions to a degree that is proportional and specific to the anticipated risk and significance of impacts*.[69] To use a scientific approach to define an area to characterize for the baseline description, the ESIA relied on Good International Industry Practices and in particular on the concept of Project's Critical Habitat Area of Analysis (AoA). A preliminary review of information on the region's ecology was carried out to characterize the AoA, species or ecosystem elements that occur or are likely to occur in the project area and that may have Critical Habitat.

The spatial scope should be ecologically determined and defined, encompassing wider distributions of potentially affected biodiversity features and the ecological patterns, processes, and functions that are necessary for maintaining them throughout this distribution.

7.1.1 PROJECT AREA

In addition to direct habitat loss and fragmentation from land clearing, habitat degradation and disturbance to terrestrial wildlife due to air emissions and noise may occur locally and extend beyond the immediate Project area. Although baseline surveys covered a larger landscape, the designated project area for terrestrial species and habitats is confined to within 550 m of the road and bridge alignments, which includes the ancillary facilities such as access roads, temporary construction sites such as workers camps, quarry and borrow sites. This distance is based on noise modeling results, which identified the primary zone of wildlife disturbance within a 550 m radius (***Section 9.2 – Noise Impact Assessment***).

Additionally, the location of conflict with the Asian Elephant may change due to construction, which may go beyond the 550 m radius. In such cases, impacts should be assessed at a larger landscape level. Elephants range in search of food, water and mates for reproduction. Since radio collaring data from 2016 show that elephants range across the trace of the road, they are searching for one or more of the reasons identified above. If a barrier is present (i.e., the fenced

[69] The World Bank, 2018. B ESS6. Environmental & Social Framework for IPF Operations. ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources [Available at: https://documents1.worldbank.org/curated/en/924371530217086973/ESF-Guidance-Note-6-Biodiversity-Conservation-English.pdf]

road), some may use the underpasses to traverse within their home range, while others may not—particularly the elephants that did not use the river crossings in the past. These elephants may expand their present range in search of food since they cannot go across the road. This could result in increased Human Elephant Conflict (HEC) as crop raiding may increase. This may be a direct result of the project's impacts. Therefore, the impact on elephants (and on humans due to elephants) will likely be larger than a 550 m radius. Therefore, the ecological impact assessment considered the impacts not only restricted to the project area, but also to the Area for Analysis (AOA).

The main impacts on aquatic species and habitats can be associated with the bridge and aggregate extraction for road construction. These construction and operational activities can cause erosion, sedimentation, water quality degradation, and alterations in natural water flow. The designated project area for aquatic species and habitats includes both upstream and downstream sections of the Project, as silt and contaminants are likely to travel downstream, and aquatic species are expected to migrate in both directions. This designation of the project area considered the impact on hydrology and water quality (***Section 9.3 – Hydrology Impact Assessment***).

1.3.1 TERRESTRIAL AOA

Raptors may be attracted to roadkill carcasses; however, with appropriate mitigation measures in place, both the number of carcasses and the raptors they attract are expected to remain minimal. Given that the insignificant impacts on volant species, as there would be no collision risks and suitable habitat can be found nearby, the terrestrial AOA was delineated to focus on potential impacts on terrestrial habitats and non-volant species. This delineation considered habitat connectivity and contiguity across the broader landscape, the extent of the Project's potential impacts, and the presence of distinct barriers to biodiversity values.

The terrestrial AOA (***Figure 7.1***) was defined to encompass the terrestrial area surrounding the Project's Area, except where it was limited by natural and man-made barriers that restrict the movement of non-volant terrestrial species. Specifically,

- To the noth and northeast of the G-T Road, the AOA includes the subtropical forest within the proposed GMC, extending to the contiguous forests connected to the Royal Manas National Park, and the Sarpang-Gelephu Foothills and Biological Corridor 3. The preferred habitat supporting potentially triggered Critical Habitat species, especially the Asian Elephant and Gee's Golden Langur, was examined during the terrestrial AOA delineation. While Asian Elephants are generalists, adaptable to a wide range of habitats, Gee's Golden Langur can be found in tropical forest or broad leaf forest with the dense canopy cover. An elevation of 500 meters[70] was used to demarcate a boundary for the terrestrial AOA, as certain species of conservation significance, i.e., Asian Elephant in the area are typically found at lower elevations up to 500m.
- On the eastern side of the G-T Road there is an existing road and hence, the proposed construction will leverage on the existing ROW, which will be widened to a double lane, which has also been considered in the AOA delineation. Further, it was understood from

[70] Palei, H. S., Jangid, A. K., Hanumant, D. D., Palei, N. C., & Mishra, A. K. (2024). On the elephant trails: habitat suitability and connectivity for Asian elephants in eastern Indian landscape. *PeerJ*, *12*, e16746.

the visit and engagement with DoFPS that the development of the to the Tarethang Gaylsung centre has resulted in some fragmentation to the elephant movement and hence, the existing movement route has been altered to a pathway immediately north of the centre, which has been included in the AOA. On the western side of the G-T Road, there are agricultural land, rangeland, and subtropical forest. The terrestrial AOA was extended to this region to include connected habitats considering the movement of the Asian Elephant, a species of significant conservation significance observed within the project area during the field survey (July - August 2024 and October-November 2024). Specifically, the movements of the "Jetsun" elephant[71] indicated that Asian Elephants travel to Umling Province, adjacent to Manas National Park, and as far west as Phibsoo Wildlife Sanctuary, traversing various land covers.[72] Therefore, the western area, including agricultural land, rangeland, and subtropical forest, was incorporated into the terrestrial AOA.The south of the road alignment across the Indian border includes some barren land, riverbanks and agricultural land. Based on stakeholder engagements with DoFPS and existing GPS tracking data (maintained by DoFPS), it is understood that the elephants traverse these areas in search of food.

7.1.3 AQUATIC AOA

The aquatic AOA has been delineated along both the Mau River and Taklai River, encompassing both upstream and downstream sections, including the areas before they merge with branches of other rivers (***Figure 7.2***). The main impact can be associated with the bridge and road construction and associated run off, erosion, siltation etc. During the seasons when the rivers have water e.g., during the monsoon, species such as Golden Mahseer migrate, and a siltation could impede its migration to spawning sites upstream at least temporarily. Therefore, the aquatic AOA includes the zone where siltation plumes are most concentrated, and the southern boundary is designed approximately where the river is receiving new tributaries that will increase the water flow and introduce new changes in the water quality. Lower order streams are preferred spawning sites, and these are likely to be located upstream Gelephu Town where the waters are faster and more oxygenated. It is understood that during the dry season, the rivers dry up considerably, with limited water flow. The delineation of the AOA has also taken into consideration the different habitat niches along the water body which may be utilized by the local fish, such as:

- Smaller hill streams/ riverbeds, most preferred spawning sites;
- Deep waters;
- Run habitats;
- Backwater pools;
- Secondary channels;
- Areas with large boulders, pebbles and gravel.

[71] "Jetsun" is an individual adult female Asian elephant. From radio-collar information tracking the hourly movements of "Jetsun", the Bhutan elephant corridor report by Department of Forestry and Park Services were able to strongly visualize where she travelled (from Jan 2015 to Sept 2016).

[72] Department of Forestry and Park Services. Bhutan elephant corridor report.

FIGURE 7.1 TERRESTRIAL AREA OF ANALYSIS

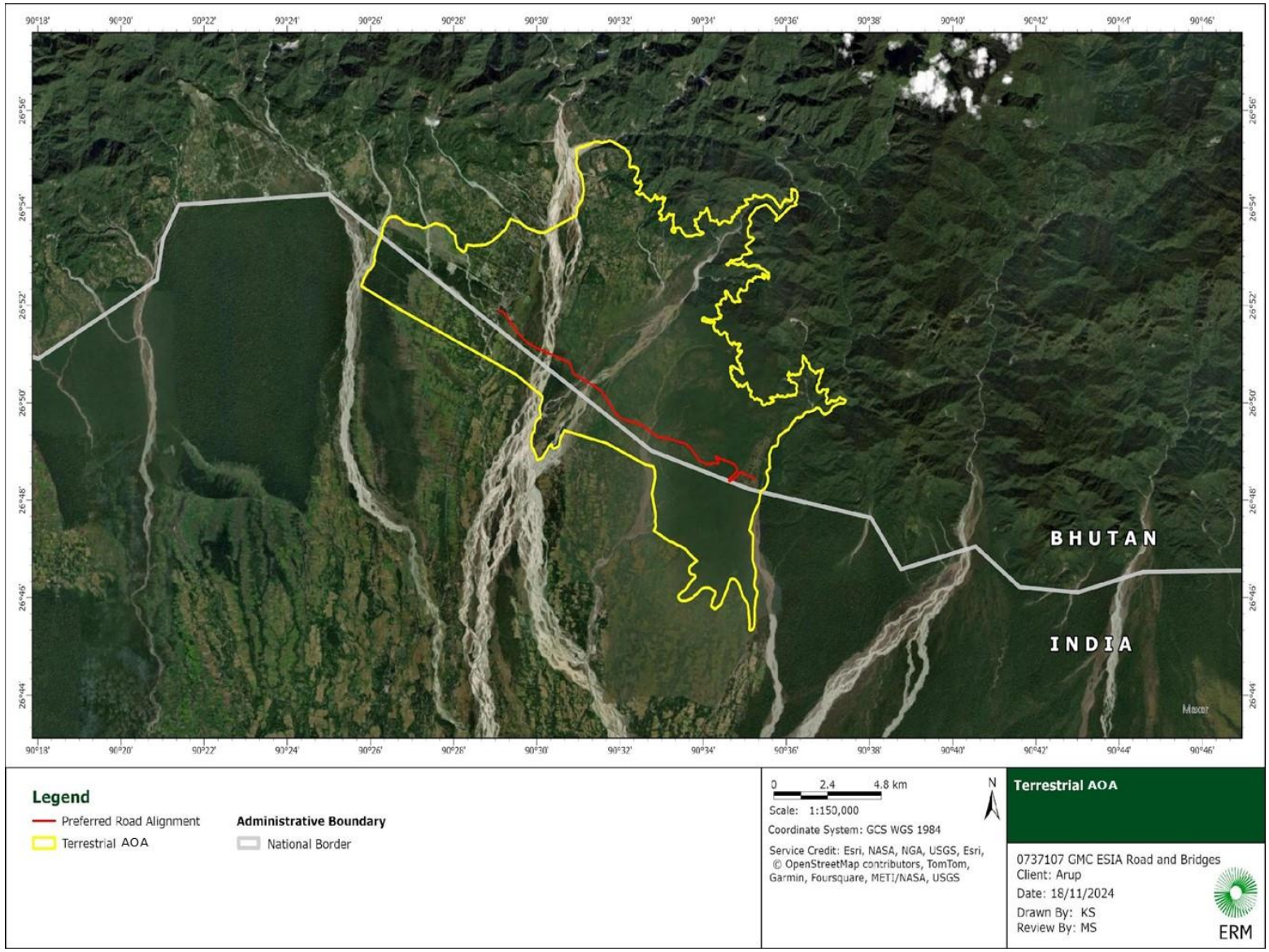
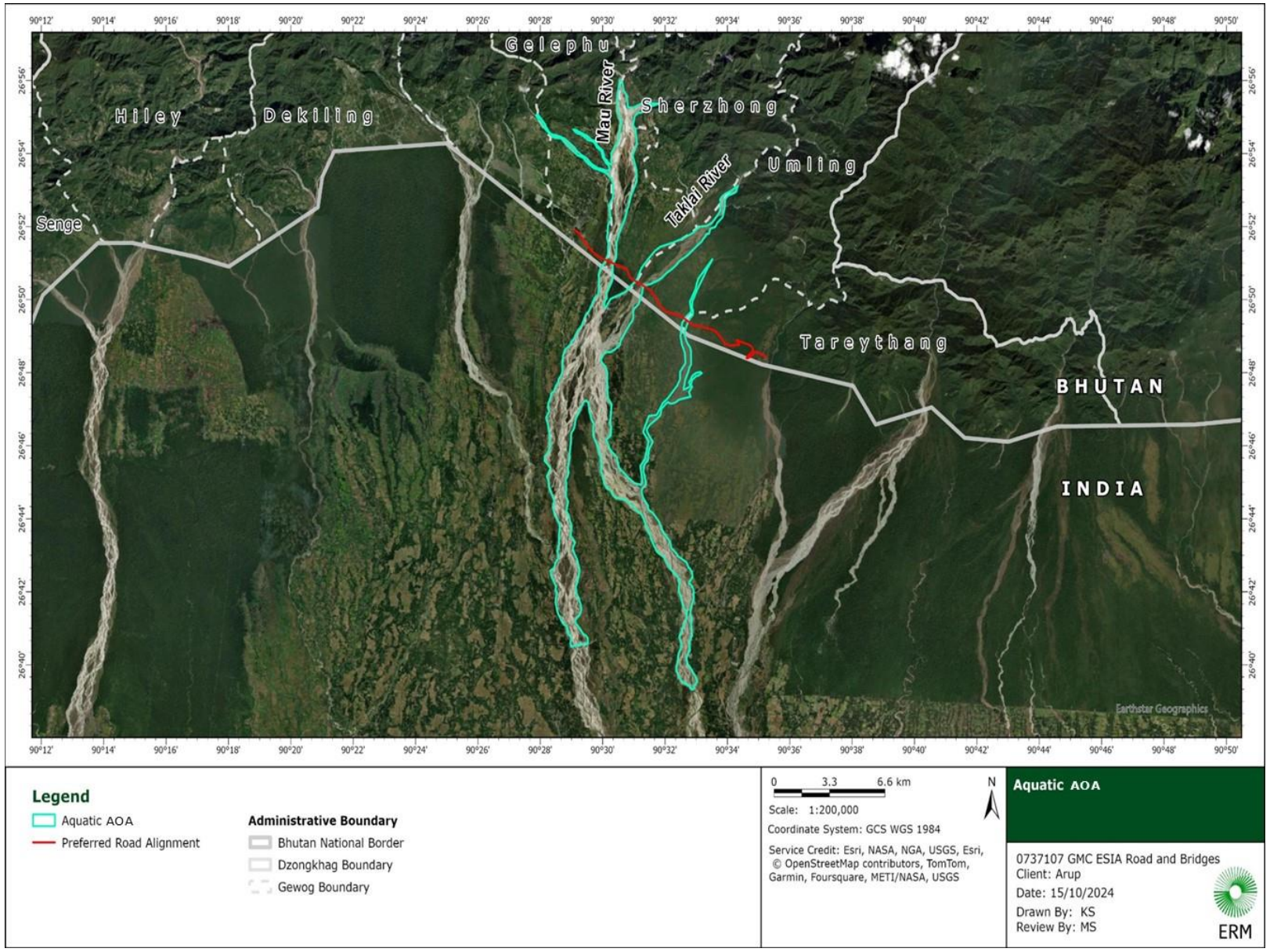


FIGURE 7.2 AQUATIC AREA OF ANALYSIS



7.2 LEGALLY PROTECTED AND INTERNATIONALLY RECOGNIZED AREAS OF HIGH BIODIVERSITY VALUE

WB ESS-6 defined Internationally recognized areas of high biodiversity value include World Heritage Natural Sites, Biosphere Reserves, Ramsar Wetlands of International Importance, Key Biodiversity Areas, Important Bird Areas, and Alliance for Zero Extinction Sites, among others.[73] 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.[74] The Legally Protected and Internationally Recognized Areas of High Biodiversity Value within 50 km radius from the Project are identified in ***Table 7.1***. The detailed information is provided in ***Appendix G.***

TABLE 7.1 LEGALLY PROTECTED AND INTERNATIONALLY RECOGNIZED AREAS OF HIGH BIODIVERSITY VALUE WITHIN 50 KM RADIUS FROM THE PROJECT

International/ National Protected Areas	Description
Ecoregion	The Project area crosses two ecoregions: • Himalayan subtropical broadleaf forest ecoregion • Brahmaputra Valley semi-evergreen forests
Legally Protected Area (PA)	There are five (05) PAs within 50 km radius of the Project, specifically: • Ripu and Chirang Reserve Forests (approx. 2 km to the Project), • Royal Manas National Park (<1 km to the Project), • Manas National Park (approx. 24 km to the Project), • Biological Corridor 3 (approx. 9 km to the Project), and • Phibsoo Wildlife Sanctuary (approx. 30 km to the Project). The Biological Corridor 3 is to ensure continuous gene flow by facilitating uninterrupted wildlife movement and habitat succession, especially between Phipsoo Wildlife Sanctuary and Royal Manas National Park.
Key Biodiversity Area (KBA)	Five (05) KBAs were in the 50 km of the Project include: • Royal Manas National Park Important Bird Area (IBA) (< 1 km to the Project) • Manas National Park (India) IBA and Alliance for Zero Extinction (approx. 24 km to the Project) • Sarpang-Gelephu Foothills IBA (approx. 3 km to the Project) • Phibsoo Wildlife Sanctuary IBA (approx. 30 km to the Project) • Ripu and Chirang Reserve Forests (India) (approx. 2km to the Project) These KBAs recorded the presence of various species of conservation, especially Asian Elephant (*Elephas maximus*, IUCN EN), Gee's Golden Langur (Trachypithecus geei, IUCN EN), and Tiger (Panthera tigris, IUCN EN).
World Heritage Site	The closest one is the Manas Wildlife Sanctuary in India, located approximately 24 km from the Project.
Ramsar Site	No Ramsar site within 50 km of the Project.
Endemic Bird Area (EBA)	The project is within the Eastern Himalayas EBA, supporting various restricted-range bird species, with the genus *Sphenocichla* being endemic to this EBA.

[73] Footnote 16. WB ESS-6.

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

FIGURE 7.3 PROTECTED AREA WITHIN THE VICINITY OF THE AOA

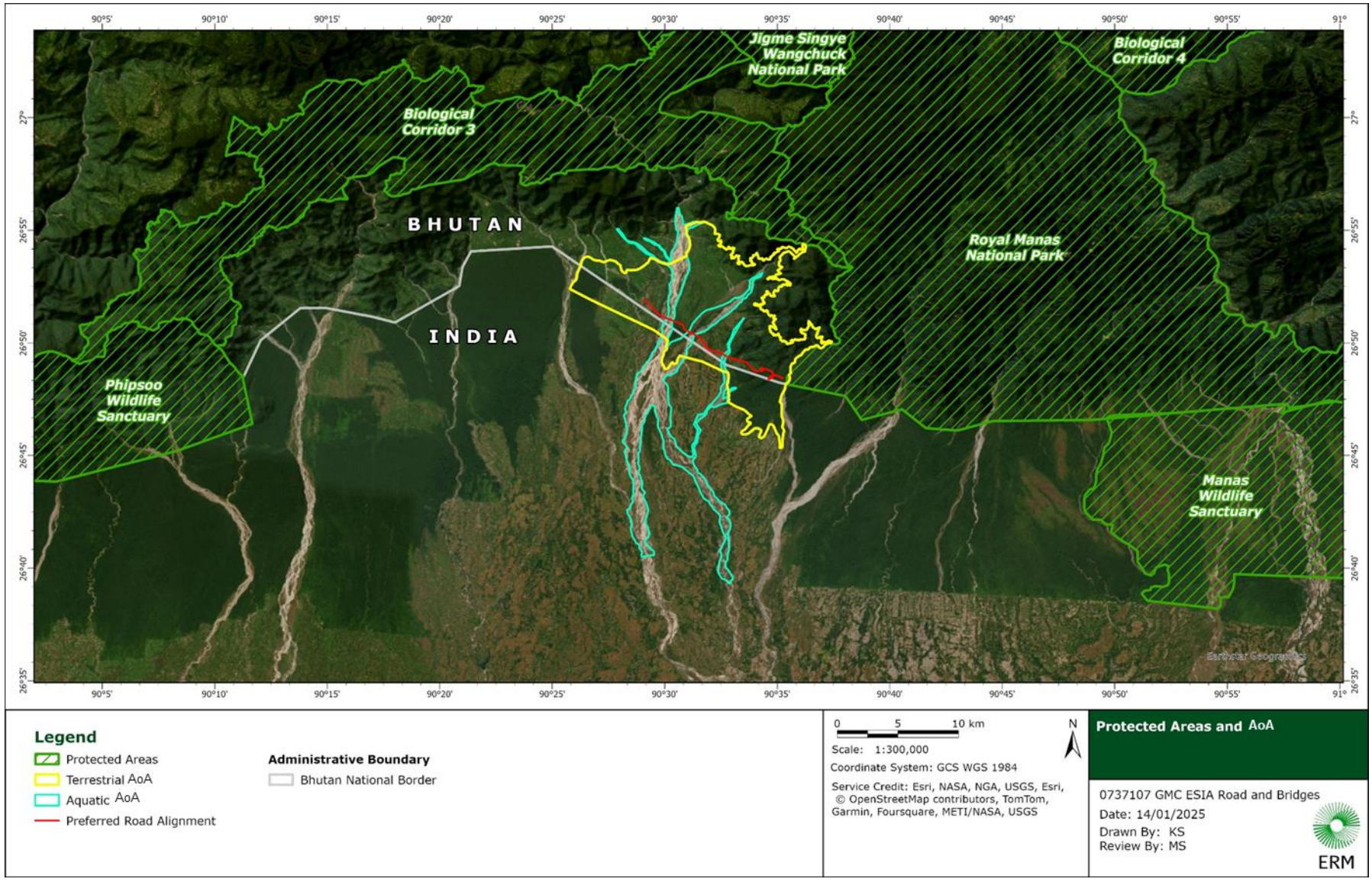


FIGURE 7.4 KEY BIODIVERSITY AREAS WITHIN THE VICINITY OF THE AOA

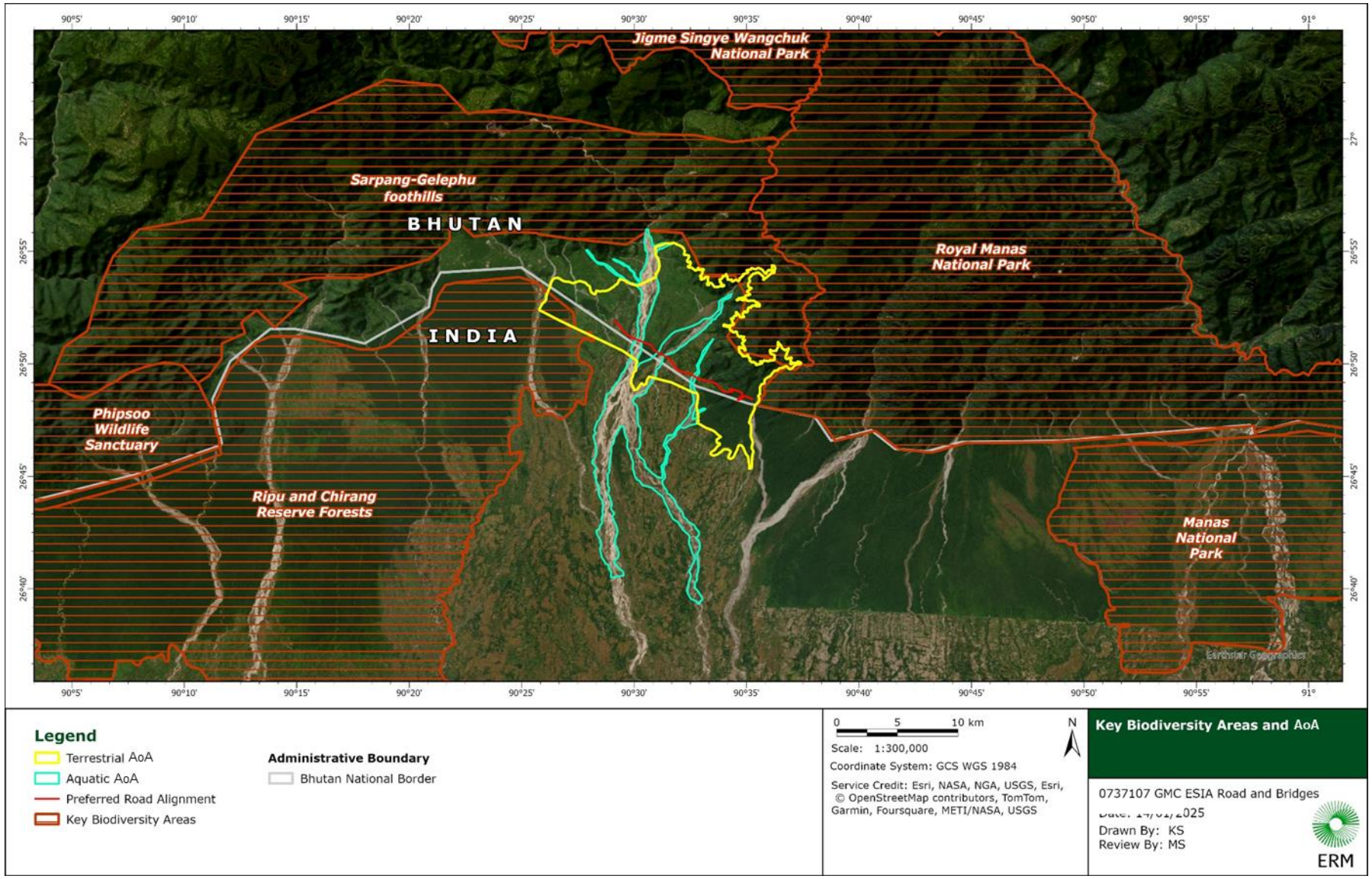
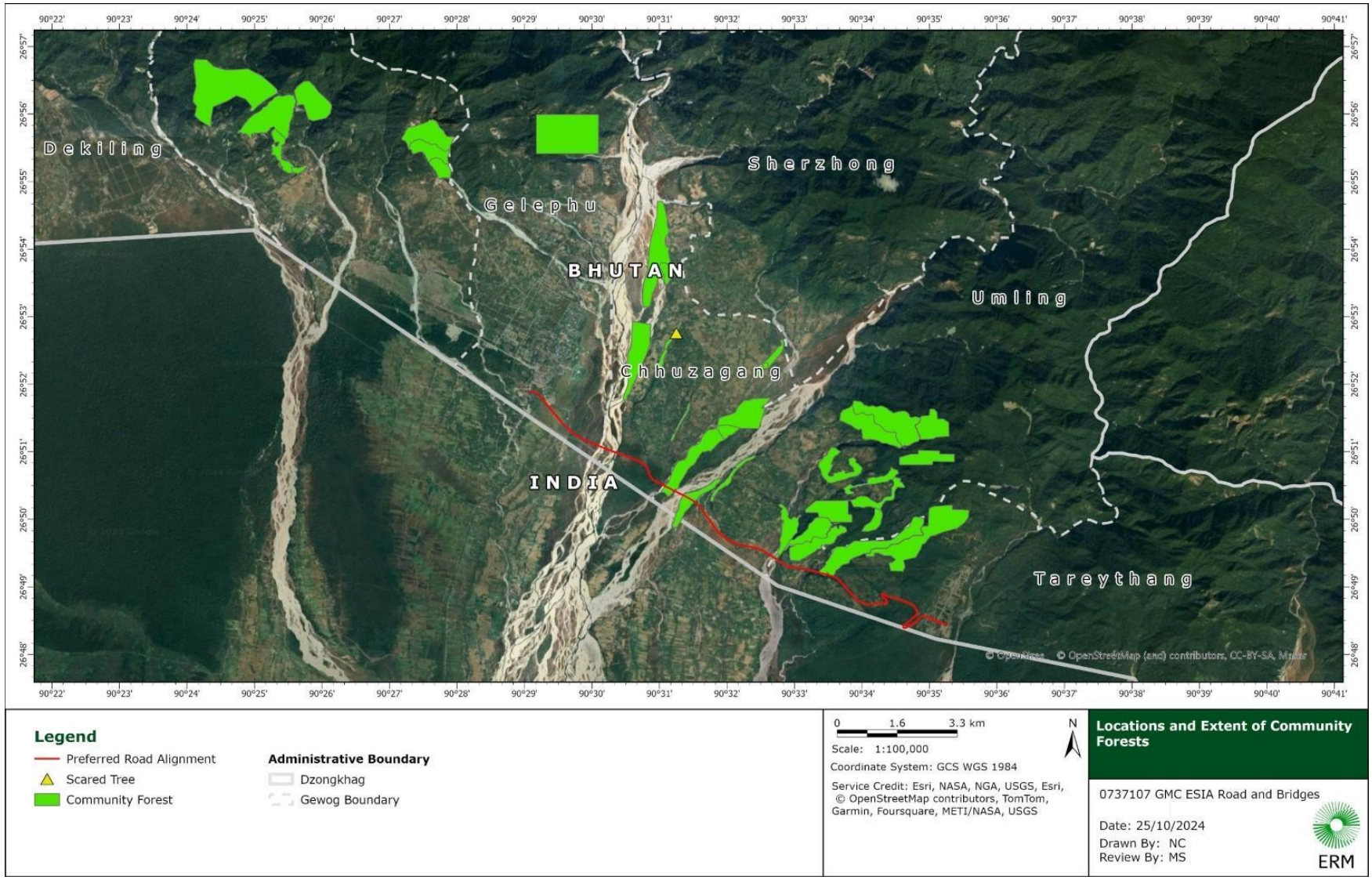


FIGURE 7.5 COMMUNITY FORESTS NEAR THE PROJECT AREA



7.3 NATURAL AND MODIFIED HABITAT

7.3.1 NATURAL AND MODIFIED HABITAT DEFINITION

Habitat is defined as a terrestrial, freshwater, or marine geographical unit or airway that supports assemblages of living organisms and their interactions with the nonliving environment. All habitats support complexities of living organisms and vary in terms of species diversity, abundance, and importance.[75]

WB ESS-6 provides the following definition of Natural and Modified Habitat:

- **Natural habitats:** Natural habitats are areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological functions and species composition.
- **Modified habitats:** Modified habitats are areas that may contain a large proportion of plant and/or animal species of nonnative origin, and/or where human activity has substantially modified an area's primary ecological functions and species composition. Modified habitats may include, for example, areas managed for agriculture, forest plantations, reclaimed coastal zones, and reclaimed wetlands.

According to WB ESS-6, both natural and modified habitats can be classified as critical habitats.[76] A Critical habitat is defined as an area with high biodiversity importance or value, including:

(a) Habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches.

(b) Habitat of significant importance to endemic or restricted range species;

(c) Habitat supporting globally or nationally significant concentrations of migratory or congregatory species;

(d) Highly threatened or unique ecosystems; and

(e) Ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d).

Critical Habitat Assessment is thereby primarily based on biodiversity value and biodiversity sensitivities associated with project landscape, rather than on anthropogenic pressure. In practice, natural and modified habitats exist on a continuum that ranges from largely untouched, pristine natural habitats to intensively managed, modified habitats. The following section is aiming at classifying the delineated "Habitat Types" as "Natural Habitat" or "Modified Habitat", primarily based on degree of anthropogenic pressure/activity on respective habitat types.

7.3.2 IDENTIFY NATURAL AND MODIFIED HABITAT

The identification of habitat types has been done by using the ESRI Land Cover 2023[77] and the open-source map service: Google Satellite Imagery. The map services have been used to manually modify and categorize the land cover types, ensuring that the data was updated with the most recent available information. The combination of these methodologies allowed for a

[75] The World Bank ESS-6 (2018)

[76] Paragraph 23. The World Bank ESS-6 (2018)

[77] https://livingatlas.arcgis.com/landcover/.

comprehensive and current representation of land cover distribution within the Project Area and AOA (***Figure 7.6, Figure 7.9, Figure 7.2***). The results are still subject to error based on artifacts generated by satellite imagery or misinterpretation of land covers with a similar spectral signature by the interpretation model (e.g. exposed bare ground and build up). The natural habitat and modified habitat classification is summarized in ***Table 7.2***.

The project footprint, project area and the terrestrial AOA are predominantly covered by agriculture and forests, with other land-use types occupying much smaller portions, i.e., bare ground, built-up, successional rangeland, and riparian rangeland (***Table 7.2, Figure 7.3, Figure 7.6, Figure 7.9***). Anthropogenic impacts in the region are considered pervasive, in the form of urbanization. This has led to extreme fragmentation of the land, with agriculture and human settlements interspersed with areas of rangeland. Land cover and natural/modified habitat calculations described in ***Table 7.3***.

The western forest contiguous with Phibsoo Wildlife Sanctuary and southern forest contiguous with Royal Manas National Park have experienced disturbances but continue to support a variety of species. In the western forest of GMC, there were records of Gee's Gloden Langur and Asian Elephant. Species of conservation concern found in the southern forest of the GMC includes King Cobra, Great Hornbill, Gee's Gloden Langur, Southern Red Muntjac, Leopard, and Tiger (***Section 7.5.2***). In addition, other species of conservation concern also found include Dhole, and Asian Elephants which are generalist, adapting to various types of habitats including modified habitat within the AOAs.

TABLE 7.2 NATURAL HABITAT AND MODIFIED HABITAT CLASSIFICATION

Land cover	Description	Natural/ Modified habitat	Photo	Google Earth Imagery
Agriculture	Human planted/plotted cereals, grasses, and crops not at tree height. The crops that can be found in the Project Area include rice, corn, areca nut plantations, etc. The community forest is also classified as agriculture given the purpose of the production forest.	Modified Habitat		
Bare Ground	Area of rock or soil with very sparse to no vegetation for the entire year; large areas of sand and deserts with no to little vegetation. Dry riverbed and landslide areas are considered as bare ground.	Natural Habitat		

Land cover	Description	Natural/ Modified habitat	Photo	Google Earth Imagery
Built-up	Human made structures; major roads and rail networks; large homogenous impervious surfaces including parking structures, office building, and residential housing.	Modified Habitat		
Successional Rangeland	Grassland or shrubland that are undergoing ecological succession, a process where plant communities change over time following a disturbance. This process is to adapt with to changes in environmental conditions, e.g., such as fire, grazing, or land use changes. In this context, successional rangeland is classified as Modified Habitat as it is likely associated with early regrowth of fallow land in abandoned (or temporarily abandoned) agriculture land plots or cleared forest areas.	Modified Habitat		

Land cover	Description	Natural/ Modified habitat	Photo	Google Earth Imagery
Forest	Any significant clustering of tall dense vegetation with tree dominance and undergrowth, typically with a closed or dense canopy.	Natural Habitat		
Riparian Rangeland	Open areas covered in homogenous grasses with little to no taller vegetation; wild cereals or grasses, mix of small clusters of plants or single plant dispersed on a landscape that shows exposed soil or rocks; scrub-filled clearings within forests that are clearly not taller than trees.	Natural Habitat		

Land cover	Description	Natural/ Modified habitat	Photo	Google Earth Imagery
Water	Areas where water is predominantly present throughout the year; may not cover areas with sporadic or ephemeral water; contains little to no sparse vegetation, no rock outcrop nor built-up features like dock.	Natural Habitat		

TABLE 7.3 LAND COVER AND NATURAL/ MODIFIED HABITAT CALCULATION

No.	Land Cover	Project footprint (km^2)	Work and Camp Area 1 (km^2)	Work and Camp Area 2 (km^2)	Project's Impact Area (550 m from the GMC) (km^2)	Terrestrial AOA (km^2)	Aquatic AOA (km^2)
Modified habitat		**0.12**	**0.03**	**0.08**	**8.79**	**52.80**	**-**
1	Agriculture	0.06	-	0.02	4.28	27.42	Not applicable
2	Bare Ground	0.01	-	-	0.53	4.86	Not applicable
3	Built-up	0.02	-	-	1.89	12.99	Not applicable
4	Successional Rangeland	0.03	0.03	0.02	2.08	7.53	Not applicable
Natural habitat		**0.07**	**-**	**-**	**6.74**	**76.80**	**71.4**
5	Forest	0.06	-	-	5.77	70.24	Not applicable
6	Riparian Rangeland	0.01	-	-	0.82	6.56	Not applicable as partially counted in the terrestrial AOA
7	Water	Not applicable	-	-	0.15	Not applicable	71.4
Total		**0.19**	**0.04**	**0.06**	**15.53**	**129.60**	**71.4**

FIGURE 7.6 LAND COVER WITHIN THE PROJECT AREA

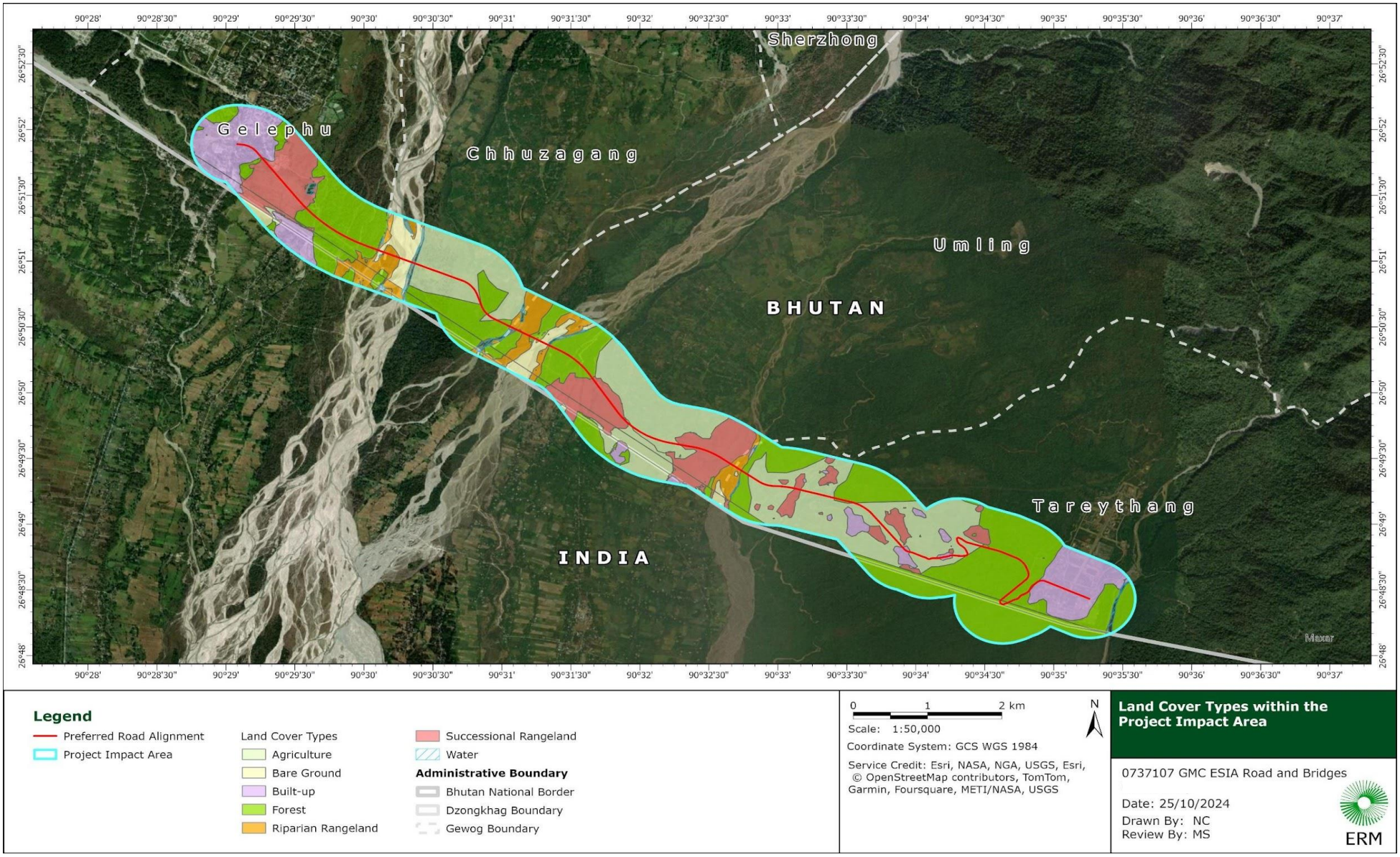


FIGURE 7.7 HABITAT TYPES WITHIN THE PROJECT AREA

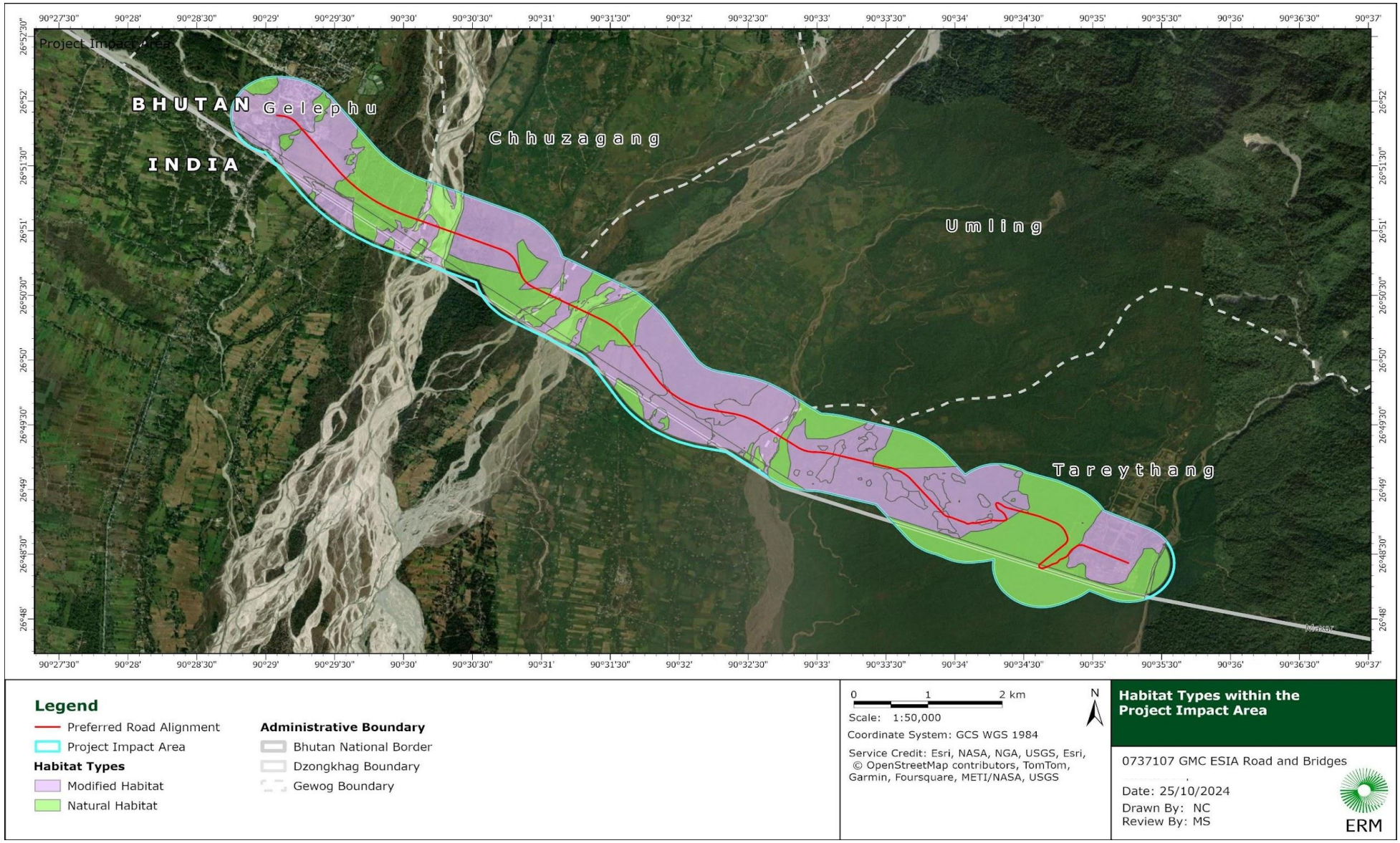


FIGURE 7.8 LAND COVER WITHIN THE AOA

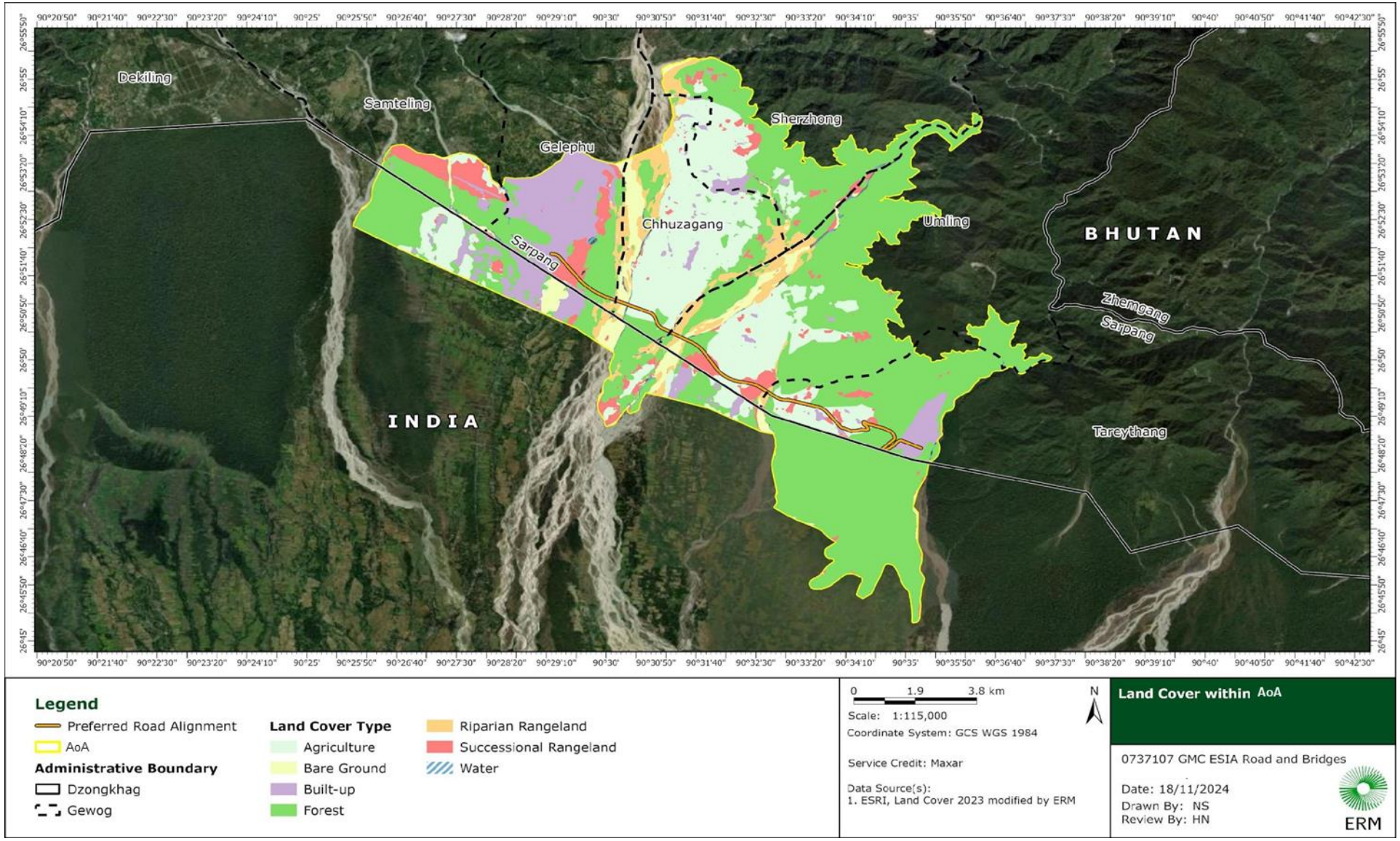
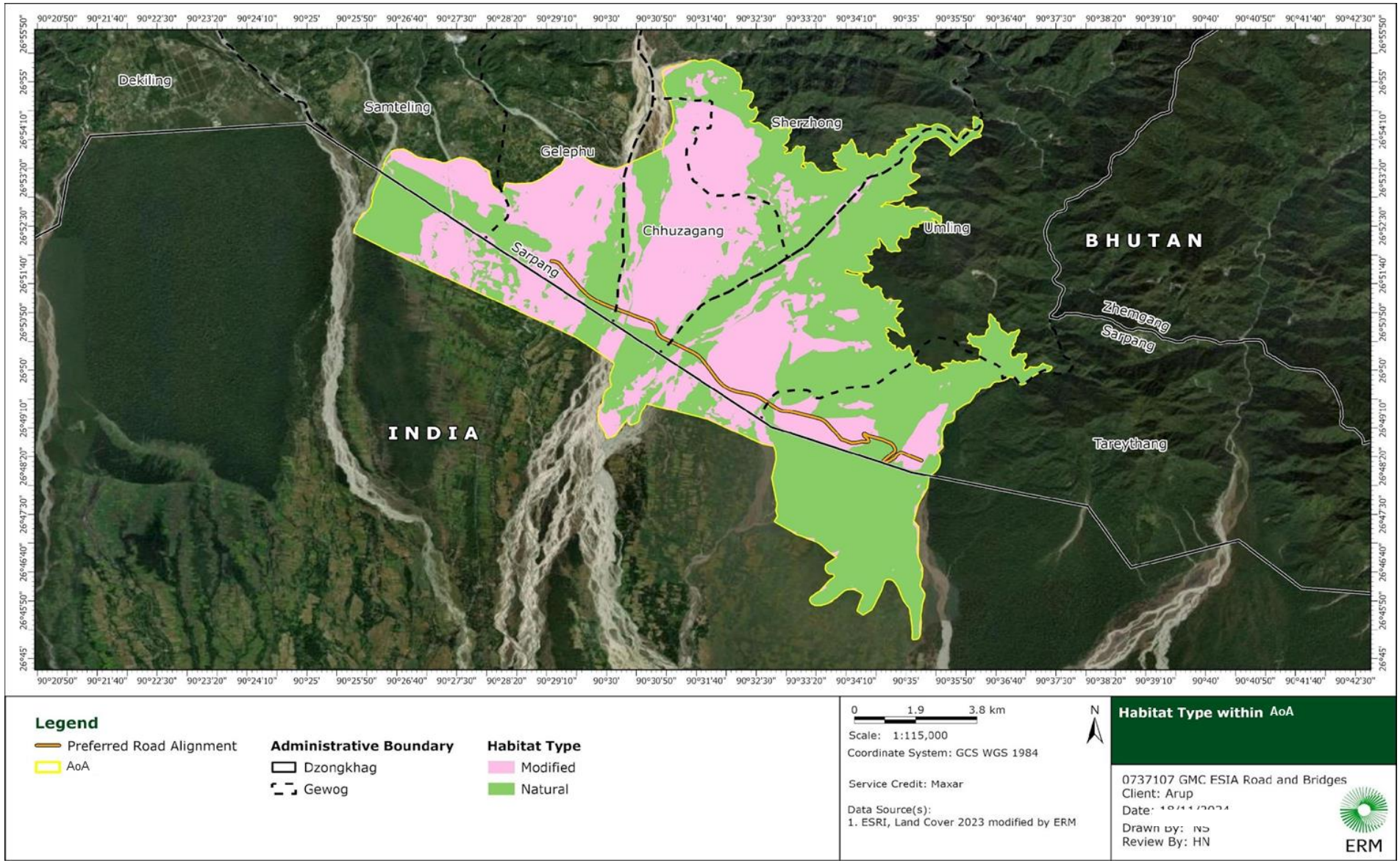


FIGURE 7.9 NATURAL/ MODIFIED HABITAT WITHIN THE TERRESTRIAL AOA



7.4 SPECIES

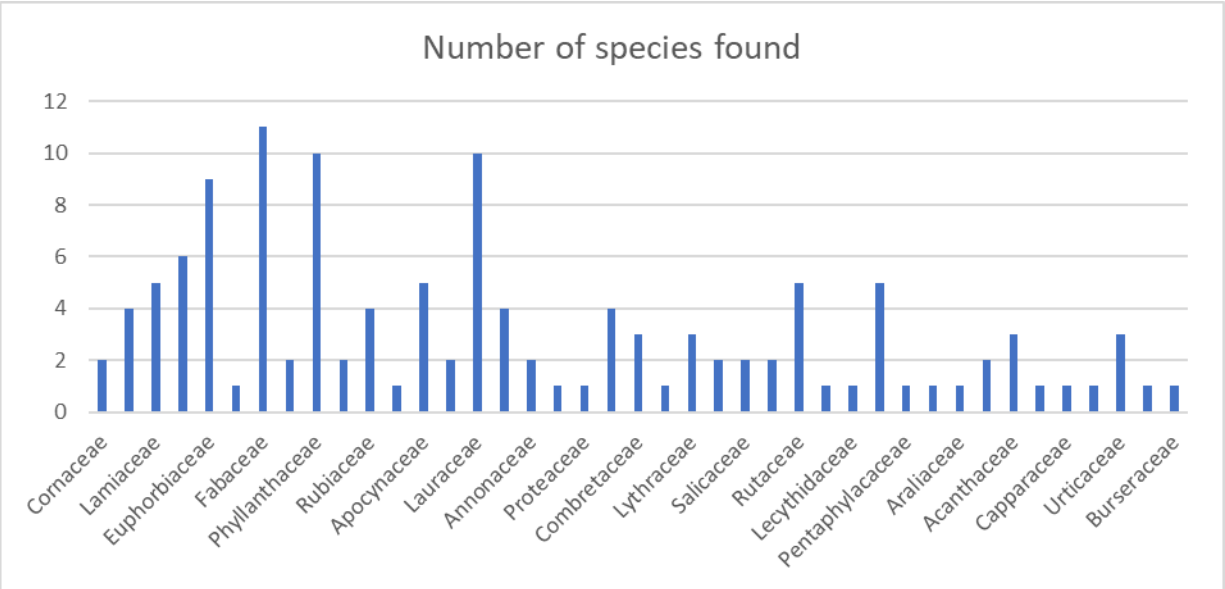
7.4.1 TERRESTRIAL FLORA SURVEY

7.4.1.1 TREES AND SHRUBS

Sarpang district has recorded 178 tree species belonging to 68 families. [78] Among 178 species, there are (i) 1 IUCN VU, i.e., Agarwood *Aquilaria malaccensis* (IUCN VU, FNCA[79], FNCRR[80]), (ii) three (03) are IUCN NT, and (iii) three (03) are IUCN LC, while six (06) species falls under the special classes timbers (FNCA 1995; FNCRR 2017) and rest were classified under NE category as per the IUCN status.[81]

A total of 127 species were recorded belonging to 41 families (***Figure 7.10***). This full list of recorded species is provided in ***Appendix I1***. The most common families were *Fabaceae*, *Phyllanthaceae*, *Lauraceae*, and *Euphorbiaceae*. Among these, there are two (02) species of conservation significance, Teak (*Tectona grandis*, IUCN EN), and *Aporosa cardiosperma* (IUCN VU). Both species were recorded in plot 1 and 2, close to the proposed road towards Gelephu Thromde (***Figure 7.11***).

FIGURE 7.10 NUMBER OF TREE AND SHRUB SPECIES RECORDED IN EACH FAMILY OF FLORA



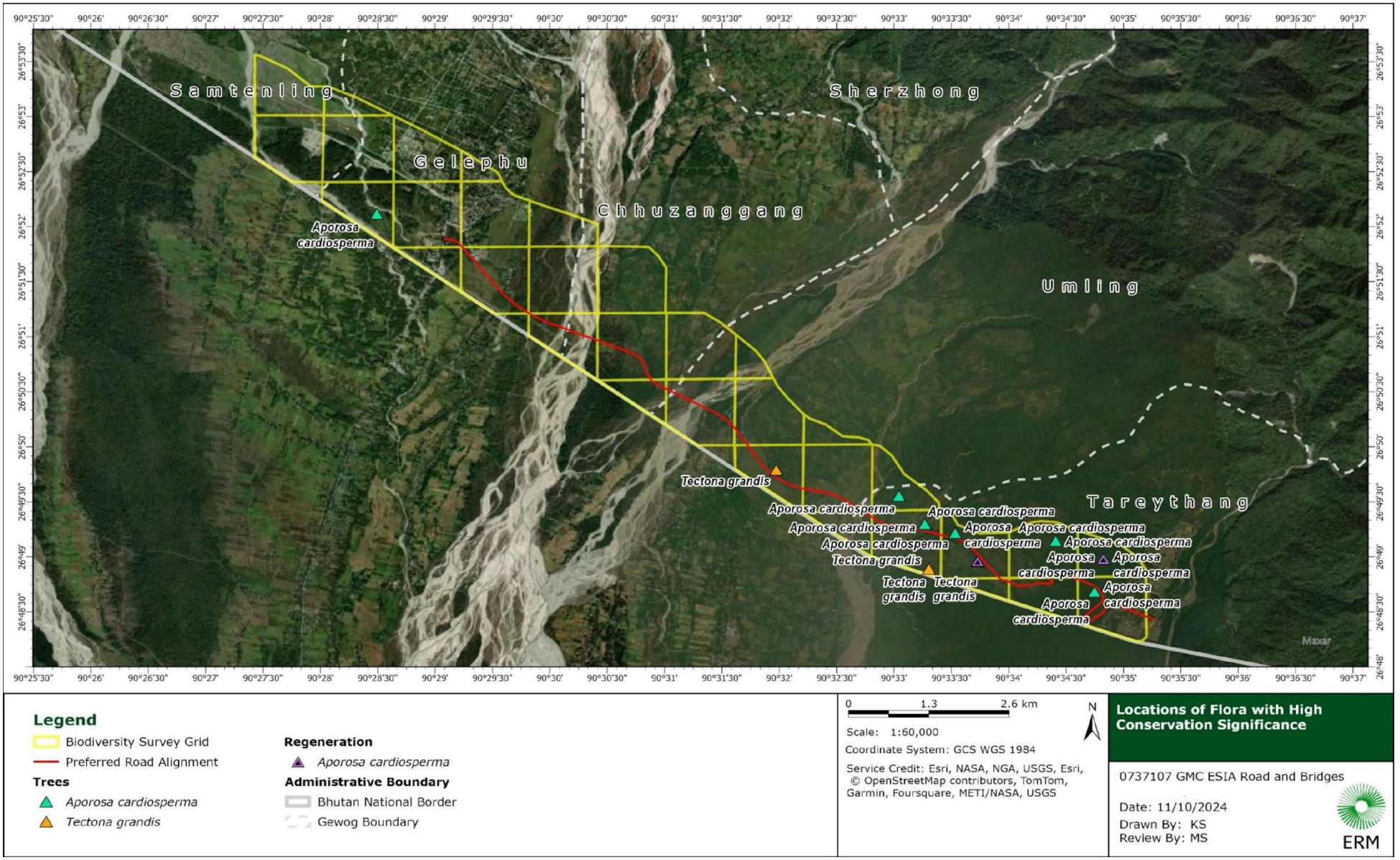
[78] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

[79] Forest and Nature Conservation Act (FNCA) 1995

[80] Forest and Nature Conservation Rules and Regulation (FNCRR) 2017

[81] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

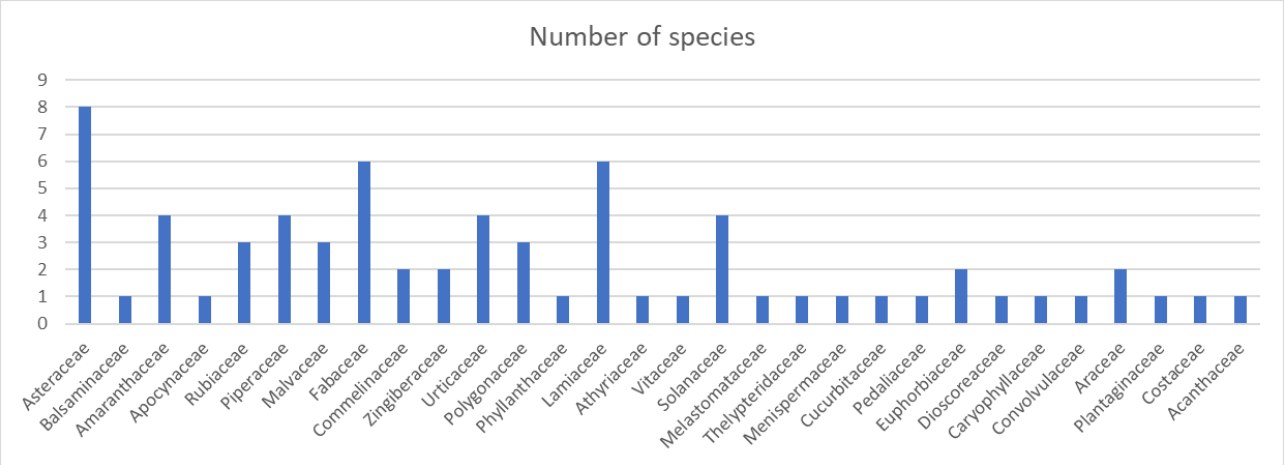
FIGURE 7.11 LOCATIONS OF TREES AND SHRUBS WITH HIGH CONSERVATION SIGNIFICANCE



7.4.1.2 HERBS

A total of 69 species were recorded belonging to 30 families (***Figure 7.12)***. This full list of recorded species is provided in ***Appendix I2***. The most common families were *Asteraceae, Fabaceae,* and *Lamiaceae*. The recorded herbs during the survey are common and no species of conservation significance was recorded. While the expert consultation and desktop assessment indicated the potential presence of *Cheirostylis sherriffii* (IUCN EN), it was not recorded during the baseline survey.

FIGURE 7.12 NUMBER OF HERBS SPECIES RECORDED IN EACH FAMILY OF HERBS



7.4.1.3 REGENERATION

Forest regeneration surveys are a critical component to the restoration process.[82] Regeneration in this context is strictly in reference to the capable tree seedling ability to reach its maturity, however there is no guarantee of it.[83] Seedling should not be confused with the herbaceous species.[84]

A total of 59 species were recorded belonging to 29 families (***Figure 7.13***). The most common families were *Fabaceae* and *Phyllanthaceae*. The recorded regeneration during the survey is common except for one species of conservation significance, i.e., *Aporosa cardiosperma* (IUCN VU), found in plot 1 and 2 (***Figure 7.14***). This full list of recorded species is provided in ***Appendix I3***.

[82] Available at: Community Forests International | Home Accessed date: Oct 17, 2024

[83] Nature Conservation Division – Department of Forests and Park Services – Ministry of Agriculture and Forests – Royal Government of Bhutan. Bhutan Flora Monitoring Protocol 2020.

[84] Nature Conservation Division – Department of Forests and Park Services – Ministry of Agriculture and Forests – Royal Government of Bhutan. Bhutan Flora Monitoring Protocol 2020.

FIGURE 7.13 NUMBER OF SPECIES IN EACH FAMILY OF RENERGATION

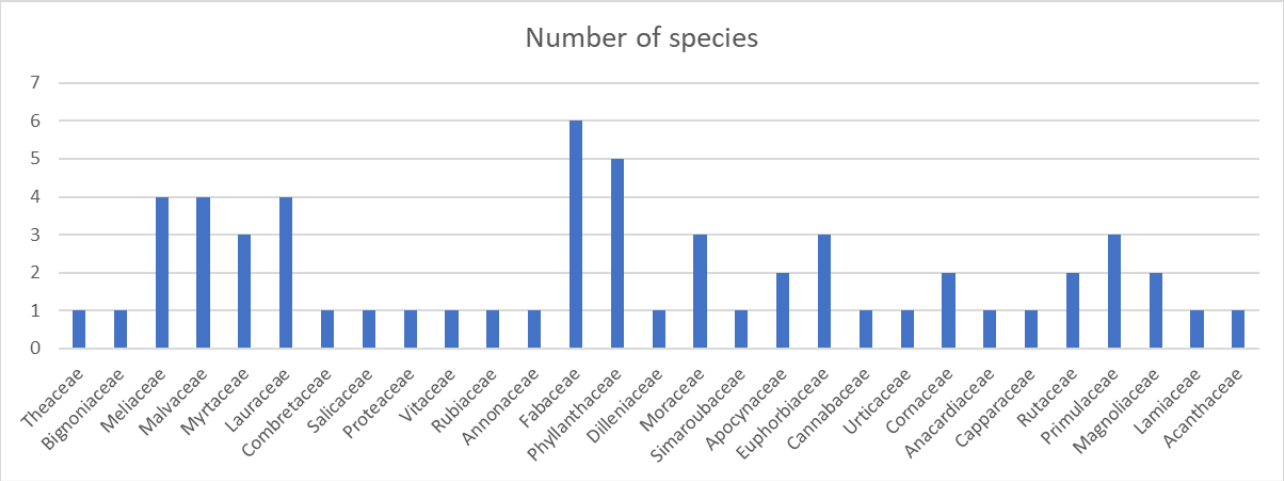
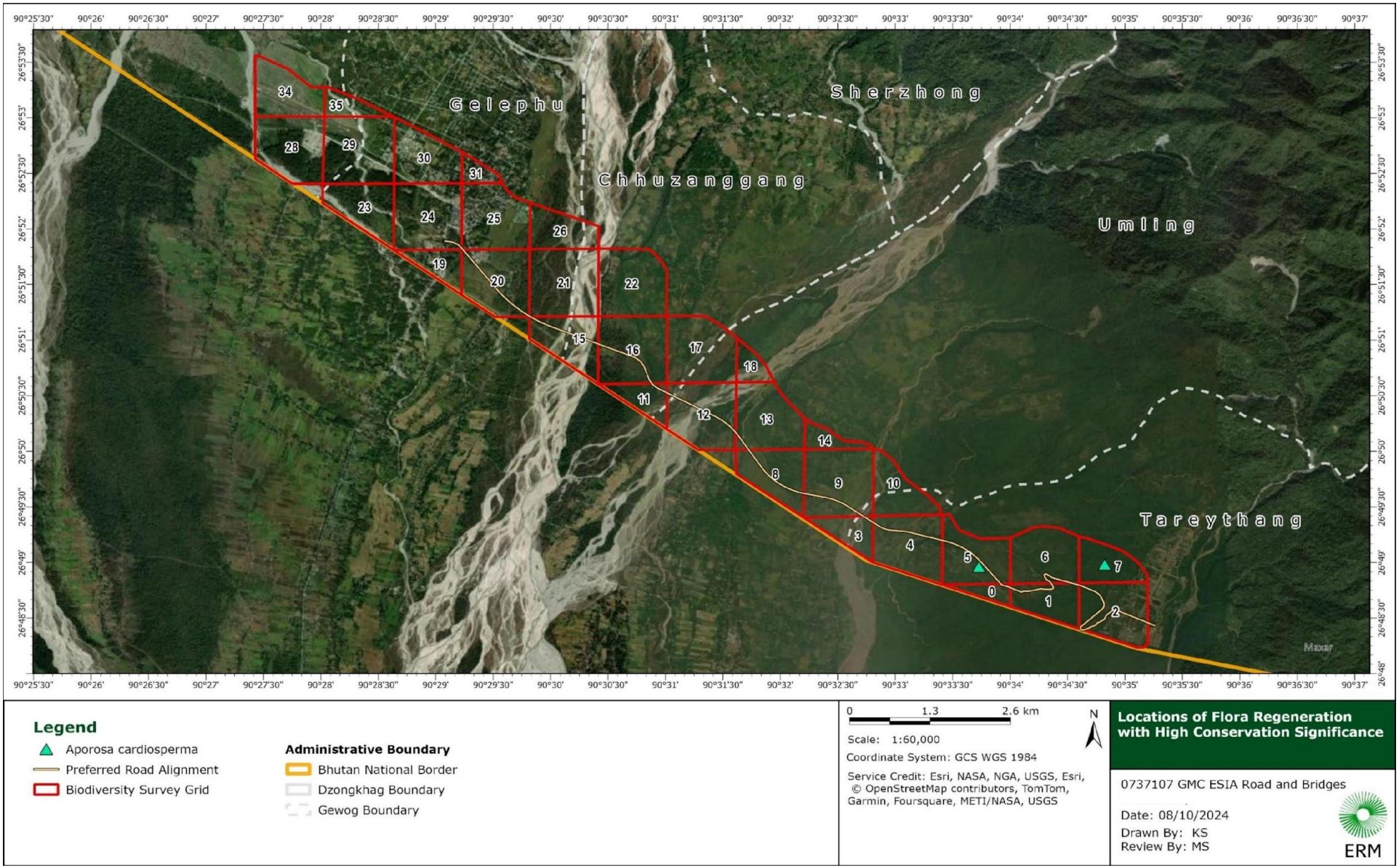


FIGURE 7.14 LOCATIONS OF FLORA REGENERATION WITH HIGH CONSERVATION SIGNIFICANCE

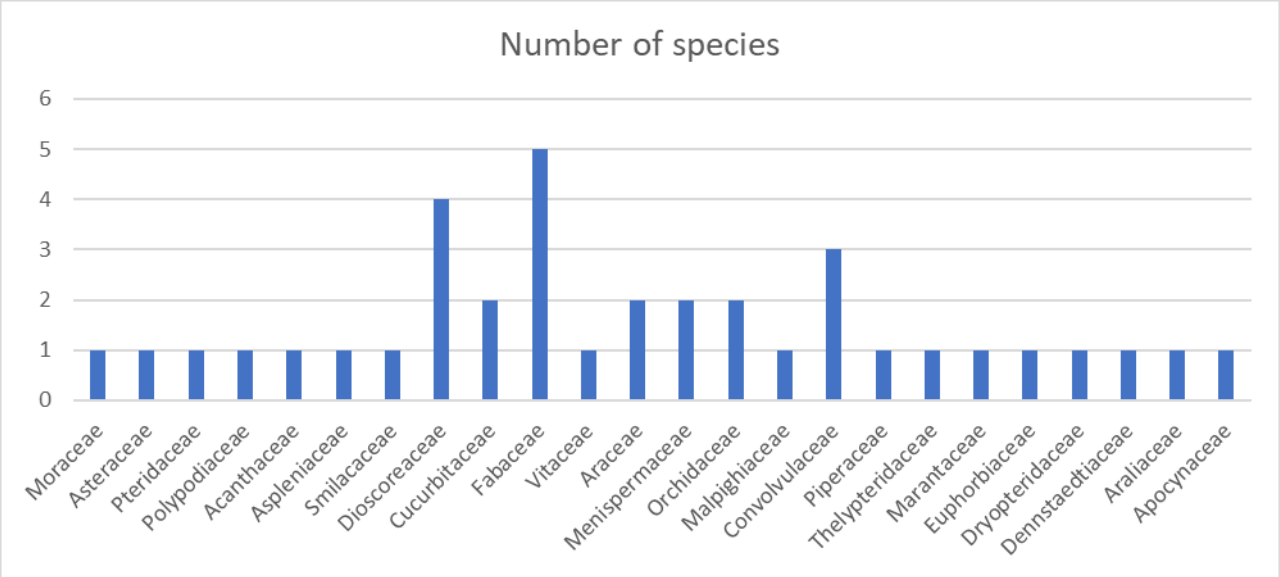


7.4.1.4 EPIPHYTES

Epiphytes are plants that grow on other plants or objects for physical support, but they are not parasitic. They obtain moisture and nutrients from the air, rain, and sometimes debris accumulating around them, rather than from the host plant.

A total of 37 species were recorded belonging to 24 families (***Figure 7.15***) shown in ***Appendix I4***. The most common families were *Fabaceae,* and *Dioscoreaceae*. The recorded epiphytes during the survey are common and no species of conservation significance was recorded. While the expert consultation and desktop assessment indicated the potential presence of *Hoya bhutanica* (IUCN EN), it was not recorded during the baseline survey. This species is endemic to Bhutan. It is recorded from two sites - one in Gelephu (Sarpang district), and one in Mondokha, Dungna-Metakha (tri-junction), Gedu (Chukha district).[85]

FIGURE 7.15 NUMBER OF EPIPHYTE SPECIES RECORDED IN EACH FAMILY OF FLORA



7.4.2 TERRESTRIAL FAUNA SURVEY

7.4.2.1 BIRD

Sarpang Forest Division has recorded 92 species of birds belonging to 43 families (***Figure 7.16***). Among these, there are two (02) IUCN VU, i.e., Rufous-necked Hornbill *Aceros nepalensis* and Lesser Adjuntant Stork *Leptoptilos javanicus*, three (03) IUCN NT, and the rest are IUCN LC.[86] These two (02) IUCN VU species were not found in the field survey. Additionally, desktop screening suggests the presence of White-bellied Heron (*Ardea insignis*, IUCN CR) but it was not recorded during the baseline survey. Additional consultation with the director of the Royal Society for Protection of Nature (23 July 2024) indicated that the Mau River is less suitable for this species, while it prefers the Punakha Basin, which is richer in fish (50 km from the Project).

[85] Bhutan Endemic Flowering Plants Workshop. 2017. Hoya bhutanica. The IUCN Red List of Threatened Species 2017: e.T84487492A84548403. https://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T84487492A84548403.en. Accessed on 25 September 2024.

[86] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

The transect bird survey (wet season surveys in 15 July – 02 August 2024 and dry season surveys in 7 to 30 November 2024) recorded 4,858 birds across seven (07) Gewok routes. The habitats within the survey routes are across three (03) categories, including (i) settlement and farmlands, (ii) sub-tropical broadleaf forests, and (iii) waterbodies and wetlands. However, most of the transects were traversed within sub-tropical forest, and settlement and farmland habitats, resulting in the birds being mostly recorded in these habitats.

Species composition was compiled from the transect bird survey , a total of 158 bird species were recorded (belonging to 57 families) during wet season and a total of 184 bird species from 57 families recorded during dry season. ***Appendix I5*** illustrates a full list of recorded species and the habitats where the species were encountered. The diversity of families and species reflects a healthy ecosystem with a variety of ecological niches, although human-modified landscapes are also contributing significantly to species richness. Among these species, there are 148 IUCN LC species, eight (08) IUCN NT species, and two (02) IUCN VU species. There are three (03) species listed as protected the Forest and Nature Conservation Rules and Regulations (FNCRR), 2017 of Bhutan (***Figure 7.17***):

- Great Hornbill (*Buceros bicornis*, IUCN VU) found in Sub-tropical Broadleaf Forest,
- Wreathed Hornbill (*Rhyticeros undulatus*, IUCN VU) found in Sub-tropical Broadleaf Forest,
- River Lapwing (*Vanellus duvaucelii*, IUCN NT) found in Sub-tropical Broadleaf Forest, and Waterbodies and Wetland habitats, and
- Peregrine Falcon (*Falco peregrinus*, IUCN LC) found in Settlement and Farmlands. Peregrine Falcon (*Falco peregrinus*, IUCN LC) is also listed in the Forest and Nature Conservation Act (FNCA) 1995 of Bhutan.

The most common species encountered are Red-vented Bulbul (*Pycnonotus cafer*, IUCN LC), Eastern Spotted Dove (*Spilopelia chinensis*, IUCN LC), Common Tailorbird (*Orthotomus sutorius*, IUCN LC), and Common Myna (*Acridotheres tristis*, IUCN LC). The most common families were *Columbidea* (pigeons, doves) and Picidae (woodpeckers) which have nine (09) species recorded, following are Sturnidae (starlings) and Accipitridae (hawks, eagles, and kites) which have eight (08) species (***Figure 7.16***).

Additionally, the camera trap recorded four (04) IUCN LC species that were also recorded by transect survey, i.e., Common Myna (*Acridotheres tristis*), Indian Peafowl (*Pavo cristatus*), Red Junglefowl (*Gallus gallus*), White-breasted Waterhen (*Amaurornis phoenicurus*), Cattle Egret (*Bubulcus ibis*).

FIGURE 7.16 NUMBER OF SPECIES OF EACH BIRD FAMILY

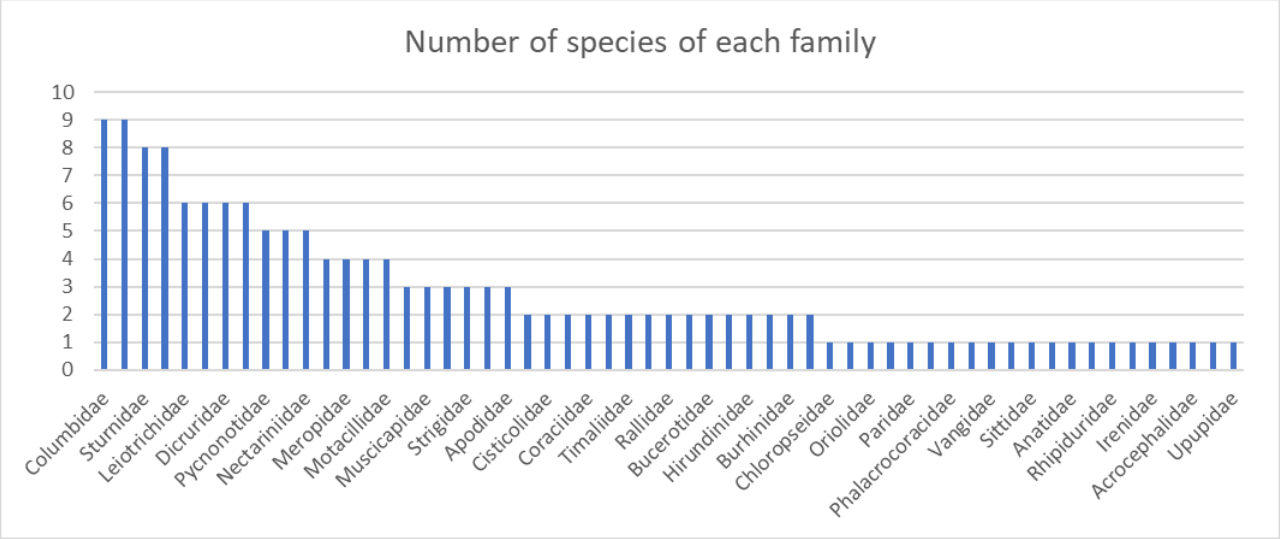
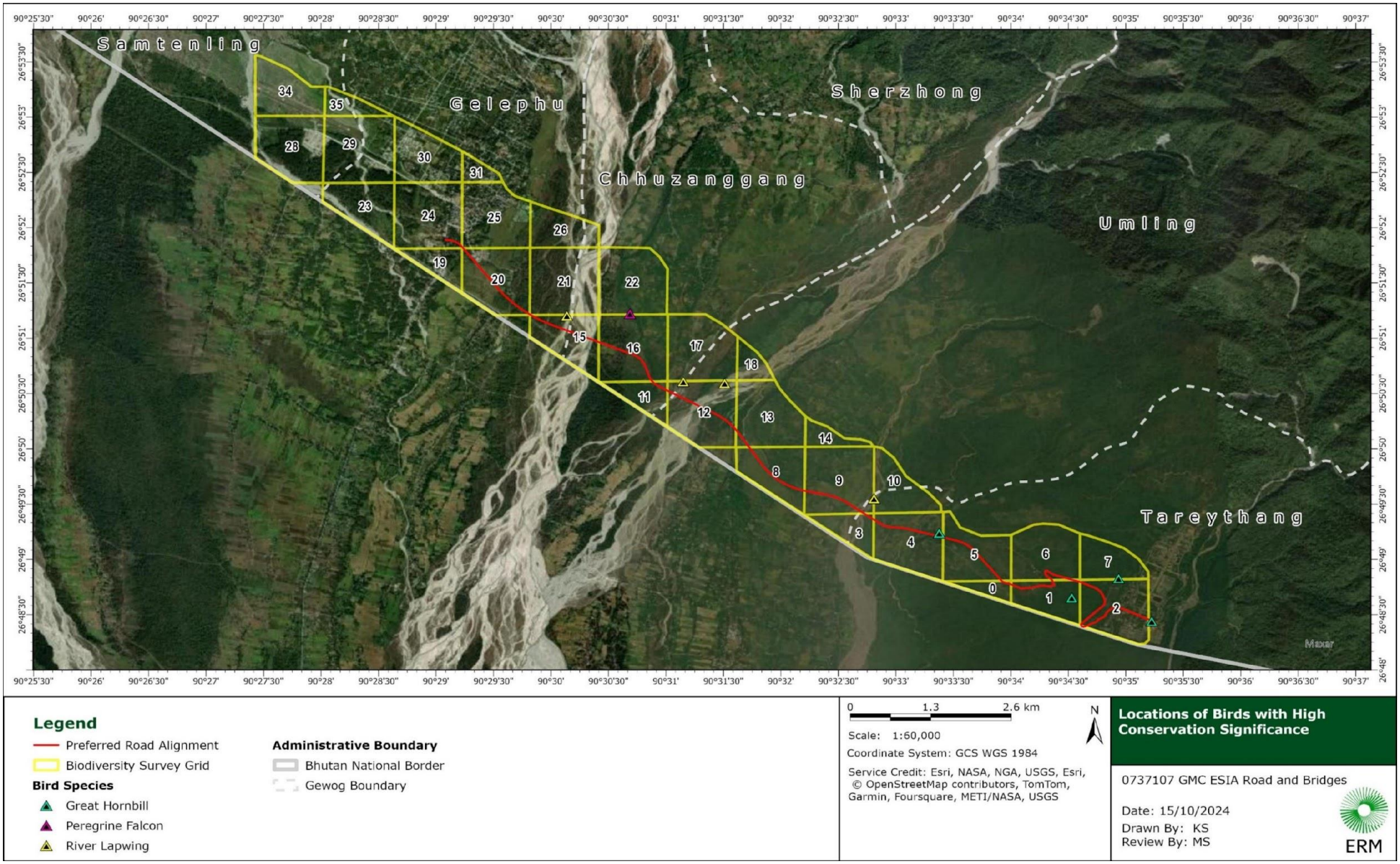


FIGURE 7.17 LOCATIONS OF BIRDS WITH CONSERVATION SIGNIFICANCE



7.4.2.2 HERPETOFAUNA

The desktop research suggested that Sarpang district has 15 amphibia species belonging to 8 families, that are listed as IUCN LC.[87] There are 19 reptiles' species encompassing snakes, tortoises and turtles belonging to nine (09) families in Sarpang district.[88] None of these is species of conservation concern, except for Burmese Python *Python bivittatu* (IUCN VU).[89] Expert consultation (July 2024) suggested the presence of Elongated Tortoise *Indotestudo elongata* (IUCN CR) and Tricarinate Hill Turtle (*Melanochelys tricarinata*) (IUCN EN) within the Project area and its vicinity.

The herpetofauna transect survey recorded a total of 332 individual sightings, comprising 166 amphibians and 166 reptiles (***Appendix I6***). These were identified as 12 amphibian species and 39 reptile species, though four (04) amphibian species and five (05) reptile species could not be identified to the species level. None of the amphibian species are of conservation concern, with most being listed as IUCN LC. The camera trap recorded Monitor Lizard (*Varanus bengalensis,* IUCN NT, CITES I), which was also recorded in the transect survey.

Amphibians were primarily recorded in settlement and forest areas, with fewer observations near Mau and Taklai rivers. This lower presence in riverine areas may be due to amphibians avoiding fast-flowing water, which is unsuitable as a spawning ground for amphibians. This is further supported by the survey's discovery of unidentified tadpoles in forest areas near Gelephu city.

Like the amphibians, reptiles were mostly observed in settlement and forest habitats, with fewer sightings in riparian habitats, suggesting they may avoid these environments. Among the identified reptile species, three (03) species of conservation concern (***Figure 7.18***):

- Tricarinate Hill Turtle (*Melanochelys tricarinata*, IUCN EN),
- King Cobra (*Ophiophagus hannah*, IUCN VU), and
- Burmese Python (*Python bivittatus*, IUCN VU).

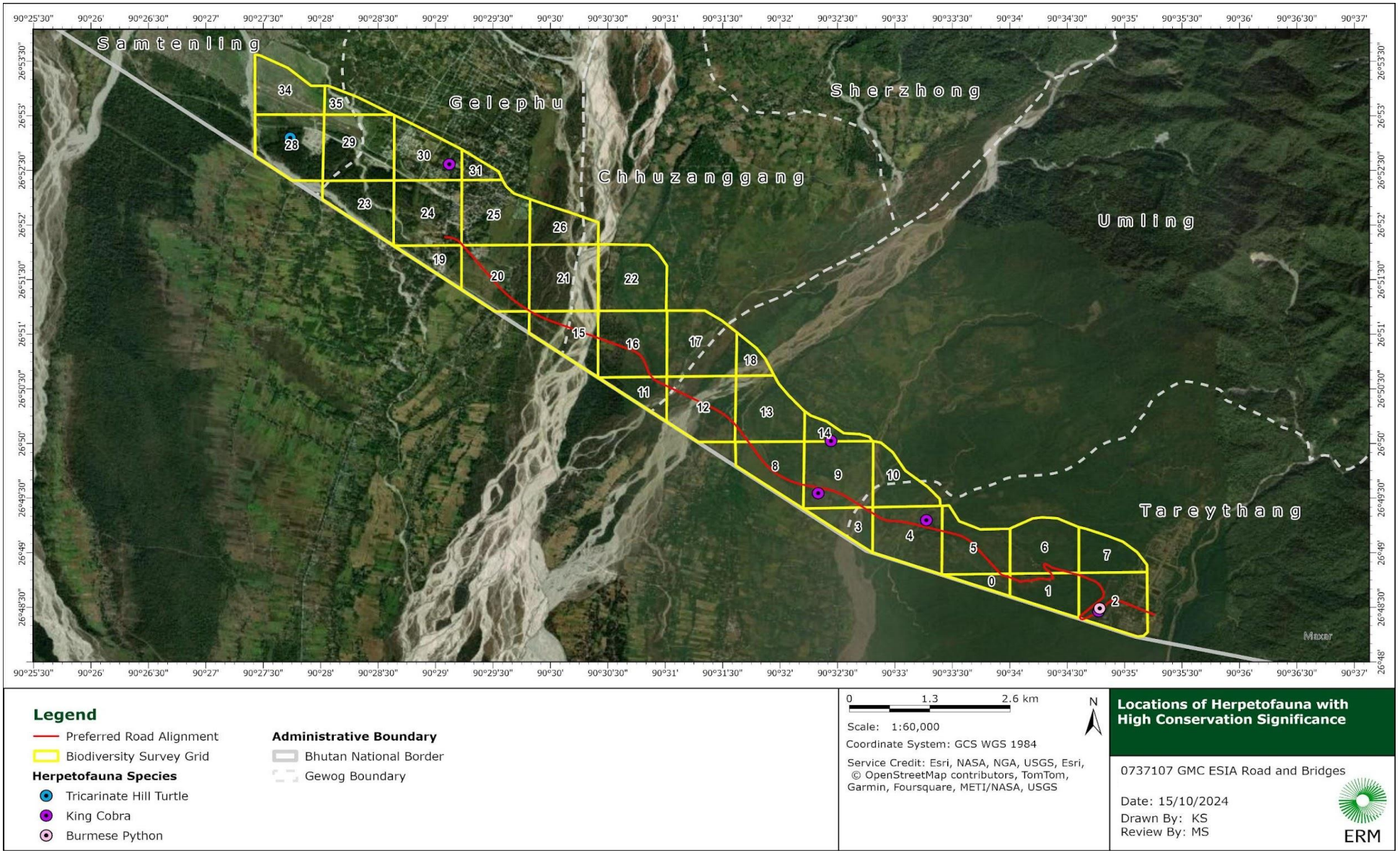
King Cobras were recorded at several locations within modified habitats, including settlements and farmlands along the road layout. This species is often found in such environments due to the presence of its prey, which includes small mammals and reptiles that inhabit croplands and nearby settlement areas. One Burmese Python was recorded in Grid_41 at the river side and one in Grid_2 in the warm broad leaf forest. One Tricarinate Hill Turtle and Burmese Python was found in Grid_28 in the warm broad leaf forest. Their presence in these areas suggests a preference for natural habitats that are essential for the species.

[87] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

[88] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

[89] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

FIGURE 7.18 FIELD RECORDS OF REPTILE OF CONSERVATION CONCERN



7.4.2.3 MAMMAL

The desktop research suggested that Sarpang district has 36 species of mammals belonging to 17 families.[90] Among these, there are five (05) IUCN EN and four (04) IUCN VU. Stakeholder consultation (July 2024) suggested the presence of one (01) IUCN CR species and seven (07) IUCN EN species (***Table 7.4***).

TABLE 7.4 MAMMAL SPECIES OF CONSERVATION CONCERN BY DESKTOP STUDY

Common Name	Scientific Name	IUCN status	National Regulation	CITES	Sarpang district checklist	Stakeholder consultation
Chinese Pangolin	*Manis pentadactyla*	CR	-	-		x
Asian Elephant	*Elephas maximus*	EN	FNCA, FNCR	I	x	x
Bengal Tiger	*Panthera tigris*	EN	FNCA, FNCR	I	x	x
Gee's Golden Langur	*Trachypithecus geei*	EN			x	x
Red Panda	*Ailurus fulgens*	EN	FNCA, FNCR	I		x
Hispid Hare	*Caprolagus hispidus*	EN	FNCR	-		x
Pygmy Hog	*Porcula salvania*	EN	-	-		x
Bengal Slow Loris	*Nycticebus bengalensis*	EN	FNCR	I		x
Dhole	*Cuon alpinus*	EN	-	II	x	
Asiatic Black Bear	*Ursus thibetanus*	EN			x	
Himalayan Serow	*Capricornis sumatraensis*	VU			x	
Gaur	*Bos gaurus*	VU	FNCA, FNCR	I	x	
Clouded leopard	*Neofelis nebulosa*	VU			x	
Small Clawed Otter	*Aonyx cinerea*	VU			x	

[90] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

The transect survey and camera trap (***Appendix I7***) recorded a total of 25 mammal species (***Table 7.5***). Among these, there are eight (08) species of conservation concern, specifically:

- Hog Deer (*Axis porcinus*, IUCN EN),
- Dhole (Cuon alpinus, IUCN EN),
- Asian Elephant (*Elephas maximus*, IUCN EN),
- Bengal Tiger (*Panthera tigris ssp. Tigris*, EN),
- Gee's Golden Langur (*Trachypithecus geei*, IUCN EN and endemic to Bhutan),
- Gaur (*Bos gaurus*, IUCN VU),
- Sambar (*Rusa unicolor*, IUCN VU), and
- Smooth-coated Otter (*Lutrogale perspicillata*, IUCN VU).

Most of the transects were traversed within sub-tropical forest habitat, resulting in the species being mostly recorded in the sub-tropical forest habitat. Camera trap suggested that the Asian Elephant had the highest number of detections (1510), indicating its abundance in the area. Hog Deer was also frequently detected with 221 camera trap hits. Other species with notable detections include Barking Deer, Gaur, Wild Boar, Assamese Macaque, Masked Palm Civet, and Dhole. Detailed records of species of conservation interest can be found in ***Table 7.6***.

TABLE 7.5 MAMMAL SPECIES RECORED DURING THE BASELINE SURVEY

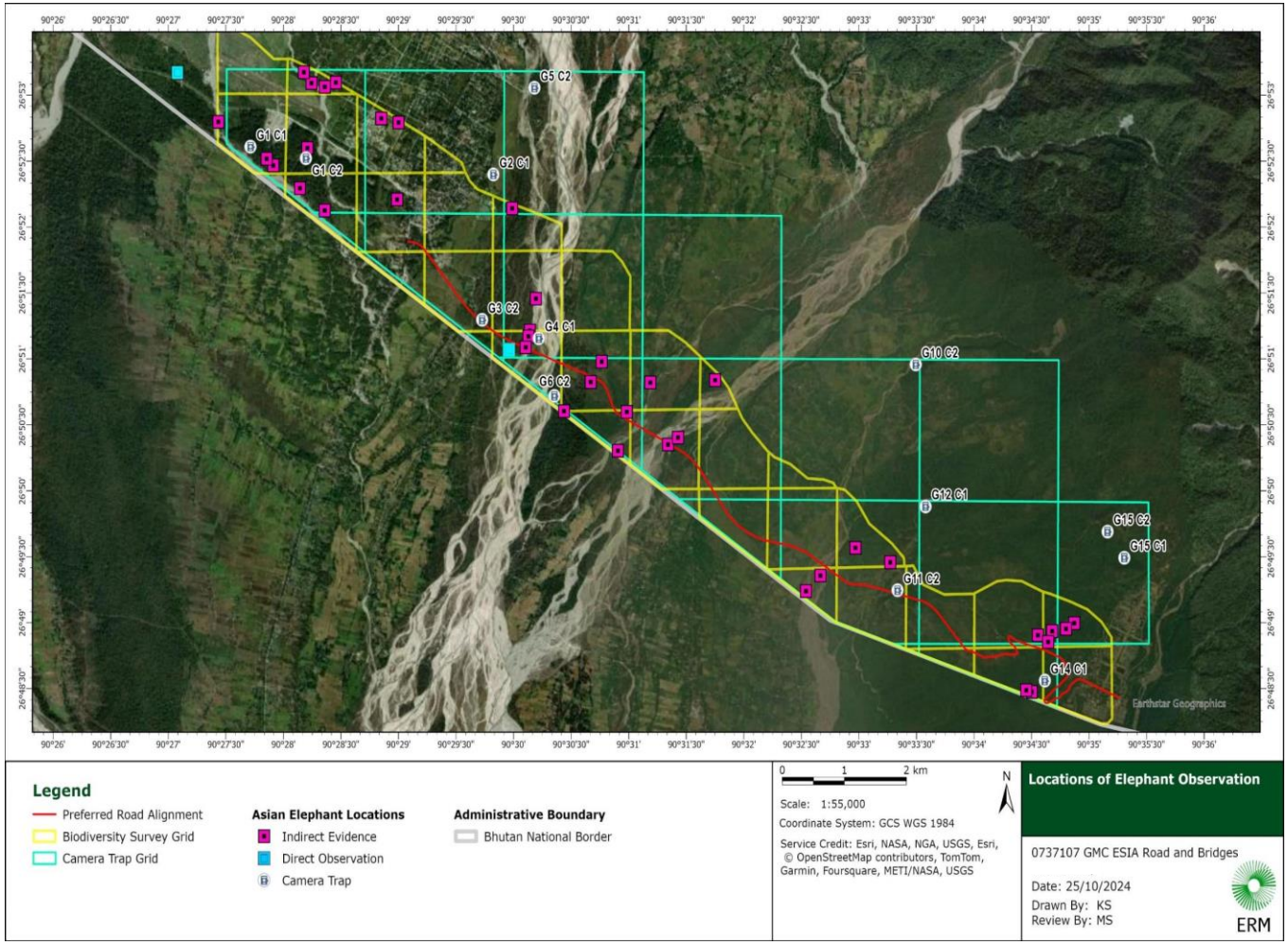
No.	Scientific name	Common name	IUCN Status	National Regulation	CITES	Camera trap - number of detections	Indirect evidence	Observation	Number of individuals each counter
1	*Arctogalidia trivirgata*	Small-toothed Palm Civet	LC	-			x	-	
2	*Axis porcinus*	Hog Deer	EN	-	III	221			
3	*Bos gaurus*	Gaur	VU	FNCA, FNCRR	I	950	x	-	
4	*Callosciurus pygerythrus*	Hoary-bellied Squirrel	LC	-				x	• 1 on 16 July 2024 • 12 on 13 July 2024
5	*Cuon alpinus*	Dhole	EN		II	35			
6	*Elephas maximus*	Asian Elephant	EN	FNCA, FNCRR	I	1,510	x	x	• 12 on 20 July 2024 (6 females, 3 males, 3 juvenile) • 25 on 14 July 2024 (16 female, 3 males, 6 juvenile) • 44 in November 2024
7	*Hystrix brachyura*	Malayan Porcupine	LC			4			
8	*Hystrix cristata*	Crested Porcupine	LC	-			x	-	
9	*Hystrix indica*	Indian Crested Porcupine	LC	-			x	-	
10	*Lepus nigricollis*	Indian Hare	LC	-			x	-	
11	*Lutrogale perspicillata*	Smooth-coated Otter	VU	-	II		-	x	• 3 on 13 July 2024 • 2 in Nov 2024
12	*Macaca assamensis*	Assamese Macaque	NT	-		309	-	-	

No.	Scientific name	Common name	IUCN Status	National Regulation	CITES	Camera trap - number of detections	Indirect evidence	Observation	Number of individuals each counter
13	*Macaca mulatta*	Rhesus Monkey	LC	-			-	x	• 16 on 13 June
14	*Muntiacus muntjak*	Southern Red Muntjac	LC	-			x	x	• 1 on 13 July • 1 on 14 July • 1 on 20 July • 1 on 29 July
15	*Paguma larvata*	Masked Palm Civet	LC			22			
16	*Panthera pardus*	Leopard	VU	FNCA, FNCRR	I		x	-	
17	*Panthera tigris ssp. Tigris*	Bengal Tiger	EN	FNCA, FNCRR	I		x	-	
18	*Prionailurus bengalensis*	Leopard Cat	LC	FNCA, FNCR	II		x	-	
19	*Ratufa bicolor*	Black Giant Squirrel	NT	-			-	x	• 1 in 13 July • 1 in 14 July
20	*Rusa unicolor*	Sambar	VU	FNCRR		3	x	-	
21	*Suncus murinus*	House Shrew	LC	-					• 1 in 14 July
22	*Sus scrofa*	Wild Boar	LC	-		920	x	-	
23	*Trachypithecus geei*	Gee's Golden Langur	EN	FNCA, FNCR	I		-	x	• 17, 23 in 13 July • 9, 11, 13 in 16 July • 7 in 20 July • 13 in 20 July • 1 in November 2024
24	*Viverra zibetha*	Large Indian Civet	LC	-		6	x	-	

No.	Scientific name	Common name	IUCN Status	National Regulation	CITES	Camera trap - number of detections	Indirect evidence	Observation	Number of individuals each counter
25	*Muntiacus muntjak*	Barking Deer	LC	-		2,808			

Note:
CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened and LC = Least Concern
FNCA - The Forest and Nature Conservation Act (FNCA) 1995
FNCRR - The Forest and Nature Conservation Rules and Regulation (FNCRR) 2017

TABLE 7.6 RECORDS OF SPECIES OF CONSERVATION CONCERN FROM THE FIELD SURVEY

Species of Conservation Concern	Record Location
Asian Elephant: Asian Elephant's presence was recorded during camera traps, transect survey (both direct observation and indirect evidence). The transect survey recorded two herds of Asian Elephants, comprising a total of 37 individuals during July 2024. The first herd was observed in Grid_15, located within sub-tropical forest near the Mau River, while the second herd was spotted in Grid_33, also within sub-tropical forest. The first herd, consisting of 12 individuals, included six (06) females, three (03) males, and three (03) juveniles. The second herd, larger with 25 individuals, comprised 16 females, three (03) males, and six (06) juveniles. They are more active during dawn and dusk showcasing crepuscular behavior. A total of 44 individuals were recorded during the transect survey in November 2024.	FIGURE 7.19 FIELD RECORDS OF ASIAN ELEPHANT 

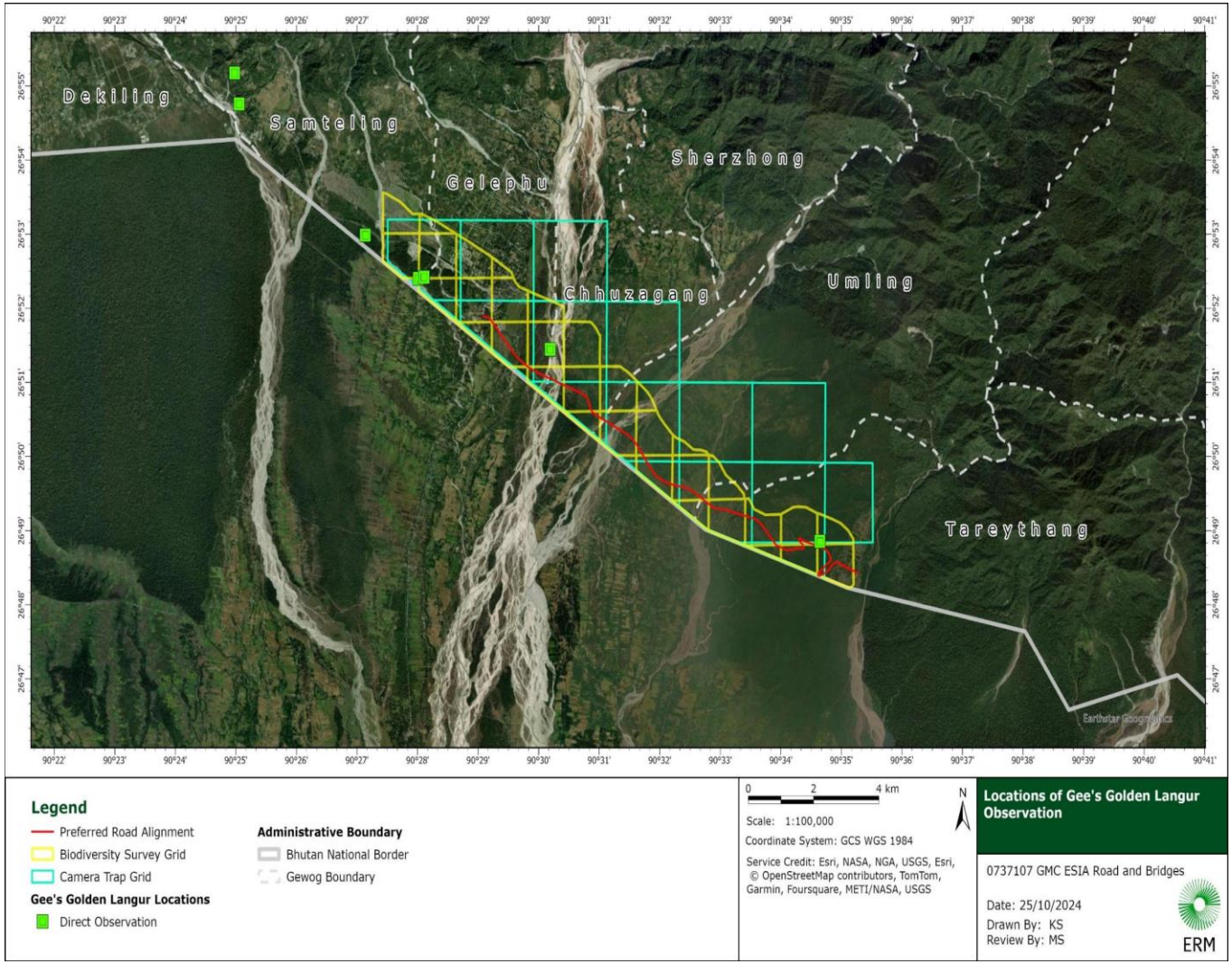
Species of Conservation Concern	Record Location

Gee's Golden Langur: During the survey, the presence of Gee's Golden Langur was directly observed across multiple dates in July (13th, 16th, 20th, and 29th) and once in November 2024 in the sub-tropical forest, with varying group sizes recorded:

- 13 July 2024: 17 individuals in Grid_43, and 23 individuals in Grid_41;
- 16 July 2024: nine (09) individuals in Grid_29, 11 individuals in Grid_27, and 13 individuals in Grid_23;
- 20 July 2024: seven (07) individuals in Grid_21; and
- 29 July 2024 : 13 individuals in Survey_000047 grid
- 8 Nov 2024: 5 individuals in Grid 43

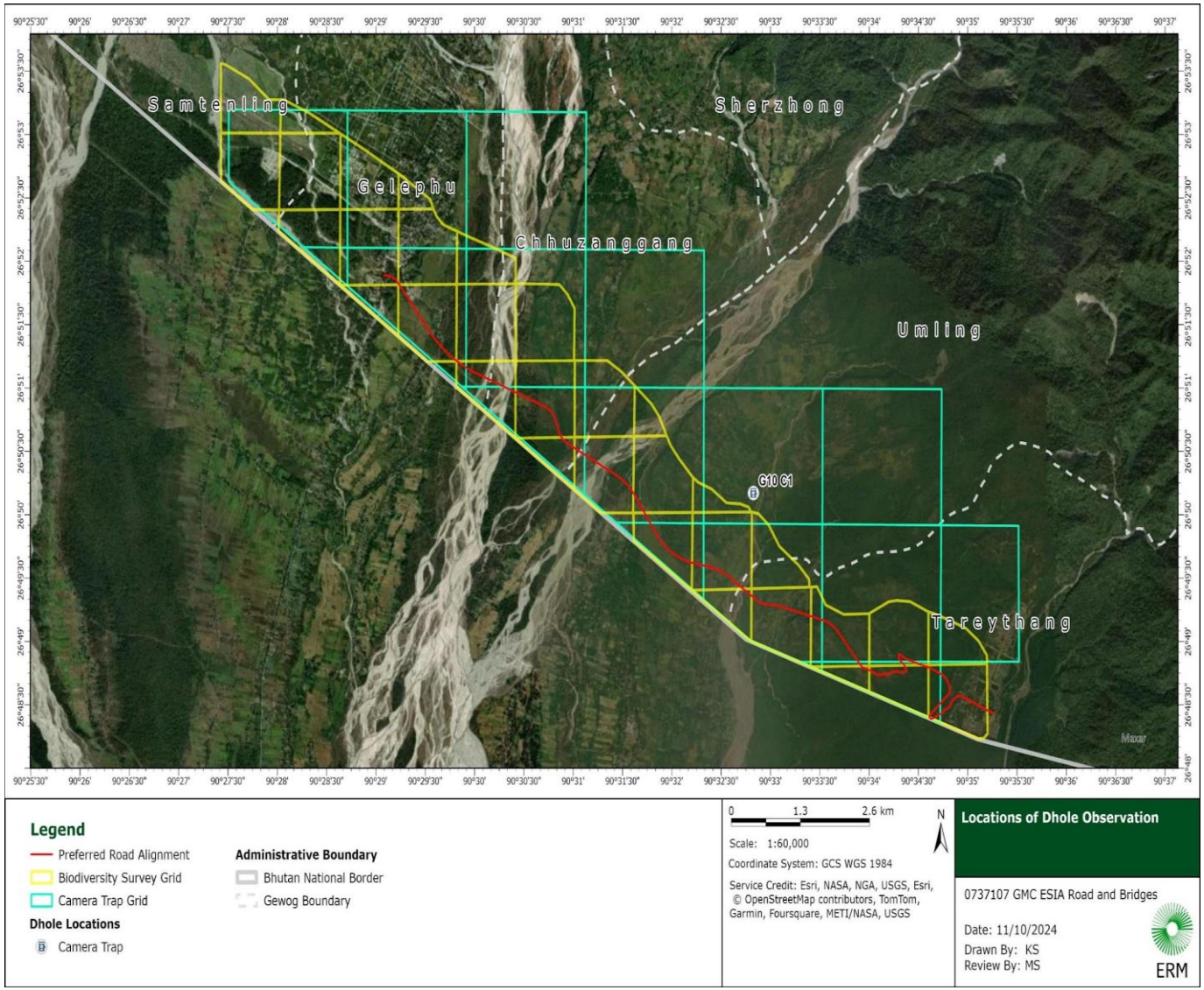
It is suspected that two groups consisting of 13 individuals in each group are different, as they were found on opposite sides of the Mau River, approximately 13 km apart. These observations suggest that Gee's Golden Langur is present in stable numbers (approximately 23- 93 individuals) within the survey area, although its endangered status highlights the importance of continued monitoring and habitat protection.

FIGURE 7.20 FIELD RECORDS OF GEE'S GOLDEN LANGUR



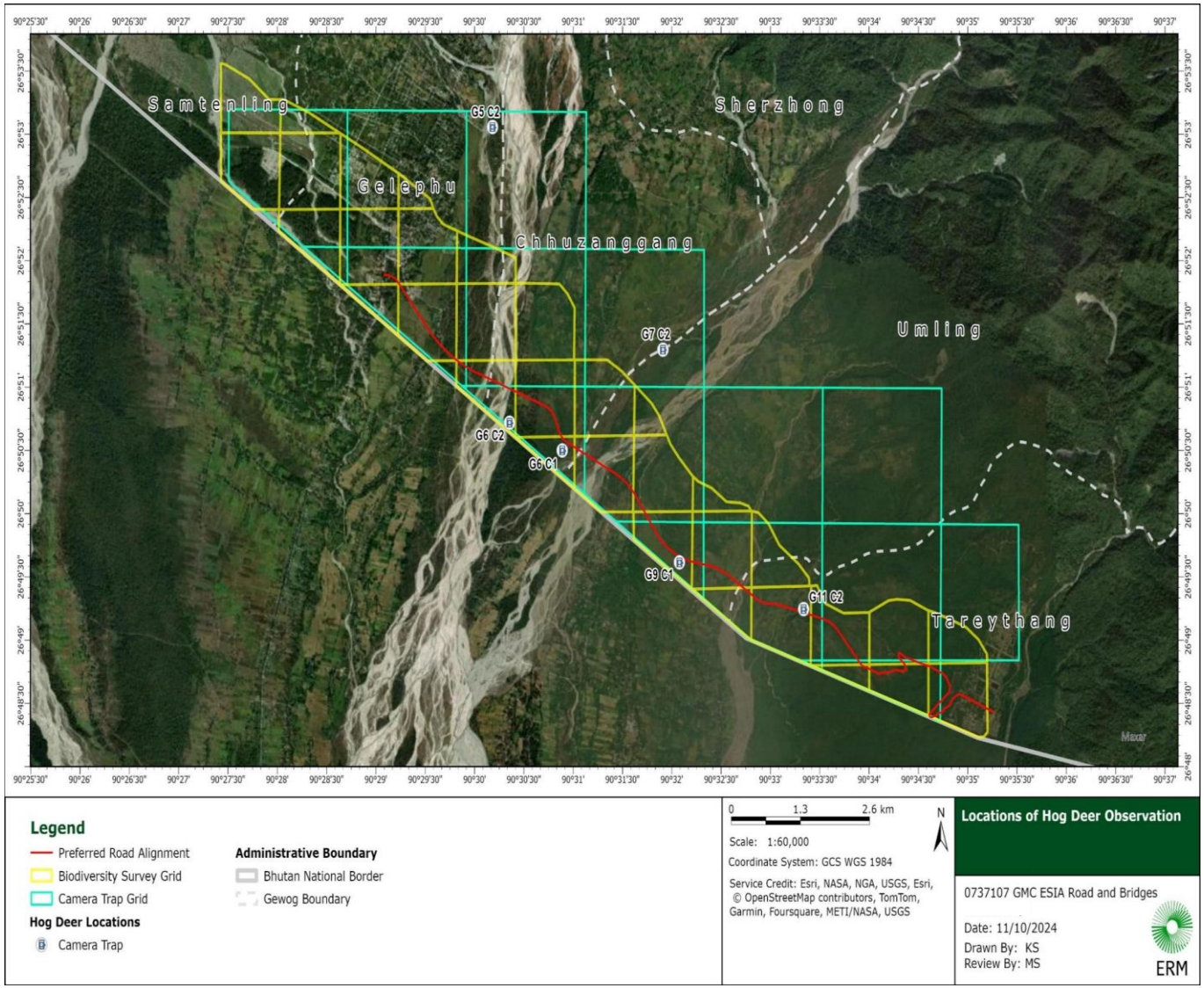
Dhole: The sole camera trap G10_C1 in the sub-tropical forest was triggered 35 times in 02 July from 11:47 to 14:01.

FIGURE 7.21 FIELD RECORDS OF DHOLES



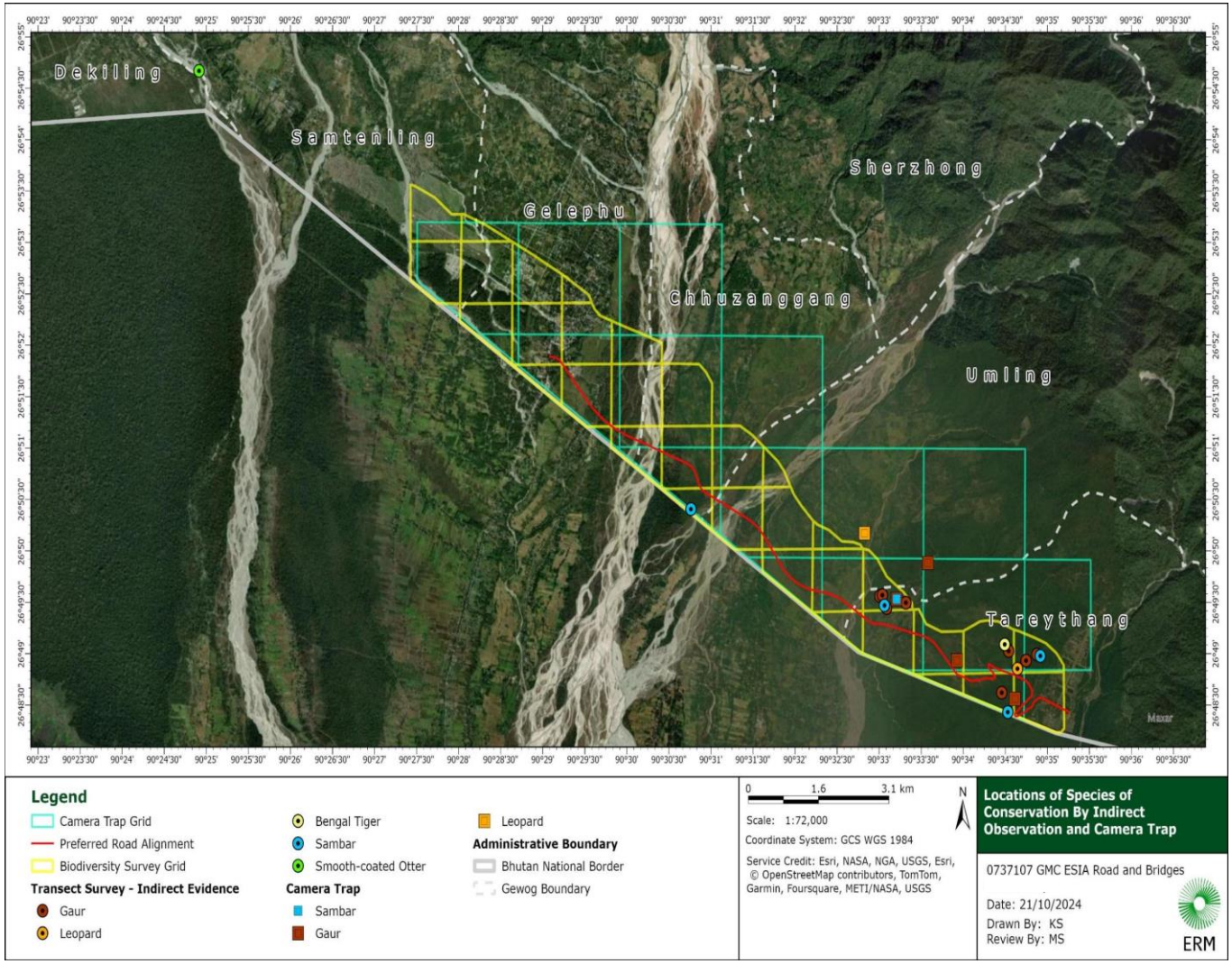
Hog Deer: It was recorded by six (06) camera traps (i.e., G5_C2, G6_C1, G6_C2, G7_C2, G9_C1, and G11_C2) in 12 nights with 221 detections. The highest number of detections occurred at Camera Station G_9_C1, with over 150 triggers, followed by Camera Station G_7_C2. They are more active during the day showcasing diurnal behavior.

FIGURE 7.22 FIELD RECORDS OF HOG DEER



Species of Conservation Concern	Record Location
Bengal Tiger (IUCN EN): The presence of Bengal Tiger is identified based on its Scrape in the Grid_6 in the subtropical habitat.	
Gaur (IUCN VU): Its tracks were found in Grid_1, Grid_6, Grid_7, Grid_10, and Survey_000047 in subtropical forests and farmland. Additionally, four camera traps (i.e., G11_C1, G12_C1, G12_C2, G14_C1) were triggered 950 times.	
Leopard (IUCN VU): Its track was found in Survey_000047 grid in sub-tropical forest.	
Sambar (IUCN VU): Its feeding was found in Grid_1, and its tracking was found in Grid_7, Grid_10 and Grid_11 in sub-tropical forest. Additionally, camera trap G11_C1 captured its presence three (03) times.	
Smooth-coated Otter (IUCN VU): Its presence was recorded in Grid_40 outside of the proposed survey grid in sub-tropical forest during the transect survey.	

FIGURE 7.23 FIELD RECORDS OF MAMMAL OF CONSERVATION SIGNIFICANCE



7.4.3 AQUATIC FAUNA SURVEY

7.4.3.1 ICHTHYOFAUNA

Sarpang district has recorded 28 fish species belonging to 11 families [91]. Among these, there are 1 Endangered and 1 Vulnerable, i.e., Golden Mahseer (Tor putitora, IUCN EN) and Wagur (Clarias magur, IUCN EN). Additionally, the presence of Snowtrout (Schizothorax richardsonii, IUCN VU) was confirmed in Indian Himalayan, and in Mangde Chuu and Berti Chhu (upstream of Mau and Taklai River). Given S. richardsonii occupies in high-elevation niches, it may be unlikely that S. richardsonii within the Project area and its proximity.

The aquatic fauna survey, during the wet season. recorded a total of 282 fish, representing 32 species from eight (08) families. There were 29 species in Mau River and 24 species recorded in Taklai River. The surveys during dry season recorded a total of 28 species under 9 families. In total, 35 fish species from 14 families were recorded across both seasons of the study. The list of species can be found in ***Appendix I8*** and ***Appendix I10*****.**

Plot 2 (Taklai river branch) appears to be the most species-rich and diverse. The upstream plots of the Mau River (Plots 1, 4, and 5) show moderate species diversity, while Plot 3 (Taklai river upstream) supports a more limited and specialized set of species (***Figure 7.24***). The most dominant species was *Garra birostris* (IUCN NE) (N = 53, Relative Abundance [RA] = 18.79%), followed by *Garra annandalei* (IUCN LC) (N = 41, RA = 14.54%). The least dominant species included *Macrognathus pancalus*, *Olyra longicaudata*, *Pseudolaguvia shawi*, and *Xenentodon cancila*, each with only a single individual encountered (N = 1, RA = 0.35%). The overall species diversity of the study site during the monsoon was H’ = 2.87, with species evenness E_H = 0.83 and species richness S_R = 12.65.

Among recorded species in Mau River and Taklai river, there are two (02) IUCN VU species, i.e., Reticulated Loach (*Schistura reticulofasciata*) in Plot 3, 4, 5, and Mrigal Carp (*Cirrhinus cirrhosus*) in plot 2, 5, but Mrigal Carp is invasive in Bhutan[92] (***Figure 7.25***). The Mau River likely serves as a migratory route for Golden Mahseer (*Tor putitora*, IUCN EN). The Golden Mahseer migrates all the way from India to upstream rivers in Bhutan for breeding and feeding.[93] Golden Mahseer migrates in two (02) phases: (i) first phase during March-April and (ii) second phase during June – September, when the rainfall occurs with the onset of monsoon when water becomes turbid.[94] Though the survey was undertaken during the migratory season of Golden Mahseer, no presence of this species was recorded.[95] There are no historical records of Golden Mahseer within the sections of Mau River and Taklai River crossed by the Project. While the species may occur within

[91] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

[92] Bhutan Biodiversity User List. Available at: Biodiversity Userlist_0.pdf (chm-cbd.net) Access date: September 24, 2024

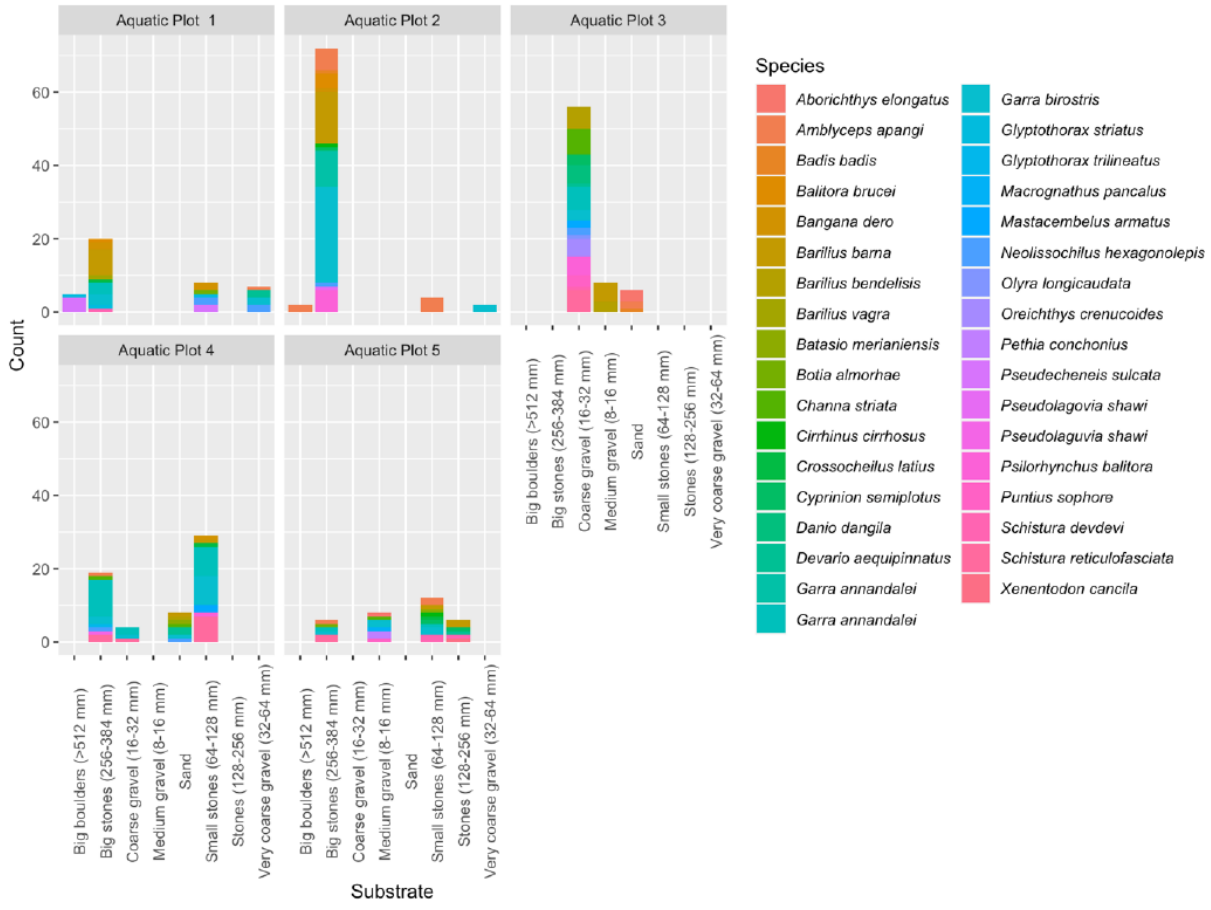
[93] Lama, U. (2022). *India and Bhutan: A Relationship Before and After Independence* (No. 560).

[94] Johnson, J. A., Dhawan, B., & Kuppusamy, S. (2021). Study on ecology and migratory patterns of golden mahseer (Tor putitora) in river Ganga using Radio telemetry techniques. *Wildlife Institute of India*.

[95] Wangchuk, K., & Wangmo, S. (2022). Climate change and freshwater fish biodiversity in Bhutan: Standardized monitoring of a Flagship Species, Golden Mahseer (Cyprinidae: Tor putitora). *Bhutan Journal of Animal Science*, *6*(1), 131-144.

these sections,[96] it should be noted that the main distribution of Golden Mahseer in Bhutan is in Amochhu, Wangchhu, Punatsangchhu/ Sunkosh, and Manas River.[97] Additionally, the Golden Mahseer was found in Manas River, is a transboundary river in the Himalayan foothills between southern Bhutan and India situated 26°10' to 26°50'N Latitudes and 90°00' to 91°00'E Longitude.[98]

FIGURE 7.24 DISTRIBUTION PATTERN OF FISH ACROSS DIFFERENT PLOTS AND HABITAT SUBSTRATUM

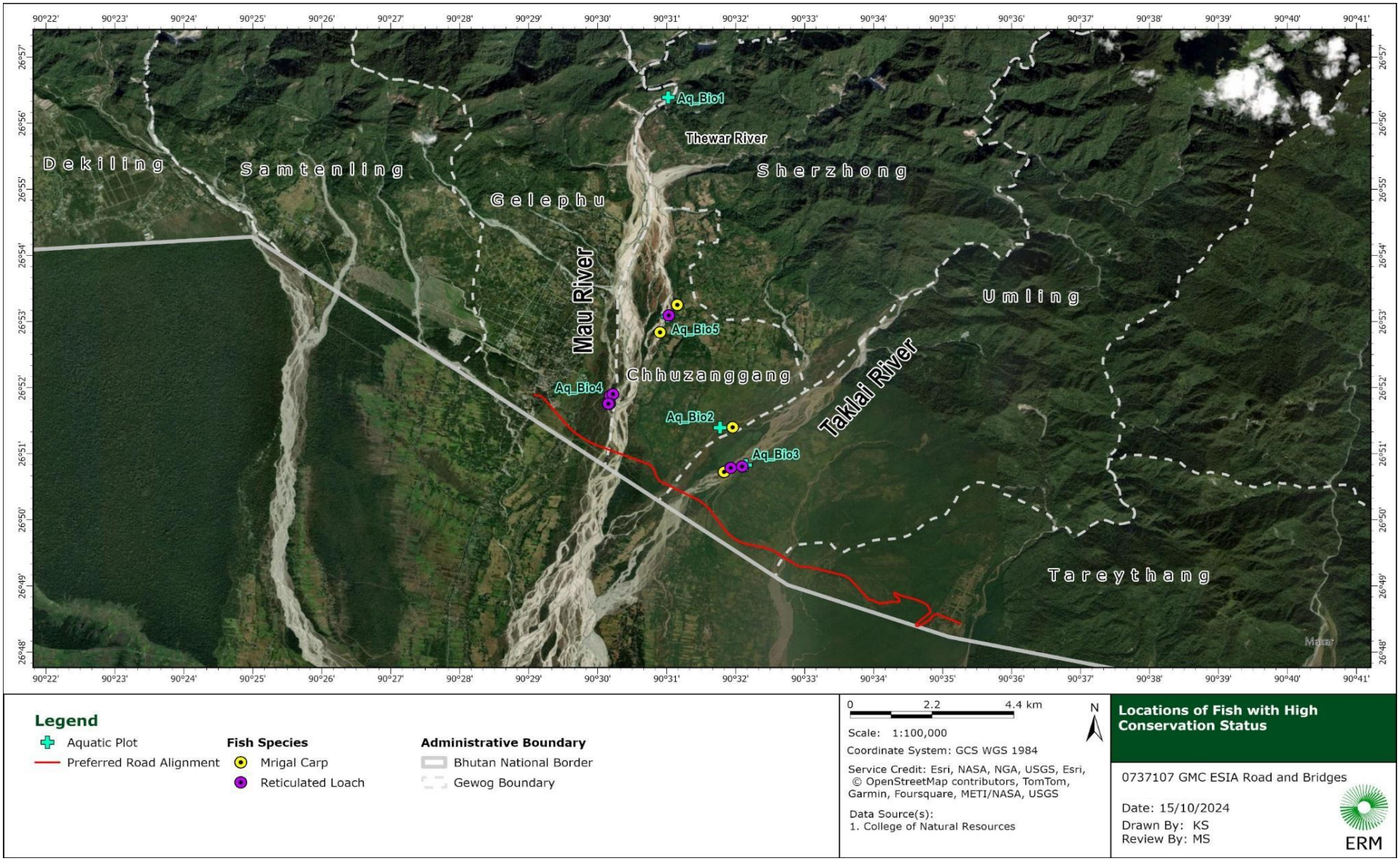


[96] Wangchuk, K., & Wangmo, S. (2022). Climate change and freshwater fish biodiversity in Bhutan: Standardized monitoring of a Flagship Species, Golden Mahseer (Cyprinidae: Tor putitora). *Bhutan Journal of Animal Science*, *6*(1), 131-144.

[97] NCD 2022. Golden Mahseer Conservation Action Plan for Bhutan (2022-2032): Securing "Tigers of the Rivers." Nature Conservation Division, Department of Forests and Park Services, Ministry of Agriculture and Forests, Thimphu, Bhutan.

[98] Baruah, D., & Sarma, D. (2018). Mahseer in recreational fisheries and ecotourism in India. *NACA Newsl*, *22*(2), 1-10.

FIGURE 7.25 FIELD RECORDS OF FISH SPECIES OF CONSERVATION SIGNIFICANCE



7.4.3.2 MACROINVERTEBRATES

A total of 535 samples of macroinvertebrates was recorded, belonging to 14 families under nine (09) orders during both the seasons (***Appendix I9***) (***Figure 7.26***). The most dominant species was *Baetis sp.* (N= 212) under the *Baetidae* family, accounting for 39.63% of the relative abundance. This was followed by *Ambrysus sp.* (N=109) under the *Naucoridae* family, representing 20.37% of the total. Mayfly fauna such as *Baetis sp.* are qualified bioindicators for water quality monitoring. Species under the order *Ephemeroptera* such as mayflies are intolerant species to pollution, and as such, are usually only found at high-quality, minimally polluted sites. [99] Their presence across all 5 plots suggests clean freshwater condition.

Under order *Trichopteran* (*Caddisflies*) order, RA of *Hydropsychidae* is 2.8% and *Rhyacophilidae* is 0.93%. Although *Caddisflies* are also indicators of good water quality, their lower abundance could suggest that the environmental conditions may not be as favorable for these taxa or that they have more specific habitat requirements that are less met in this ecosystem. Under order *Plecoptera* (*Stoneflies*), the RA of *Perlidae* is 0.93%. Stoneflies are very sensitive to water quality, particularly to oxygen levels and pollution. Their low relative abundance could indicate that the habitat is not optimal for this group, potentially due to environmental stressors such as water temperature, pollution, or habitat degradation.

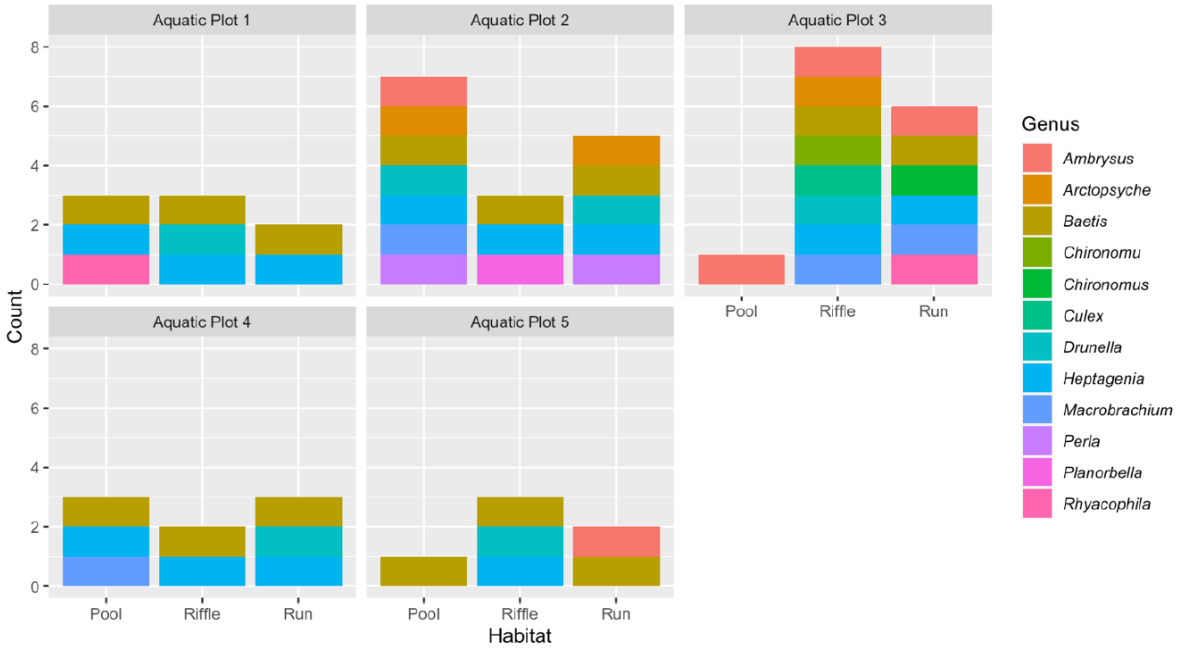
The macroinvertebrate survey conducted during the monsoon season indicates that Plot 3 is the most ecologically diverse and resilient site. Plot 3 recorded the highest overall count of macroinvertebrates, with a significant abundance of Creeping Water Beetles (*Ambrysus*) and Small Minnow Mayflies (*Baetis*). Specifically, the Creeping Water Beetle population reached 40 individuals in the riffle habitat, while Small Minnow Mayflies peaked at 68 individuals in the same habitat. Plot 3 also exhibited a wide range of species with varying pollution tolerance levels, from the highly tolerant Culex mosquitoes (tolerance level 10) to the more sensitive Spiny Crawler Mayflies (tolerance level 2). This variety of pollution tolerance indicates a stable environment with good water quality, capable of supporting species with differing ecological needs.

In contrast, Aquatic Plot 1 had a lower overall count of macroinvertebrates and lacked any particularly high concentrations of individual species. While it did host species like Flat-headed Mayflies (*Heptagenia*) and Small Minnow Mayflies, their numbers were considerably lower than in Plot 3. The range of species in Plot 1 also reflects varied pollution tolerance, but the lower abundance and diversity may suggest suboptimal habitat quality or environmental conditions less favorable than those in other plots.

Aquatic Plot 2 ranked between Plots 1 and 3 in terms of ecological stability. It recorded notable counts of Small Minnow Mayflies, with up to 19 individuals in both pool and riffle habitats. This plot also featured a mix of species with high and low pollution tolerance, such as the highly tolerant Lamarck's Prawn (tolerance level 8) and Net-spinning Caddisflies (tolerance level 4). The diversity of macroinvertebrates in Plot 2, coupled with its broad spectrum of pollution tolerance, suggests a moderately stable environment, though it is not as robust as the ecosystem in Aquatic Plot 3.

[99] Alhejoj, I., Hiasat, T. H., Salameh, E., Hamad, A. A., & Al Kuisi, M. (2023). Use of the aquatic mayfly (Insecta: Ephemeroptera) as environmental bio-indicator in Jordan. *Int. J. Design Nat. Ecodyn*, *8*(1), 133-139.

FIGURE 7.26 DISTRIBUTION OF MACROINVERTEBRATES BY GENUS ACROSS PLOTS AND HABITATS



7.5 SPECIES OF CONSERVATION SIGNIFICANCE

From the baseline survey, 28 species of conservation concern were identified (***Table 7.7***). From all terrestrial species of conservation significance, many were recorded on the west side of the road and bridge alignment in sub-tropical forest of Tareythang and Umling Gewog. This area has large forest habitats that can support these species, stretching from the Bhutan border to the northern hills. The continuous forest provides a good habitat for wildlife.

TABLE 7.7 SUMMARY OF SPECIES WITH HIGH CONSERVATION STATUS

No.	Scientific name	Common name	IUCN Red List	National Regulation	CITES	Occurrence within and adjacent to the GMC
Mammals						
1.	*Ailurus fulgens*	Red Panda	EN	FNCA, FNCR	I	Expert consultation
2.	*Cuon alpinus*	Dhole	EN	-	-	Confirmed
3.	*Caprolagus hispidus*	Hispid Hare	EN	FNCR	-	Expert consultation
4.	*Elephas maximus*	Asian Elephant	EN	FNCA, FNCR	I	Confirmed
5.	*Trachypithecus geei*	Gee's Golden Langur	EN	FNCA, FNCR	I	Confirmed
6.	*Panthera tigris*	Tiger	EN	FNCA, FNCR	I	Confirmed
7.	*Manis pentadactyla*	Chinese Pangolin	CR			Expert consultation
8.	*Porcula salvania*	Pygmy Hog	EN			Expert consultation
9.	*Trachypithecus geei*	Gee's Golden Langur	EN	FNCA, FNCR	I	Expert consultation
10.	*Nycticebus bengalensis*	Bengal Slow Loris	EN	FNCR	I	Expert consultation
11.	*Trachypithecus pileatus ssp. tenebricus*	Tenebrous Capped Langur	EN			Expert consultation
12.	*Axis porcinus*	Hog Deer	EN		I, III	Confirmed
13.	*Bos gaurus*	Gaur	VU	FNCA, FNCR	I	Confirmed
14.	*Panthera pardus*	Leopard	VU	FNCA, FNCR	I	Confirmed
15.	*Rusa unicolor*	Sambar	VU	FNCR		Confirmed

No.	Scientific name	Common name	IUCN Red List	National Regulation	CITES	Occurrence within and adjacent to the GMC
16.	*Lutrogale perspicillata*	Smooth-coated Otter	VU	-	II	Confirmed
Reptiles						
17.	*Melanochelys tricarinata*	Tricarinate Hill Turtle	EN		I	Confirmed
18.	*Indotestudo elongata*	Elongated Tortoise	CR			Expert consultation
19.	*Ophiophagus hannah*	King Cobra	VU			Confirmed
20.	*Python bivittatus*	Burmese Python	VU			Confirmed
Birds						
21.	*Buceros bicornis*	Great Hornbill	VU		I	Confirmed
22.	*Rhyticeros undulatus*	Wreathed Hornbill	VU			Confirmed
23.	*Ardea insignis*	White-bellied Heron	CR			Expert consultation
Fish						
24.	*Schistura reticulofasciata*	Reticulated Loach	VU			Confirmed
25.	*Cirrhinus cirrhosus*	Mrigal Carp	VU			Confirmed
Plants						
26.	*Tectona grandis*		EN			Confirmed
27.	*Aporosa cardiosperma*		VU			Confirmed
28.	*Litchi chinensis*		VU			Confirmed

Note: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, and LC = Least Concern
FNCA - The Forest and Nature Conservation Act (FNCA) 1995
FNCRR - The Forest and Nature Conservation Rules and Regulation (FNCRR) 2017

7.6 INVASIVE SPECIES

A report suggested that about 94.5% of seed plants recorded from Bhutan are native species and 105 are currently endemic to Bhutan.[100] During the field survey, a total of 10 invasive species found within the Project area and its vicinity, according to the Biodiversity Bhutan User List by the National Environment Commission, Royal Government of Bhutan.[101] These include nine (09) flora species, and one (01) fish (***Table 7.8***). Invasive flora was found in both natural habitats that are close to settlement and modified habitat. The invasive Mrigal Carp was found in Plot 2 (upstream Taklai River) and Plot 5 (upstream Mau River).

TABLE 7.8 LIST OF INVASIVE SPECIES RECORDED IN BHUTAN BASED ON GISD

No.	Scientific Name	Common Name	IUCN Status	Invasive Status
Plant				
1.	*Leucaena leucocephala*	Coffee bush	NE	Alien
2.	*Acmella uliginosa*	-	LC	Alien
3.	*Bidens pilosa*	Hairy Beggarticks	NE	Alien
4.	*Chromolaena odorata*	Armstrong's weed	NE	Alien
5.	*Hyptis suaveolens*	-	NE	Alien
6.	*Mikania micrantha*	American Rope	NE	Alien
7.	*Mimosa pudica*	Sensitive Plant	LC	Alien
8.	*Scoparia dulcis*	licorice weed	NE	Alien
9.	*Sida acuta*	Common Wireweed	NE	Alien
		Fish		
10.	*Cirrhinus cirrhosus*	Mrigal Carp	VU	Alien

Note: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, NE = Not Evaluated

1.4 CRITICAL HABITAT ASSESSMENT (CHA)

Critical habitat is assessed against the following five criteria in ESS6:

(a) Habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches.

(b) Habitat of significant importance to endemic or restricted range species;

(c) Habitat supporting globally or nationally significant concentrations of migratory or congregatory species;

[100] Available at: Biodiversity Checklist of Sarpang district based on the secondary information 2022. (researchgate.net) Accessed date: Oct 17, 2024

[101] National Environment Commission Royal Government of Bhutan. 2021. Bhutan Biodiversity User List (1st ed.). National Environment Commission, Royal Government of Bhutan. Available at: Biodiversity Userlist_0.pdf (chm-cbd.net)

(d) Highly threatened or unique ecosystems; and

(e) Ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d).

The approach to Critical Habitat Assessment (CHA) uses a method developed in the South Asia Region for the five ESS6 criteria. The method is applied to the AoA and involves the following stages: Step 1 to generate a list of species; Step 2 to screen species based on likelihood of occurrence; Step 3 to evaluate species against the ESS6 criteria; and Step 4 to assess the requirements and feasibility for Net Gain for critical habitat features that will be impacted.

Identification of Threatened Species

The Integrated Biodiversity Assessment Tool (IBAT) generated a list pf 1,687 species with special conservation status as occurring within a 50 km radius of Project. These species were screened down to a list of 571 CH candidate species comprising 139 CR, EN, VU species and/ or national conservation concern; 57 restricted-range species; and 421 migratory species. These species were subjected to the Step 3 analysis (justifications are described in **Annex G2 of *Appendix J)*** which revealed only the following four (4) species qualify as critical habitat features:

Asian Elephant (*Elephas maximus,* IUCN EN).

Gee's Golden Langur (T*rachypithecus geei*, IUCN EN).

Hoya bhutanica (IUCN EN)

Bengal Tiger (*Panthera tigris*, IUCN EN)

The screening and evaluation exercise also indicates the presence of other endangered species such as Tricarinate Hill Turtle (*Melanochelys tricarinata*, IUCN CR), Hog Deer (*Axis porcinus*, IUCN EN) and other IUCN vulnerable species. However, these species are not currently considered to trigger Critical Habitat designation at this stage. Additional information from future surveys may refine this assessment and potentially lead to a trigger or non-trigger status for these species.

The four (4) critical habitat species above were further assessed to determine relevance to the Project (Table 7.1). This analysis revealed that only Asian Elephant and Gee's Golden Langur are likely to be significantly impacted and require Net Gain measures to be considered. Impacts to these species associated with the road can be mitigated through provision of wildlife crossings, and alignment to ESS6 requirements is feasible. Application of mitigation measures and the achievement of net gain outcomes is addressed in the Project BMP.

TABLE 7.1 CRITICAL HABITAT RELEVANCE ASSESSMENT RESULTS

Species	Relevance
Asian Elephant (*Elephas maximus*) Endangered	Elephants were observed during field surveys with an estimated population of 37 individuals, while DoFPS estimate over 100 elephants are present in the Project area. The Project supports at least 6.12% of the National population, which is significant and the Project AoA qualifies as a critical habitat for Asian Elephants. A desktop review of movement data for two elephants, "Jetsun" and "Dema" indicated that the GMC area is utilized as elephant corridors. As such, the loss of GMC and its vicinity can result in elephants altering their movement routes.

Species	Relevance
Gee's Golden Langur (*Trachypithecus geei)* Endangered	During field surveys, Gee's Golden Langur were recorded within the GMC area during field surveys. It is estimated that at least 23 - 93 individuals of Golden Langur were found within the AoA, representing (i) 0.35% - 1.55% of the global population and (ii) 1.7% of the National population. The Project AoA therefore supports significant population of this Endangered and restricted-range species. Genetic diversity and structural issues among isolated populations of the Gee's Golden Langur in Assam, India have been recorded, indicating that gene isolation can be the most extreme consequence among population fragments, which leads to local extinction. Habita fragmentation as a result of the project development can exacerbate gene isolation effects.
Hoya bhutanica (Endangered)	The potential presence of *Hoya bhutanica* was identified as part of the desktop assessment (as per the Bhutan Endemic Flowering Plants Workshop and IUCN database) and expert consultation. However, the following were noted: • It was not recorded during the baseline survey which covered the road alignment and a 750m buffer zone. • It was previously reported in (i) Gelephu (Sarpang district) and (ii) Mondokha, Dungna-Metakha (tri-junction), Gedu (Chukha district). • The previous record within Gelephu was reported approximately 1.65 km north of the Project RoW, which is beyond the Project Impact Area, as well as the identified lands to be cleared as part of the Project development. There is no evidence that this plant will be significantly impacted and net gain measures are not necessary for alignment to ESS6 requirements. As a precautionary approach, the BMP has included mitigation to confirm no species of conservation significance are present within the working areas. If any are present, these shall be translocated to a suitable area. Hence, it is not envisaged that the project activities will result in adverse impacts to the species.
Bengal Tiger (*Panthera tigris*) Endangered	The 2021 – 2022 National Tiger Survey for Bhutan estimated 131 tigers nationwide, with an estimated 90 adult tigers (60 females) and a mean density of 0.23 adult tigers per 100 km² in the mountainous terrain of Bhutan. The RMNP supports a Bengal Tiger population, and these cats are known to regularly occur in the nearby Biological Corridor #3. Field transect surveys recorded evidence of a tiger towards the southeast end of the GT Road close to the RMNP, but DoFPS camera trapping surveys did not detect tigers in the area. DoFPS staff have stated that tigers currently do not present a concern for human wildlife conflict in Gelephu and surrounding gewogs. Expert consultations and previous research conducted by the Ugyen Wangchuk Institute for Conservation and Environment Research (UWICER) of Bhutan, reveals tigers in Bhutan are typically found in higher elevations. Also the future presence of tigers is considered incompatible with development of the GMC. Based on this Step 4 assessment, Bengal tigers are not likely to be significantly impacted net gain measures are not necessary for alignment to ESS6 requirements.

Net Gain Requirements

ESS6 paragraph 24 requires, in areas of critical habitat, the Borrower will not implement any project activities that have potential adverse impacts unless all of the following conditions are met:

(a) No other viable alternatives within the region exist for development of the project in habitats of lesser biodiversity value;

(b) All due process required under international obligations or national law that is a prerequisite to a country granting approval for project activities in or adjacent to a critical habitat has been complied with;

(c) The potential adverse impacts, or likelihood of such, on the habitat will not lead to measurable net reduction or negative change in those biodiversity values for which the critical habitat was designated;

(d) The project is not anticipated to lead to a net reduction in the population[102] of any Critically Endangered, Endangered, or restricted-range species, over a reasonable time period;[103]

(e) The project will not involve significant conversion or significant degradation of critical habitats. In circumstances where the project involves new or renewed forestry or agricultural plantations, it will not convert or degrade any critical habitat;

(f) The project's mitigation strategy will be designed to achieve net gains of those biodiversity values for which the critical habitat was designated; and

(g) A robust and appropriately designed, long-term biodiversity monitoring and evaluation program aimed at assessing the status of the critical habitat is integrated into the Borrower's management program.

As part of the Biodiversity Management Plan (BMP), a preliminary framework comprising of three (03) core components has been proposed to support the Net Gain strategy of the Project. This framework will be expanded in further detail in the subsequent iteration of the BMP.

7.6.1 CRITICAL HABITAT SPECIES 1 - ASIAN ELEPHANT

Asian Elephant (*Elephas maximus*, FNCA[19], FNCRR, IUCN EN, CITES I[20]) is one of the last few mega-herbivores still extant on Earth.[21] The Asian Elephant is distributed in 13 countries across South Asia and South East Asia spread over an area of 486,800 km^2.[22,23] Asian Elephant is generalists and feed on a variety of plants, which vary depending upon the habitat and season.[24] Estimated populations is about 48,323–51,680 in the wild and 15,000 in captivity.[25]

Under the Forest and Nature Conservation Act of 1995 of Bhutan, the species is classified as a "totally protected species," meaning any harm to elephants is subject to severe penalties, including imprisonment and fines.[26] The legal framework in Bhutan also supports the conservation of elephant habitats through the establishment of protected areas and wildlife corridors, which are critical for maintaining the ecological connectivity essential for the survival of the species.

DoFPS has also developed an Elephant Conservation Action Plan for Bhutan 2018-2028, which is used as an important guiding document for development of the Biodiversity Management Plan.

1.4.1.1 MOVEMENT

Role of the AOA in promoting dispersal across the Asian Elephant is distributed throughout the southern belt of Bhutan along the border with India (Samtse, Chhukha, Dagana, Phibsoo Wildlife

[102] Net reduction is a singular or cumulative loss of individuals that affects the species' ability to persist at the global and/or regional/national scales for many generations or over a long period of time. The scale (i.e., global and/or regional/ national) of the potential net reduction is determined based on the species' listing on either the (global) IUCN Red List and/or on regional/national lists. For species listed on both the (global) IUCN Red List and the national/regional lists, the net reduction will be based on the national/regional population.

[103] The timeframe in which Borrowers will demonstrate "no net reduction" of Critically Endangered and Endangered, endemic and/or restricted-range species will be determined on a case-by-case basis and, where appropriate, in consultation with qualified experts and taking into account the species' biology.

Sanctuary, Sarpang, Royal Manas National Park, Samdrup Jongkhar, Jomotshangkha Wildlife Sanctuary, Chirang Ripu RF, and the Manas National Park); elevation ranging between 100 m to above 2,000 m (Nature Conservation Division, 2018).[27] Site visits and expert consultations suggest that elephants are attracted to the foothills of Gelephu City due to the presence of salt licks and bamboo shoots. Asian Elephants utilize the Project area and its proximity for its movement between Phibsoo Wildlife Sanctuary and Manas National Park. Elephants migrate primarily to access seasonal resources such as food and water, avoid human conflict, and maintain traditional social and ecological behaviors. The dispersal of male elephant is critical for its reproduction.[28] Specifically, this helps in avoiding inbreeding and is critical for gene flow through the population.

A desktop review of available data on the movements of two individual elephants, "Jetsun" and "Dema,"[29] revealed that they utilized different geographic areas and did not share the same locations, even across different months. For this assessment, 'Jetsun' movements were assessed as her movements included the GMC and its surrounding areas. 'Jetsun' was observed reaching the boundary of Umling province, adjacent to Manas National Park (***Figure 7.27, Figure 7.28)***, and travelling as far west as Phibsoo Wildlife Sanctuary. She visited this sanctuary in the first half of 2015 and again in the second quarter of 2016, indicating that she consistently remained in forested or shrubland areas. The loss of GMC and its vicinity can result in elephants to alter their movement routes. There are no records of elephants using "Northern Biodiversity Corridor" or Biological Corridor 3 (329–2,647 masl). Additionally, the research shows a negative correlation between elephant abundance and elevation,[30] thus the elephant may be hindered using Biological Corridor 3 as an alternative.

At the time of this report, it is planned that the area to the north of the Project within the AOA will be maintained as an elephant corridor to support adequate dispersals of elephants (***Figure 7.29***). Therefore, the AOA is important for maintaining habitat connectivity across the landscape spanning the western forest areas in India and Bhutan with the eastern forest areas largely comprising of the Royal Manas and Manas National Park.

In 2021, the Southern Bhutan Ecological Corridor Forecasting II was conducted, utilizing National Aeronautics and Space Administration (NASA) earth observations to model land cover change and elephant wildlife corridors in Southern Bhutan (Figure 7.1). The results indicate that the Project Area and the larger AoA are suitable for elephant corridors. However, it should be noted that urban settlements have been omitted as part of the NASA analysis of expected movement routes. While the most suitable linkages according to elephant habitats have been identified, these may not actually be the most feasible/ utilized by the elephants.

FIGURE 7.27 HOURLY DATA-POINTS FOR RADIO-COLLARED ADULT FEMALE ASIAN ELEPHANT "JETSUN" PER QUARTER IN 2015[31]

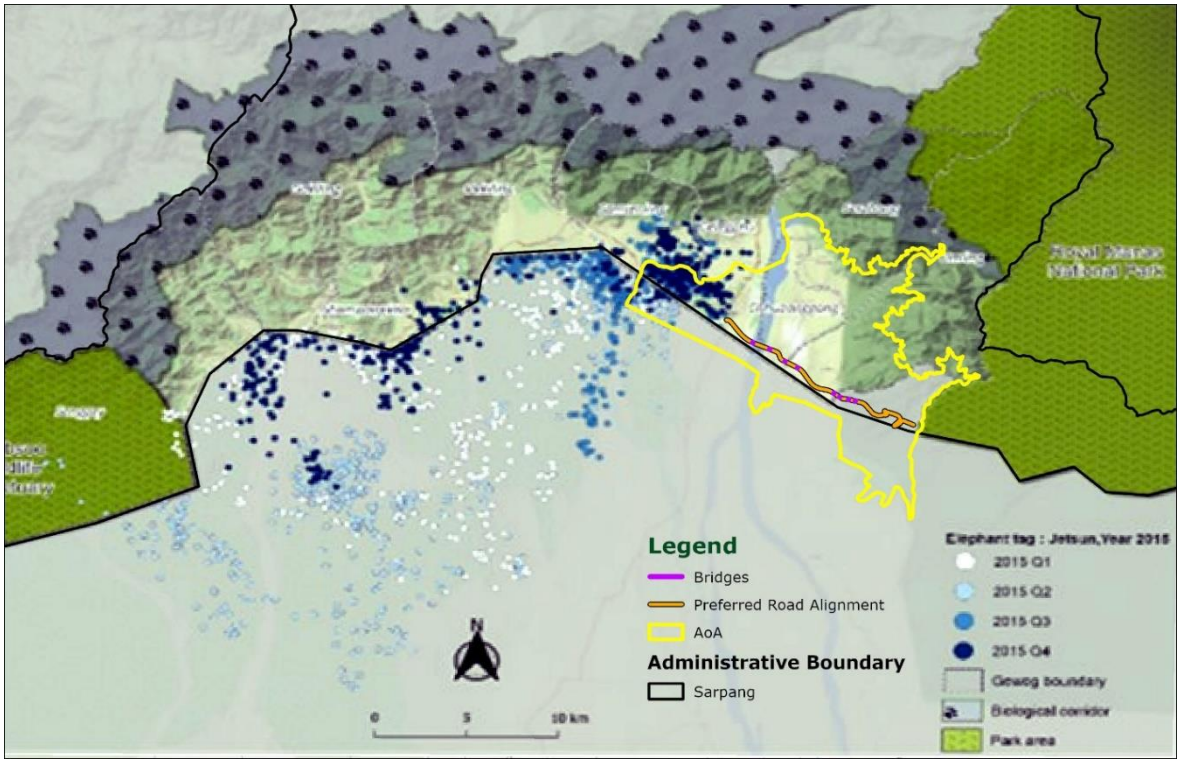


FIGURE 7.28 HOURLY DATA-POINTS FOR RADIO-COLLARED ADULT FEMALE ASIAN ELEPHANT "JETSUN" PER QUARTER FROM JAN TO SEPT 2016[32]

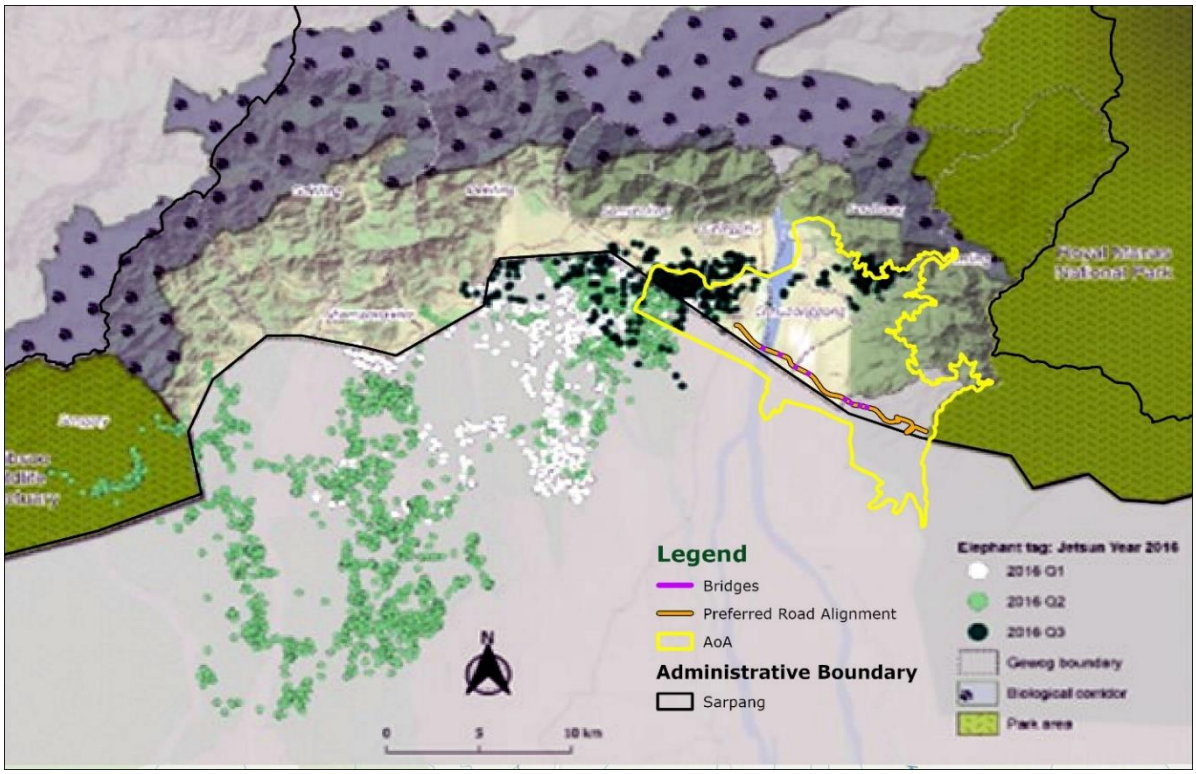


FIGURE 7.1 NASA'S SOUTHERN BHUTAN ECOLOGICAL CORRIDOR FORECASTING II

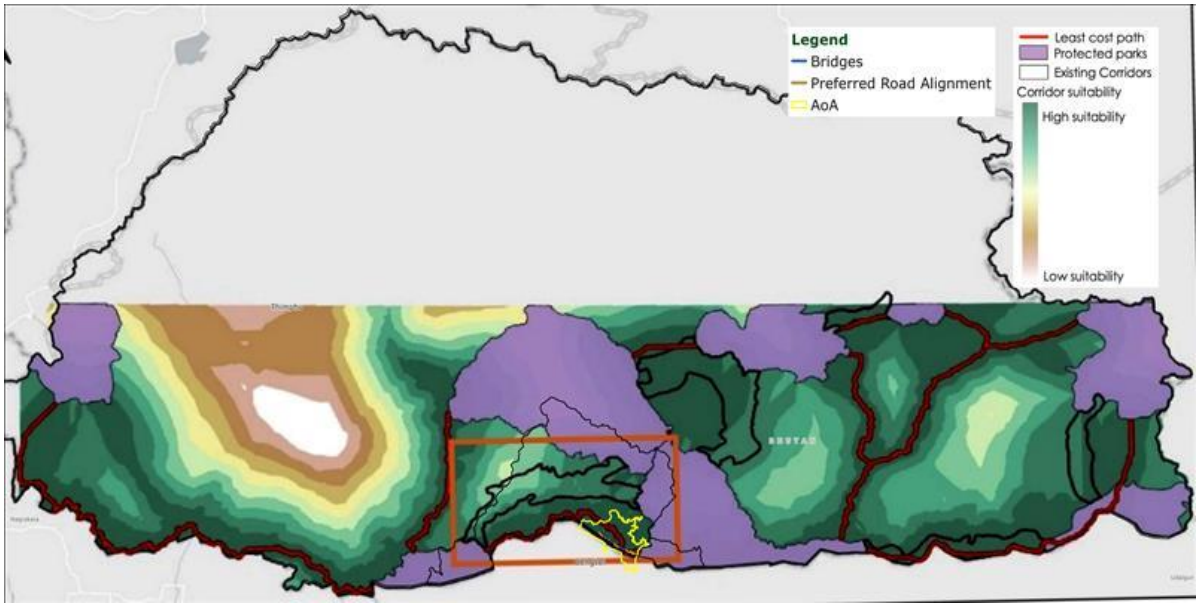
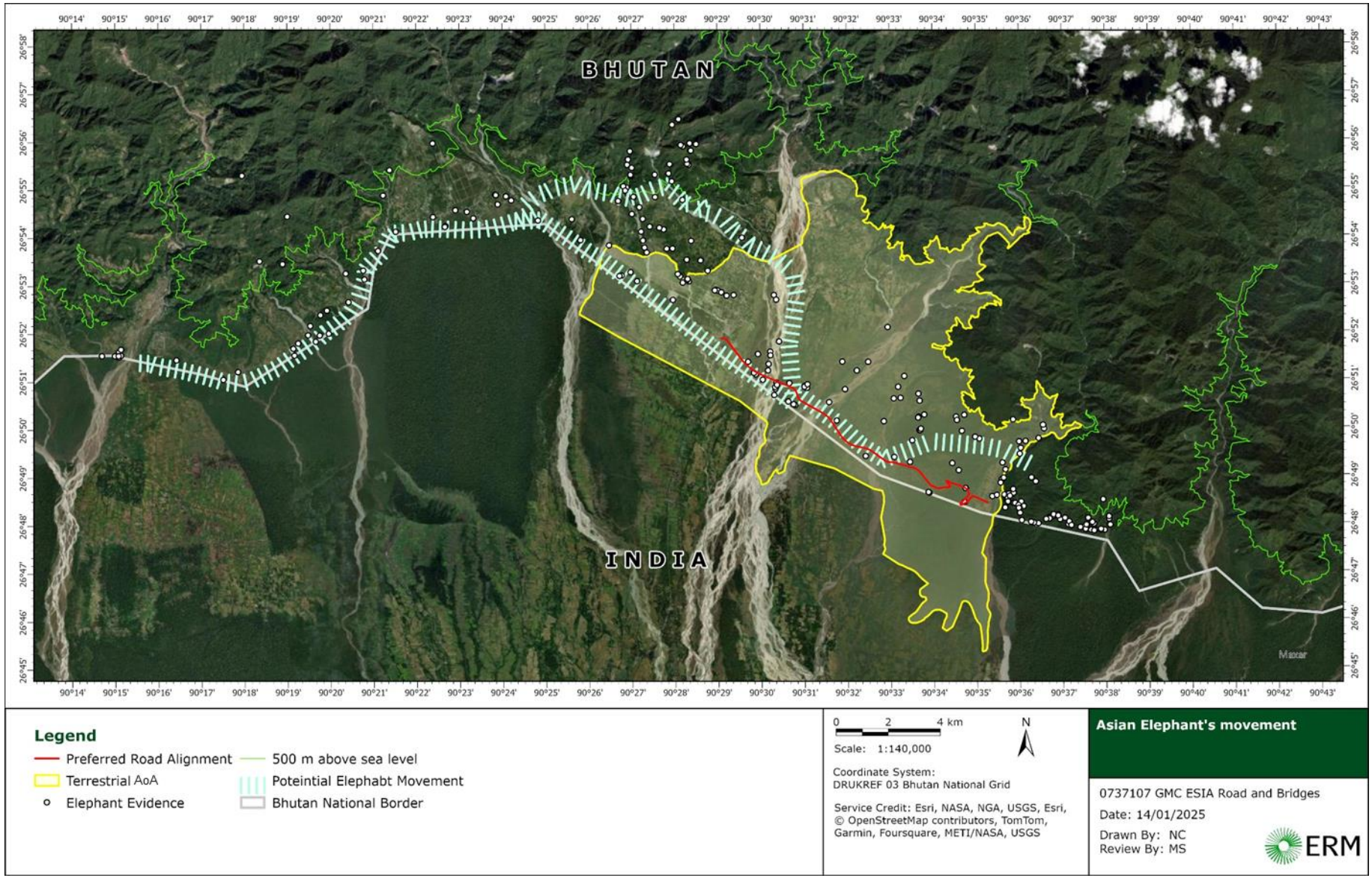


FIGURE 7.29 ELEPHANT SIGHTING LOCATIONS (DESKTOP SCREENING)



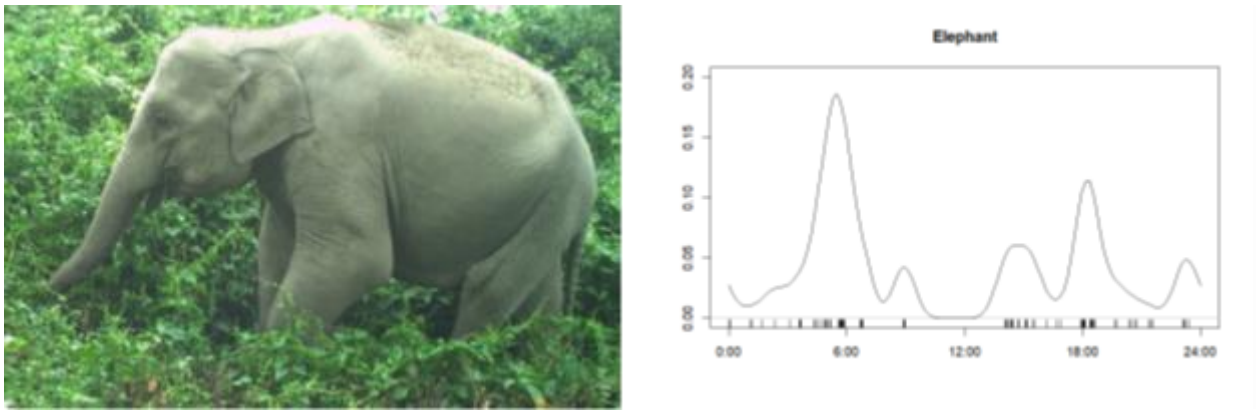
7.6.1.1 POPULATION

It is estimated that approximately 605-761 individuals of wild population and 9 individuals of captive population exist in Bhutan.[33] The National Elephant Survey Report indicated elephant density mean is estimated at 0.297 individuals per 100 km^2 (95% CI: 0.26 – 0.33).[34] The research indicated that elephant abundance was positively associated with forest cover while negatively with elevation.[35]

The camera trap and transect survey recorded the presence of Asian Elephant. During the transect survey, there were 2 direct sightings, the first encountered a herd of 12 elephants with six (06) females, three (03) males and three (03) juveniles; and the second encountered a herd of 25 elephants with 16 females, three (03) males and six (06) juveniles. In addition to direct sightings, evidence of Asian Elephants' occurrence such as droppings, feeding signs, tracks, and scrapes suggested the species' presence in different types of habitats within the GMC, i.e., farmland, grassland, and sub-tropical. The camera trap captured Asian Elephants on multiple days in 26 days during the period of 13 July - 29 August 2024 (***Figure 7.30***). It suggests the frequent occurrence of Asian elephants within the GMC. Based on the current data regarding the presence of Asian elephants within the Project area, it is likely that there are two herds consisting of 37 individuals. The first herd, which includes 6 females, three (03) males, and three (03) juveniles, likely represents three (03) reproductive units, as three (03) adult females are potentially the mothers of the three (03) juveniles. The second herd, consisting of 16 females, three (03) males, and 6 juveniles, likely represents six (06) reproductive units, with six (06) adult females possibly being the mothers of the six (06) juveniles. The Project supports the habitat of 4.86% - 6.12% of the National population (37/761 X 100% = 4.86%; 37/605 X 100% = 6.12%).

In conclusion, the Project AOA contains critical habitat for Asian Elephants that support significant national important concentrations of this species.

FIGURE 7.30 ASIAN ELEPHANT AND THEIR ACTIVITY PATTER



7.6.2 CRITICAL HABITAT SPECIES - GEE'S GOLDEN LANGUR

Gee's Golden Langur (*Trachypithecus geei*, IUCN EN, FNCA[36], FNCRR, IUCN EN, CITES I[37]) (***Figure 7.31***) is a restricted-range species with the Estimated Extent of Occurrence (EOO) of about 9,235–30,000 km². This species occurs only in Bhutan and northeastern India (Assam).[38] The Bhutan population occurs within an area of about 3,136 km² and the Indian population in an area of about 1,255 km².[39] This species is found in moist evergreen, dipterocarp forests, riverine, and moist deciduous forests, temperate and subalpine forests and occasionally

in degraded habitats with secondary growth and broad leaf forest, sal forest, sub-tropical forest.[40] The global population is approximately 6,000-6,500 mature individuals.[41]

The activity pattern exhibited a bimodal diurnal feeding behavior, with peaks observed in the morning and evening hours. [42] Golden Langur is threatened by habitat fragmentation.[43] Five habitat threats in Bhutan include (1) hydropower development, (2) road development, (3) housing development, (4) resource extraction, and (5) agricultural expansion.[44]

In Bhutan, the langur is distributed from the subtropical forests of Western Assam to the broadleaf forests of Bhutan.[45] IUCN Red List report suggested an estimation of 6,600 total individuals of this species in Bhutan.[46] However, a comprehensive research regarding the population abundance and distribution of Gee's Golden Langur in Bhutan in 2019 documented a total of 2,439 langurs in 222 groups.[47] In which, there was a total of 468 adult males (19%), 924 adult females (38%), 649 juveniles (27%), and 398 infants (16%).[48]

Its Extent of Occurrence (EOO) overlaps the Project AOA.[49] During the transect survey, Gee's Golden Langur individuals were recorded in the sub-tropical region within the GMC. During the survey, the presence of Gee's Golden Langur was directly observed across multiple dates in July (13th, 16th, 20th, and 29th) in the sub-tropical forest, with varying group sizes recorded:

- July 13: 17 individuals in Grid_43, and 23 individuals in Grid_41;
- July 16: 9 individuals in Grid_29, 11 individuals in Grid_27, and 13 individuals in Grid_23;
- July 20: 7 individuals in Grid_21; and
- July 29: 13 individuals in Survey_000047 grid.

Therefore, it is estimated that a total of approximately 23 - 93 individuals of Golden Langur were found within the Project Area. It accounted for (i) 0.35% - 1.55% of the global population (23/6500*100%= 0.35%; 93/6000*100% = 1.55%) and (ii) 1.7% of the National population (42/6500*100%= 0.65%). In conclusion, considering the Project AOA supports significant population of this restricted-range species, the Critical Habitat supporting Golden Langur is triggered.

FIGURE 7.31 A TROOP OF GOLDEN LANGUR SITTING ON TERMINALIA CHEBULA TREE FOUND IN "PEACOCK ISLAND", INDIA[50]

7.7 HUMAN WILDLIFE CONFLICTS

A social survey was conducted to study the **perception of HEC and conservation attitudes** in 79 villages across 10 gewogs of Sarpang Dzongkhag. A total of 815 individuals was interviewed, comprising 49% males and 51% females.

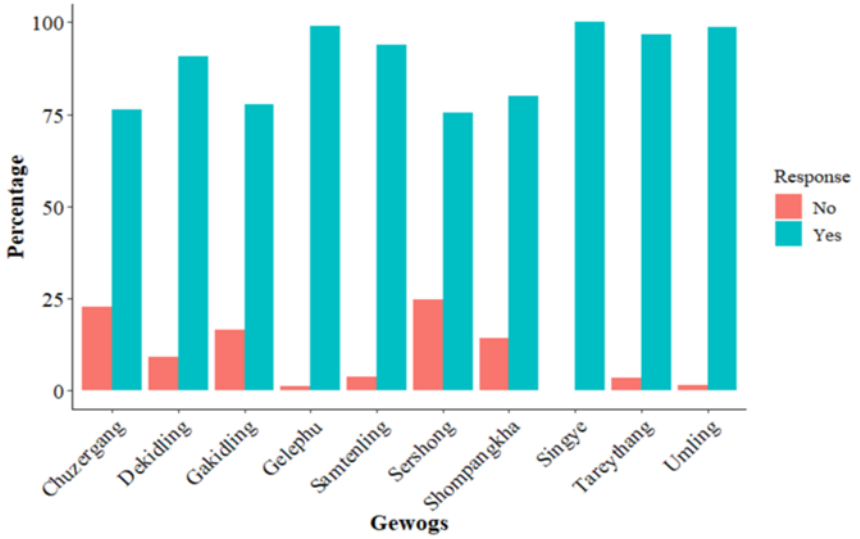
Human-elephant conflict (HEC) is one of the emerging challenges in the district, alongside other hazards identified by the district administration and the Thromde. Among the wildlife, the Asian Elephant is considered the most conflicting animal due to the significant damage they cause to communities.

HEC awareness and community encounters[104]

According to a Department of Forests and Park Services (DoFPS) survey, the majority of respondents (88%) confirmed experiencing HEC in their community. In Singye gewog 100% respondent reported encountered HEC while on average 87.6% of respondents from all other gewogs encountered HEC in the past three years (***Figure 7.32***).

[104] NCD, 2024. Perception of Human Elephant Conflict and conservation attitudes of affected communities in Sarpang, Bhutan. Nature Conservation Division, Department of Forests and Park Services, Ministry of Agriculture and Forests, Thimphu, Bhutan

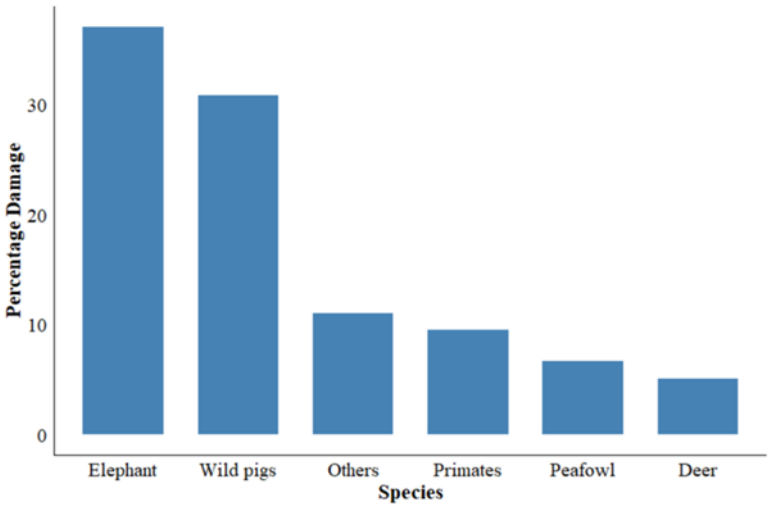
FIGURE 7.32 HEC ENCOUNTERED IN PAST THREE YEARS (SOURCE – HEC REPORT DOFPS (2024)



HEC data maintained with DFO for the reported cases also shows that Chhuzanggang, Gelephu, Samtenling, Serzhong) experienced HEC in past two years (2022 to 2023). A total of 48 HEC incidences were reported in 2022 to 57 in 2023, showing an increase in HEC incidences by 8.6%.

The study **identified six wildlife categories** causing conflict with local communities (***Figure 7.33***). Elephants were identified as the most frequently involved species in human-wildlife conflicts, accounting for 37% of cases, followed by wild pigs (30.8%), primates (9.5%), peafowl (approx.7%) and deer (5.1%). Since HEC remains a significant concern, it is crucial to implement conservation efforts that balance the protection of elephants with effective strategies to mitigate HEC.

FIGURE 7.33 CONFLICTING WILDLIFE SPECIES



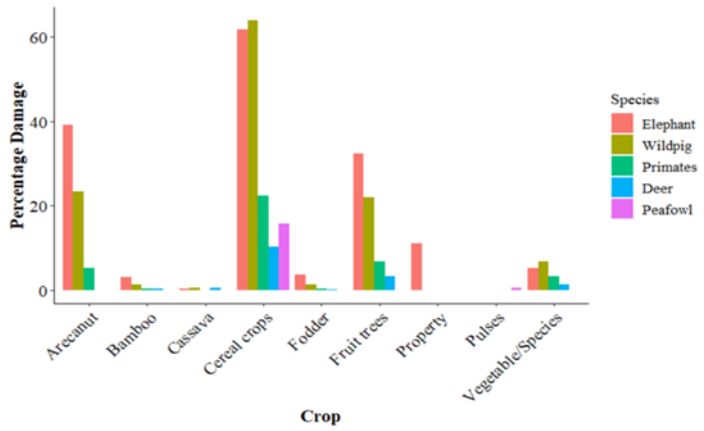
Types of HWC damages

According to Letro et al. (2021), HWC in Bhutan is broadly classified into three main categories: damage to crops and property, livestock predation, and human casualties. Destruction of crops by Asian Elephant, primates (Assamese macaque, gray langur, and capped langur), and ungulates (wild boar, sambar deer, barking deer, spotted deer, goral, and Himalayan serow) reported as the most common conflict type in the country.

Similar to the national HWC trend, Sarpang Dzongkhag experienced crop and property damage as the most frequent type of conflict. While occasional human casualties and livestock predation were also reported in the Dzongkhag, the social survey results excluded findings on these two conflicts.

An analysis of conflict data revealed that crop damage was the most prevalent form of HWC in Sarpang Dzongkhag (***Figure 7.34***). Cereals (61.83%) were the most impacted crop, followed by the damage to areca nut trees (37%) and other fruit trees including banana, mango, orange, and litchi at 36%. Vegetables and species also experienced some damage, but to a lesser extent. Property damaged, including houses, fences, water tanks, pipelines, and vehicles, represents a smaller portion (10.3%) of HWC incidents.

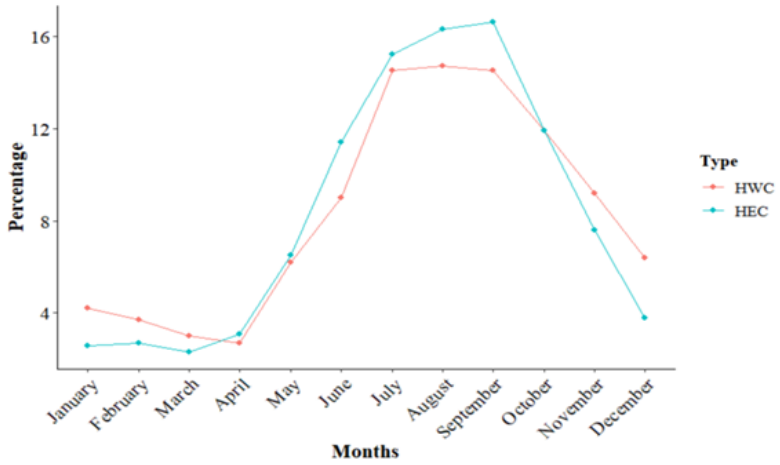
FIGURE 7.34 TYPES OF HWC DAMAGES



Seasonal trend of HWC and HEC

The survey results concluded that HWC is a year-round challenge for the communities. However, the severity fluctuated throughout the year. Respondents reported an increase in conflicts during the summer (June, July, August) and autumn months (September, October, November) compared to other seasons. This seasonal variation likely coincides with factors like food availability and wildlife breeding patterns (***Figure 7.35***).

FIGURE 7.35 SEASONAL VARIATION IN HWC AND HEC



Perception on seasonal trends of HEC

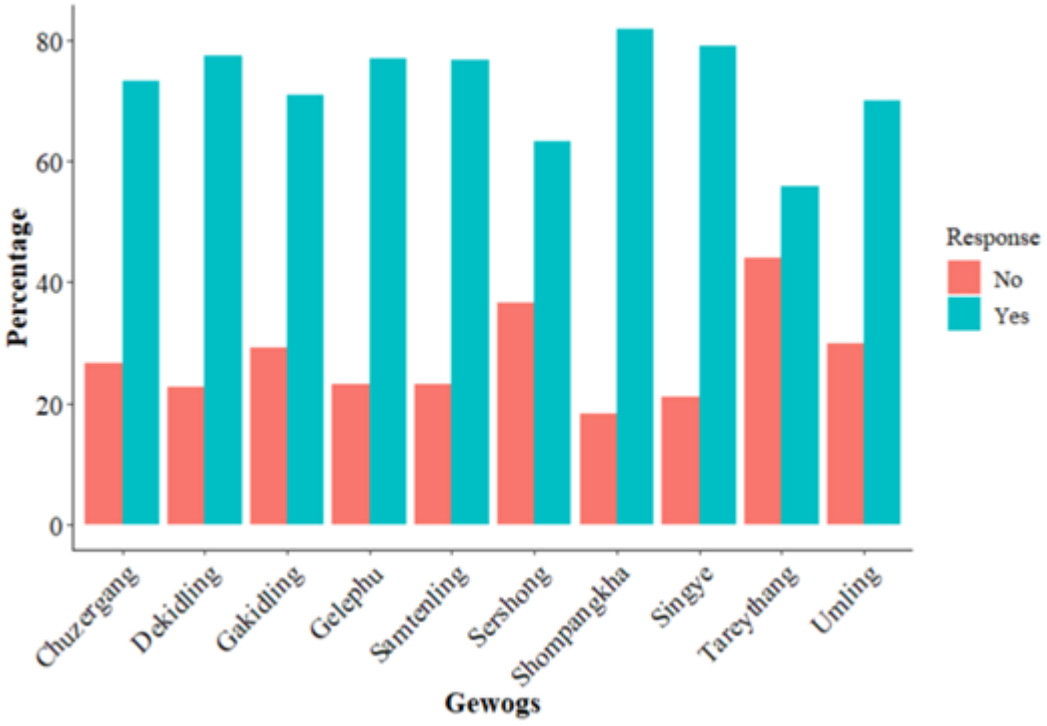
The majority (52%) of respondents indicated that HEC incidents are on the rise throughout the summer and autumn months. This aligned with the data showing a peak in HEC during August and September

A majority (89%) of respondents viewed HEC as a problem for their locality, and 83.7% of respondents felt that HEC affected community well-being. Additionally, 65% reported that mitigation measures adopted in the community. Most respondents (75 %) reported HEC to concerned agencies like gewogs administration, Forest Range Office, etc.

Respondents who suffered losses to HEC

HEC is prominent in Sarpang and the community succumbs to losses every year. Around 70% of the people suffered loss to HEC while 30% responded that they have not suffered losses due to HEC in the last three years. Among the respondents who reported to have suffered loss to HEC, Shompangkha stands highest with 81.7% followed by Singye (78.9%) and Dekiling (77.4%) while Tareythang reported to have suffered the least loss (55.9%).

FIGURE 7.36 PERCENTAGE OF RESPONDENT WHO SUFFERED LOSS DUE TO HEC BY GEWOG



On the contrary, among the 30% respondents who reported to have not suffered losses to HEC, **Tareythang** stands highest with 44.1% followed by **Sershong** (36.7%), Gakidling (29.1%) and **Chuzergang** (26.7%) while Shompangkha reported to have not suffered the loss with 18.3%.

TABLE 7.10 GEWOG WISE MONETARY LOSSES (NI.) DUE TO ELEPHANTS OVER 3 YEARS

Gewogs	Sum of Loss in Monetary Value (Nu. in millions)
Chhuzanggang	3.787
Dekidling	3.637
Gakidling	3.641
Gelephu	1.682
Samtenling	1.835
Sershong	3.576
Shompangkha	4.595
Singye	1.403
Tareythang	1.977
Umling	3.284
Grand Total	**29.344**

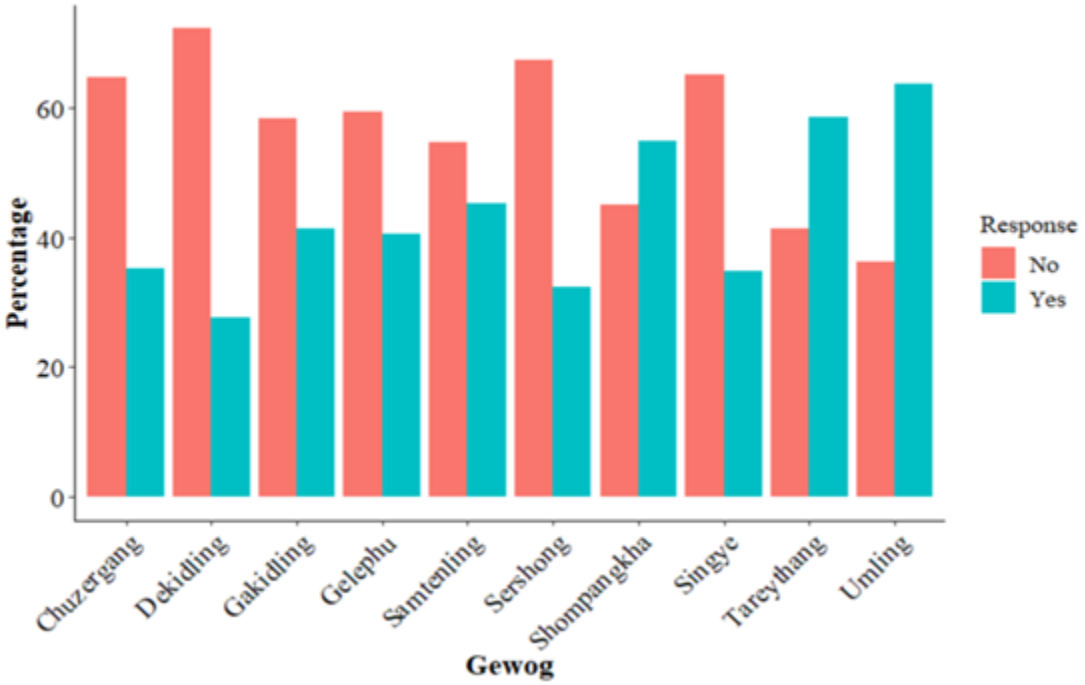
Among the 10 gewogs surveyed, Shompangkha gewog suffered the highest losses (Nu.4.595 million) in terms of monetary value to elephant menaces followed by Chhuzergang (Nu.3.714 million) while Singye gewog suffered the least (Nu.1.403 million). Overall, the district suffered total loss of Nu.**29.343** million within three years

Respondents' livelihood affected by HEC

To understand the current situation on the livelihood in the HEC prevalent areas, respondents were asked if their livelihood were at all affected due to HEC and 57% responded to "no" while 43% responded to "yes".

Among the affected respondents residing in the affected gewogs, **Umling gewogs responded maximum with 63.8% followed by Tareythang with 58.6% and Shompangkha gewog with 54.9**% while Dekidling gewog was least affected with 27.7% only. However, almost all the respondents in the affected gewogs have reported of being affected to their livelihood due to HEC as is evident in the ***Figure 7.37.***

FIGURE 7.37 PERCENTAGE OF RESPONDENTS AFFECTED BY HEC IN EACH GEWOG



7.8 ECOSYSTEM SERVICES

Under the WB ESS-1, and ESS-4, the scope of the ESIA shall include consideration of Ecosystem Services, which is defined as any important ecosystem services that are provided by the biodiversity and living natural resources that may be affected by the project, and their value to project-affected and other interested parties.[105]:

[105] WB 2018. ESS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources. [Available at: https://documents1.worldbank.org/curated/en/924371530217086973/ESF-Guidance-Note-6-Biodiversity-Conservation-English.pdf]

According to WB ESS-6, Ecosystem services (ES) are the benefits that people derive from ecosystems. They are organized into four (04) types:

(i) Provisioning services, which are the products people obtain from ecosystems and which may include food, freshwater, timbers, fibers, and medicinal plants;

(ii) Regulating services, which are the benefits people obtain from the regulation of ecosystem processes and which may include surface water purification, carbon storage and sequestration, climate regulation, and protection from natural hazards;

(iii) Cultural services, which are the nonmaterial benefits people obtain from ecosystems and which may include natural areas that are sacred sites and areas of importance for recreation and aesthetic enjoyment; and

(iv) Supporting services, which are the natural processes that maintain the other services and which may include soil formation, nutrient cycling, and primary production.

To provide a uniform basis to assess the status of all major global habitat across all of the word's bioregions, the United Nation's Millennium Ecosystem Assessment (UN 2005) combines diverse ES typologies into a consistent classification scheme similar to the classification of ESS-1 and ESS-6 as described above.

The ES identified within the project area are described in ***Table 7.11***. In general, while the Project Area provides some ES(s), i.e., forest products and supporting fishing and aquaculture, these are not considered prioritized ES as alternatives can be found in the proximity of the Project.

TABLE 7.11 ECOSYSTEM SERVICES WITHIN THE IMPACTED AREA

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
Provisioning Services				
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of fresh- or salt-water confinement for harvesting	Based on stakeholder engagement activities, it is understood that the local villagers utilize some water bodies for subsistence fishing activities and for small-scale local sale in the upstream of the Project location. Note that these are licensed. Aquaculture is also undertaken on a small scale by six (06) households in Samtenling Gewog and by the National Research and Development Centre for Aquaculture, Department of Livestock in Gelephu Thromde.	No	The Project is expected to have minimal impact on fishing and aquaculture activities, as alternative fishing locations are available, and no aquaculture areas will be directly loss by the Project's development.
Food: wild meat	Animals hunted for primarily for food (Recreational hunting covered under cultural services)	Hunting may occur but insignificant.	No	Although increased hunting activity may occur due to the presence of workers, particularly during the construction phase, it is anticipated that the workers will not compete with local communities for hunting resources.
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale	The primary land use pattern within the project area involves agricultural activities in the rural areas or Gewogs, including Umling, Tareythang, Chhuzanggang and Samtenling. Amongst the cultivated crops include rice, paddy, ginger, oranges, cardamom, fruit plants, lychee and mangoes. Additionally, the cultivation of Betel nut or Arcea nut is widespread and exported to India.	Yes	The Project area is not unique to provide the area of cultivated crops and alternatives can be found in the proximity of the Project. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
Food: herbs and plants	Herbs and plants collected for food by local people	Based on stakeholder engagement activities, the locals forage for edible forest products such as berries, mushrooms .etc for personal consumption.	Yes	The Project area is not unique to provide the area of cultivated crops and alternatives can be found in the proximity of the Project. Thus, they

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
				are not considered prioritized ES and effects on the ES may occur but insignificantly.
Livestock farming	Sedentary and nomadic livestock farming	Livestock rearing is conducted in the Samtenling Gewog.	Yes	The Project area is not unique to provide this ES, and alternatives can be found in the proximity of the Project. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
Biomass fuel	Wood, dung and plant matter collected for charcoal, fuel	Collecting fuelwood may occur[106]. Firewood is collected in the community forests in Chhuzanggang Gewog and Samtenling Gewog.	Yes	The Project area is not unique to provide this ES, and alternatives can be found in the proximity of the Project. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp and paper	Based on stakeholder engagement activities, the locals forage for timber from the Community Forest in Tareythang, Umling, Chhuzanggang, and Samtenling Gewogs as building materials and for commercial sale.	Yes	The Project area is not unique to provide this ES, and alternatives can be found in the proximity of the Project. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
Non- Timber Forest Products (NTFP)	Non-timber products collected from the forest. For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber	N/A	No	-

[106] UNDP (2011) Bhutan Gender Analysis, Executive Summary. Available from: https://climatepromise.undp.org/sites/default/files/research_report_document/undp-ndcsp-bhutan-gender-analysis-report.pdf

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
Regulating Services				
Freshwater	Freshwater for bathing, drinking, irrigation, laundry, household and industrial use	As no municipal water system has been established within the rural areas, some local villagers still utilise freshwater from the rivers for daily activities. It was noted that water shortages have been reported during the summer periods, whereby the villagers harvest rainwater to supplement the freshwater supply. Note that some developed areas are equipped with water treatment plants such as in Gelephu Thromde.	Yes	During construction stage, water will be required during civil work, dust suppression, and domestic use. At time of writing, it is envisaged that potable water will be sourced from the local municipality or purchased from a supplier. However, if this is insufficient, water may need to be sourced from nearby rivers or streams, this could potentially impact local communities' availability of water resources.
Biochemical, natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use. For example, pelts, carved or decorative animal products, live animal trade	Pipla (*Piper longum*) is one of the most important medicinal plants.[107] Pipla can be found in the community forests, i.e, (i) Dangling CF, Tashithang CF, Gaden CF, Samdrupcholing CF, Dungmin CF in Umling Gewog and (ii) Geyser Trashicholing CF (Block I and II), Juenphen CF (Block I and II), Thrungthu CF (Block I and II) in Tareythang Gewog.	Yes	The Project area is not unique to provide this ES, and alternatives can be found in the proximity of the Project. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
	Genes and genetic information used for animal breeding, plant improvement, and biotechnology	N/A	No	-
Ecosystem functions	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a "sink") or emitting chemicals to the atmosphere (i.e., serving as a "source")	The surrounding forests play a role in regulating the air quality, sequestering carbon, filtration of organic wastes and general nutrient cycle.	No	The Project area is not unique to provide this ES, and alternatives can be found in the proximity of the Project. Additionally, the Project area is considered small compared to the

[107] FAO. Available at: Non-Wood Forest Products in 15 Countries Of Tropical Asia : An Overview (fao.org)

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
	Carbon sequestration (impacts on global climate change) regulation of temperature, shade air quality by vegetated areas		No	broader landscape proving this ES. Thus, they are not considered prioritized ES and effects on the ES may occur but insignificantly.
	Role played by vegetation and bacteria in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds.		No	
	Role of natural habitats (e.g. wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms.	N/A		
	Regulation of fire frequency and intensity (e.g. dense forest can provide firebreaks)	N/A		
	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock	N/A		
	Influence ecosystems have on the incidence and abundance of human pathogens	N/A		
	Role of vegetation in regulating erosion on slopes and riparian areas	Yes; riparian vegetation along the riverbanks provide erosion control during the wet season.		

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops	The species within the surrounding forests play a role in pollination of some agricultural crops.		
Cultural Services				
Spiritual, religious or cultural value	Natural spaces or species with spiritual, cultural or religious importance	One (01) sacred tree has been identified within the Community Forest, while a number of other sacred trees have been identified within the general vicinity of the Project	No	The impact due to the Project may occur but insignificantly as the scared tree is outside the Project area and it is expected to not be cut down.
	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources.	N/A	No	-
	Use of natural spaces and resources for tourism and recreation (e.g. swimming, boating, hunting, birdwatching, fishing)	N/A	No	-
	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks	N/A	No	-
	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation.	N/A	No	-
	Ornamental resources	N/A	No	-
Supporting Services				
Non-use value of biodiversity (e.g. existence,	Formation of biological material by plants through photosynthesis and nutrient assimilation.	The surrounding forests play a role in photosynthesis and nutrient cycling/ assimilation.	No	The Project area is not unique to provide these ecosystem services and alternatives can be found in the

ES Type	Definition of ES Type [a]	ES Screening within the Project area and its proximity	Affected by Project (yes/no)	Affected by Project
bequest value)	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems.			proximity of the Project. Thus, they are not considered prioritized ecosystem services.
	Natural soil-forming processes throughout vegetated areas.			
	Flow of water through ecosystems in its solid, liquid, or gaseous forms.	The surrounding water bodies and land play a role in the regulation of freshwater and groundwater.	Np	

8. SOCIO-ECONOMIC BASELINE

The purpose of this section is to present the socio-economic profile for the social study area[108], which comprises both direct and indirect impact areas This section provides an overview of the following aspects:

- Administrative set up of Bhutan and the district where the Project is located.
- Demographic profile of the communities in the social study area.
- Livelihood profile of the communities in the social study area.
- Land use patterns in the social study area.
- Gender aspects in the social study area.
- Social infrastructure available in the social study area (e.g. education and health infrastructure), and
- Physical infrastructure available in the social study area (e.g. water supply, electricity, and roads).

Refer to ***Appendix K*** for baseline methodology.

8.1 NATIONAL OVERVIEW

Bhutan is a lower-middle income country.[109] Bhutan's development strategy is guided by a philosophy of Gross National Happiness (GNH)[110].The annual real Gross Domestic Product (GDP) growth has averaged 7.5% since the 1980s, largely driven by the public sector-led hydropower sector and strong performance in service industries, including tourism[111].

Data suggests that extreme poverty was eliminated in Bhutan in 2022, and the population living below the USD 6.85 per day poverty line (used for upper middle-income countries) decreased from 39.5% to 8.5% between 2017 and 2022[112]. This reduction in poverty has been attributed to two factors: (1) growth in agriculture and agricultural productivity, and (2) remittances, which has led to an increase in the real per capita consumption, especially in rural areas. The Gini Index[113] in Bhutan decreased from 37 in 2017 to 28 in 2022[114].

The state religion of Bhutan is Buddhism, a branch of Mahayana Buddhism. Bhutanese language and literature, arts and crafts, drama, music, ceremonies and events, architecture, and basic social and cultural values draw their essence from Buddhism. About 22% of the population in

[108] The Social Study Area, which includes both direct and indirect impact areas, consists of Gelephu Thromde and six Gewogs: Gelephu, Samtenling, Umling, Chhuzanggang, Serzhong, and Tareythang.

[109] Ibidem.

[110] The World Bank country overview, Bhutan, available at Bhutan Overview: Development news, research, data | World Bank, accessed on September 27, 2024.

[111] Ibidem.

[112] Ibidem.

[113] The Gini coefficient, or Gini Index, is the most used measure of inequality. It was developed by an Italian statistician Corrado Gini and named after him.

[114] The World Bank country overview, Bhutan, available at Bhutan Overview: Development news, research, data | World Bank, accessed on September 27, 2024.

Bhutan follows Hinduism , who are mainly concentrated in southern Bhutan[115]. The country of Bhutan shifted from a monarchy to a democratic constitutional monarchy in 2008. The Local Government Act of Bhutan was enacted on 11 September 2009, to further implement Bhutan's programme of decentralization of power and authority[116]. The Act establishes local governments in each of the 20 Dzongkhags, all of which are overseen ultimately by the Ministry of Home Affairs. Bhutan's administrative divisions include Dzongkhags (20), Dunkhags (15), Gewogs (205), Chiwogs[117] and Thromdes (4) or municipalities. The Project is located in Sarpang District.

8.2 SARPANG DISTRICT OVERVIEW

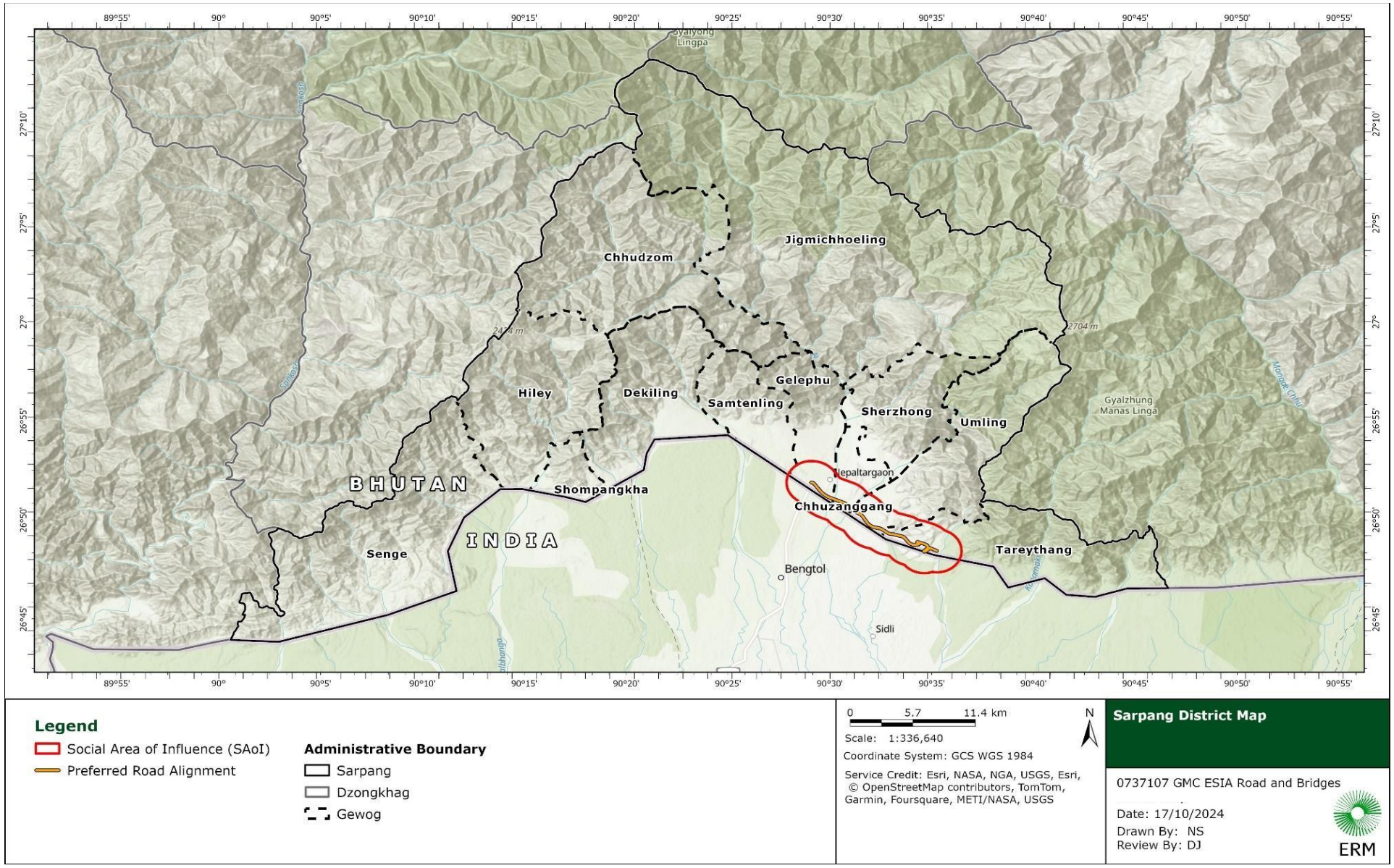
Sarpang District, located in the southern part of Bhutan, covers an area of 1,655 km². It includes urban areas of Gelephu Thromde and Sarpang Town, along with twelve (12) rural areas, namely: Samtenling, Chhuzanggang, Gelephu, Jigme Chhoeling, Serzhong, Tareythang, Umling, Dekiling, Chhudzom, Gakiling, Senggey, and Shompangkha Gewogs. The locations of the Sarpang District are shown in ***Figure 8.1***.

[115] Susmika Subba and Phanchung, *A thriving Devi Puja ritual of Southern Communities in Bhutan*, available at CBA2020-02MY-Mizuno-15-20.pdf, accessed on 21 November 2024.

[116] Bhutan Government and Political System, available at Government & Political System in Bhutan, Local Parties - HeavenlyBhutan, access on September 24, 2024.

[117] It is estimated that Bhutan has over a 1000 Chiwogs.

FIGURE 8.1 SARPANG MAP



As per the 2017 Population and Housing Census of Bhutan, Sarpang District has a population of 46,004, which increased to 50,221 as of 2023. The district sex ratio is 109.2 males per 100 females. Sarpang District has 10,369 households with an average household size of 4.0 ***(Table 8.1)***.

TABLE 8.1 POPULATION DENSITY OF SARPANG

Dzongkhag	Area (km²)	Population		Density (Population per km²)	
		2005	2017	2005	2017
Sarpang	1,946	41,549	46,004	21.35	23.64

Source: Statistical yearbook 2021

Table 8.2 provides an overview of the demographic profile of Sarpang District. This is based on the 2017 Population and Housing Census of Bhutan, which is the most recent census.

TABLE 8.2 DEMOGRAPHIC PROFILE OF SARPANG DISTRICT

Topic	Indicator	2017
Demographic Characteristics	Total Population	46,004
	Male	24,018
	Female	21,986
	Sex Ratio (Males per 100 Females)	109.2
	Total Dependency Ratio	43
	Child Dependency Ratio	34.9
	Aged Dependency Ratio	8.1
	Population by Broad Age Group	
	0-14 years	11,215
	15-64 years	32,177
	65 years and over	2,612
Annual Household Income by Source [118]	Wages	127,427 Nu
	Agriculture	53,057 Nu
	Non-agriculture	97,218 Nu
	Total	277,702 Nu
Education	Literacy Rate (%)	72.4
	Male (%)	78.6
	Female (%)	65.5

[118] National Statistics Bureau (2022).

Topic	Indicator	2017
	School Attendance (% of 6 Years and Above)	29.7
Health	Crude Birth Rate (Per 1,000 Population)	13.3
	Total Fertility Rate	1.5
	Crude Death Rate (Deaths per 1,000 Population)	6.4
	Infant Mortality Rate	14.7
	Child Mortality Rate	18
	Under Five Mortality Rate	32.7
Housing, Household Amenities and Food Sufficiency	Total Regular Households	10,369
	Average Household Size	4
	Improved drinking Water Source (%)	99.1
	Improved Sanitation Facility (%)	75.7

Source: Population and Housing Census of Bhutan 2017, Sarpang Dzongkhag (PHCB 2017) and Bhutan Living Standard Survey Report, National Statistics Bureau (2022)

With regards to health infrastructure, the district has three (03) hospitals, two (02) Basic Health Units, 10 Primary Health Centres (PHCs), one (01) Sub Post, 13 outreach clinics, and approximately 13 ambulances. The district has 44 doctors, 68 nurses and 78 technicians. The district has an average of four (04) doctors per bed.

The number of educational institutions, including private institutions in the district include two (02) central schools, three (03) higher secondary schools, six (06) middle schools, 11 primary schools, two (02) extended classrooms, 15 Non-Formal Education (NFE) Centres (NFE), 22 Early Childhood Care and Development Centres (ECCD), and two (02) Zorigchusum institutes, which teach traditional arts and crafts[119].

Given Sarpang District's proximity to India, specifically the state of Assam, a number of cultural similarities have been observed among the population of Sarpang District when compared to its Indian counterpart. This can be seen in the presence of a high number of Hindu populations in Sarpang District, including within the social study area. This means that the Hindu festivals of Diwali and Dusshera are widely practiced, in addition to Tshechu and other Buddhist ceremonies, and there is a sizeable population in Sarpang District that is well versed in the Hindi language. This may be attributed to the open access that exists between the two countries, which results in a high degree of trade between the two countries.

Moreover, the areas closer to the Indian border, most notably the Gelephu Thromde, also have small to medium hotels for tourists that visit from India. It is estimated that Sarpang District had about 263 tourist arrivals in the year 2019. The number of tourists dropped in 2020[120], which can be attributed to the Covid-19 pandemic. However, these numbers do not reflect the day tourists. It was found through consultations in the social study area that a large number of

[119] Includes carpentry, masonry, carving, painting, sculpting, blacksmithing, ornament making, tailoring, and other.

[120] Ibidem.

workers from India[121] are present in Sarpang District, due to their lower wage rates as compared to their Bhutanese counterparts.

Demographic Profile of the social study area

The social study area comprises one (01) Thromde and six (06) Gewogs. As per the Population and Housing Census of Bhutan 2017 (PHCB 2017), the total population of the social study area is 25,869 ***(Table 8.3)***. The population in the social study area is reflective of the wider Sarpang District.

The social study area has a population of approximately 25,869 people, and a total of 5,881 households. The Gewogs and Thromde in the social study area are characterized by an average household size of four (04) persons per household. This makes up 56% of the population of the Sarpang District.

[121] Daily wage labor also includes day workers, who mostly reside in the border areas in India, and travel daily for work.

TABLE 8.3 SUMMARY OF THE SOCIAL STUDY AREA

Gewog / Thromde	**No. of Households (HHs)**	**Total Population**	**Population**		**Average Household Size**[122]	**Educational Institutions / Centres**[123]	**Health Infrastructure** [124]	**Community Forests**
			Male	Female				
Gelephu Thromde[125]	2847	9,858	5,146 (52%)	4,712 (48%)	3.8	12	4	0
Gelephu Gewog [126]	1027	4,461	2,171 (49%)	2,290 (51%)	4.1	12	1	1
Samtenling Gewog[127]	467	2,801	1,456 (52%)	1,345 (48%)	4.3	6	1	2
Umling Gewog[128]	377	1,586	754 (48%)	832 (52%)	3.7	4	2	7
Chhuzanggang Gewog[129]	625	2,499	1,262 (51%)	1,237 (49%)	4.2	6	1	2

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[122] Population and Housing Census of Bhutan 2017 Sarpang Dzongkhag (PHCB 2017).

[123] Includes schools, NFEC, ECCD, extended classrooms [ECR], community learning centres [CLC] and youth centres.

[124] Includes hospitals, PHCs, outreach clinics and sub posts.

[125] Information sourced from Gelephu Thromde website, available at Background History | དགེ་ལེགས་ཕུག་ཁྲོམ་སྡེ (gcc.bt), accessed on 26 November 2024.

[126] Information sourced from Gelephu Gewog website, available at Gelephu | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

[127] Information sourced from Samtenling Gewog website, available at Samtenling | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

[128] Information sourced from Umling Gewog website, available at Umling | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

[129] Information sourced from Chhuzaggang Gewog website, available at Chhuzaggang | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

Gewog / Thromde	No. of Households (HHs)	Total Population	Population		Average Household Size[122]	Educational Institutions / Centres[123]	Health Infrastructure [124]	Community Forests
			Male	Female				
Serzhong Gewog[130]	407	4,313	2,183 (51%)	2,130 (49%)	4.1	9	3	0
Tareythang Gewog[131]	131	351	225 (64%)	126 (36%)	3.4	3	1	3
Social study area	**5,881**	**25,869**	**13,197 (51%)**	**12,672 (49%)**	**3.9**	**52**	**13**	**15**

[130] Information sourced from Serzhong Gewog website, available at Serzhong | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

[131] Information sourced from Tareythang Gewog website, available at Tareythang | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 26 November 2024.

8.2.1 SOCIO-CULTURAL DYNAMICS

While the official national language of Bhutan is Dzongkha, and the official national religion is Buddhism, there is a degree of socio-cultural and linguistic diversity reflected in the population demographics of the country. The largest socio-cultural groups are the Ngalong, Sharchop, and Lhotsham.

FIGURE 8.2 SITE PHOTOS FROM SOCIAL STUDY AREA

Source: ERM, 2024

Buddhism is prominent in the social study area, however, consultation with stakeholders and in-field observations, suggest that there are numerous people who practice Hinduism. Estimates indicate that approximately 67% of the population in the social study area is Buddhist, while 33% is Hindu. The majority (about 60%) of those who are Hindu reside in Gelephu Thromde and Gelephu Gewog. The presence of Hindu religious influence is reflected in the cultural practices, such as the observance of Diwali and Dusshera, and infrastructure, including six (06) Hindu temples or Mandirs, present in the social study area (***Appendix K5*** provides further details on religious structures in the social study area). This is in line with the national trend, wherein Hinduism is the second most popular religion in the country.

The degree of socio-cultural and linguistic diversity present in the social study area has been linked to a range of factors. For example, the proximity to the Indian border, which means that people regularly transit between the two countries, often for economic opportunity. For better economic opportunities people from other Districts have resettled in the social study area.

Within the Bhutanese context everyone in Bhutan, irrespective of the socio-cultural identity and linguistic practices, has equal access to economic opportunities, health, employment, services, assets, and other resources.

8.2.2 SOCIO-CULTURAL AND LINGUISTIC DEMOGRAPHICS

An assessment of the socio-cultural groups as per World Bank ESS-7 criteria conducted by the World Bank team has identified local groups in the project area who present degrees of self-identification as distinct, have unique customary practices, or distinct language/dialects. While these groups do not satisfy all four criteria of ESS7, they possess varying distinct characteristics that place them at risk of experiencing differentiated adverse impacts from the project and more limited than others in their ability to access project benefits due to smaller representation in decision-making, different language and cultural practices.

Consultations with socio-cultural groups conducted during the assessment reveal five major distinct socio-cultural linguistic groups of people in the project area: Lhotsham, Sharchop, Khengpa, Brami and Brokpa/Saktenpa, and Ngalops. Further, the Brokpas, Bramis, Khengpas, and Rais each have distinct identities and cultural traditions, but are gradually losing or have already lost elements of their traditional identity due to generational shifts and geographical distance from their ancestral villages, deities, and practices. This erosion may be attributed to increased intermingling with people from other regions and the blending of diverse socio-cultural groups, intermarriage, and adoption of widely used languages such as Lhotsamkha, Sharchopkha and Dzongkha.

In addition to the above, there are a number of smaller other socio-cultural groups such as Ngalongs from the West, Mangdip, Trongsap and Bumthaps from the centre, and Kurtoeps. The presence of these socio-cultural groups was validated during Local Government meetings conducted for the assessment, as shown in ***Table 8.4*** .

The 42 KII's and 16 FGD's conducted for the assessment show that there are 3 prominent languages spoken in the project area and 12 other dialects. In descending number of mentions, they are Sharchopkha (39), Lhotshamkha (35), Khengkha (24), Rai (9), Brokpakha (6), Tamang (5), Kurtoepkha (5), Bumthapkha (5), Brami (4), Yangtsepa (1), Lepcha (1), Ghalley (1), Trongsap (1), Zoma (1) and Bhagwoan (1).This identification of socio-cultural at risk of losing their distinct languages, dialects, self-identification and cultural traditions is not exhaustive. During the project life-cycle, further assessments and meaningful consultations for identification of socio-cultural groups, assessing project impacts, inclusion in project benefits, and protecting their linguistic and cultural heritage will be conducted social management measures will be updated accordingly.

TABLE 8.4 SOCIO-CULTURAL GROUPS IN SOCIAL STUDY AREA

Gewog/Thromde	Socio-cultural groups in the Chiwog/Gewog/Demkhong/Thromde
Tareythang	60% Sharchop, 30% Lhotsham, 10% Khengpa, Saktengpas and Brokpas
Chuzanggang	Mostly Khengpa, 5 Tamang, 2 Gurung (Lhotshampa, 2 Sharshop, 2 Ngalong, and 3 Trongsap

Umling	5 chiwogs under gewog. Gaden (1 village) and Rijook (2 villages) are in the project area. Gaden chiwog 40% Sharchop, 30% Khengpa and remaining 30% are equal (Lhotsham, Ngalong, Brokpa) Rijook chiwog has majority Lhotshams (almost 100%), 3 Brami households and 2 from merak/sakteng.
Thromde	70% in Namkharling are Christian, other groups not described during LG meeting

8.2.3 VULNERABILITY WITHIN THE POPULATION

There are a range of vulnerable groups that are present in Sarpang District, including within the social study area. This includes women (See ***Section 8.7***), youth, elderly, those living with disabilities (***Table 8.5*** and ***Table 8.6***), those living below the poverty line, and socio-cultural groups as (see **Section 8.2.2**).

TABLE 8.5 PERSONS WITH DISABILITIES (INCLUDING YOUTH AND CHILDREN)

Gewog	Persons with Disability (M)	Persons with Disability (F)	Total
Tareythang	12	2	14
Umling	14	11	25
Chhuzanggang	22	17	39
Serzhong	36	18	54
Gelephu Thromde	25	16	41
Gelephu Gewog	7	6	13
Samtenling	15	6	21
Total	**131**	**76**	**207**

Source: Ability Bhutan Society survey 2019, Sarpang Dzongkhag

TABLE 8.6 CHILDREN AND YOUTH WITH DISABILITIES

Gewog	Children with Disability (M)	Children with Disability (F)	Total
Tareythang	3	1	4
Umling	2	2	4
Chhuzanggang	3	2	5
Serzhong	15	4	19
Gelephu Thromde	18	12	30
Gelephu Gewog	2	3	5
Samtenling	2	3	5
Total	**45**	**27**	**72**

Source: Ability Bhutan Society survey, 2019, Sarpang Dzongkhag

8.3 LAND COVER AND LAND USE

The social study area intersects with a range of land covers. These land covers include agriculture, forest, riparian rangelands, successional rangelands, and built-up urban areas of various densities and land use types. Crucially, land cover types may highlight existing land uses that are not represented by formal land title classifications, which is critical for identifying informal land users.

Table 8.7 outlines the land cover areas associated with the social study area. It is noted that detailed land use patterns of potentially project affected persons (PAPs) will be identified through a socio-economic survey as part of the Resettlement Action Plan (RAP).

TABLE 8.7 LAND COVER AREAS WITHIN PROJECT FOOTPRINT AND SOCIAL STUDY AREA

Land Cover	Project footprint		Social study t Area		Dzongkhag[132]		National[133]	
	km^2	%	km^2	%	km^2	%	km^2	%
Agriculture	0.0596	33.63	11.83	18.6	86.74	5.24	1137.92	2.96
Bare Ground	0.0053	2.99	3.48	5.5	-	-	-	-
Built-up[134]	0.0169	9.54	9.70	15.2	7.10	0.43	96.83	0.25
Forest	0.0551	31.09	31.91	50.2	1448.92	87.55	26414.32	69.00
Riparian Rangeland[135]	0.0078	4.40	2.66	4.2	-	-	-	-
Successional Rangeland[136]	0.0313	17.66	3.53	5.5	-	-	-	-
Water	0.0012	0.68	0.50	0.8	13.72	0.83	233.54	0.61

The key land cover categories within the Project alignment are agriculture and forest, followed by successional rangeland and built-up land areas. Within the social study area, the largest land cover type is forest followed by agriculture, built-up, successional and riparian rangeland ***(Figure 8.3)***. A hierarchical spatial analysis shows that agricultural land and built-up land is most concentrated in the project footprint, decreasing progressively at the social study area, Dzongkhag, and national levels. Conversely, the proportion of forest is highest at the Dzongkhag level and decreases progressively at more local scales.

[132] National Land Commission, 'Bhutan Land Use Land Cover', 2020 (Available at- NLCS-GOV.pdf)

[133] Ibid.

[134] Built-up land cover comprises residential , commercial and industrial land uses as well as urban infrastructure, such as roads.

[135] Riparian rangeland refers to land located along the banks of rivers, streams, lakes, or other water bodies, which have a unique soil profiles, vegetation and water bodies.

[136] Successional rangeland refers to land undergoing a process of ecological succession, which is the progression of plant and animal communities over time.

Built-up areas comprise approximately 9.54% of the social study area. The remaining 90.46% of land cover is relatively low-density rural areas, forested areas and water bodies.

FIGURE 8.3 LAND COVER AND LAND USE MAP WITHIN SOCIAL STUDY AREA

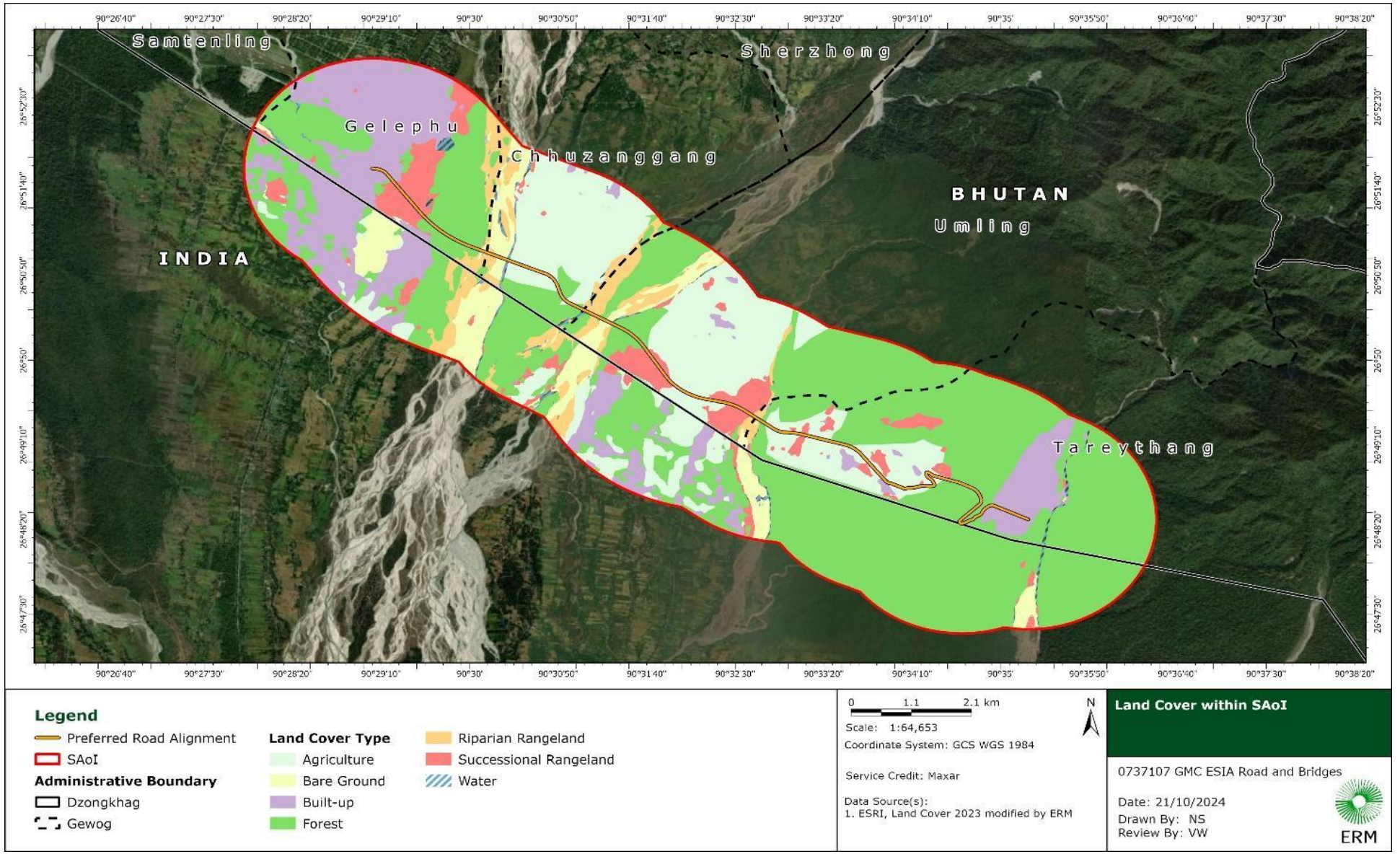


Table 8.8 highlights the land cover areas and associated land use impacts by Gewog both within the social study area and other total Gewogs.

TABLE 8.8 LAND COVER AREA BY GEWOG

Gewog / Thromde	Land Cover	Land Area within Project Social Area (km^2)	Total Land Area in Gewog / Thromde (km^2)
Gelephu Thromde	Agriculture	0.005	0.031
	Bare Ground	0.02	0.025
	Built-up	3.71	6.11
	Forest	2.55	2.95
	Riparian Rangeland	0.03	0.13
	Successional Rangeland	1.15	1.38
	Water	0.092	0.12
Gelephu Gewog	Agriculture	0.005	31.12
	Bare Ground	0.035	1.61
	Built-up	0.13	5.66
	Forest	0.69	2.7
	Riparian Rangeland	0.37	0.93
	Successional Rangeland	0.04	1.49
	Water	0.01	0.2
Samtenling Gewog	Agriculture	0	41.06
	Bare Ground	0.0036	0.87
	Built-up	0.02	2.87
	Forest	0.09	5.48
	Riparian Rangeland	0	0
	Successional Rangeland	0.001	3.91
	Water	0.005	0.48
Umling Gewog	Agriculture	4.39	36.58
	Bare Ground	0.50	1.11
	Built-up	0.07	0.12
	Forest	3.85	80.92
	Riparian Rangeland	1.27	2.27
	Successional Rangeland	0.61	1.10
	Water	0.03	0.32
Chhuzanggang Gewog	Agriculture	0.89	5.20
	Bare Ground	0.57	1.83
	Built-up	0.06	0.53
	Forest	3.65	9.56
	Riparian Rangeland	0.57	3.85
	Successional Rangeland	0.04	0.23

Gewog / Thromde	Land Cover	Land Area within Project Social Area (km²)	Total Land Area in Gewog / Thromde (km²)
	Water	0.14	0.21
Serzhong Gewog	Agriculture	0	18.79
	Bare Ground	0	0.70
	Built-up	0	0.79
	Forest	0	55.83
	Riparian Rangeland	0	0.97
	Successional Rangeland	0	1.11
	Water	0	0.15
Tareythang Gewog	Agriculture	2.06	2.06
	Bare Ground	0.02	0.36
	Built-up	1.62	1.62
	Forest	7.96	102.22
	Riparian Rangeland	0.002	0.07
	Successional Rangeland	0.58	2.41
	Water	0.06	0.30

Table 8.9 provides an overview of the key land uses by Gewog relevant to land acquisition impacts and provides a characterization of the different land use patterns across the social study area. Key findings for each land use across the social study area are identified below:

- 95.01% of built-up land is within Gelephu Thromde (66.13%) and Tareythang Gewog (28.88%).
- 82.28% of forest is within Umling (20.49%), Chhuzanggang (19.43%) and Tareythang (42.36%) Gewogs.
- 99.80% of agricultural land is concentrated in Umling (39.95%), Chhuzanggang (38.84%) and Tareythang (21.01%) Gewogs.

TABLE 8.9 KEY LAND USES RELEVANT TO LAND ACQUISITION

Gewog / Thromde	Built up		Agriculture		Forest	
	Km²	%	Km²	%	Km²	%
Gelephu Thromde	3.71	66.13	0.010	0.10	2.55	13.57
Gelephu Gewog	0.13	2.32	0.010	0.10	0.69	3.67
Samtenling Gewog	0.02	0.36	0.000	0.00	0.09	0.48
Umling Gewog	0.07	1.25	3.914	39.95	3.85	20.49
Chhuzanggang Gewog	0.06	1.07	3.805	38.84	3.65	19.43
Serzhong Gewog	0	0.00	0.000	0.00	0	0.00
Tareythang Gewog	1.62	28.88	2.058	21.01	7.96	42.36
Total	**5.61**	**100**	**9.80**	**100**	**18.79**	**100**

The highest density of urban areas within the social study area is in Gelephu Thromde, where there are a higher number of commercial establishments such as shops and small businesses. The Project also intersects with two small urban areas in Umling and Tareythang, which contain fewer businesses and a greater portion of pop-up stalls than Gelephu Thromde.

FIGURE 8.4 SHOPS IN GELEPHU THROMDE

Source: ERM, 2024

Within the ROW, there are approximately 190 land plots that are subject to land acquisition and approximately 18 structures, of which 11 structures in Gelephu Gewog are estimated to be households[137] (refer to Figure ***8.5*** and ***Figure 8.6***). In addition, a total of 17 land plots for work area and worker camp 1, and 19 land plots for work area and worker camp 2 are subject to land acquisition. Therefore, a total of approximately 226 land plots are subject to acquisition of land. Consultations and field observations revealed that agricultural land plots along the alignment contained multiple structures, including residential and non-residential structures (i.e. sheds,

[137] Estimates were based on a desktop review of GIS and field observations.

observation towers, barns and fencing). Accordingly, it is estimated that the remaining seven (07) structures in the ROW are non-residential structures that will require compensation.

FIGURE 8.5 RECEPTORS IN GELEPHU THROMDE

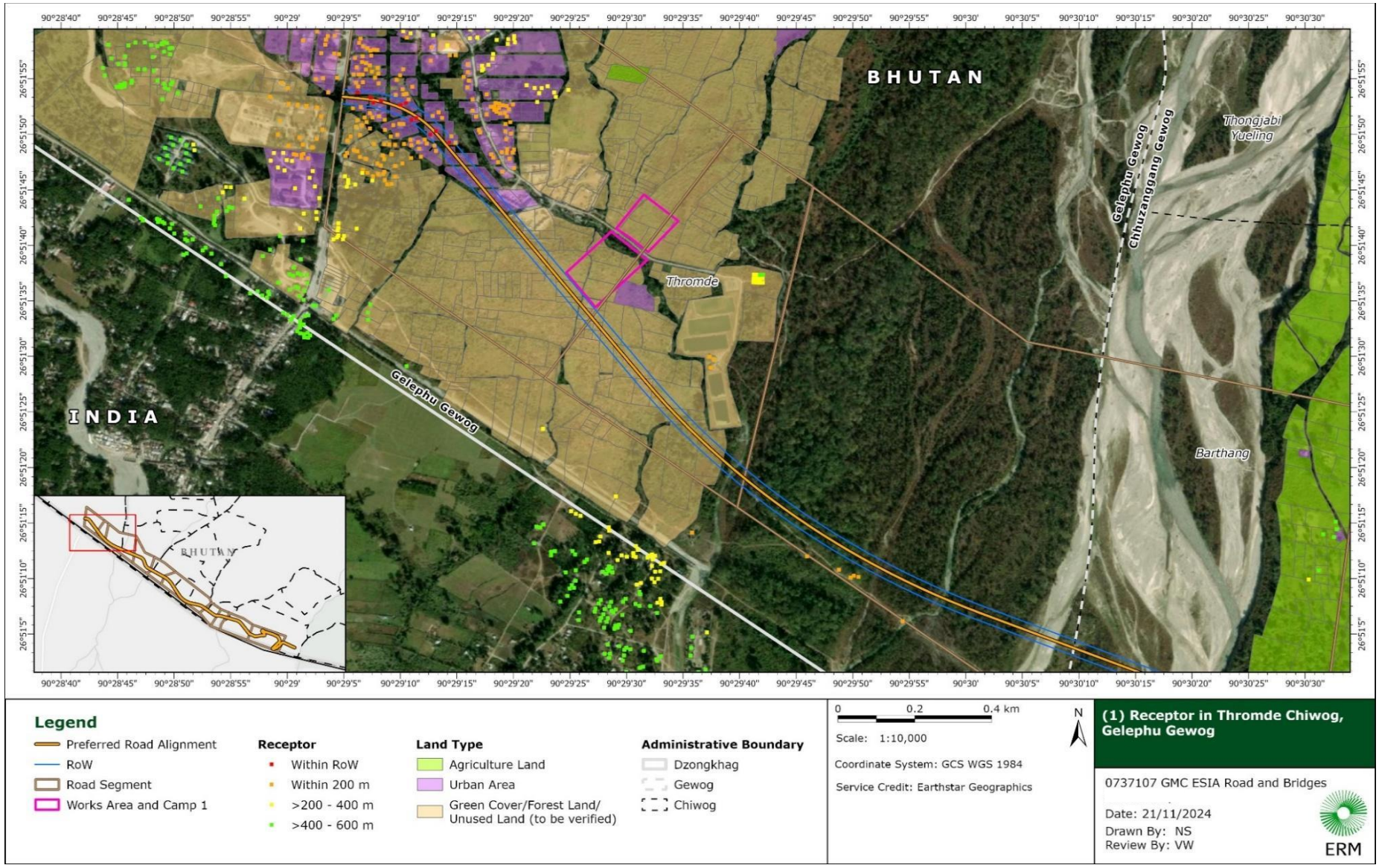
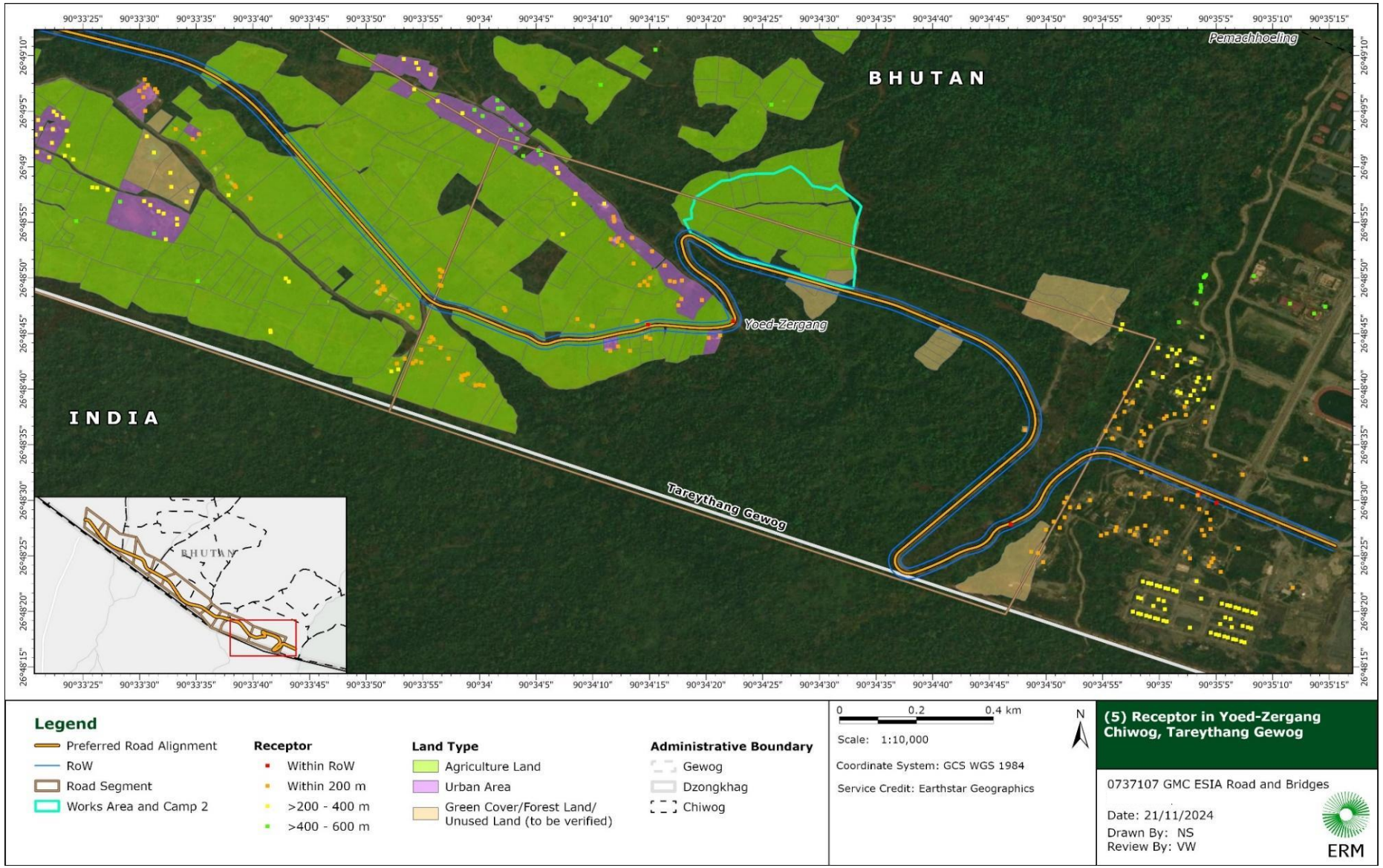


FIGURE 8.6 RECEPTORS IN TAREYTHANG GEWOG



Agricultural land use practices in the social study area reflect typical subsistence mountain farming[138], where smallholder farmers use integrated family farming practices that closely link agriculture, livestock, and forest resources—such as timber, leaf litter, fodder, and wild-harvested foods—from state and community forests. This farming system predominantly depends on organic manures and has little dependence on the use of chemical fertilizers and pesticides.

Table 8.10 provides the estimated landholding area by household for each Gewog. The size of household landholdings is an indicator of the potential severity of displacement impacts of land acquisition, with smaller holdings often facing more acute livelihood and displacement. The weighted average across the social study area is similar to the average landholding for Bhutan (340 decimals).

TABLE 8.10 AVERAGE HOUSEHOLD LANDHOLDING BY GEWOG/THROMDE

Thromde / Gewog	**Average landholding per household[139]**	
	Acres	Decimals
Gelephu Gewog	1.69	169
Samtenling Gewog	5.80	580
Umling Gewog	4.10	410
Chhuzanggang Gewog	3.75	375
Serzhong Gewog	3.86	386
Tareythang Gewog	3.65	365
Weighted average[140] of social study area	3.4	340
Bhutan	**3.4**	**340**

Source: Sarpang Dzongkhag: Gewog statistics

[138] Tirtha Bdr Katwal and Didier Bazile, 'First adaptation of quinoa in the Bhutanese mountain agriculture systems', 2020 (available at- Journal-Plos.org)

[139] Sarpang Dzongkhag: Gewog statistics - http://www.sarpang.gov.bt/gewogs/

[140] The weighted average landholding size per household is calculated by multiplying each Gewog's average landholding size by the number of households in that Gewog, summing these products, and then dividing by the total number of households across all Gewogs.

8.3.1 COMMUNITY FORESTS

Bhutan's revised Forest and Nature Conservation Rules, 2006 have broadened the scope of community participation in forest management [141]. The Rules not only encourage rural communities to manage forests for their basic needs, but also allows them to carry out their own income generating activities in the community forests.[142]

The social study area has a total of 15 community forests (see ***Table 8.11***). Except for Gelephu Thromde, which is classified as a municipality and Serzhong Gewog, each of the Gewogs has community forests in and around their boundaries.

It is found that Umling Gewog has the highest number of community forests which stands at seven (07). Tareythang Gewog has three (03) community forests, followed by Chhuzanggang and Samtenling Gewogs each having two (02) community forests within and around boundaries.

[141] Sonam Phuntsho, Kaspar Schmidt, Riamsara Kuyakanon, Karma Jigme Temphel, 'Community Forestry in Bhutan – Putting People at the Heart of Poverty Reduction', 2011 (available at - UWICER-CFIB.pdf).
[142] Ibidem.

TABLE 8.11 COMMUNITY FORESTS IN THE SOCIAL STUDY AREA

Gewog	Name of Community Forest (CF)	Area (Hectares)	Production and Protection Area (Hectares)	Number of Users (Households)	List of Products and Services
Umling Gewog	Dangling CF: Block I – Yarphu Block II – Pematsholing	170.40 Ha: 65.4 Ha 105 Ha	Production area – 162.28 Ha Protection area – 8.12 Ha	• 34 HHs • Total persons – 195 • 58% Male and 42% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber
	Tashithang CF: Block I – Tashichuzom Block II – Lukchu Norbugang	75.30 Ha: 19.9 Ha 55.4 Ha	Production area – 69.23 Ha Protection area – 6.07 Ha	• 9 HHs • Total persons – 47 • 89% Male and 11% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber
	Gaden CF: Block I – Phunsumthang Block II – Taklaithang Block III – Drupchugyapa	102.31 Ha: 68.8 Ha 29.4 Ha 4.11 Ha	Production area – 98.2 Ha Protection area – 4.11 Ha	• 32 HHs • Total persons – 608 • 49.68% Male and 50.32% Female	• Pipla • Bamboo • Mushroom • Timber
	Linger CF: Block I – Khairthang Block II – Lingergaypa	93.36 Ha: 80.53 Ha 12.8 Ha	Production area – 71.55 Ha Protection area – 21.8 Ha	• 30 HHs • Total persons – 247 • 54.48% Male and 53.84% Female	• Fern • Bamboo • Mushroom • Timber
	Rejuk CF: Block I – Tshomae Block II – Silchu	75.96 Ha: 29.48 Ha 45.39 Ha	Production area – 44.96 Ha Protection area – 30.57 Ha	• 15 HHs • Total persons – 84 • 87% Male and 13% Female	• Mushroom • Bamboo • Soft Broom • Timber

Gewog	Name of Community Forest (CF)	Area (Hectares)	Production and Protection Area (Hectares)	Number of Users (Households)	List of Products and Services
	Samdrupcholing CF: Block I – Krachu Mae Block II – Silchu Block III – Karchu Tae	85.49 Ha: 21.35 Ha 25.427 Ha 38.714 Ha	Production area – 64.141 Ha Protection area –21.35 Ha	• 20 HHs • 55% Male and 45% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber
	Dungmin CF: Block I – Karchu Tae Block II – Karchu Mae	170.11 Ha: 99.02 Ha 71.09 Ha	Production area – 124.78 Ha Protection area – 45.33 Ha	• 44 HHs • Total persons – 255 • 58% Male and 42% Female	• Mushroom • Bamboo • Soft Broom • Pipla • Timber
Tareythang Gewog	Geyser Trashicholing CF: Block I – Trashitoe Block II – Zhingchuka	81.89 Ha: 33.85 Ha 48.02 Ha	Production area – 76.01 Ha Protection area – 5.88 Ha	• 19 HHs[143] • 47% Male and 53% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber
	Juenphen CF: Block I – Thingzorling Block II – Ugyentse	96.72 Ha: 44.92 Ha 51.80 Ha	Production area – 91.177 Ha Protection area – 5.53 Ha	• 20 HHs • Total persons – 44 • 58% Male and 42% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber
	Thrungthu CF: Block I – Chuzhingtae Block II – Thungchutae	86.8 Ha: 32.17 Ha 54.63 Ha	Production area – 84.34 Ha Protection area – 2.46 Ha	• 26 HHs • Total persons – 48 • 58% Male and 42% Female	• Pipla • Bamboo • Soft Broom • Mushroom • Timber

[143] Data on total persons not available.

Gewog	Name of Community Forest (CF)	Area (Hectares)	Production and Protection Area (Hectares)	Number of Users (Households)	List of Products and Services
Chhuzanggang Gewog	Thongjabi - Yueling CF	72.40 Ha	Production area – 10 Ha Protection area – 62.40 Ha	32 HHs[144]	• Cham trees • Firewood (inferior trees) • Sand, gravels and boulders
	Chhuzanggang CF: Block I – Chaskhar Block II – Dawathang Block III – Nimaling Block IV – Thongjabi	163.13 Ha: 114.80 Ha 37.85 Ha 4.41 Ha 6.07 Ha	Production area – 540.93 Ha Protection area – 122.74 Ha	33 HHs[145]	• Bamboo • N-trees • Water/wetlands • Gravel, sand, stones and boulders • Water sources
Samtenling Gewog	Dungkarling CF: Block I – Dungkarling Block II – Paithachu Block III – Baluchu	359.484 Ha 105.36 Ha 70.924 Ha 183.2 Ha	Production area – 131 Ha	88 HHs[146]	• Drashing • NWFP – Firewood, fencing posts, bamboo, fodder, leaf litters, agricultural tools, mushroom, fern and broom
	Pema Yoezer CF: Block I – Dewaling Block II – Tsholing Block III – Tashiling Block IV – Bartsaling	151 Ha: 16 Ha 18 Ha 68 Ha 49 Ha	Production area – 131 Ha Protection area – 20 ha	• 58 HHs • Total persons – 1187 persons • 55.7% males and 44.3% females	• Drashing • Cham • Tsim • Danchung • Firewood • Bamboo • Fencing posts

[144] Data on Male/Female community forest users not available.

[145] Ibidem.

[146] Ibidem.

Gewog	Name of Community Forest (CF)	Area (Hectares)	Production and Protection Area (Hectares)	Number of Users (Households)	List of Products and Services
Gelephu Gewog	Raidangra CF: Block I – Amaladangra Block II – Passangchhu	91.35 ha: 58.90 Ha 32.65 Ha	Production area – 82.35 Ha Protection area – 9 Ha	34 HHs[147]	• Drashing tree (potentially for plywood manufacturing) • Firewood • Non-Wood Forest Products (NWFP)
Total:					
5 Gewogs	**15 CFs**	**1875.704Ha**		**494 HHs**	-

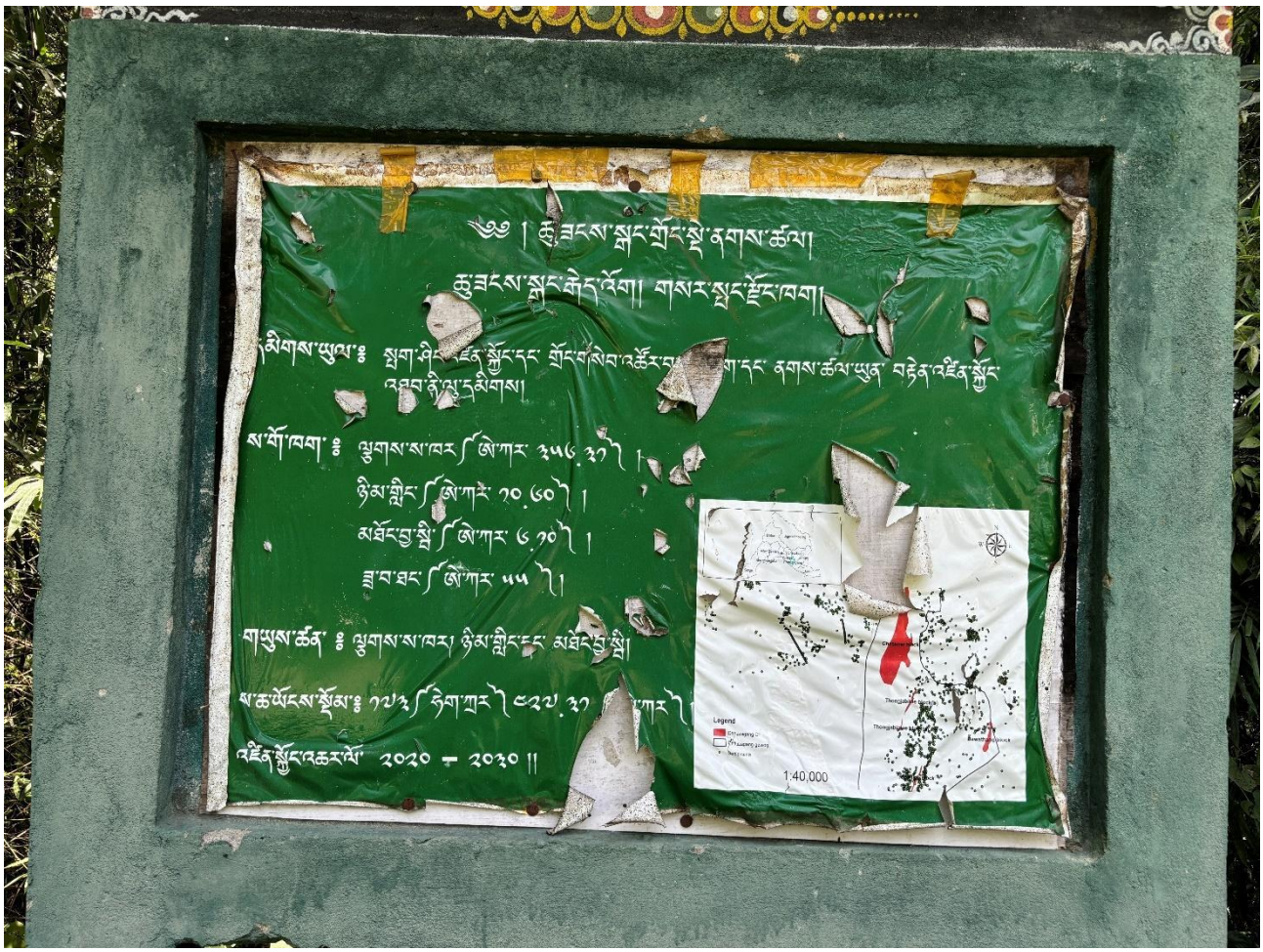
Source: Community Forest Plans, DoST, 2024.

[147] Ibidem.

The total area of the community forests in the social study area is estimated to be 1875.704 Ha. A total of 494 households have been identified as community forest users in the social study area. While data on the total number of persons using these community forests is not uniformly available, it can be estimated based on the existing numbers that an average of 55% forest users are men, whereas an average of 45% forest users are women.

Figure 8.7 and ***Figure 8.8*** are photos taken from community forests.

FIGURE 8.7 DEMARCATION OF A COMMUNITY FOREST IN CHHUZANGGANG GEWOG



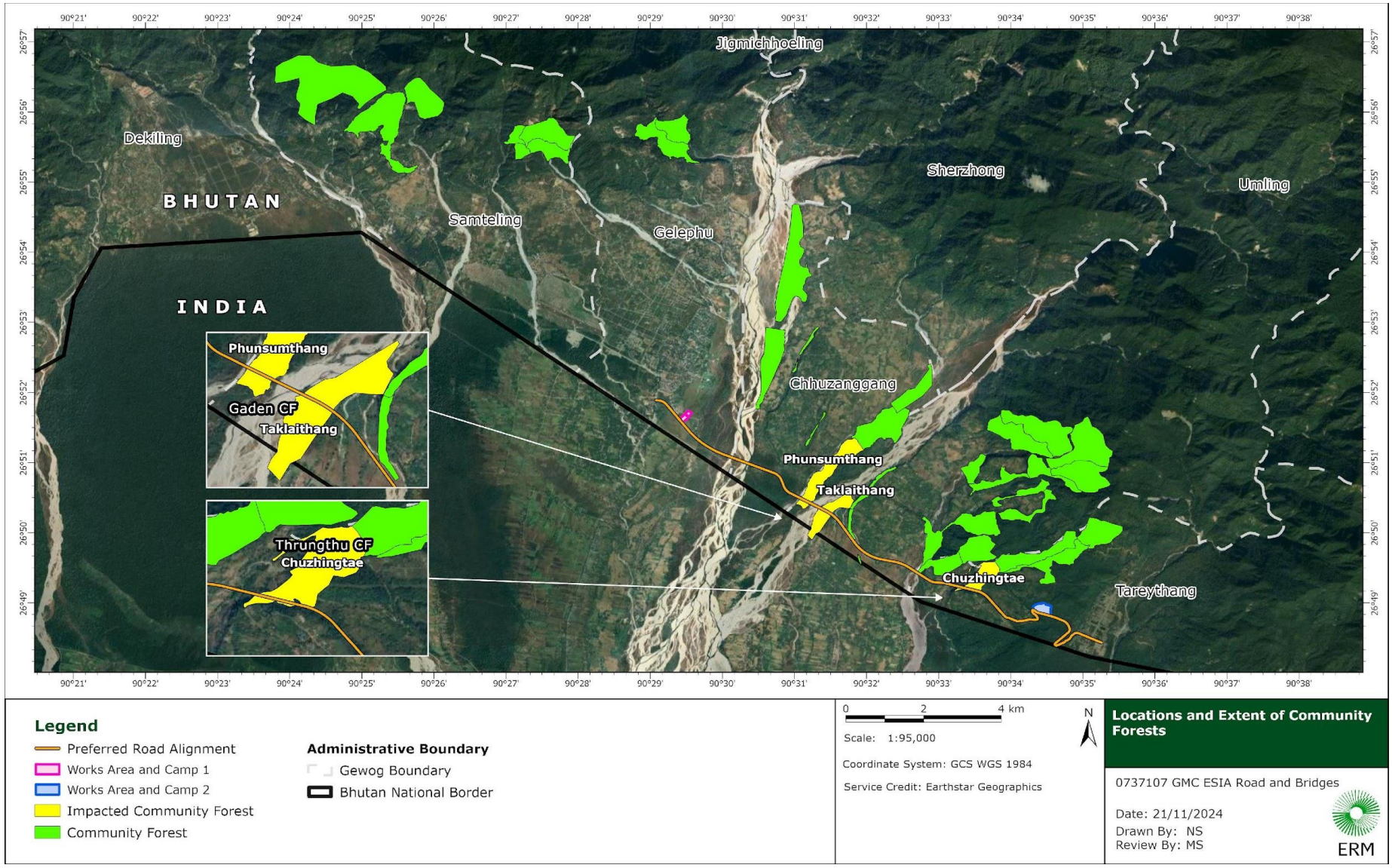
Source: ERM, 2024

FIGURE 8.8 VIEW (FROM CHHUZANGGANG GEWOG) OF THE COMMUNITY FOREST ALONG TAKLAI RIVER

Source: ERM, 2024

Gelephu Gewog has one (01) community forest in and around its administrative area. ***Figure 8.9*** provides a visual of the locations of the community forests in the social study area.

FIGURE 8.9 COMMUNITY FORESTS IN THE SOCIAL STUDY AREA



8.3.1.1 MANAGEMENT OF COMMUNITY FORESTS

Primary data collected from the social study area reveals that each of the community forests has a certain number of user households, who hold the exclusive right to use the forest resources. Management plans are usually put in place for sustainable production and utilization of timber and other products of the forests. The management plans are approved by the Social Forestry and Extension Division, Department of Forest and Park Services.

Moreover, community forest plans also provide an opportunity to improve the condition of the forests, promote good governance that is participatory in nature, and provide easy access to members for various services such as micro-credit and support in case of disasters. Further, forest management plans aim to help reduce land degradation and embed scientific understanding into the management of forests.

Each community forest has a chairperson or a secretary who is also a community member and forest user. It was reported that a chairperson or secretary of the community forest is eligible for a monthly stipend for the role they play as the head of the group. The chairperson or secretary is responsible for coordination with the Gewogs, local administration, forest department and all other administrative and planning oversight.

There is a level of dependence on the community forests by households [148], since communities rely on these for to cultivation of crops such as maize, millet, paddy, areca nuts, ginger, rice and other[149]. Further, consultations revealed that forest users also used timber from these forests for building / upgrading their houses and structures. Moreover, many of the user households also own cattle for dairy products which are sold locally and are used for self-consumption.

With regards to the list of forest products and services, it was found that the users rely on the community forests for firewood, Non-Wood Forest Products (NWFP), plywood, timber, bamboo, fodder, mushrooms, brooms, and similar. Interestingly, it was observed that some of the community forests are located along rivers and even on small landmasses within rivers, which are used for extraction of gravel, sand, stones and boulders. To summarize , it was observed that the dependence on community forest products by households varied under each Gewog. Largely, in the social study area, forest users were dependent on these for both personal consumption as well as completing their household incomes. For instance, in Chhuzanggang Gewog, communities used sand and boulders locally, within the forest user group. The members of this Gewog also used bamboos for their own use, such as in agricultural lands for marking boundaries, cattle shed construction among others .

Incomes of community forest user groups were also found to be supplemented by livestock and cattle rearing. In Umling Gewog, Dangling community forest, about 88% of the forest users were reported to own cattle. Similarly, in Dungmin community forest 68% forest users reported to own cattle, 90% in Gaden community forest, 85% in Linger community forest, 53% in Rejuk community forest, 45% in Samdrupcholing community forest and 100% in Tashithang community forest. In Chhuzanggang community forest, around 40% of the forest user households were found to be involved in cattle rearing. It is also found community forests also

[148] Information sourced through review of community forest plans, in-field observations, consultations and KIIs.

[149] Information sourced from the Community Forest Plan of the given Gewogs.

have restrictions on cattle grazing within the forest areas and attract penalties for such offences on households that are not members of the community forests.

8.3.1.2 SACRED SITES IN COMMUNITY FORESTS

Consultations revealed that some community forests hold sacred sites which were of cultural relevance to the local population. It was reported that such sites were typically either open spaces close to water bodies or natural springs, and in other forests were also trees. Community members, especially community forest users maintain and access these sites.

For instance, community members in Samtenling Gewog, the Dungkarling community forest had a 'Devithan' or sacred site, which was an open space in the forest. It was reported that the community prays at this site for good rainfall, increased availability of spring water and a good harvest.

A scared tree was found in the Chhuzanggang community forest, access to which was restricted. The sacred tree was fenced off by a railing of stones and could be accessed only by the local community forest users (see ***Figure 8.10***).

FIGURE 8.10 SACRED SITE AT CHHUZANGGANG COMMUNITY FOREST

Source: ERM, 2024

Note: The pictures were clicked keeping in view the local sensitivities and with prior intimation to the local community. The team maintained a considerable distance from the stone railing and did not cross the same.

8.4 OCCUPATION AND LIVELIHOOD PROFILE

In Bhutan, the labor force participation rate among females is 64.5% and among males is 73.9% for 2023[150]. Since 1990, female labor force participation has increased. Compared with labor force participation in the lower middle-income group, the gap between men and women is lower in Bhutan. The Labour Force Population in Sarpang District is 19,025, with a rate of

[150] World Bank Group (2024) Bhutan Gender Data Portal. Available at: https://genderdata.worldbank.org/en/economies/bhutan

63.4%. Of the total Labour Force Participation Rate, 68.3% are male, whereas 57.9% are female.[151]

8.4.1 INCOME SOURCES

Data from the Integrated Agriculture and Livestock Census (IALC) 2023 shows that the highest sown area is for paddy, which stands at 1850.39 acres, with a production of 2,491 MT. This is followed by cultivation of maize, on a sown area of 901.77 acres and production of 1,624.95 MT. Millet was reported to be cultivated on an area of 154.43 acres, with a production of 55.31 MT. Further, around 15.35 MT of, and 15.35 MT of mustard were produced, in addition to 10.26 MT of Mung Beans. It was reported in the social study area that both men and women work on their own agricultural lands for income generation activities and self-use. For additional incomes, men and women also work on other agricultural lands for additional sources of income. In particular, women are reported to be mostly engaged in cultivation of paddy, ginger and millet. Further, it was found that women also take up daily wage works in weeding and harvesting and other labor work. In the urban areas in Gelephu Thromde, community members reported that some women work at restaurants and as saleswomen in stores in the municipality. Livestock rearing such as feeding pigs and chicken is another income earning activity undertaken by women in the social study area. Some women are found to be engaged in weaving works and earning incomes from household level businesses.

In addition to agriculture, labor and livestock rearing, women are engaged in domestic chores.

The following tables provide an overview of the crop production in the district and the social study area.

TABLE 8.12 FOOD CROPS IN SARPANG DISTRICT

Food Crops	Number of Growers	Sown Area (acre)	Harvest Area (acre)	Production (MT)
Irrigated paddy	1216	1,850.39	1,768.05	2,491.76
Maize	2,120	901.77	612.81	1,624.95
Wheat	21	4.23	3.76	1.71
Buckwheat	199	38.15	30.53	10.36
Barley	2	0.70	0.55	0.25
Millet	525	154.43	128.96	55.31
Quinoa	12	1.16	1.11	0.58
Mustard	287	77.23	59.94	15.82
Rajma Beans	577	49.43	46.39	15.35
Mung beans	412	74.08	53.59	10.26

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

TABLE 8.13 VEGETABLE CROPS IN SARPANG DISTRICT

Vegetable crops	Number of Growers	Sown Area (acre)	Harvest Area (acre)	Production (MT)
Cabbage	2,651	52.21	50.97	80.94

[151] Labour Force Survey Quarterly Report, 2024, Second Quarter.

Vegetable crops	Number of Growers	Sown Area (acre)	Harvest Area (acre)	Production (MT)
Cauliflower	1,991	37.76	36.43	46.51
Beans	3,062	78.10	75.81	85.01
Broccolis	2,048	29.66	28.77	31.16
Chillis	2,816	74.17	72.04	79.31
Onion	714	10.87	10.82	10.57
Tomatoes	1,744	21.14	20.84	32.20
Asparagus	6	0.08	0.08	0.17
Carrot	283	2.80	2.71	3.03
Green leafy vegs	3,424	-	-	99.00
Pumpkin, squash, gourd	3,796	-	-	184.63
Cucumbers	1,143	12.60	12.49	29.52
Garlic	558	6.07	6.03	5.08
Mushroom				4.14

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

TABLE 8.14 FRUIT AND NUT CROPS IN SARPANG DISTRICT

Fruit Crops	Number of Growers	Sown Area/Total trees	Harvest Area/ Bearing Trees	Production (MT)
Cardamom (area in acres)	1,068	950.04	864.50	146.95
Ginger (area in acres)	1,359	77.26	69.32	94.30
Potatoes (area in acres)	2,121	125.17	116.33	168.84
Cassava (area in acres)	363	13.45	10.18	15.16
Areca nut (nos of trees)	3,323	2,846,063	950,686	4,581.56
Mandarin orange (nos trees)	1,378	87,197	56,369	1,828.23
Peach (nos trees)	657	1,059	707	10.46
Pear (nos trees)	479	988	562	19.67
Lemon and lime (nos trees)	1,221	6,426	2,119	17.04
Mango (nos trees)	2,334	10,062	3,688	50.46
Guava (nos trees)	2,037	6,119	4,588	44.91
Avocado (nos trees)	1,517	5,870	541	4.84
Litchi (nos trees)	2,258	13,315	10,131	158.47

Fruit Crops	Number of Growers	Sown Area/Total trees	Harvest Area/ Bearing Trees	Production (MT)
Jack Fruit (nos trees)	623	1,143	675	48.60
Banana (nos trees)	3,377	118,320	32,295	12.06
Papaya (nos trees)	747	2,260	1,674	21.11

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

As shown in ***Table 8.15*** below, rice is the primary food crop grown in the social study area, which was most concentrated in Chhuzanggang Gewog followed by Samtenling, Serzhong and Gelephu Gewogs.

TABLE 8.15 MAJOR FOOD CROP PRODUCTION IN SOCIAL STUDY AREA

Crops	Chhuzanggang	Samtenling	Tareythang	Serzhong	Umling	Gelephu
Rice (MT)	648.71	187.81	12.49	137.67	66.2	107.73
Maize (MT)	3.94	72.63	21.11	7.61	19.27	3.94
Millets (MT)	1.8	2.31	0.6	2.77	29.89	0.05
Buckwheat (MT)	-	0.33	0.008	0.02	-	-
Grain legumes (MT)	0.92	0.11	0.13	2.77	0.35	0.13
Mustard (MT)	0.05	0.18		0.051	-	0.57
Vegetables (MT)	41.62	51.41	10.98	37.63	13.91	32.51

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

Table 8.16 highlights that Areca Nut is the primary cash crop across the social study area, notably in Chhuzanggang and Umling followed by Serzhong and Tareythang.

TABLE 8.16 PRODUCTION OF CASH CROPS IN SOCIAL STUDY AREA

Crops	Chhuzanggang	Samtenling	Tareythang	Serzhong	Umling	Gelephu
Areca nut (MT)	1215.22	182.27	300.3	303.74	1,171.07	127.84
Oranges/mandarin (MT)	0.084	11.57	1.02	287.04	5.57	0.24
Other Fruits (MT)	69.46	58.32	46.12	106.78	59.13	27.84
Cardamom (MT)	0.06	1.06	0.03	0.02	0.03	0.02
Ginger (MT)	6.06	4.72	7.95	6.17	31.08	1.88

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

Data highlights that the District of Sarpang has about 344 functional irrigation channels. Communities rely on rainwater as well as rivers and streams for the use of water for cultivation. Around 9822.3 acres of area in Sarpang is covered by irrigation facilities and about 3551 households benefited from irrigation in 2021. It was reported that in 2021, Sarpang District had a total of 148 agriculture mills, including traditional mills.

See ***Table 8.17*** for data on farmer's groups, associations and cooperatives registered in 2021 in Sarpang.

TABLE 8.17 FARMER GROUPS IN SARPANG DISTRICT

S. No.	Farmers' Group/Associations/Cooperatives	Number	Year Registered
1.	Chhuzanggang Sonam Nyamley Tshogdey	Coop/02	FY 2012-2013
2.	Phuentshum Nya Sochong Gongphel Nyamley Tshogdey	Coop/11	FY 2012-2013
3.	Sarpang Poultry Cooperative	Coop/18	FY 2013-2014
4.	Sarpang Broiler Cooperative	Coop/19	FY 2013-2014
5.	Gelephu Om Detshen	FG/06	FY 2013-2015
6.	Lothuen Om Detshen	FG/07	FY 2013-2016

Source: Dzongkhag Agriculture Section

Table 8.8 shows that milk and egg production are the two primary forms of livestock production in the social study area. Both egg and milk production are highest in Samtenling with the second highest rate of milk production being Gelephu.

TABLE 8.18 LIVESTOCK IN SOCIAL STUDY AREA

Type of Livestock Production	Chhuzanggang	Samtenling	Tareythang	Serzhong	Umling	Gelephu
Milk (liters)	211,928	333,598	60,930	218,042	200,960	249,920
Chicken meat (local + broiler) kgs	2,384	18,378	431	24,198	2,542	9,065
Eggs (numbers)	289,220	3,038,516	400,913	13,112	1,055,038	123,943
Pork (Kgs)	8650	32,432	800	7,046	12,170	9,790
Chevon (Kgs)	949	1,376	171	706	194	1,010
Fish (Kgs)	250	265	-	260	848	-

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023

With respect to livestock centers , Sarpang District had around 174 poultry firms, 80 fishery firms and 161 piggery farms in 2021.

See ***Table 8.19*** for the livestock population in Sarpang District.

TABLE 8.19 LIVESTOCK POPULATION IN SARPANG DISTRICT

	Bovine population					Other livestock population				
	Cattle	Mithun	Yak	Zo-Zom	Buffalo	Equine	Pig	Poultry	Sheep	Goat
Sarpang	14,363	4	-	-	19	118	3,760	164,740	697	7,412
Bhutan	222,597	263	29,699	7,584	422	10,117	29,625	819,335	9,411	60,798

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

TABLE 8.20 LIVESTOCK IN THE SOCIAL STUDY AREA

	Chhuzanggang		Samtenling		Tareythang		Serzhong		Umling		Gelephu	
Type	Local Breed (nos)	Improved Breed (nos)	Local Breed (nos)	Improved Breed (nos)	Local Breed (nos)	Improved Breed (nos)	Local Breed (nos)	Improved Breed (nos)	Local Breed (nos)	Improved Breed (nos)	Local Breed (nos)	Improved Breed (nos)
Cattle	275	853	258	824	62	134	149	692	285	502	324	452
Poultry	771	1265	1,665	21,450	225	869	395	50	327	3,811	584	1,615
Pigs	4	102	93	456	-	14	25	86	-	177	45	172
Sheep	14	-	84	-	-	-	-	-	52	-	5	-
Goats	391	21	258	824	77	-	189	-	88	-	382	-
Fish	-	-	1,665	21,450	-	-	-	-	-	-	-	-

Source: Integrated Agriculture and Livestock Census Data (IALC) 2023: NSB

It is found that those in the social study area who live in or near Gelephu Thromde, primarily derive their income from small businesses, service jobs and some levels of agriculture. In the Thromde, cattle breeding of Jersey cows and Hollister chicken, small retail shops and commercial shops such as bars and restaurants have been reported. Some of the households are also engaged in government services, while a few have cattle, which sell milk locally to hoteliers and Om Deche Cooperative. It was reported that while agriculture was predominant earlier, over the last few years, this has gone down considerably. Most households undertake minimal cultivation of maize and vegetables. Areca nut farming is undertaken to a certain extent, which is largely transported to India. Rice farming has gone down considerably over the years. It has found that about 70% of the produce is sold locally in the Thromde market. Farming and small businesses contribute to household incomes of families that are poor.

It was found that often community members are engaged in more than one source of income. It was also noted, during the primary data collection process, that employment opportunities for women remain notably limited, with many relying on informal daily wage labor or small-scale agricultural activities as primary sources of income. Despite the availability of skill training programs, such as those for tailoring and weaving, broader economic participation is hindered by societal norms and restricted job access. Women are often responsible for household chores, agricultural work, and informal roles, although some engage in community-based skill training. Financial decision-making roles vary by region; in some areas, women participate equally, while in others, men continue to dominate property ownership and major household decisions. Socio-economically, households rely heavily on agriculture and manual labor, with men typically involved in construction and fieldwork, while women handle household tasks, agricultural work, and, in some instances, small business ventures.

8.4.1.1 INCOME SOURCES IN THE SOCIAL STUDY AREA

As given in the section above, moving from Gelephu Thromde to the Gewogs in the social study area, the primary sources of income shift, with the focus increasingly being on cultivation and livestock rearing.

In Samtenling Gewog, agriculture and livestock farming have been reported as the primary sources of income. Agriculture includes crops such as ginger, areca nuts, oranges, cardamom, fruit plants, lychee and mangoes. Most vegetables are cultivated during the winters. About six (06) households reportedly practice aquaculture.

A similar trend is observed in Gelephu Gewog, wherein the primary sources of income are livestock and agriculture. The former includes dairy products, poultry and piggery; these are seven (07) poultry farms (egg layers), four (04) broilers and 10 piggeries, of which two (02) are commercial and 10 semi-commercial. Around 190 households in Gewog own cows for dairy products. The Gewog send dairy to the Om Deche Cooperative, and a small ice cream unit called AAPAO. It was reported that breeding of cows is undertaken in the Gewog through artificial insemination. Agriculture in the Gewog includes vegetables and paddy fields. However, it was found that paddy fields are used by communities mostly for self-consumption. Communities are also engaged in cultivation of areca nuts which are exported to India.

In Chhuzanggang, it was reported that the average land holding is around 3.75 acre per household, and the main crops that are cultivated include millet, maize, cash crops such as areca nut, ginger, mango, lychee, bananas and coconuts. Similarly, in Umling, primary incomes sources are through cultivation of areca nuts, ginger and rice. Rice is grown seasonally here, cultivation in the month of June and harvest in the month of December. Ginger and areca nuts are cultivated in Tareythang as well. Maize wine is another crop grown here along with rice. However, these are mostly cultivated for self-consumption.

As given in ***Section 8.3.1.1***, majority of the households (including community forest users) also own livestock which complement their household incomes. ***Table 8.21*** provides an overview of crops cultivated in the social study area.

TABLE 8.21 AGRICULTURAL PRODUCTION (I.E. CASH CROPS)

Thromde / Gewog	Crops	Livestock
Gelephu Thromde	Rice and areca nuts	Hollister chicken, Jersey cows
Gelephu Gewog	Vegetables, paddy, areca nuts, peach, plum, walnut, banana, lychee, sugarcane, passion fruit, pineapple, pomegranate	Chicken, broiler, pigs, cows
Samtenling Gewog	Ginger, areca nuts, oranges, cardamom, fruit plants, lychee, mangoes	Chicken, cows, goats
Umling Gewog	Areca nuts, ginger, rice, maize, paddy, wheat, barley, bitter buckwheat, sweet buckwheat, millet, rajma, mug bean, lentil and other vegetables	Chicken, cows, goats
Chhuzanggang Gewog	Millet, maize, cash crops such as areca nut, ginger, mango, lychee, bananas, coconuts, groundnut, mustard, sunflower, soya bean, lentil, mug bean, barley, buckwheat, fruits and other vegetables	Chicken, cows, goats

Thromde / Gewog	Crops	Livestock
Tareythang Gewog	Areca nuts, ginger, rice, maize wine, vegetables, lentils, chickpea, mug bean, paddy, buckwheat, fruits.	Chicken, cows, goats

Across the social study area, it was found that the cultivation of areca nut was undertaken at a large scale. Most community settlements had areca nut plantations. It was reported that areca nuts are exported to neighboring India on a large scale for consumption. Areca nut chewing is also widely practiced in Bhutan and is an integral part of community cultures in many households.

FIGURE 8.11 ARECA NUT PLANTATION IN THE SOCIAL STUDY AREA

Source: ERM, 2024

8.4.2 BUSINESS AND SERVICES

Business and services in the social study area were largely noted to be medium to small. Cottage industries were also reportedly prevalent in the social study area. The social study area does not have any large industries, and most of the business and services include small shops and businesses, which include groceries, private taxi services, and other such as fabrication, garages, printing services, and other. The social study area also has a few restaurants, hotels and bars, particularly in the Thromde area of Gelephu. While labor and services were previously a significant sector for work opportunities, this has gone down considerably since all construction works in the GMC area have been restricted. It was found through consultations that houses

/ structures whose construction was completed up to 70% prior to announcement of GMC, were permitted to continue with construction activities for completion. No new structures can be built in the social study area.

8.4.3 FISHING

Consultations revealed that fishing is not recognized as a primary or even a secondary source of occupation of communities. A small number of general community members are engaged in fishing activities, wherein fish catch is used for self-consumption or, in some instances, sold locally.

Fishing can be undertaken only by procuring a fishing license, which costs about 6000 NU and is valid for six (06) months. Within this duration, the communities have no restrictions on the number of fish they can catch. However, fishing is not permitted during certain periods, such as auspicious days and after sunset. Further, communities are not allowed to fish Golden Mahseer due to its cultural relevance. It was reported that fishing is undertaken by cast nets and hooks.

Similarly, it was found that aquaculture is not undertaken on a large scale by communities. However, the National Research and Development Centre for Aquaculture, Department of Livestock, is located in Gelephu Thromde. The Centre was established in 1984, and is spread across 19.67 acres, and currently holds 26 ponds. It aims to enhance the livelihood of farms through this initiative. It also aims to conserve native species such as the Golden and Chocolate Mahseer. In addition, it is involved in ornamental sale of Goldfish, Koi Carp and Molly fish.

The Centre reported that of the 20 districts in Bhutan, around 11 districts undertake fish farming. The facility supplies fish fingerlings and other fish such as Chinese Major Carp and Indian Carp to farmers.

8.4.4 REMITTANCES

Out-migration of youth is high in Sarpang District, and specifically in the social study Area. It was found through consultations that limited work opportunities and opportunities for higher education were two of the key reasons why youth from the social study area chose to travel to other countries such as Australia, Dubai, Kuwait, Canada and the United States of America (USA).

As of 2018, a total of 20,366 persons are lifetime migrants in Sarpang District excluding Gelephu Thromde which means that they have moved from their Gewog/Town of birth and are currently residing in Sarpang District. Out of these migrants, 16,017 persons are from other Dzongkhags/Thromdes. Conversely, a total of 9,939 persons have migrated out of Sarpang District to other Dzongkhags/Thromdes. For Sarpang Dzongkhag, the percent of urban-urban migration is 1.7%, urban-rural migration is 9.7%, rural-urban migration is 5.2%, and rural-rural migration is 42.1%. A total of 6,609 persons have in-migrated to Gelephu Thromde and 4,627 have out-migrated from Gelephu Thromde, which accounts to a population increase of 1,982 persons for the Thromde. The percent of urban-to-urban migrants is 17.7% and rural to urban migrants is 57.3% for Gelephu Thromde[152].

Due to the high out-migration of youth, it was found through the consultations that remittances in the social study area were high. It was noted during consultations that men have been forced into out-migration in search of off-farm employment. However, these were largely limited to the

[152] 2018 National Statistics Bureau of Bhutan.

transfer of money back to family members and parents as a monthly support measure. Remittances were not reported to be intended to be used for any form of local savings or investments in the social study area.

8.4.5 LABOUR INFLUX

It was found through consultations that the social study area, given its proximity to the Indian border, sources labor workers majorly from India due to their lower daily wage rates as compared to local Bhutanese workers. The Indian workers belong to states such as Assam, West Bengal, Uttar Pradesh and Bihar. The minimum wage rate for unskilled workers was 460 Nu per day for Bhutanese workers. These workers charged about 500 to 600 Nu per day. For skilled workers, it was reported by the Labour Office that the Bhutanese workers get about 800 to 1000 Nu per day. Whereas Labor Contractors, who provide labour workers from India, charge about 500 Nu per day for unskilled workers. It is understood that the amount charged by the labor contractor eases the process of finding workers as required. It is therefore also assessed that Labor Contractors deduct a certain amount from the workers, therefore paying them much less than 500 Nu.

Consultations with the Regional Labour and Human Resource Office located in Gelephu Thromde, which is responsible for worker management, including providing permits for foreign workers, indicate that the social study area and the larger region relies on 'labor contractor' or 'contracting' system, wherein contractors or labor contractors on the Indian side supply labor based on worker requirement. Labour supplied through labor contractors are temporary and usually move from one job to another, depending on worker requirement, which may vary from daily to monthly basis. The Labor Contractors usually pay workers their daily wages and keep a share for the service provided. It was however reported that such a system is legally not recognised in Bhutan but is resorted to in the social study area due to the strong networks of Labor Contractors in sourcing labor from different parts of India.

Moreover, the social study area also receives wage workers from India, both men and women, who obtain passes to enter and work in Bhutan. It was found that families of unskilled male labor workers are not allowed to stay in the country. Instead, only families of workers who are classified as 'professional' workers are allowed to do so. For unskilled women workers from India, it was reported that these are provided with day passes only, and have to return to India at the end of their shifts.

8.5 SOCIAL AND PHYSICAL INFRASTRUCTURE

8.5.1 HEALTH

Bhutan's health infrastructure is divided into three (03) types – primary, secondary and tertiary. Primary Health Centres (PHCs) are located in all 206 Gewogs across the country. PHCs are divided into Type 1, which have general doctors, and Type 2, which have health assistants. Secondary health centers are district hospitals, which have one (01) or more doctors depending on the population. The tertiary level has three (03) hospitals, which are specialty hospitals. These include the National Referral Hospital located in Thimpu, the Eastern Referral Hospital and the Central Referral Hospital located in the social study area, in Gelephu Thromde.

Health care in the social study area (and Bhutan) is free, and all expenses are paid for by the government. For cases that cannot be treated in the social study area or the country, the Royal

Government of Bhutan has agreements with the Government of India, wherein Bhutanese citizens are sent to hospitals in India, at the government's cost.

Health infrastructure in the social study area is dispersed across the communities. The health infrastructure in the social study area is summarized in ***Table 8.22***. As given above, the Gelephu Thromde area has one regional hospital namely the Central Referral Hospital. Thromde also has two (02) private clinics, whereas Chhuzanggang Gewog has one (01) Grade-1 hospital with one (01) doctor. This hospital also takes in referrals from three (03) PHCs located in the nearby areas. Moreover, Umling Gewog was found to have one (01) Basic Health Unit (BHU), while Tareythang Gewog has one (01) BHU. Samtenling Gewog has no hospitals or PHCs. Instead, the Gewog has one (01) outreach clinic. Gelephu Gewog has one (01) PHC. Serzhong Gewog also has one (01) PHC and two (02) outreach clinics.

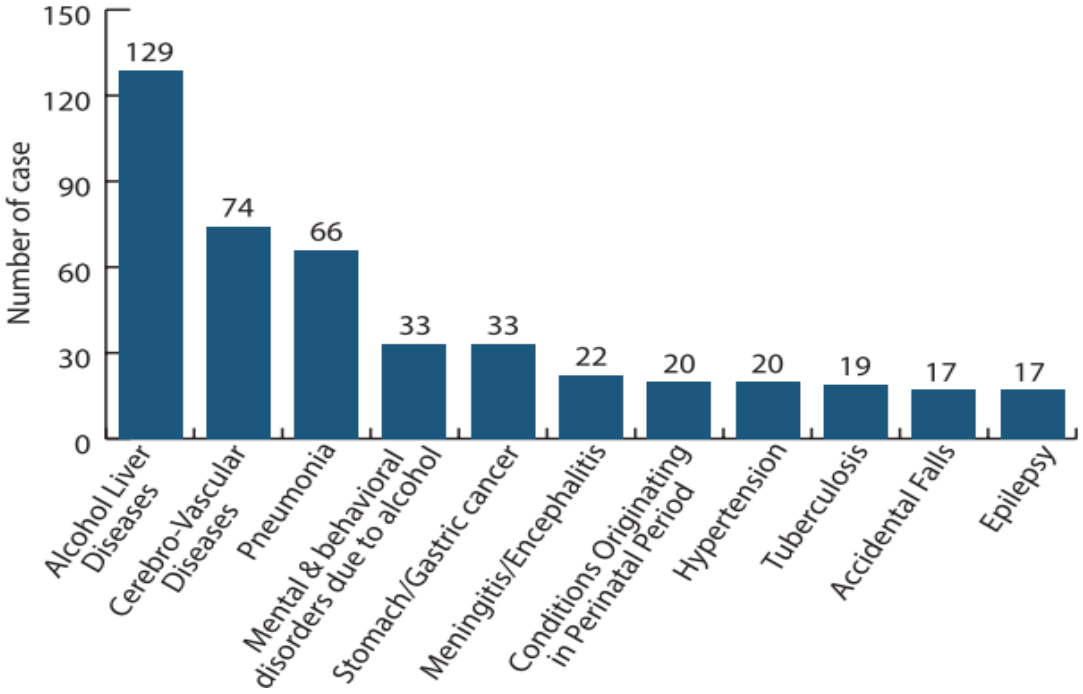
TABLE 8.22 HEALTH INFRASTRUCTURE IN THE SOCIAL STUDY AREA

Gewog / Thromde	Health Infrastructure	Number
Gelephu Thromde	Regional Hospital	1
	Private Clinics	2
Gelephu Gewog	Primary Health Centre	1
	Outreach Clinics	2
Samtenling Gewog	Outreach Clinic	1
Chhuzanggang Gewog	Grade one (01) Hospital	1
Umling Gewog	Basic Health Unit	1
Tareythang Gewog	Basic Health Unit	1
Serzhong Gewog	Primary Health Centre	1
	Outreach Clinics	2

Source: Primary Consultations

With regards to the disease profile, the top causes of mortality, in order of prevalence in 2023, based on data provided by the Central Regional Referral Hospital, were as follows: alcohol related liver disease, respiratory illness, heart failure, sepsis, stroke, cancer and chronic kidney disease. The data largely aligns with national trends (***Figure 8.12***). Based on the consultations, the social study area reflects the national health profile.

FIGURE 8.12 TOP CAUSES OF MORTALITY IN BHUTAN (2024)



Source: Annual Health Bulletin, 2024, Ministry of Health

With reference to health programmes, the South Asian Association for Regional Cooperation (SAARC) is running a tuberculosis (TB) control programme. In 2023, the District Hospital treated 58 cases of TB. In addition, kidney related issues were frequently raised as a health concern during the consultations undertaken in the social study area. This is indicative from the fact that the Kidney Health Foundation is running a programme in the social study area.

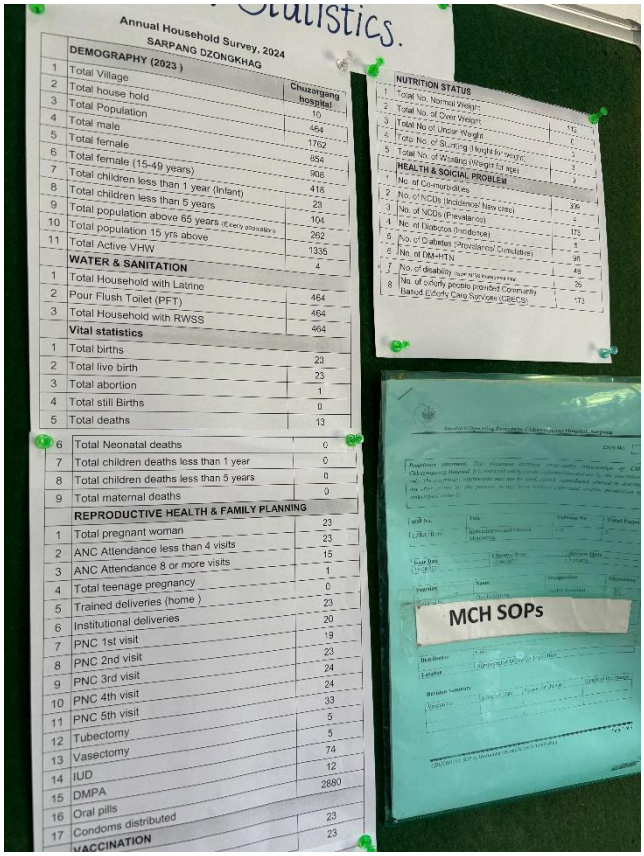
It is reported, during the consultations, that the vaccination rate in the social study area is 99%, the coverage for which is up to 12 years. It was reported that the cases of Hepatitis B are increasing, the country now has a national immunization policy on this.

It was found through consultations that non-communicable diseases (NCDs) are prevalent in the social study area. Data from the NCD Clinic of the Central Regional Referral Hospital in Gelephu Thromde suggests that in 2023, the clinic registered 124 new diabetes cases. Of these, 63 were male and 61 female cases. Further, 8964 hospital visits by old cases with diabetes were recorded, of which 3,113 were male and 4,353 were female[153].

It was reported that the social study area has a high level of drug use of opioids. Moreover, the consumption of alcohol was also reported to be high. The cases of oral cancer were on the rise as well, linked to the prevalent areca nut chewing practices among the communities. Consultations revealed that family planning initiatives in the social study area are effective and birth rates in the social study area have dropped. Lastly, it was reported by health care workers that human resources in the health care sector in the social study area are limited.

[153] 2023 Annual Report of the Central Regional Referral Hospital.

FIGURE 8.13 HEALTH STATISTICS IN CHHUZANGGANG HOSPITAL



Source: ERM, 2024

FIGURE 8.14 CHHUZANGGANG HOSPITAL AND UMLING PHC

Source: ERM, 2024

8.5.1.1 HUMAN-WILDLIFE CONFLICT

It is found that the project area has a high prevalence of human-wildlife conflict. This is largely due to the movement of elephants along the settlements located in the project area.

Based on consultations undertaken to date, it is understood that each Gewog has a dedicated response team, who work with the Department of Forests and Park Services. During peak periods, approximately 3 - 4 response events are undertaken each week.

Conflict primarily includes trampling of crops and human mortality (~one death a year). Elephant trespassing on agricultural lands is common, especially during the crop ripening seasons. Records from a publicized interview with a Gelephu forest range office indicate that more than 65 elephant-related incidents were reported from 19 July to 05 September 2023 in Gelephu and Samtenling. In the same interview, it was reported that there has been an increasing trend of human elephant conflict, with the elephants demonstrating increasingly aggressive behavior[71]. At least 59 trespassing incidences have been recorded from December 2017 to August 2024, from evenings till dawn in agricultural lands[154]. However, the number of conflicts may be higher in the project area with one fatality reported in 2024 during the consultations.

8.5.2 EDUCATION

As outlined in ***Table 8.23*** the social study area has approximately six (06) public schools, of which five (05) are day schools. Further, Gelephu has a boarding school namely the Losel Gyatsho Academy.

TABLE 8.23 EDUCATIONAL INSTITUTIONS

Name of School	Gewog	Type	No of Students	No. of Teachers (including VP & Principal)
Chhuzanggang Primary School	Chhuzanggang	Day School	236	14
Losel Gyatsho Academy	Gelephu	Boarding School	561	34
Dechenperli Public School	Samtenling	Day School	155	10
Samtenling Public School	Samtenling	Day School	288	18
Tareythang Public School	Tareythang	Day School	97	7
Umling Public School	Umling	Day School	331	24

Source: DoST, 2024

In addition, it is found that the social study area has a high number of Non-Formal and Continuing Education Division (NFCED) Centers, which stand at seven (07). The highest number of such centers are found in Chhuzanggang Gewog, which stand at three (03), and two (02) each are located in Samtenling and Umling Gewogs respectively[155]. NFCED is a division under the Department of Adult and Higher Education, the objectives of which are to provide quality literacy and numeracy education in Dzongkha (official language of Bhutan) to those who have not received / completed formal education, and to provide life skills and livelihood skills education and to provide lifelong learning opportunities[156]. Those who complete NFE courses, over a two (02) year period, receive completion certificates which is equivalent to completing class six (06). The certification enables the candidates to apply for jobs, which includes jobs in

[154] Data provided by DoST, 2024.

[155] Bhutan Dzongkhag Administration, Sarpang, available at Gewogs | ROYAL GOVERNMENT OF BHUTAN (sarpang.gov.bt), accessed on 21 August 2024.

[156] Department of Adult and Higher Education, Ministry of Education, available at Department of Adult and Higher Education - Non-Formal and Continuing Education Division Board (dahe.gov.bt), accessed on 20 August 2024.

the local government administration. For those who chose to, they can also continue their education.

The social study area, that is Gelephu Thromde, has one (01) higher secondary school, one (01) middle school and one (01) lower school. It has one (01) private nursery for children, one (01) ECCD center located in Namkheling and one (01) NFE. Sarpang DzongkhagThromde has one (01) vocational training institute in Deki ling. It was found that the social study area does not have a college for higher education. Students reportedly travel to institutions located in Phuentsholing, Trashigang and Thimpu for higher education. Students also travel to countries such as India, Australia, Japan, Thailand and Canada to pursue higher education.

Based on consultations it is estimated that around 20% to 30% of the school students pursue higher education. The students who do not continue with higher education either continue with setting up local businesses or join supporting their families in agriculture or other household income earning work. The small number of students that pursue higher education is indicative of high level of illiteracy in the social study area.

FIGURE 8.15 NORBULING CENTRAL SCHOOL, SERZHONG GEWOG

Source: ERM, 2024

8.5.3 ELECTRICITY

It was found that electricity supply in the social study area was non-disruptive. Gewogs and the Thromde received 24 hours electricity from the Chhukha Hydropower Plant. However, some Gewogs such as Chhuzanggang have reported that while the supply is 24 hours, supply is often disrupted, especially during the summer seasons due to bad weather and thunderstorms. Apart from local issues that temporarily affect power supply, the social study area is considered to have a good supply of electricity.

8.5.3.1 INTERNET CONNECTIVITY

Internet connectivity in the social study area has improved over the years, with providers such as Gelephu Digital Network, Bhutan Telecom and Tashi Cell providing connectivity, the latter acting as a mobile phone distributor as well. It is found that television and internet connectivity in Bhutan were introduced in the year 1999. Households presently have access to various local

channels and access news content through local independent newspapers and radio. More lately, communities also access social media applications such as Telegram and WhatsApp for communication.

8.5.4 WATER AND SANITATION

The Thromde and Gewogs in the social study area cut across five major (05) rivers. These include the Mau, Jengkhurung, Taklai, Langer and Singye rivers. These rivers, and their tributaries, serve as a source of water for communities.

However, while the rivers play an important role, the Thromde and Gewogs in the social study area often rely on more than one water source to meet their needs. For example, in Umling Gewog, it was reported that it has about four (04) upstream sources of water, from the Jengkhurung river. It was reported in Umling Gewog that while it had an irrigation channel for drinking water, budget for managing this channel was an issue in the Gewog.

Tareythang Gewog reported that it has about four (04) sources of water which are seasonal and become dry during the summers. The sources include rainwater – stored in rainwater tanks, the Singye river – used for irrigation and drinking, Sukonriver, which supplies water to four (04) villages in the Gewog, and two (02) springs - namely Ksarkhola and Chargarey. The Gewog does not rely on borewells for water.

In Chhuzanggang Gewog, the main water source was the Taklai river, which uses a canal to transport water to the Gewog. A part of this canal is also used by the Upper Serzhong Gewog. This water is only used for agriculture. For drinking water, the Chhuzanggang Gewog is dependent on the Panch Pali River, transported through a pipe. This Gewog also sources drinking water from a small stream from the Taklai river, and a small stream located in Serzhong Gewog called the Upper Chaskar. It was reported in Chhuzanggang Gewog that the water supply was not sufficient since the rivers were drying and the average size of the families was increasing every year. In order to manage the water in this Gewog, the administration managed/controlled water supply through a tank since continuous supply of water is not possible.

It was also reported in Gelephu Gewog that it has only one (01) source of drinking water and domestic water, which is not sufficient for the community. This Gewog will reportedly soon have His Majesty's Landmark project for drinking water.

While efforts have gone into diversification to ensure water is readily available throughout the year, it was noted in most Gewogs that water availability is an issue, particularly during the dry season. In some instances, depending on rainfall, the Gewog administration has had turned off the supply of water for limited durations, by identified during the consultations. For example, water may be supplied to households from 7 AM to 11 AM and 2 PM to 5 PM and stopped during the remainder of the day with the exception of emergency situations. However, water supply is constant for schools and health care centres.

Despite availability being an issue, infrastructure is in place. Across the Gewogs the supply of water to households is piped.

The Gelephu Thromde was reported to have a reliable water source. For instance, the Jampeling Demkhong shares its water source with an aquaculture centre located in the same Demkhong, which sources water from the Mao Khola. For drinking water, this is sourced from Phulari and Mao Chu water treatment plant, and another borewell in the Demkhong. The borewell water is

reportedly used as a backup source of water. Many households in the Thromde are also used spring water for drinking purposes. As given above, all households in the Thromde receive piped water.

Sanitation practices in the social study area were observed to be safe, with no practices of open defecation reported. Toilets in the social study area were largely found to be squat toilets, with commodes noted mostly in the Thromde areas – in hotels and restaurants. No major diseases linked to sanitation were reported in the social study area.

8.5.5 POLICING AND CRIME

The *Penal Code (Amendment) Act of Bhutan* 2011, *Civil and Criminal Procedure Code of Bhutan 2001* and the *Royal Bhutan Police Act 2009* provide the statutory guidelines for policing and investigations.

The Royal Bhutan Police (RBP) is transitioning from military to civilian policing while adapting to rapid social changes in Bhutan. Additionally, the policing services are bolstered by the 42,775 Desuups (or Guardians of the Peace) who provide auxiliary support[157] to the RBP. While their primary role is not law enforcement, Desuups have been involved in numerous community service and security-related tasks. The policing standards and capacity[158] in Bhutan, under the oversight of the Royal Bhutan Police (RBP), are deemed sufficient to meet the requirements of the Project, particularly regarding managing worker behavior and upholding cultural norms[159].

The data identified instances of alcohol and drug use in people of varying age groups, which was identified as leading to financial stress for families. In support of this data, there are numerous studies have identified existing crime and drug use as a growing issue in Bhutan (Wangdi & Jamtsho, 2019). The available data for 2023 in Gelephu finds that cases related to drugs were the highest, which stood at 123. However, Wangdi & Jamtsho (2019) recognized that "compared to other countries in the World Health Organization (WHO) South-east Asia region, the prevalence of ever drug use in Bhutan is low". National Baseline Assessment (NBA) (2009) on drugs and controlled substance use identified that the mean age of alcohol use was 16 years in 14 districts.

There is currently a drop-in centre located in Gelephu, supported by RGoB in partnership with United Nations Office on Drugs and Crime (UNODC) and United Nations International Children's Emergency Fund (UNICEF).

Drug use was followed by cases of domestic violence, 31 of which were reported in 2023. The major causes of domestic violence were found to be alcohol consumption, poor economic situations, extra marital affairs, influence of social media platforms, and negligence of existing laws. It was found through consultations that coordination of government departments such as

[157] As of 2023, approximately 42,775 Desuups (volunteers trained under the De-Suung program) have completed basic military training in Bhutan. The program focuses on providing volunteers with skills in disaster management, national service, and leadership, while also preparing them for roles in various national projects.

[158] Approximately 8,000 personnel as of 2023 Source: https://theodora.com/wfbcurrent/bhutan/bhutan_military.html

[159] A recent study by Gyeltshen, Kamnuansilpa, Crumpton, & Wongthanavasu (2021) highlights the need for police training in areas like cybercrime investigation, disaster management, and adjusting police culture to meet new demands.

the police and health centers , with organizations such as RENEW[160] play a crucial role in handling cases of domestic violence in the social study area. RENEW has a center located in the social study area, which is attached to the Central Regional Referral Hospital located in Gelephu Thromde. The health unit and RENEW representatives work together to report cases of domestic violence to the police. While the hospital provides health care to the victims, RENEW provides mental health counseling , as well as facilitates the participation of any other relevant stakeholder as needed. RENEW also runs shelter homes for victims at risk of further violence. Consultations suggest that a clear protocol for cases of domestic violence does not exist. This indicates potential gaps in implementation of regulations such as the Domestic Violence Prevention Act (DVPA), 2013, and other national level overarching policies the National Gender Equality Policy (NGEP), 2020. However, it is understood that reporting of domestic violence cases has gone up significantly post Covid-19.

Further, 21 cases of larceny and 14 cases of motor vehicle accidents. In Bhutan, the vehicle speed limits are 50 km per hour for light vehicles and 35 km per hour for medium and heavy weight vehicles. It was reported by the police that speed is a national policy and accordingly, accident prone areas are earmarked. It was further reported that accidents usually involve migrant workers or foreign visitors and other casual visitors who drink and drive.

In case of non-penal offenses , in 2023, a total of 12 such cases were reported in Gelephu. Of these suicides (un-natural deaths) were the highest and stood at seven (07), followed by cases of drowning (03) and accidental deaths – two (02).

In the social study area, it was reported that Namkheling Demkhong in Gelephu Thromde had the highest crime rate, which was attributed to it being the area with the highest number of businesses. The area reportedly has more entertainment options such as bars, restaurants and clubs. Moreover, it was reported that the population of Namkheling is the highest. Moreover, it was reported that while sex work was a concern, the administration, including the police did not have the statistics on the prevalence of these[161].

In view of the upcoming development of the GMC, the government has allocated Nu 37.12 million for the development of 'Safe City Project' in Gelephu, which is to be implemented by March 2025. The government has completed four (04) rounds of public consultations as part of this initiative to seek feedback from the population currently living in the GMC footprint.

8.6 CULTURAL HERITAGE

8.6.1 ARCHAEOLOGICAL AND HISTORIC BACKGROUND

Archaeological studies and insight into the cultural heritage of Bhutan is a recent occurrence. Within the last two (02) decades, Bhutan-Swiss collaborative projects have sprouted in an attempt to institutionalize archaeology and formalize archaeological regulations and site protection. The first archaeological excavation took place in 2008 at the ruins of Drapham Dzong in Bumthang, showcasing Bhutan's distinctive cultural heritage and raising public awareness about the importance of protecting and preserving cultural heritage and archaeology, while engaging the local community. The excavations yielded several artifacts including arrowheads, ceramics and pottery sherds (***Figure 8.16***)

[160] Respect Education Nurture & Empower Women (RENEW) is an NGO based in Thimpu, with centres located nationally.

[161] Information provided by the Superintendent of Police (SSP, Division V, Royal Bhutan Police, Gelephu).

Leaning on oral history and local informants for academic research, it is widely understood that Bhutan entered its historic period in the mid-seventh century AD, with the emergence of two Buddhist temples, Kyichuu Lhakang located in the Paro Valley and Jampa Lhakang in the Choekhor Valley. Part of a larger group of 108 temples, they were built by the 32nd King of the Yarlung Dynasty of Tibet, Sangsten Gampo between 605 and 650 AD[162].

Bhutan's early history and prehistory relies on mythology and remains largely obscure. A handful of megalithic structures indicate that people settled in Bhutan as early as 2000 BP, but not much is known prior to the introduction of Tibetan Buddhism in the 9th Century.

Stupas hold cultural heritage value, playing an important role in the daily lives of people who recognize it. The sacred monuments protect against evil, bring prosperity and promote well-being. They serve as central points for religious rituals, pilgrimage sites and landmarks for orientation.

FIGURE 8.16 DRAPHAM DZONG ARCHAEOLOGICAL EXCAVATION

8.6.2 CULTURAL HERITAGE IN THE SOCIAL STUDY AREA

A total of 26 cultural heritage resources were identified in the social study area. Of these, none have been identified as designated (i.e. listed as having legal protection). Please see ***Appendix K6*** for the list of sites.

[162] Fux, Peter; Walser, Christoph; Tshering, Namgyel (2014). Archaeology in the Kingdom of Bhutan: Exploring the country's prehistory. Zürich: Schweizerisch-Liechtensteinische Stiftung für archäologische Forschungen im Ausland. Accessed 08/10/2024

8.6.3 INTANGIBLE CULTURAL HERITAGE

Around ten (10) key festivals have been identified in Sarpang district (including the social study area), which range from local to national to local level celebrations. These festivals find its roots in both Buddhist and Hindu traditions. ***Table 8.24*** provides an overview of these.

TABLE 8.24 LIST OF FESTIVALS

S. No.	Name of Festival	Religion	Date as per Buddhist/Hindu Calendar
1.	Annual Dzongkhag Tshechu	Buddhist	8-10th day of the 11th month
2.	Vijrakhaya Drupchen	Buddhist	November-December
3.	Chhuzanggang Tshechu	Buddhist	8-10th day of the 12th month
4.	Serzhong Tshechu	Buddhist	22nd day of the 9th month (Buddhist calendar)
5.	Weeklong Janachidue Kurim	Buddhist	24-30th day of the 10th month (Buddhist calendar)
6.	Dekiling Tshechu	Buddhist	10th day of the 10th month
7.	Gomdey Tshechu	Buddhist	January 22nd to 24th
8.	Drupchen	Buddhist	-
9.	Dashain	Hindu	6th October
10.	Various annual ancestral rituals	Buddhist and Hindu	Once a year celebrated by different groups

Source: DoST, 2024

8.7 GENDER

Gender refers to the socially constructed roles and responsibilities of men and women that are created within our families, our societies and our cultures[163]. The concept of gender also includes the expectations held about the characteristics, aptitudes and likely behaviors of both women and men (femininity and masculinity)[164].

8.7.1 DEMOGRAPHIC PROFILE

Of the total population in the social study area, 51% are male whereas 49% of the population is female. The Gewogs and Thromde in the social study area have an average sex ratio of 112 males per 100 females, which is higher than the sex ratio of Sarpang District, which is 109.2[165]. The sex ratio in the social study area are presented in ***Table 8.25***.

TABLE 8.25 SEX RATIO IN THE SOCIAL STUDY AREA

Thromde / Gewog	Sex Ratio[166]
Gelephu Thromde	109.2
Gelephu Gewog	105.4

[163] NCWC (2019a) Gender Equality in Bhutan – A Situational Analysis - Kunzang Lhamu, NCWC, Director. Available from: https://www.ncwc.gov.bt/notifications/324

[164] NCWC (2019a) Gender Equality in Bhutan – A Situational Analysis - Kunzang Lhamu, NCWC, Director. Available from: https://www.ncwc.gov.bt/notifications/324

[165] Population and Housing Census of Bhutan 2017 Sarpang Dzongkhag (PHCB 2017).

[166] Number of males for every 100 females, as defined in the Population and Housing Census of Bhutan (PHCB 2017).

Thromde / Gewog	Sex Ratio[166]
Samtenling Gewog	108.3
Umling Gewog	90.6
Chhuzanggang Gewog	102
Serzhong Gewog	90.4
Tareythang Gewog	178.6
Social study Area	**112**
Sarpang	**109.2**

Source: Population and Housing Census of Bhutan 2017 Sarpang Dzongkhag (PHCB 2017)

8.7.2 GENDER PERCEPTIONS

Bhutan is often considered as a country where women enjoy relative freedom and equality in many spheres of life, however the Bhutanese woman is not without her share of problems. The status of women in Bhutan is influenced by socio-cultural perceptions that generally hold women as less confident, capable and strong and sexually more vulnerable than men[167]. This has influenced access to education, employment and public decision-making and presented a greater challenge as it is to do with the more subdued and indirect forms of gender bias.

8.7.3 GENDER AND LITERACY

Adult literacy is lower among women than men, with a gender gap of 15.3, which is wider than the South Asia regional gap of 14.6[168]. However, during consultations with stakeholders, a comment was made that the literacy rates are perceived to be the same between genders.

8.7.4 VIOLENCE AGAINST WOMEN AND CHILDREN

8.7.4.1 VIOLENCE AGAINST WOMEN

Intimate partner violence is the most prevalent form of violence against women globally and is defined as the percentage of ever-married women (ages 15-49) who have ever experienced physical or sexual violence committed by their husband or partner[169].

There has been a growing number of reports on domestic violence cases in Bhutan in recent years. In the five years preceding 2023, the Royal Bhutan Police (RBP) recorded almost 2,500 domestic violence cases[170].

According to the World Bank's Gender Data Portal, the share of women in Bhutan who have experienced intimate partner violence is 27%, less than the world average. Nonetheless, domestic violence is a significant issue in Bhutan, and there have been increasing efforts to address it in recent years.

[167] NCWC (2019a) Gender Equality in Bhutan – A Situational Analysis - Kunzang Lhamu, NCWC, Director. Available from: https://www.ncwc.gov.bt/notifications/324.

[168] World Bank Group (2024) Bhutan Gender Data Portal. Available here: https://genderdata.worldbank.org/en/economies/bhutan.

[169] "Ibidem"

[170] BBS (2023) Tackling domestic violence. Available from: https://www.bbs.bt/news/?p=185543

According to the National Study on Women's Health and Domestic Violence[171], 1 in 3 Bhutanese women (33%) aged 15–64 reported experiencing physical, sexual, emotional, or economic violence from their intimate partners at least once in their lifetime. About 24% of women reported having experienced emotional violence, 12% physical violence, and 5% sexual violence.

Like many countries, Bhutan saw an increase in domestic violence cases during the COVID-19 lockdowns. According to a 2021 report[172], around 900 domestic violence cases were reported to NCWC between 2016 and 2021. However, underreporting is still a major concern due to societal stigma, fear of retaliation, and deeply rooted social and cultural gender-based norms.

Gender-based violence cases reported to the NGO Respect, Educate, Nurture, and Empower Women (RENEW)[173] increased by 36.6% in 2020. The organization recorded about 700 cases as of November 2020, an increase of 200 plus cases compared to the 2019, reflecting the exacerbation of the issue due to confinement measures and economic stress (NCWC, 2021).

8.7.4.2 VIOLENCE AGAINST CHILDREN

According to a national survey conducted in 2016, more than 6 out of 10 children (64%) aged 13–17 years have experienced at least one incident of physical violence in their lifetime (NCWC, 2016). The majority of boys and girls (44.8%) first experienced physical violence before they reached their teenage years (NCWC, 2016). Of those children who had experienced physical violence at least once in their lifetime, more than half of them (67.3%) reported that they had experienced physical violence at school. More than 4 in 10 children (43.6%) recalled physical violence at home, usually meted out by parents, relatives or siblings[174].

More than 1 in 10 children in the national survey reported experiencing at least one incident of sexual violence in their lifetime (12.8%), with a slightly larger proportion of girls (13.5%) than boys (11.9%)[175].

8.7.4.3 VIOLENCE AGAINST LGBTI+

The presence of LGBTI+ individuals in the social study area was reported during the consultations, but these communities have faced discrimination, particularly in rural areas, due to a general lack of understanding. Stigmatization and cases of violence against LGBTI+ individuals were also noted.

8.7.4.4 LEGISLATION AND ADVOCACY

Violence against women and children continues to be a priority area in Bhutan's gender equality policies and legal reforms. Bhutan has strengthened its legal framework to address domestic violence through the Domestic Violence Prevention Act (2013) and the Child Care and Protection

[171] National Commission for Women and Children (NCWC) (2017) Summary Report, National Study on Women's Health and Life Experiences 2027, A Study on Violence against Women and Girls in Bhutan, Available from: https://www.undp.org/sites/g/files/zskgke326/files/migration/bt/Vaw-report_small.pdf

[172] NCWC (2021) Covid-19 Impact on Women and Children Study (Bhutan). Available from: https://ncwc.gov.bt/publications/COVID19-Impact%20of-Women-and-Children-Study1646648937.pdf

[173] RENEW (2024) Respect Educate Nurture & Empower Women Website. Available from: https://renew.org.bt/

[174] NCWC (2016) Research on Violence Against Children in Bhutan A Report. Available from: https://www.unicef.org/bhutan/media/341/file/Research%20on%20Violence%20Against%20Children%20in%20Bhutan.pdf

[175] "Ibidem"

Act (2011) (Box 8.1). These laws, along with the Penal Code of Bhutan (2004), provide legal avenues for victims to seek justice and protection. The Revised National Gender Equality Policy[176] is also expected to further strengthen efforts in combating gender-based violence, including domestic violence.

Box 8.1 Overview of the Regulatory Framework in Bhutan as it Applies to Gender Matters

The National Gender Equality Policy (NGEP) 2020 is envisaged to provide an overarching policy directive for the government to promote gender equality and gender mainstreaming in legislation, policies, plans, and programmes. The policy serves as a guiding document that echoes and reaffirms the commitment of the RGoB achieving substantive equality through gender-responsive policies, plans, and programs.

The National Commission for Women and Children (NCWC) was established in 2004 as the nodal agency for women and children. It is responsible for the protection and promotion of rights of women and children through advocacy, monitoring, and resource mobilization. The NCWC is responsible for promoting gender equality and women's empowerment in collaboration with relevant government and non-government agencies.

Gender Responsive Planning and Budgeting (GRPB) was introduced in 2012 as an important strategy to accelerate investment in gender equality and women's empowerment interventions. The RGoB began piloting GRPB in three sectors (education, health, and agriculture) in 2014.

A strategic framework for gender mainstreaming and GRPB was prepared in 2013 to provide an overall framework for the RGoB and to enhance coordinated efforts across sectors. The MoF was identified as the lead agency for implementing GRPB supported by the NCWC as well as a steering committee and a working-level committee.

The National Gender Equality Policy, approved by the RGoB in 2020, provides an effective framework within which legal acts, policies, programs, and practices ensure equal rights, opportunities and benefits for all individuals, communities, workplaces and society at large. It serves as a guiding document for the RGoB to facilitate deeper and wider inclusion across all sectors towards achieving a common vision on gender equality. The policy explores gender equality through the lens of three domains – political, social, and economic. The National Gender Equality Policy has been revised in 2023 by adding the LGBT+ perspectives .

The National Plan of Action for Gender Equality (2019-2023) was developed in 2019 by the NCWC in collaboration with relevant government and non-government agencies. The plan presents a holistic approach to achieving gender equality by addressing the gaps and challenges identified, and by taking into consideration new and emerging issues. It outlines key gender equality targets and interventions across 10 critical areas of good governance; education and training; health; ageing, mental health, and disabilities; violence against women; stereotypes and prejudices; economic development; women and poverty; sports; and climate change and poverty.

[176] NCWC (2023) Revised National Gender Equality Policy. Available from: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.ncwc.gov.bt%2Fdocuments%2FFinal%2520version-NGEP%2520(LGBT%2B%2520integration)%2520revised%252010.01.23.docx&wdOrigin=BROWSELINK

According to the National Gender Equality Policy of Bhutan (2020), gender equality implies that the interests, needs and priorities of both women and men are taken into consideration, recognising the diversity of different groups of women and men. Gender equality is not a women's issue but should concern and fully engage men as well as women. Equality between women and men is seen as a human rights issue as well as a precondition for, and indicator of, sustainable people-centric development.

The Labour and Employment Act 2007 prohibits sexual harassment, and the Regulation on Working Conditions 2012 looks into appropriate and safe conditions at the workplace.

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

The NCWC, along with the Royal Bhutan Police and non-government organizations (NGO) such as RENEW are raising awareness and providing services to support survivors of domestic violence. RENEW has a shelter in the social study area and a centre attached to the Central Regional Referral Hospital in Gelephu for mental health counselling of victims. It also provides legal support to victims in addition to other forms of support. However, challenges remain in terms of societal attitudes and access to resources, especially in rural areas, as the majority of shelters, livelihood skills development and advance medico-legal services are available in Thimphu[177].

8.7.5 LAND USE AND OWNERSHIP

8.7.5.1 LAND OWNERSHIP

According to the Bhutanese Land Act of 1979, men and women have the same rights in land ownership. In 2012 45% of property titles in urban areas (shares, buildings, and licenses) were registered to women[178].

In Bhutan, most women acquire land ownership through inheritance, particularly in matrilineal communities. Under the matrilineal inheritance system, agricultural land and other property such as livestock is usually inherited by the eldest daughter. However, inheritance practices vary by region. In the western part of the country, the matrilineal practice is common; but in the southern region, and to a smaller extent the eastern region, the inheritance practice is from father to son[179]. During consultations, it was noted that in modern times there is more equal inheritance between men and women.

[177] NCWC (2020) Assessment Report of Implementation Progress of the Domestic Violence Prevention Act of Bhutan 2013 and its Rules and Regulation. Available from: https://www.ncwc.gov.bt/publications/Report1670316825.pdf

[178] Social Institution and Gender Index (SIGI) (2012) Bhutan. Available from: http://genderindex.org/country/bhutan

[179] World Bank Group (2013) Bhutan Gender Policy Note. Available here: https://www.ncwc.gov.bt/publications/Bhutan%20Gender%20Policy%20Note.pdf

8.7.5.2 WOMAN HEADED HOUSEHOLD

In Bhutan, female headed household proportion are around 35%, out of which 39% is in rural and 29% is in the urban region[180]. The poorest members of Bhutanese society are often cited as female-headed rural households due to divorce or widowhood[181]. The survival of these households depends on the female-head's income-earning potential, they generally face limited employment opportunities and lower wages. Due to climate change and deteriorating agro-ecological conditions, many men have been forced into out-migration in search of off-farm employment, increasing the number of women-headed households and the burden of responsibilities that women carry[182].

8.7.6 EMPLOYMENT

8.7.6.1 VULNERABLE EMPLOYMENT

Vulnerable employment[183] for females has worsened in Bhutan since 1991. Vulnerable employment among women is 82.7% and among men is 61.6% in Bhutan for 2022, a higher rate for women than the regional average for South Asia[184].

8.7.6.2 UNPAID DOMESTIC AND CARE WORK

According to the World Bank's Gender Data Portal, in 2015, women in Bhutan spent 15% of their day and men spent 5.9% of their day on unpaid domestic and care work.[185]. In rural households, daily tasks are divided according to societal gender roles and expectations as outlined in ***Section 8.4.*** According to National Gender Equality Policy 2020 women in Bhutan perform 71% of unpaid care work, which is 2.5 times more than men.

It was also reported during consultations that women's participation in technical and vocational training remains low, with women and girls taking on unpaid care work, a situation that worsened during the COVID-19 pandemic.

It was also noted during the consultations with stakeholders in the social study area that there are, and in many places no, childcare options if women would like to return to work after having a child. For some, they are able to get help from family or even take their children to work with them. This was identified as a barrier for women in taking up formal, paid roles.

8.7.6.3 AGRICULTURAL LIVELIHOOD

[180] Dzed, L., Joshi, V., Zangpo, L., Tshomo, T., and Mongar, C. n.d. (2019) Creating an enabling environment for delivering maternal nutrition interventions in Bhutan. Available from: https://www.ennonline.net/nex/southasia/maternalnutritionbhutan

[181] ADB (2011) Gender Equality Results, Case Studies: Bhutan. Available from: https://www.adb.org/sites/default/files/publication/28287/gender-case-study-bhu.pdf

[182] Verma, R. & Ura, D.K. (2018) Gender Differences in Gross National Happiness in Bhutan: Abridged Analysis of the GHN Survey' in: Proceedings 6th International Conference on GHN, 4-6 November 2015, Paro. Center for Bhutan Studies, Thimphu.

[183] Vulnerable employment refers to work that is often precarious and insecure, lacking formal work arrangements, social security benefits, or adequate legal protections.

[184] World Bank Group (2024) Bhutan Gender Data Portal. Available here: https://genderdata.worldbank.org/en/economies/bhutan

[185] "Ibidem"

Women predominate in Bhutan's agricultural sector, a trend that is growing as men increasingly leaving farms in search of off-farm work[186]. Females make up 57.8% of those engaged in agriculture. Social expectations and matrilineal inheritance practices result in women having the obligation to look after their aging parents in rural areas. Women also generally lack the necessary skills required to be employed in urban areas, which pushes the majority of women into agriculture[187].

During consultations, it was noted that many women in the social study area were involved in household chores, and informal labor, such as participating in agricultural activities such as farming, cultivation, and cattle grazing.

8.7.6.4 NON-LAND-BASED LIVELIHOOD

More men than women owned a business in 2018, the share of female business owners in Bhutan falls in the fourth quintile of all economies for which there are data[188].

8.7.7 PHYSICAL AND SOCIAL INFRASTRUCTURE

8.7.7.1 ACCESS TO PUBLIC HEALTHCARE

Bhutan has a free healthcare system that covers almost 90% of the population within 2 hours of travel distance (Tenzin, et al. 2022). However, women in rural areas face vulnerabilities and lack of opportunities to access comprehensive health services, particularly those that cater specifically to women's sexual and reproductive needs. Women from rural areas have a 17% higher unmet need for family planning than those from urban areas[189].

The World Bank Group Gender Data Portal includes the following health statistics:

- 60 women die per 100,000 live births due to pregnancy-related causes in Bhutan: The maternal mortality ratio in Bhutan has improved from 305 in 2000 to 60 in 2020. Maternal mortality in Bhutan is lower than its regional average.
- 18 of every 1,000 girls aged 15-19 gave birth in 2022, the rate of adolescent fertility has decreased since 2010. The rate in 2022 was lower than the average rate in its income group.

Regarding health in the social study area, it was found that in some parts of the social study area women faced nutrition issues in the past because maize was the only crop that could be grown, limiting access to diverse nutrients.

8.7.7.2 ACCESS TO EDUCATION

Bhutan has witnessed impressive achievements in terms of girls' participation rates, with girls making up 50.5% of the total enrolment in education in 2017. The primary level Net Primary Enrolment Rate is almost 100% for both boys and girls. The survival rate for girls at the primary

[186] FAO (2023) National Gender Profile of Agriculture and Rural Livelihoods, country Gender Assessment Series, Bhutan. Available from: https://openknowledge.fao.org/server/api/core/bitstreams/f7630f3b-8de4-4e1f-bac6-2bc15bba6f28/content

[187] "Ibidem"

[188] World Bank Group (2024) Bhutan Gender Data Portal. Available here: https://genderdata.worldbank.org/en/economies/bhutan

[189] UNDP (2011) Bhutan Gender Analysis, Executive Summary. Available from: https://climatepromise.undp.org/sites/default/files/research_report_document/undp-ndcsp-bhutan-gender-analysis-report.pdf

level stands at 95.3% exceeding that of boys at 86.5%. Furthermore, there is an equal representation of girls at the secondary level, including in private schools, with Gross Enrolment Ratio of 101.4% girls as compared to 90.2% boys. However, according to World Bank 2022 data, only 65.8% of girls and 53.6% of boys complete lower secondary school in Bhutan. Despite such parity at the primary and secondary level, the enrolment of girls at the tertiary level remains low (19.1% as compared to 23.7% of boys)[190].

In terms of education, consultations revealed that as the level of education increases, girls' participation declines, with dropout rates being relatively high due to reasons such as poverty, early pregnancy and domestic responsibilities. Girls tend to pursue general education more than technical or professional courses.

8.7.7.3 WATER, SANITATION AND HYGIENE

Nationally, water access is high, with 99% of the population able to access a water supply[191] however, only 63% has 24-hour access and 32.9% of people consider adequate water supply their primary concern[192]. Bhutan achieved 100% access to improved sanitation in 2022[193], however the challenge remains to accelerate access to safely managed sanitation, including safeguarding vital water sources from faecal contamination.

8.7.7.4 ACCESS TO INTERNET AND COMMUNICATION DEVICES

Access to the internet and communication devices has improved over the years with Bhutan Telecom and Tashi Cell as the primary internet service providers offering 3G and 4B mobile data and broadband services. A recent report indicates that 86% of the population has access to the internet (World Data, 2023). However, despite advancements, women in rural areas face greater challenges in accessing the internet due to limited infrastructure, inconsistent connectivity and gender roles. While this applies nationally, within the social study area, internet connectivity is strong, regardless of gender. However, there is a degree of digital literacy upskilling required to ensure that women have the same level of access as men.

[190] Ministry of Education (2017) Annual Education Statistics 2017. Available from: Annual-education-Statistics-2017.pdf

[191] Royal Government of Bhutan (2023) Water Flagship Program Support Project: Social Monitoring Report (July-December 2023), Available from: https://www.adb.org/sites/default/files/project-documents/42173/42173-017-smr-en_0.pdf

[192] UNDP (2011) Bhutan Gender Analysis, Executive Summary. Available from: https://climatepromise.undp.org/sites/default/files/research_report_document/undp-ndcsp-bhutan-gender-analysis-report.pdf

[193] Water for Women (2022) Bhutan boosts happiness quotient with 100% improved sanitation declaration on World Toilet Day. Available from: https://www.waterforwomenfund.org/en/news/bhutan-boosts-happiness-quotient-with-100-improved-sanitation-declaration-on-world-toilet-day.aspx

8.7.7.5 ACCESS TO PUBLIC, POLITICAL AND FINANCIAL INSTITUTIONS

Women represented 17.9% of those employed in senior and middle management in 2023, placing Bhutan in the lowest quintile for female representation in management globally[194]. Women comprise about one in every three doctors and three in every five nurses[195]. Politically, women's representation has improved, with the percentage of women in Parliament increasing from 8.3% in 2013 to 15.2% in 2018[196]. Only one-fourth of women in Bhutan own a bank account[197].

8.7.8 GENDER NORMS, ATTITUDES AND PRACTICES

8.7.8.1 EARLY MARRIAGES, FAMILY PRESSURES AND NEGOTIATIONS

Consultations with stakeholders revealed that historically, early marriages were common in the social study area, however, these were prevalent earlier, and the situation has improved. Some instances of early marriageOther problems persist, such as domestic violence linked to poverty, alcoholism, and a societal tolerance for violence. In the social study area, domestic violence, as reported by stakeholders, was not universally prevalent, but is seen as an issue of concern, particularly linked to alcohol abuse and unemployment. The local police, the health care providers (in particular the regional hospital) and local non-governmental organizations (such as RENEW) are working together to provide a linked-up system of support for survivors

Stakeholders noted that teenage pregnancies are prevalent within the social study area. Within the context of educational attainment, while highly valued, girls face barriers, as reported by stakeholders during the consultations in the social study area, such as school dropouts due to early marriage, pregnancy, and financial difficulties.

8.7.8.2 MOBILITY, SAFETY AND RISK TAKING

Bhutanese women generally enjoy a high status and equal rights, however their mobility can be restricted as a result of traditional gender roles and safety concerns. During consultations with stakeholders, there were concerns raised around teenage pregnancy and suggesting that one intervention could be to have their daughter stay indoors and not let her go anywhere. As described in ***Section 8.7.4*** gender-based violence is a key concern. Additionally, consultations with stakeholders in the social study area suggested that human trafficking may be occurring, partly linked to the nearby border with India.

1.4.1.2 HOUSEHOLD DECISION MAKING

The involvement in women in economic activities and household decision-making is not on par with men, as reflected by Bhutan's national labor force participation rate of 65.3% for women, compared to 73.1% for men[198]. This was reflected in the consultations with stakeholders in the

[194] World Bank Group (2024) Bhutan Gender Data Portal. Available here: https://genderdata.worldbank.org/en/economies/bhutan

[195] WHO (2021). Bhutan: gender and health. World Health Organization, Regional Office for South-East Asia. Available from: https://iris.who.int/handle/10665/344672

[196] IDEA (2020) Strengthening women's pollical participation in Bhutan. Available from: https://www.idea.int/news/strengthening-womens-political-participation-bhutan

[197] UNDP (2020) Human Development Reports. Available from: http://hdr.undp.org/en/countries/profiles/BTN

[198] NCWC (2019b) Accounting for Unpaid Care Work in Bhutan. Available from: https://www.ncwc.gov.bt/publications/UNPAID_CARE_WORK_IN_BHUTAN%20_20191570788312.pdf

social study area, in which stakeholders noted that employment remains a persistent challenge, as there is limited access to formal jobs and reliance on informal labor.

A UNDP General Analysis survey in Bhutan found that while both sexes are involved in making household decisions, there are clear differences based on gender roles for some of the decisions. For instance, women are more heavily involved in decision-making related to 'household food expenditure' and 'minor household non-food expenditures', whereas men are more heavily involved in decisions like 'major farm investments', 'buying and selling of land', 'whether or not members of the household engage in salary or wage employment', and 'major household expenditure' on durable goods[199].

[199] UNDP (2011) Bhutan Gender Analysis, Executive Summary. Available from: https://climatepromise.undp.org/sites/default/files/research_report_document/undp-ndcsp-bhutan-gender-analysis-report.pdf