Environmental and Social Impact Assessment

PUBLIC

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Project No: 58265-001
February 2026

Bhutan: Solar Farm Expansion Project (Wobthang Transmission Subproject)

Appendices

Prepared by Bhutan Power Corporation (BPC) for the Asian Development Bank (ADB).

Appendix 1-1. Salient features of the Transmission Line

Section	Towers	Length (km)	Gewog	Land use	Remarks
1	AP-1 to AP4	1.58	Tang	SRF & CF Temperate coniferous forest	Initial part of this line is in modified habitat (370m) AP 2 in Garabling CF
2	AP-4 to AP 7	1.29	Tang	SRF Temperate coniferous forest	
3	AP-7 to AP-10	0.88	Tang	SRF & CF Temperate coniferous forest	AP-8 in Nangnang CF
4	AP-10 to AP-13	0.96	Tang	SRF & Pvt land Temperate coniferous forest	
5	AP- 13 to AP-16	0.61	Tang	SRF Temperate coniferous forest	
6	AP-16 to AP-19	0.50	Tang	SRFTemperate coniferous forest (Blue Pine dominant)	
7	AP-19 to AP-22	0.95	Tang	SRF Mixed Conifer, Fir and Blue Pine	
8	AP-22 to AP-25	0.83	Tang	SRF Mixed Conifer, Fir and Blue Pine	
9	AP-25 to AP-28	0.73	Tang	SRF Mixed Conifer, Fir and Blue Pine	AP 27-28: Gewog road Crossing
10	AP-28 to AP-31	0.61	Tang	SRF + Private land Mixed Conifer, Fir and Blue Pine	AP 29-30 RoW in Private Land
11	AP-31 to AP-34	0.97	Tang	SRF Mixed Conifer, Fir and Blue Pine	
12	AP-34 to AP-37	1.21	Tang	SRF Mixed Conifer, Fir and Blue Pine	
13	AP-37 to AP-40	0.73	Tang	SRF & CF Mixed Conifer, Fir and Blue Pine	AP 40 falls under Phomrong CF
14	AP-40 to AP-43	0.60	Tang	CF Mixed Conifer, Fir and Blue Pine	Falls under Phomrong CF
15	AP-43 to AP-46	1.25	Tang	SRF & CF Mixed Conifer, Fir and Blue Pine	
16	AP-46 to AP-49	0.92	Tang	SRF Mixed Conifer, Fir and Blue Pine	
17	AP-49 to AP-52	1.26	Tang, Chokhor	SRF Mixed Conifer, Fir and Blue Pine	Highway crossing
18	AP-52 to AP-54	0.67	Chokhor	SRF Mixed Conifer, Fir and Blue Pine, thick bushes	
19	AP-54 to AP-57	0.79	Chokhor	SRF Mixed Conifer, Fir and Blue Pine, thick bushes	
	Total Length				**17.33**

Appendix 2 – Landscape Features Throughout TL Chainage

Chainage To Forest Type Mixed Cultivated Agriculture Water Bodies Total area (acres)

Length	Chainage From	To	Forest Type Bluepine	Mixed Conifer	Broadleaf	Cultivated Agriculture Kamzhing	Water Bodies Rivers	Shrubs	Meadows	Total area (acres)
31.7	4,406.5	4,438.1	-	0.1	0.1	-	-	-	-	0.2
218.6	4,438.1	4,656.8	-	1.5	-	-	-	-	-	1.5
31.2	4,656.8	4,688.0	0.2	-	-	-	-	-	-	0.2
52.1	4,688.0	4,740.1	0.1	0.2	-	-	-	-	-	0.3
240.7	4,740.1	4,980.8	1.6	0.0	-	-	-	-	-	1.6
65.7	4,980.8	5,046.5	-	0.4	-	-	-	-	-	0.4
32.8	5,046.5	5,079.3	0.2	-	-	-	-	-	-	0.2
64.4	5,079.3	5,143.7	0.0	0.4	-	-	-	-	-	0.4
62.4	5,143.7	5,206.1	0.4	0.0	-	-	-	-	-	0.4
206.1	5,206.1	5,412.2	0.1	1.3	-	-	-	-	-	1.4
965.8	5,412.2	6,378.0	6.5	0.0	-	-	-	-	-	6.6
59.7	6,378.0	6,437.8	-	0.4	-	-	-	-	-	0.4
1,140.4	6,437.8	7,578.2	7.5	0.1	-	-	-	-	-	7.6
50.0	7,578.2	7,628.1	0.2	0.3	-	-	-	-	-	0.4
886.0	7,628.1	8,514.2	5.8	-	-	-	-	0.1	-	5.8
31.9	8,514.2	8,546.1	0.0	-	-	0.2	-	-	-	0.2
677.0	8,546.1	9,223.1	4.4	-	-	0.0	-	0.0	0.1	4.5
29.9	9,223.1	9,253.0	0.1	-	-	-	-	0.2	-	0.2
36.2	9,253.0	9,289.2	0.2	-	-	-	-	0.1	-	0.2
33.1	9,289.2	9,322.2	-	-	-	-	-	0.2	-	0.2
33.1	9,322.2	9,355.3	-	-	-	-	0.1	0.1	-	0.2
2,175.9	9,355.3	11,531.1	14.5	-	-	-	-	-	-	14.5
25.4	11,531.1	11,556.5	0.1	0.1	-	-	-	-	-	0.2
46.5	11,556.5	11,603.0	0.3	0.0	-	-	-	-	-	0.3
21.5	11,603.0	11,624.5	0.0	0.1	-	-	-	-	-	0.1
68.0	11,624.5	11,692.6	0.5	0.0	-	-	-	-	-	0.5
34.0	11,692.6	11,726.6	-	0.2	-	-	-	-	-	0.2
20.1	11,726.6	11,746.7	0.1	0.0	-	-	-	-	-	0.1

Appendix 3-1. BPC Substation Audit Report (2022)

Length	Chainage		Forest Type			Cultivated Agriculture	Water Bodies	Shrubs	Meadows	Total area (acres)
	From	To	Bluepine	Mixed Conifer	Broadleaf	Kamzhing	Rivers			
48.0	11,746.7	11,794.6	0.1	0.3	-	-	-	-	-	0.3
780.3	11,794.6	12,574.9	5.2	-	-	-	-	-	-	5.2
33.6	12,574.9	12,608.5	-	0.2	-	-	-	-	-	0.2
70.4	12,608.5	12,678.8	0.4	0.0	-	-	-	-	-	0.5
35.4	12,678.8	12,714.3	0.1	0.2	-	-	-	-	-	0.2
336.6	12,714.3	13,050.8	-	2.2	-	-	-	-	-	2.2
108.2	13,050.8	13,159.0	0.7	-	-	-	-	-	-	0.7
474.9	13,159.0	13,633.9	-	3.2	-	-	-	-	-	3.2
103.5	13,633.9	13,737.4	0.6	0.0	-	-	-	-	-	0.7
64.0	13,737.4	13,801.4	-	0.4	-	-	-	-	-	0.4
81.4	13,801.4	13,882.8	0.4	0.1	-	-	-	-	-	0.6
140.2	13,882.8	14,023.1	0.1	0.9	-	-	-	-	-	1.0
105.8	14,023.1	14,128.8	0.7	-	-	-	-	-	-	0.7
114.1	14,128.8	14,242.9	-	0.8	-	-	-	-	-	0.8
567.0	14,242.9	14,809.9	3.8	-	-	-	-	-	-	3.8
93.7	14,809.9	14,903.6	0.1	-	-	-	0.6	-	-	0.6
310.4	14,903.6	15,214.0	2.1	-	-	-	-	-	-	2.1
61.7	15,214.0	15,275.6	0.0	-	-	-	0.4	-	-	0.4
667.2	15,275.6	15,942.8	4.5	-	-	-	-	0.0	-	4.5
109.1	15,942.8	16,051.9	0.1	-	-	-	-	0.8	-	1.0
784.0	16,051.9	16,836.0	4.9	-	-	-	-	0.1	-	5.0
33.8	16,836.0	16,869.8	-	-	-	-	0.3	-	-	0.3
467.8	16,869.8	17,337.7	3.1	-	-	-	-	-	-	3.1
Total length		**17,337.7**	84.1	25.6	0.1	0.2	1.4	2.3	2.5	116.1

Form No.:	ISO/IMS/BPC/FR/NCR		
Rev. No.:	0		
Issue No.:	0		

NON-CONFORMITY REPORT

ISO Standard	*ISO 9001:2015 (Clause 9K 7.1.5 Monitoring and measuring resources)*	Audit Date	*23.06.2022*
Audit Area	*ESD Operation and Maint.*	Office	*ESD, Bumthang*
Auditor(s)	Mr. BISWADIP GANGULY	NCR No.	*02*
Auditee	*Kinley Dorji and Guru Tshering*	*Circle the Correct one* Minor (*) Major (**)	

Description of Finding : [To be filled by Auditor(s)]

Statement of nonconformity: Process to ensure measurement traceability of monitoring & measuring equipment found ineffective.

Requirement of Standard:

7.1.5.2 Measurement traceability
When measurement traceability is a requirement, or is considered by the organization to be an essential part of providing confidence in the validity of measurement results, measuring equipment shall be:
a) calibrated or verified, or both, at specified intervals, or prior to use, against measurement standards traceable to international or national measurement standards; when no such standards exist, the basis used for calibration or verification shall be retained as documented information;

Standard: ISO 9001:2015

Objective Evidence: Calibration validity expired for Digital Power Meter (WT230), Sl No: 91H832307, Ref. doc: Calibration certificate no: YMPL/298578/90107, calibration due date was: 15/9/2018, by M/S Yadav Measurements Pvt. Ltd.

Auditee-Signature Auditor(s) - Signature

Root Cause Analysis [To be filled by Auditee]

- ESD, Bumthang would like to justify that the preventive of 33/11 kV substations are done yearly by operation and maintenance team, but due to COVID-19, the calibration for digital power meter could not be carried out due to non-availability of calibration equipment and expertise as the lockdown was imposed in the country.

Correction(s) Action [To be filled by Auditee]

- ESD, Bumthang will be carrying out ~~Eats~~ calibration of digital power meters in the current year.

Auditee - Signature Verified by Auditor(S)- Signature

Corrective Action(s)/Preventive Action (s): [To be filled by Auditee]

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Auditee- Signature

15/07/2022

BPC

NON-CONFORMITY REPORT

Form No.:	ISO/IMS/BPC/FR/NCR
Rev. No.:	0
Issue No.:	01

ISO Standard	*ISO 14001:2015*	**Audit Date**	*14.07.2022*
Audit Area	*Substation and Office building of ESD Bumthang*	**Office**	*ESD, Bumthang*
Auditor(s)	*Mr. Tshering Dorji & Mr. Nima Drukchen*	**NCR No.**	*01/2022*
Auditee	*Mr. Chipchu Dukpa, Chief Manager*	*Circle the Correct one* **Minor (*)**	**Major (**)**

Description of finding: [To be filled by Auditor(s)]

Statement of NC: Operational planning and control is not effective

Requirement: Based on the site visit, the following clause of the ISO 14001:2015 are not complied with.
a. 8.1 Operational Planning and Control.

Evidence:

a. The surroundings of the office especially the substation area need some cleaning up.
b. The use of stationaries like papers has reduced compared to previous years. However, it is observed that due to coming up of e-payment system recently, the printing of vouchers has increased the usage of papers.

14/07/2022

Auditee-Signature 14/7/2022

Auditor(S)- Signature

Root Cause Analysis[to be filled by Auditee]

- Growth of grass around u/s 8/1 due to monsoon season.

Auditee – Signature

Correction(s) Action [To be filled by Auditee]

- Planned to uproot the grass and clear it with in two days latest by monday.

Auditee – Signature 15/7/2022

Verified by Auditor(S)- Signature

Corrective Action(s)/Preventive Action(s): [To be filled by Auditee]

- To be uprooted before the bushes grows tall and carry out the inspection as per the schedule.

Auditee- Signature

Follow-up Audit: [To be filled by Auditor(s)]

Corrective/ Preventive Action: ☐ Completed ☐ Open

Non-Conformity Report: ☐ Closed ☐ Not Completed

Verification Details:
If NC opens, raise fresh NCR. New NCR No. : ***reference to old NCR/New NCR number***

Follow-up Audit Date: Auditor(s) – Signature MR - Signature

Appendix 3-2 Existing Facility Audit and Corrective Action Plan

February 20th 2026

Environmental, Health and Safety (EHS) Audit Summary
Garpang Substation, Choekhor, Bumthang

Prepared by Phuensum Consultancy Services.

Location. The Garpang substation is located on the outskirts of Bumthnag (27.518051667 N, 90.785046667 E), approximately 11.2km from the first transmission line tower and 80m from tower 57. Within the Garpang campus there is one office, three staff quarters and 1 store keeper residence. All building structures are well maintained and not damaged. The site is securely fenced with chain-link and guarded, and overall housekeeping within the boundary is good.

History, Description, Facility Details. The facility was commissioned in 2008. The substation occupies 4.56 acres, with an additional 4.366 acres secured for expansion. It is a combination of GIS and AIS systems, equipped with two 2.5 MVA power transformers and two 2.5 MVA station transformers. Transformers are approximately 18 years old, and maintenance is conducted by BPC's Central Maintenance Section at Begana, Thimphu. The last transformer maintenance (minor) was carried out in November, 2024. SOP checklist for onsite R&M is available. An O&M checklist for internal components of the substation is also available (Appendix 2). No EMF monitoring is conducted at the facility

Applicable Environmental laws, regulations and standards.

Due to the nature of the infrastructure requirements, site locations, and material requirements Bhutan Power Corporation is required to comply with a number of Rules and Regulations mostly pertaining to the Environment, Forest, Water and Waste Generation. These are listed below and detailed in the Wobthang TL ESIA.

- The Constitution of Bhutan 2008
- Environmental Assessment Act 2000
- National Environment Protection Act 2007
- Waste Prevention and Management Act 2009
- Waste Prevention and Management Regulation 2012
- Water Act 2011
- Forest and Nature Conservation Act 1995
- Forest and Nature Conservation Rules & Regulations 2017
- Biodiversity Act of Bhutan 2003
- Land Act 2007
- The Land Rules & Regulations of the Kingdom of Bhutan 2007
- Regulations for Environmental Clearance of Projects 2016
- The Water Regulation of Bhutan 2014
- Revised Regulation on control of Ozone Depleting Substances 2008

Staffing. There are 36 staff (27M, 9F). Of these two males and one female are employed on a contract basis, while the rest are permanent staff.

Surrounding Environment. The surrounding area consists primarily of forest land, with the nearest households located approximately 700–800 meters away. No sensitive receptors are located in the facilities immediate proximity. The site does not fall within any protected area.

Audit and Compliance Background. BPC is certified under ISO 9001:2015, ISO 14001:2015 and ISO 45001:2018 with a dedicated Safety and Quality Unit (SQU) under the Corporate Strategy Division responsible for all related functions including internal compliance audits. The SQU of BPC carries out ISO auditing for BPC's QMS, EMS and OHSMS requirements annually. As part of the distribution system, the Substation must comply with the following:

- BPCs Operational and Maintenance Manual for Distribution System, 2012 (Appendix 1)
- Procedures followed as part of the ISO (Appendix 2)

The most recent ISO audit for the 33/11kV Garpang Substation was carried out in 2022 and is presented in Appendix 3-1. The next ISO auditing is scheduled in the second quarter of 2026.

Environmental aspects. Environmental clearance was obtained at the time of the facilities establishment, although is not required for operational purposes. During the time of establishment, no resettlement or compensation was required as the land is state-owned forest land and land lease certificate was issued to BPC by the National Land Commission.

Waste Management. Hazardous waste such as used transformer oil is sent to Begana In Thimphu where BPC has their Central Maintenance Office for reuse. While evidence of waste management exists, documentation of solid waste generated is limited. Equipment is stored on the ground, and transformer oil barrels do not have secondary containment (bunding). It is adjacent to the drain, which presents a minor environmental risk, in case of spillage.

Drainage. Drainage infrastructure extends from the gate, is around the buildings and also near the transformers. Since the site is about 600m above the flood level, there has been no flood incidence at the site and no issues with waterlogging. The runoff from the drains is toward forested areas and there are not mechanisms to deal with oil spillage. There are no streams in the vicinity of the site.

Occupational health and Safety. BPC has an OHS Policy, (Appendix 3.1), Safety Management System (Appendix 3.2), Safety Rules (Appendix 3.3) and also follows procedures such as the Procedure for HIRA and Incident investigation (Appendix 2). The BPC Corporate office is responsible for planning and coordinating all OHS training for its offices- this is carried out annually.

Training. Staff are nominated for training sessions with the last training was provided in 2025 by the Institute of Technology and Professional Learning to three batches of BPC employees (53) on OHS requirements. The training lasted five days and provided information on OHS standards prescribed by the Department of Labour under the Ministry of Industry, Commerce and Employment (MoICE). The latest OHS training order is included in Appendix 3.4. Induction training is also provided to all new workers, enforcing compulsory temporary local earthing, use of safety wears, ensuring regular refill of first aid kits, providing general as well as specific safety instructions pertaining to various works to all crew members and ensuring the staff area assigned tasks according to their work and capacity

The Office in-charge is responsible for ensuring safe working conditions at the work place and ensuring that maintenance works are executed in a safe manner.

Reporting. Reporting on worker accidents are prescribed in the BPC's Safety Management System 2021 and Safety Manual 2021 in alignment with prevailing safety rules and regulations by the Electricity Regulatory Authority and Department of Labour, MoICE. The last registered case of worker accident was in 2015. No community related accidents have been reported as the site is gated and public access is restricted.

Emergency Preparedness. The substation does not have an Emergency Preparedness and Response Plan, but follows an Emergency Response Procedure (Appendix 2). This Procedure is inadequate for broader emergency situations. A proper Plan is required to detail actions for various emergencies, establish an emergency response team, define coordination mechanisms with the Gewog and Dzongkhag authorities, clearly assign roles and responsibilities, and allocate a dedicated emergency budget for the same.

Warning signage is installed across the site to indicate hazards and dangers, and provide locational information for fire protection equipment. Personal Protective Equipment (PPE) is available and reportedly used daily according to the officer interviewed.

Community consultations. Community consultations are not conducted regularly due to the remote location of the facility. However, there are other formal avenues for community consultations such as the Dzongkhag (District Level) Tshogde Meetings which convene monthly wherein any issues pertaining to BPC are discussed.

Grievance Redress Mechanism. There are guidelines for GRM that are shared with all offices including substations and trainings is provided on Gender based violence and sexual harassment at workplace especially for new staff during onboarding programs. Online reporting through BPC's official website is available for harassment, wrongdoing and grievances. However, there is no system of maintaining a grievance register for each specific substation.

Table 1. Observations and Corrective Actions

No.	Observation	Corrective Action	Timeline
1	Oil containment	Oil containers must be correctly stored and labeled to prevent spill incidents. Elving containers exposed to weather and the sun is not aligned with GIP. Bund capacity must be assessed and a retrofit of the transformer area to provide a bund volume of at least 110% of the container volume or 25% of total volume stored (whichever is greater).	June 2026
2	Waste Documentation	Compile monthly report on quantity and types of waste (all waste types)	March 2026
3	EMF Monitoring	BPC to purchase equipment and initiate EMF monitoring semi-annually	June 2026
4	GRM documentation	Maintain workers' grievance register at site	March 2026
5	Emergency Preparedness and Response Plan (EPRP)	Prepare an EPRP for the substation	June 2026

6	Measures for combating large fires and explosions	Additional measures such as fire detection and alarm systems, automatic water spray systems, oil drainage system must be assessed and gaps addressed.	June 2026
7	First aid kit	Review ability of first aid kit to respond to a serious medical incident or accident and address accordingly	March 2026
8	Materials Storage	To prevent trips and unnecessary site hazards assess the storage of materials across the site	March 2026

Table 2. Template checklist for site visit

No.	Item	Observation / Status
1.0	Details of the Substation	GIS and AIS Substation, commissioned 2008
1.1	Location	Garpang, Choekhor, Bumthang
1.2	Geographic Coordinates	27.518051667 N, 90.785046667 E
1.3	Area of Land	4.56 acres (existing) + 4.366 acres (expansion acquired)
1.4	Surrounding Land Use	Forested area; households 700–800 m away
1.5	Major Equipment	2 × 2.5 MVA power transformers; 2 × 2.5 MVA station transformers
2.0	Site Condition	Clean, well maintained, guarded and securely fenced
2.1	Expansion Feasibility	Adequate land available for upgrade/expansion
2.2	Water Logging	The site is about 600m above the Chamkarchhu river. It has not been affected by flooding in the past. During the site visit, no waterlogging has occurred to date,
2.3	Drainage System	The drain extends from the entry gate, around the building and transformers (see photo 7,9 and 11). The outlet of the drains is on forest land.
2.4	Access Road	The substation is accessible from the Bumthang highway. This 200 m of paved road is solely for the substation.
2.5	Environmental Clearance	Obtained in 2008. The Environmental Clearance is required only for the construction phase as prescribed under the Environmental Assessment Act 2000 and not for the operation phase.
2.6	Resettlement / Compensation	The land is leased (state-owned forest land) and the Land Use Certificate is attached (till 2043). Since there was no private land, there was no need for resettlement.
2.7	Donor Involvement	None
3.0	Hazardous Waste Management	The used transformer oil is stored in Fuel barrels near the transformer. This is transported to Begana Central Maintenance Section for reuse. The substation also has a DC backup system in place which was set up in 2025. The battery type is dry and sealed. The life span is usually 7-10 years and capacity testing is generally scheduled from year 3 onwards after first installation and disposed off through auctions to certified recyclers at the end of its life cycle.
3.1	Solid Waste Management	The City waste receptacle (photo 12). General waste is stored onsite and collected by the Municipal once a month (as there is very little waste generated). The waste is disposed of at the waste landfill site. BPC is guided by the DHI's SOP for Waste Management 2021.
3.2	Equipment Storage	Stored directly on ground (no bunded surface)
3.3	Transformer Maintenance	Transformer Maintenance is carried out by BPC's Central Maintenance Section at Begana, Thimphu. The last transformer maintenance (minor) was carried out in November, 2024. SOP checklist for onsite R&M is available. An O&M checklist for internal components of the substation is also available.

No.	Item	Observation / Status
3.4	Circuit Breakers	GIS (SF_6) and AIS (vacuum)
3.5	EMF Monitoring	Not carried out currently
4.0	EHS Plan Availability	Available in office (see Appendice Part-3 of the Operation Manual is the 'Safety Guidelines with regards to Operation and Maintenance of distribution system'
4.1	Emergency Response Plan (ERP)	Available in office
4.2	SOP Awareness	Staff aware of SOPs related to the operation and maintenance of substations. SOPs are designed and adopted against concerned offices' roles and functions prescribed in O&M and Safety Manuals. In addition, the implementation of the Integrated Manual System (IMS) for ISO 9001, ISO 14001 and ISO 45001 has established two tiers of SOPs; 1. 18 Procedures, 2. 26 Operational Control Procedures (OCPs).
4.3	Safety Signage	Safety signage is posted at
4.4	Fire-Fighting Equipment	4 fire extinguishers; 4 sand buckets The fire extinguishers are of two types: Dry Chemical Power (DCP) and CO_2. Refilling and recalibrations were carried out on 28 October 2025 by trained BPC employees. The next date of change is on 27 October 2026. . Fire safety systems are maintained annually by the Safety and Quality Unit under the Corporate Strategy Division.
4.5	PPE Availability and Use	PPE are provided to staff during induction and are used daily. The O&M in-charges or work supervisors are responsible to ensure that all his/her crew members put on necessary safety equipment/ tools such as safety helmets, belt, shoe, insulated handgloves, and use appropriate hot sticks and proximity detectors
4.6	EHS Training	Environment, Health and Safety trainings are provided annually to employees including new recruits during onboarding programs. The training is provided by the Human Resource Management Section, Support Services Division, Corporate Services Department. The last training was provided in 2025 by the Institute of Technology and Professional Learning to over 3 batches of BPC employees (53) on OHS requirements each spread across 5 days. The training was provided based on the OHS standards prescribed by the Department of Labour under the Ministry of Industry, Commerce and Employment (MoICE).
4.7	Worker Accidents	There is a first aid box and a list of medicines. As and when the medicines are used, the first aid box is replenished. Reporting on worker accidents are prescribed in the BPC's Safety Management System 2021 and Safety Manual 2021 in alignment with prevailing safety rules and regulations by the Electricity Regulatory Authority and Department of Labour, MoICE. The last registered case of worker accident was in 2015.
4.8	Community Accidents	None reported. The substation is gated and access by the public is restricted.
5.0	Community Consultation	Not conducted (remote location) Other formal avenues for community consultations are available such as the Dzongkhag (District Level) Tshogde Meetings which convene monthly wherein any issues pertaining to BPC are discussed.
5.1	Grievance Redress Mechanism Awareness	There are guidelines for GRM that are shared with all offices including substations. Trainings on Gender based violence and sexual harassment at workplace especially for new staff during onboarding programs. Online reporting through BPC's official website is available for harassment, wrongdoing and grievances.
6.0	Wildlife Issues	None reported
7.0	Key Gaps Identified	No EMF monitoring; storage of Transformer Oil drums on bare ground; limited documentation of waste and grievances.

Images from Substation Site Audit

Photo 1. The Substation Board

Photo 2. Land use certificate

དཔལ་ལྡན་འབྲུག་གཞུང་།

རྒྱལ་ཡོངས་ས་ཆ་ལྷན་ཚོགས།

Land Lease Certificate

No. BUM-73-144

Lessee:

Name	BHUTAN POWER CORPORATION LTD
Citizenship ID No.	
Gewog	CHHOEKHOR
Dzongkhag	BUMTHANG

Land Details				Lease Details				
Dzongkhag	Gewog	Plot No.	Area	Activity	Land Use	Lease Type	Start Date	End Date
BUMTHANG	CHHOEKHOR	LCHR-10	4.563	BUSINESS	CONSTRUCTION OF 2x5 33/11 SUBSTATION	LONG TERM	29/03/2016	29/03/2046

Note : The area reflected above is in Acre

Issuing Authority

Issue Date : 30/06/2017

Page 1 of 1

Photo 3. Entry to the Substation

Photo 4. Fencing around the substation

Photo 5. Security Gate

Photo 6. Substation

Photo 7 and 8. Transformers

Photo 9 and 10. Barrels for transformer oil collection stored incorrectly

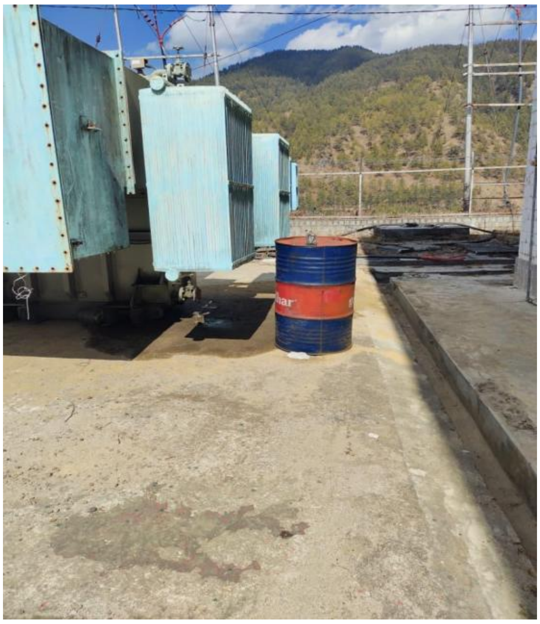


Photo 11. Drainage extending from the gate

Photo 12.Waste receptacle for solid waste

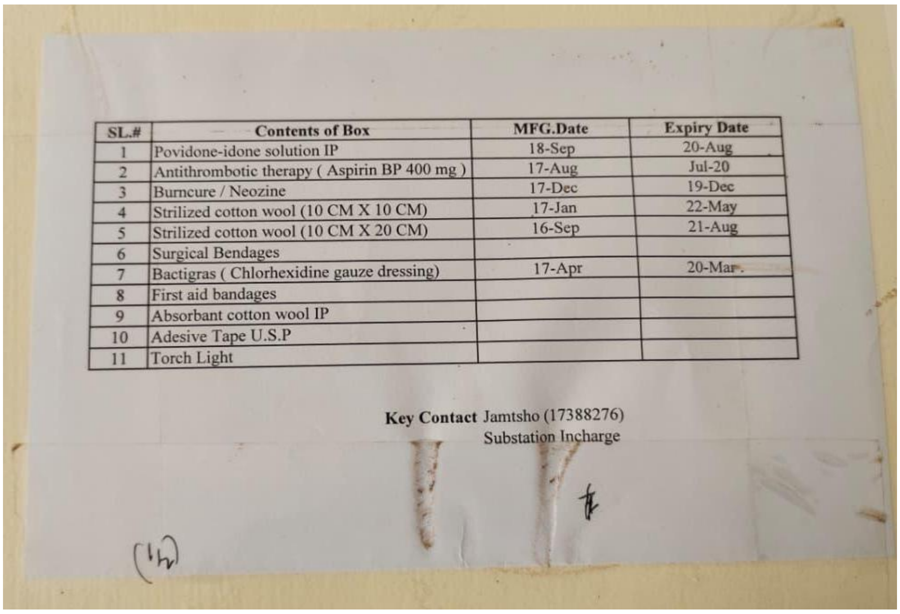
Photos 13-15. Untidy housekeeping of material storage onsite

Photos 16.Material store room (inside)

Photo 17. Battery room for backup

Photos 18. Poster depicting PPE usage in the substation

Photos 19 and 20. First Aid Kit on site and list of medicines



SL.#	Contents of Box	MFG.Date	Expiry Date
1	Povidone-idone solution IP	18-Sep	20-Aug
2	Antithrombotic therapy (Aspirin BP 400 mg)	17-Aug	Jul-20
3	Burncure / Neozine	17-Dec	19-Dec
4	Strilized cotton wool (10 CM X 10 CM)	17-Jan	22-May
5	Strilized cotton wool (10 CM X 20 CM)	16-Sep	21-Aug
6	Surgical Bendages		
7	Bactigras (Chlorhexidine gauze dressing)	17-Apr	20-Mar
8	First aid bandages		
9	Absorbant cotton wool IP		
10	Adesive Tape U.S.P		
11	Torch Light		

Key Contact Jamtsho (17388276)
Substation Incharge

Photos 21 and 22. Fire extinguishers (refilled on 28 October 2025).

Photos 31. Consultation during the Audit.

Appendix 4-1. Environmental Survey

3.2.1. Ambient Noise, Air Quality, Climate Meteorology

A purposive sampling design was adopted to assess ambient noise, air quality, and meteorological conditions across the Area of Influence (AoI) of the project. Monitoring stations were strategically selected to represent a range of land-use types, with emphasis on sensitive areas such as settlements and forest zones, as well as industrial and semiurban sites where applicable. The selected locations ensured adequate spatial coverage along the transmission line corridor and were chosen to capture potential variability in environmental conditions due to human activity, topography, and land-use patterns. For environmental monitoring the air quality monitoring machine AQM 09 (Oceanus, Henan, the People's Republic of China) was used.

3.3. Data Collection Methods

3.3.1. Ambient Noise, Air Quality, Climate and Meteorology

To monitor noise and ambient air quality in the project area, a real-time ambient air quality monitoring system, AQM-09 (Oceanus, Henan, the People's Republic of China), was deployed across five strategically selected locations (Table 3.1), representing a mix of sensitive and industrial areas to ensure comprehensive spatial coverage and variability. The instrument is capable of simultaneously measuring particulate matter and gaseous pollutants, along with auxiliary environmental parameters such as ambient temperature, relative humidity, atmospheric pressure, wind direction, and wind speed. The AQM-09 is also integrated with a noise meter, enabling concurrent measurement of sound levels in decibels alongside air quality parameters. Noise monitoring was conducted over a 24-hour period, with measurements categorized into day (6:00 a.m. to 10:00 p.m.) and night (10:00 p.m. to 6:00 a.m.) intervals, in accordance with standard environmental assessment practices (National Environment Commission [NEC], 2020).

The device operates on the principle of light scattering to determine concentrations of particulate matter and utilizes electrochemical sensors for detecting gaseous pollutants. It is equipped with light-scattering diodes capable of measuring PM2.5, PM10, and total suspended particulates (TSP), and features pre-calibrated sensors for gaseous pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

Table 3.1: Ambient Noise and Air Quality Sampling Station Location Details

Sl. No.	Site Code	Date of Monitoring	Latitude	Longitude	Elevation
1	NA1	July 08, 2025	27.56233961	90.84364313	2808.80
2	NA2	July 10, 2025	27.50806837	90.80978459	2827.91
3	NA3	July 12, 202	27.50388024	90.76474474	2663.81
4	NA4	July 14, 2025	27.46390653	90.49728101	1918.30
5	NA5	July 16, 2025	27.387850	90.545917	2147.31

3.3.4. Water Sampling

Water samples were collected and analyzed at the same locations where aquatic biodiversity surveys were conducted, allowing for direct correlation between physicochemical parameters and biotic communities. A total of 31 physicochemical water parameters were measured. Eleven parameters (pH, Temperature, Conductivity, Total

Dissolved Solids (TDS), Salinity, Turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand, Total Coliform, Fecal Coliform, and *Escherichia coli* (*E. coli*) were tested on site, while water samples were collected using grab method for other parameters.

For total suspended solids (TSS), Chloride, Nitrate, Ammonia, Sulphate, Sodium, Potassium, and Fluoride, 500 mL of water were collected in clean polyethylene bottles without preservatives and refrigerated at 4°C (Zhang et al., 2017). For Iron, Manganese, Zinc, Copper, Calcium Hardness, Magnesium Hardness, Total Hardness, Mercury, Arsenic, and Cadmium, 250 mL of water were collected in acid-washed bottles and preserved with concentrated nitric acid (HNO_3) to maintain pH below 2. Similarly, for Chemical Oxygen Demand (COD), 250 mL of water was collected in acid-washed bottles, preserved with concentrated sulfuric acid (H_2SO_4) to pH < 2, and refrigerated at 4°C.

Similarly, for Total Orthophosphate, 250 mL of water was preserved with concentrated sulfuric acid (H_2SO_4) and stored in amber bottles in the dark to prevent photodegradation. Each sample bottle was clearly labeled with the sample ID, date and time of collection, preservation method, and targeted parameters. Samples were transported in coolers with ice packs to maintain a temperature of approximately 4°C and delivered to the Soil Air and Water Testing (SWAT) laboratory, College of Natural Resources, Royal University of Bhutan, for analysis (Table 3.3).

Table 3.3: Summary of Water Quality Parameters, Methods, Preservation, and Holding Time

Sl. No.	**Parameter**	**Method / Instrument Used**	**Sample Volume**	**Storage Condition**	**Maximum Holding Time**
1	pH	PCS Testr 35	On-site	Analyze immediately	15 minutes (max)
2	Temperature	PCS Testr 35		Analyze immediately	Instantaneous
3	Conductivity	PCS Testr 35		Analyze immediately	28 days (if cooled)
4	Total Dissolved Solids	PCS Testr 35		Analyze immediately	7 days
5	Salinity	PCS Testr 35		Analyze immediately	28 days
6	Turbidity	Nephelometric		≤6°C	48 hours
7	Dissolved Oxygen	Membrane Electrode		Analyze immediately	15 minutes (if unpreserved)

8	Biochemical Oxygen Demand (BOD)	Membrane Electrode		Analyze immediately	48 hours
9	Total Suspended Solids	Evaporating Method		≤6°C	7 days
10	Chloride	Argentometric		≤6°C	28 days
11	Nitrate	Jal Tara Test Kit		≤6°C	48 hours (unpreserved)
12	Ammonia	Phenate (4500-NH_3)		≤6°C, unpreserved or acidified	28 days (if acidified)
13	Sulphate	Turbidimetric		≤6°C	28 days
14	Sodium	Flame Photometer		≤6°C, acidify with HNO_3 (optional)	6 months (if acidified)
15	Potassium	Flame Photometer		≤6°C	6 months (if acidified)
16	Fluoride	Jal Tara test kit	500 mL	≤6°C	28 days

17	Iron (Fe)	Phenanthroline		pH < 2 with HNO_3, ≤6°C	6 months
18	Manganese (Mn)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
19	Zinc (Zn)	Spectrophotometric,		pH < 2 with HNO_3, ≤6°C	6 months
20	Copper (Cu)	UV/VIS Spectrophotometry	250 mL	pH < 2 with HNO_3, ≤6°C	6 months

21	Calcium Hardness	EDTA Titrimetric		≤6°C, acidified	6 months
22	Magnesium Hardness	EDTA Titrimetric		≤6°C, acidified	6 months
23	Total Hardness	EDTA Titrimetric		≤6°C, acidified	6 months
24	Mercury (Hg)	Colorimetric		pH < 2 with HNO_3, ≤6°C	28 days
25	Arsenic (As)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
26	Cadmium (Cd)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
27	Chemical Oxygen Demand (COD)	Dichromate		pH < 2 with H_2SO_4, ≤6°C	28 days (EPA)
28	Total Orthophosphate	Ascorbic Acid		pH < 2 with H_2SO_4,	28 days (EPA max)
				amber bottle, ≤6°C	
29	Total Coliform	Macconkey and Blood agar media and inoculation for 24 hours within 37°C	On-site /100 mL	≤10°C	24 hours
30	Fecal Coliform				
31	*E. coli*				

4. Results and Discussion

4.1. Environmental Baseline

4.1.1. Air Quality

Air quality data collected from five sampling sites (NA1–NA5) indicate that concentrations of particulate matter (PM2.5, PM10, and total suspended particulates) were consistently low and well within the limits established by both the NEC (2020) and World Health WHO (2021) guidelines. The highest particulate levels were recorded at Site NA4, with PM2.5 at 3.6 µg/m^3, PM10 at 5.2 µg/m^3, and TSP at 8.5 µg/m^3, all significantly below the respective standards (Table 4.1). This elevated concentration at NA4 could be attributed to its proximity to the Dzongkhalum, Trongsa which may influence local dust or emissions. All the sites reported undetectable levels of particulates. Gaseous pollutants such as nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) were below detection limits at all sites, while carbon monoxide (CO) was negligible, with only a trace concentration of 0.02 µg/m^3 recorded at Site NA4. The overall low pollutant concentrations can be attributed in part to the sampling occurring during the wet season, which facilitates the removal of airborne particulates through precipitation and atmospheric cleansing processes. These findings suggest that the ambient air quality in the project area was good during the monitoring period, with minimal influence from industrial or combustion-related emissions.

Table 4.1: Concentrations of Particulate Matter (PM2.5, PM10, TSP) and Gaseous Pollutants (NO_2, SO_2, CO) at Five Monitoring Sites Compared with NEC and WHO Standards (µg/m^3)

Parameters		**PM2.5**	**PM10**	**TSP**	**NO_2**	**SO_2**	**CO**
Unit		**µg/m^3**					
Standards	NEC	60a 60^b	75^a 200^b	100^a 500^b	15^a 80^b	30a 120^b	1000^a 5000^b
	WHO	15	45	-	25	40	7
Sampling Sites	NA1	1	2	3.3	0	0	0
	NA2	1	2	4.6	0	0	0
	NA3	0	0	0	0	0	0
	NA4	3.6	5.2	8.5	0	0	0.02
	NA5	0	0	0	0	0	0

Note: $PM_{2.5}$ = Particulate Matter 2.5, PM_{10} = Particulate Matter 10, TSP = Total Suspended Particualtes, NO_2 = Nitrogen Dioxide, SO_2 = Sulphur Dioxide, CO = Carbon Monoxide.
NA1-NA5 = Noise and Air Monitoring sites 1 to 5,
- = No standard reference available [a] = Sensitive area (place like hospitals, schools, sensitive ecosystem) [b] = Industrial area
NEC = National Environment Commission Environmental Standards, 2020.
WHO = World Health Organization Global Air Quality Guidelines
The observations and air quality criteria is for 24 hours average

4.1.3. Noise

Noise levels were measured in A-weighted decibels [dB(A)] across five monitoring sites (NA1–NA5) during both daytime (6:00 a.m. to 10:00 p.m.) and nighttime (10:00 p.m. to 6:00 a.m.) and evaluated against NEC (2020). According to the standards, the maximum permissible noise levels are 55 dB(A) during the day and 45 dB(A) at night for sensitive areas, and 75 dB(A) during the day and 65 dB(A) at night for industrial areas (Table 4.7).

At Sites NA1, NA2, NA3, and NA5, both daytime and nighttime noise levels remained well within the prescribed limits for sensitive areas. Daytime noise levels ranged from 38 to 50 dB(A), while nighttime levels were between 30.8 and 42.6 dB(A). These values reflect relatively quiet ambient conditions, suitable for residential, institutional, or ecologically sensitive environments.

However, Site NA4 recorded significantly higher noise levels, with 67 dB(A) during the day and 60.3 dB(A) at night. These values remain within the NEC's permissible limits for industrial zones (75 dB(A) day / 65 dB(A) night), suggesting compliance with national standards. However, the relatively high values at this site, compared to others, may be attributed to its proximity to the Dzongkhalum, Trongsa, where infrastructure operations may contribute to ambient noise. Furthermore, high vehicular movement near Site NA4 likely adds to the elevated levels, particularly during the daytime.

Table 4.7: Day and Night Noise Levels [dB(A)] Recorded at Five Monitoring Sites Compared with NEC 2020 Standards for Sensitive and Industrial Areas

Noise		**Day**	**Night**
Unit	dB (A)		
Standards	NEC	55[a] 75[b]	45[a] 65[b]
Sampling Sites	NA1	41	34.4
	NA2	38	30.8
	NA3	50	42.6

	NA4	67	60.3
	NA5	46	39
Note: dB(A) = A-weighted decibels [a] = Sensitive area (place like hospitals, schools, sensitive ecosystem) [b] = Industrial area NA1-NA5 = Noise and Air Monitoring sites 1 to 5 NEC = National Environment Commission Environmental Standards, 2020			

4.1.4. Climate and Meteorology

Meteorological conditions recorded during the sampling period across five sites (NA1– NA5) showed notable spatial variation (Table 4.8). Ambient temperature ranged from 21.3°C at NA1 to a peak of 27.1°C at NA4, with the highest temperature likely influenced by industrial activity and lower vegetation cover at the site. Relative humidity varied between 43.6% (NA4) and 77% (NA2), indicating moderate to high moisture levels. Wind speeds were generally low, ranging from 0.10 m/s at NA5 to 0.59 m/s at NA2, suggesting limited atmospheric dispersion during the monitoring period. Rainfall was recorded as zero across all locations, as no precipitation occurred during the sampling timeframe. Atmospheric pressure varied between 72.2 mbar and 82.5 mbar, with higher values at site NA4 reflecting more stable weather conditions. Overall, the meteorological parameters during the monitoring period were relatively stable and dry, which is important for interpreting pollutant behavior in ambient air.

Table 4.8: Meteorological Parameters Recorded at Five Sampling Sites During the Monitoring Period

Parameters		**Temperature**	**Humidity**	**Wind**	**Rainfall**	**Pres**
Unit		°C	%	m/s	mm	mbar
Sampling Sites	NA1	21.3	69.1	0.36	0	72.5
	NA2	21.6	77	0.59	0	72.2
	NA3	22.7	58.1	0.13	0	75.4
	NA4	27.1	43.6	0.26	0	82.5
	NA5	23.6	67.3	0.1	0	79.9
Note: °C = Degree Celsius, % = Percent, m/s = meter per second, mm = millimeter, mbar = millibar NA1-NA5 = Noise and Air Monitoring sites 1 to 5						

4.1.2. Water Quality

For the study, out of three water quality parameters *viz.,* biological, physical and chemical, the latter two were dealt with and studied in detail while only the microbiological parameters were studied for biological parameters. There were 31 water quality parameters studied from the water sampling sites.

Under the physical parameters, pH, Temperature, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Salinity, Turbidity and Electrical Conductivity (EC) were studied. The chemical parameters included Dissolved Oxygen (DO), Total Hardness, Chloride (Cl), Ammonia (NH_3), Iron (Fe), Manganese (Mn), Copper (Cu), Magnesium (Mg), Fluoride (F), Nitrate (NO_3), Phosphate (P), Potassium (K), Mercury (Hg), Arsenic (As), Zinc (Zn), Cadmium (Cd), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Sulphate (SO_4), Sodium (Na) and Calcium (Ca). While under the microbiological parameters, Fecal Coliform, *Escherichia coli* and Total Coliform were taken into consideration.

Physical parameters

Overall, the water quality parameters across all sites during the monsoon season indicate excellent quality, within international and national standards. The water is soft, slightly acidic to neutral, and low in dissolved and suspended solids, which are characteristic of upland river systems with minimal anthropogenic influence. Slight turbidity exceedance at W10 likely results from increased sediment input due to monsoon runoff or localized erosion, which should be monitored. The low EC and TDS values confirm that the rivers are pristine and free from significant chemical contamination, making them suitable for drinking with minimal treatment (Table 4.2).

Table 4.2: Physical parameters for monsoon season and recommendations/limits

Parameters		**pH (scale)**	**Temp (°C)**	**TDS (mg/L)**	**TSS (mg/L)**	**Salinity (mg/L)**	**Turbidity (NTU)**	**EC (µS/cm)**
Standards	AWQC	6.5-8.5	-	5001 1500[2] 2100[3]	251 1002	-	5[a]	800[1]
	BDW	6.5-8.5	-	-	-	-	5	-
	EPA	6.5-8.5[a]	25[a]	500a 1500[b]	50	<500 (Fresh water)	≤5[a]	2500[b]
	WHO*	6.5-8.5	-	1000	-	-	10[b]	1500
Sampling Sites	W1	7.12	17.1	19.1	6.89	18	1.07	26.7
	W2	7.5	17.3	12.9	4.61	14.3	1.28	18.9

	W3	6.95	19.2	20.2	5.19	19.2	1.29	28.7
	W4	6.69	16.4	22.1	10.67	15.9	3.22	22.1
	W5	6.95	17.2	26.8	3.46	22.3	5.74	38
	W6	7.22	14.7	31	4.46	23.8	6.74	44.2
	W7	7.05	15.4	22.4	5.46	26.9	7.74	38.4
	W8	7.07	16.8	34.9	6.46	27.3	8.74	48.8
	W10	7.09	15.5	17.3	8.46	16.4	10.74	23.5
Notes:								

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

1. pH

The pH across all sites ranged from 6.69 (W4) to 7.50 (W2). According to WHO, EPA, and BDW standards (6.5–8.5), all sites fall within the permissible range, indicating neutral to slightly acidic conditions at W4 and slightly alkaline at W2. These values suggest that the water is generally suitable for drinking and aquatic life without significant risk of acidity or alkalinity issues.

2. Temperature

The water temperature varied between 14.7°C (W6) and 19.2°C (W3). Although there is no explicit drinking water temperature standard, temperatures between 15–25°C are generally considered acceptable for human consumption and aquatic ecosystems. All sites fall within this acceptable range, indicating no thermal stress on aquatic organisms. 3. Total Dissolved Solids (TDS)

TDS ranged from 12.9 mg/L (W2) to 34.9 mg/L (W8), which is far below the WHO limit of 1000 mg/L and the EPA desirable limit of 500 mg/L. Such low concentrations indicate very soft water with minimal dissolved minerals. This suggests excellent water quality with no salinity concerns, making it ideal for drinking and irrigation.

4. Total Suspended Solids (TSS)

TSS values were between 3.46 mg/L (W5) and 10.67 mg/L (W4). While WHO and BDW do not provide specific limits, the Ambient Water Quality Criteria (AWQC) recommend a maximum of 25 mg/L. All sites are within this range, indicating low levels of suspended matter and good water clarity. W4 recorded the highest TSS but remains acceptable.

5. Salinity

The salinity levels ranged from 14.3 mg/L at W2 to 27.3 mg/L at W8, which are well below the maximum permissible limits specified by international and Bhutanese standards. According to the AWQC (2020) and EPA (2015) guidelines, no explicit salinity limit is set, but related parameters like TDS and electrical conductivity (EC) show values consistent with freshwater quality. The salinity values observed indicate that the water samples are fresh and unlikely to pose salinity-related issues for drinking or aquatic life. These low salinity levels correspond with low TDS and EC values, confirming minimal dissolved salts in the water. Overall, the salinity concentrations in the sampled water bodies are within acceptable ranges for both human consumption and ecological health, reflecting good water quality conditions in the surveyed locations.

6. Turbidity

Turbidity ranged from 1.07 NTU (W1) to 10.74 NTU (W10). WHO's permissible limit is 10 NTU. All sites are within the safe limit except W10 (10.74 NTU), which slightly exceeds the threshold, possibly due to localized sediment disturbance during monsoon runoff. Higher turbidity at W10 suggests increased particulate matter and may require monitoring for filtration purposes.

7. Electrical Conductivity (EC)

EC ranged from 18.9 µS/cm (W2) to 48.8 µS/cm (W8), significantly lower than the WHO permissible limit of 1500 µS/cm. This indicates very low mineralization and negligible salinity, making the water suitable for drinking, irrigation, and industrial use without scaling risks.

Chemical parameters

Overall, the chemical water quality in the study area during the monsoon season is largely within permissible limits for drinking and aquatic life, except for dissolved oxygen (DO) in some sites and iron (Fe) in all sites. Low DO in upstream sites (W1–W4) suggests reduced aeration during high flows, which could affect sensitive macroinvertebrates. High iron concentrations, especially at W10, likely result from monsoon-driven soil erosion and runoff from iron-rich geology. Hardness, chloride, ammonia, manganese, and fluoride remain within safe limits, confirming that the water is chemically suitable for most uses, with minimal treatment needed for Fe removal. Most nutrient and trace element concentrations are within safe limits, except phosphorus, which is alarmingly high at several sites (W6–W10). This suggests significant nutrient loading from agricultural runoff, soil erosion, and organic matter decomposition during monsoon floods. While low nitrate minimizes the immediate risk of eutrophication, elevated phosphorus could trigger algal blooms during low-flow periods. Mercury, arsenic, and zinc remain negligible, indicating no industrial or heavy metal contamination. Overall, phosphorus enrichment appears to be the major chemical concern in the monsoon season. All tested parameters—Cd, BOD, COD, SO_4^{2-}, Na, and Ca—are within permissible limits, indicating no heavy metal contamination and low to moderate organic load in the monsoon season (Table 4.3). However, sites W7–W10 show slightly higher BOD, likely from organic matter influx during heavy rains. Overall, the water remains of good chemical quality, with soft characteristics due to low hardness and major ions. The dominant concern remains organic load in downstream sites, which may affect oxygensensitive aquatic species.

Table 4.3: Chemical parameters for monsoon season and recommendations/limits

Parameters		**DO (mg/L)**	**Total Hardness (mg/L caco3)**	**Cl (mg/L)**	**NH_3 (mg/L)**	**Fe (ppm)**	**Mn (mg/L)**	**F (mg/L)**
Standards	AWQC	61 4[2]	200[1]	501 2002	0.05[1] 0.5[2]	0.05[1] 0.5[2]	0.05[1] 0.5[2]	0.05[1] 0.5[2]
	BDW	-	-	-	-	-	-	-
	EPA	8.5[a]	100a 500[b]	250[b]	0.3[b]	0.3[b]	0.3[b]	0.3[b]
	WHO*	-	500	250	1.5	1.5	1.5	1.5
Sampling Sites	W1	5.13	24.00	49.63	0.05	0.624	<0.001	0.200
	W2	5.12	40.00	24.82	0.03	0.703	<0.001	0.100
	W3	4.9	22.00	24.82	0.03	0.628	<0.001	0.200
	W4	5.89	24.00	49.63	0.03	0.491	<0.001	0.100
	W5	7.01	42.00	49.63	0.03	0.794	<0.001	0.300

	W6	6.8	48.00	49.63	0.03	1.794	<0.001	0.100
	W7	6.08	40.00	74.45	0.02	2.794	<0.001	0.100
	W8	6.01	56.00	99.26	0.03	3.794	<0.001	0.100
	W10	5.9	48.00	99.26	0.03	5.794	<0.001	0.100

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

8. Dissolved Oxygen (DO)

DO ranged from 4.9 mg/L (W3) to 7.01 mg/L (W5). According to AWQC, the desirable limit for aquatic life is ≥6 mg/L. Only W5, W6, W7, and W8 meet or approach this requirement, while W1, W2, W3, W4, and W10 fall below the limit, indicating potential stress for sensitive aquatic species like mayflies and stoneflies. Lower DO levels during the monsoon may result from increased organic matter decomposition and reduced aeration due to high flow turbidity.

9. Total Hardness (as $CaCO_3$)

The total hardness levels, expressed as mg/L of $CaCO_3$, ranged from 22.00 mg/L (W3) to 56.00 mg/L (W8) across the sampling sites. These values were well below the WHO and EPA maximum permissible limit of 500 mg/L, indicating that the water is soft to moderately hard, with no adverse health implications. Water hardness in this range is not considered a health hazard; in fact, moderate hardness contributes essential minerals such as calcium and magnesium, which are beneficial to human health. Ecologically, such levels are ideal for aquatic life, supporting enzyme function and shell formation in invertebrates. Therefore, the observed hardness levels are safe for drinking and pose no ecological concern, although slightly higher values at W8 and W10 may influence taste or soap lathering but remain within acceptable limits.

10. Chloride (Cl^-)

Chloride levels varied from 24.82 mg/L (W2 & W3) to 99.26 mg/L (W8 & W10), remaining well below the WHO limit of 250 mg/L. Higher values at W7–W10 compared to upstream sites may reflect slight anthropogenic input or natural mineral weathering. All sites are safe for drinking and irrigation, with no risk of salinity issues.

11. Ammonia (NH_3)

Ammonia concentrations were consistently low across all sites (0.02–0.05 mg/L), which is within EPA and WHO limits (1.5 mg/L). These low levels indicate minimal organic pollution and healthy nitrogen cycling, likely due to well-oxygenated flow despite some sites having marginal DO.

12. Iron (Fe)

Iron showed significant variation, from 0.491 ppm (W4) to 5.794 ppm (W10). WHO and EPA recommend a maximum of 0.3 ppm, meaning all sites exceed permissible limits, with W10 showing the highest concentration. Elevated Fe during the monsoon likely results from soil leaching, erosion, and sediment inflow. This could cause staining and taste issues in drinking water and suggests a need for filtration if used domestically.

13. Manganese (Mn)

Manganese was below detection level (<0.001 mg/L) in all sites, well within the WHO limit of 0.1 mg/L. This indicates no contamination from Mn-bearing minerals or industrial sources.

14. Fluoride (F^-)

Fluoride concentrations ranged from 0.1 to 0.3 mg/L, well below the WHO limit of 1.5 mg/L. These levels suggest no risk of dental or skeletal fluorosis and indicate safe water for consumption.

Table 4.4: Chemical Parameters for Monsoon Season and Recommendations/Limits

Parameters		**NO3 (mg/L)**	**P (ppm)**	**K (mg/L)**	**Mg (mg/L)**	**Hg (mg/L)**	**As (mg/L)**	**Zn (mg/L)**
Standards	AWQC	0.05[1] 0.5[2]	0.05[1] 0.5[2]	-	-	0.0005	0.01[1] 0.05[2]	0.21 0.5[2]
	BDW	-	-	-	-	0.006	0.01	-

	EPA	0.3[b]	0.3[b]	-	-	0.001[b]	0.01[b]	1b (Fresh water)
	WHO*	1.5	1.5	1.5	50	0.001	0.01[a] 0.05[b]	3
Sampling Sites	W1	<10	0.04	3.6	8.00	<0.001	<0.02	<0.001
	W2	<10	0.05	1.8	30.00	<0.001	<0.02	<0.001
	W3	<10	0.04	2.7	8.00	<0.001	<0.02	<0.001
	W4	<10	0.05	3.4	18.00	<0.001	<0.02	<0.001
	W5	<10	0.03	2.7	36.00	<0.001	<0.02	<0.001
	W6	<10	1.03	1.6	40.00	<0.001	<0.02	<0.001
	W7	<10	2.03	1.3	36.00	<0.001	<0.02	<0.001
	W8	<10	3.03	0.1	46.00	<0.001	<0.02	<0.001
	W10	<10	5.03	3	46.00	<0.001	<0.02	<0.001

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

15. Nitrate (NO_3^-)

Nitrate levels were recorded as <10 mg/L at all sites. This is well below WHO's permissible limit of 1.5 mg/L and the EPA limit of 0.3 mg/L for freshwater ecosystems. These low levels indicate minimal agricultural runoff or sewage contamination during the monsoon season, possibly due to dilution from heavy rainfall. Low nitrate suggests low risk of eutrophication in these streams.

16. Phosphorus (P)

Phosphorus ranged from 0.03 ppm (W5) to 5.03 ppm (W10). WHO and EPA guidelines recommend a maximum of 0.3 mg/L (0.3 ppm), so W6 (1.03 ppm), W7 (2.03 ppm), W8 (3.03 ppm), and W10 (5.03 ppm) greatly exceed the permissible limits. High phosphorus levels in these downstream sites could be attributed to runoff from agricultural lands, organic matter decomposition, and soil erosion during the monsoon. Elevated P indicates a risk of nutrient enrichment and potential algal growth if flow conditions stabilize.

17. Potassium (K)

Potassium levels were generally low, ranging from 0.1 mg/L (W8) to 3.6 mg/L (W1), with no established WHO or EPA limits. These concentrations are typical for natural waters and do not pose any health risk. Variability likely reflects geological differences and leaches from soils.

18. Magnesium (Mg)

The magnesium concentrations across the sampling sites ranged from 8.00 mg/L (W1 and W3) to a high of 46.00 mg/L (W8 and W10). These levels fall well within the generally accepted natural background range for freshwater ecosystems and do not pose ecological risks, as magnesium is an essential nutrient for both aquatic flora and fauna. It plays a key role in enzyme activation, photosynthesis, and fish metabolism. No thresholds for ecological toxicity were breached. From a drinking water perspective, while BDWQS 2016 do not specify a permissible limit for magnesium, the WHO Guidelines for Drinking Water Quality suggest that magnesium concentrations below 50 mg/L are generally considered safe and do not present a health concern for most individuals. Therefore, based on existing international references and ecological tolerances, the magnesium levels observed at these sites are not only safe for human consumption but also environmentally benign. However, in cases such as W8 and W10 where the concentrations approach the upper informal limit (46 mg/L) (Table 4.4), regular monitoring is advisable, especially in areas with populations sensitive to water hardness or with pre-existing renal issues.

19. Mercury (Hg)

Mercury was below detection (<0.001 mg/L) at all sites, meeting the WHO and EPA limit of 0.001 mg/L. This suggests no contamination from industrial discharge or mining activities.

20. Arsenic (As)

Arsenic concentrations were also below detection (<0.02 mg/L) across all sites, complying with the WHO and EPA limit of 0.01 mg/L. This indicates the absence of geogenic arsenic contamination, which is a concern in some regions.

21. Zinc (Zn)

Zinc was below detection (<0.001 mg/L) at all sites, well within the WHO permissible limit of 3 mg/L and EPA's 1 mg/L for freshwater. This means no anthropogenic zinc input and safe levels for aquatic life and drinking purposes.

Table 4.5: Chemical Parameters for Monsoon Season and Recommendations/Limits

Parameters		**Cd (mg/L)**	**BOD (mg/L)**	**COD (mg/L)**	**SO4 (mg/L)**	**Na (mg/L)**	**Cu (mg/L)**	**Ca (mg/L)**
Standards	AWQC	0.003[1]	21 52 50[3]	0.05[1] 0.5[2]	250a 400[b]	-	0.05[1] 0.01[2]	-
	BDW	-	-	-	-	-	-	-
	EPA	0.005[b]	10	0.3[b]	250[b]	-	0.005[a] 0.01[b]	-
	WHO*	0.003	6	1.5	250 500[b]	200	1	75
Sampling Sites	W1	<0.02	2.83	1.43	3.36	2.100	0.030	16.00
	W2	<0.02	3.14	2.83	2.10	2.600	0.030	10.00

	W3	<0.02	1.45	2.63	3.16	1.000	0.030	14.00
	W4	<0.02	0.46	4.07	2.90	1.400	0.030	6.00
	W5	<0.02	1.02	3.73	2.56	4.300	0.080	6.00
	W6	<0.02	1.46	6.61	2.18	2.600	0.080	8.00
	W7	<0.02	3.78	4.59	2.56	2.700	0.090	4.00
	W8	<0.02	3.57	8.50	3.57	2.600	0.090	10.00
	W10	<0.02	5.24	9.66	2.90	1.000	0.050	2.00

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

22. Cadmium (Cd)

Cadmium was below detection (<0.02 mg/L) in all sites. The WHO permissible limit is 0.003 mg/L, and EPA sets 0.005 mg/L. Although the reported detection limit is higher than the standards, the non-detection suggests cadmium is not a concern in these waters.

Its absence indicates no contamination from industrial sources or phosphate fertilizers.

23. Biochemical Oxygen Demand (BOD)

BOD ranged from 0.46 mg/L (W4) to 5.24 mg/L (W10). WHO recommends ≤6 mg/L for surface waters, while EPA suggests 10 mg/L as a desirable limit. All sites are within permissible limits, but W10 shows the highest BOD (5.24), indicating moderate organic pollution, likely from domestic waste or agricultural runoff during monsoon rains. Sites W7 and W8 (3.78–3.57 mg/L) also indicate organic load that could stress sensitive aquatic organisms.

24. Chemical Oxygen Demand (COD)

COD ranged from 1.43 mg/L (W1) to 9.66 mg/L (W10), all well below the WHO permissible limit of 250 mg/L and AWQC's guideline for good quality water (≤50 mg/L). These low values indicate limited industrial or chemical contamination, consistent with a rural watershed setting.

25. Sulfate (SO_4^{2-})

Sulfate levels ranged from 2.10 mg/L (W2) to 3.57 mg/L (W8), far below the WHO and EPA guideline of 250 mg/L. These values are typical of natural background concentrations and pose no health or environmental concerns.

26. Sodium (Na)

Sodium concentrations varied from 1.0 mg/L (W3, W10) to 4.3 mg/L (W5). No strict drinking water standards exist for sodium (except for taste concerns at >200 mg/L), so these levels are extremely low and safe, suggesting minimal contribution from urban or industrial effluents.

27. Copper (Cu)

The concentration of copper across the water samples from ranged from 0.030 mg/L to 0.090 mg/L, with the lowest values observed at W1–W4 (0.030 mg/L) and the highest at W7 and W8 (0.090 mg/L). While the BDWQS (2016) does not specify a limit for copper, international benchmarks provide context. The WHO guideline sets a health-based maximum of 2.0 mg/L, and the EPA drinking water Action Level is 1.3 mg/L, both of which are significantly higher than the concentrations observed at all sites. However, when referenced against the more stringent AWQC for high-quality source waters—0.05 mg/L for Class A waters—Cu levels at W5–W8 and W10 exceed this threshold, suggesting potential concern for direct abstraction without treatment. Despite this, from a drinking water safety perspective, all sites remain well within international safety limits, indicating that the copper concentrations present no significant health risk. Ecologically, such low levels of copper are unlikely to cause toxicity to aquatic organisms, though continuous monitoring is advisable for upstream catchments where values begin to approach Class A limits, particularly if the water body is intended for sensitive uses.

28. Calcium (Ca)

Calcium ranged from 2 mg/L (W10) to 16 mg/L (W1), which is well below the WHO limit of 75 mg/L for drinking water. These low levels indicate soft water, consistent with the geology of the region. Higher Ca in W1 (16 mg/L) could be due to localized carbonate rock influence.

Microbiological Parameters

Microbiological quality is the most critical concern during the monsoon season. E. coli presence in most sites confirms recent fecal contamination, while elevated fecal and total coliform counts at W5, W6, W7, and especially W10 suggest domestic sewage and agricultural runoff influence downstream (Table 4.6). Sites W3 and W8 are the only locations with zero coliforms, indicating relatively protected catchments. Direct consumption without treatment poses a high health risk, particularly for diarrheal and waterborne diseases. Boiling, chlorination, or advanced disinfection is essential before drinking.

Table 4.6: Microbiological Parameters for Monsoon Season and

Recommendations/Limits

Parameters		*E. coli*	Fecal Coliform (CFU/100ml)	Total Coliform (CFU/100ml)
Standards	AWQC	0	201 2,000[2] 5,000[3]	501 5,000[2] 10,000[3]
	BDW	0	0	-
	EPA	0	0	Not more than 5%
	WHO*	0	0	95% in sample
Sampling Sites	W1	Present	3	10
	W2	Present	5	25
	W3	Absent	0	0
	W4	Present	25	50
	W5	Present	100	300
	W6	Present	50	150
	W7	Present	40	100
	W8	Absent	0	0
	W10	Present	150	450

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

29. E. coli

E. coli was present in 7 out of 9 sites, except W3 and W8, which showed absence.

According to WHO, EPA, and BDW standards, the permissible limit for *E. coli* is 0 CFU/100 mL, meaning any presence is unsafe for drinking without treatment. The detection of E. coli at W1, W2, W4, W5, W6, W7, and W10 suggests recent fecal contamination, likely from domestic sewage, livestock runoff, or open defecation during heavy rains.

30. Fecal Coliform

Fecal coliform counts ranged from 3 CFU/100 mL (W1) to 150 CFU/100 mL (W10). WHO and EPA standards require 0 CFU/100 mL for drinking water, but AWQC allows up to 20 CFU/100 mL for high-quality sources and 5,000 CFU/100 mL for moderate use. W1 and W2 have relatively low levels (3–5 CFU/100 mL), while W10 (150 CFU/100 mL) indicates significant contamination. High counts at W4, W5, W6, and W7 point to stormwater or livestock contributions during the monsoon.

31. Total Coliform

Total coliform ranged from 10 CFU/100 mL (W1) to 450 CFU/100 mL (W10), well below AWQC's moderate-use threshold of 10,000 CFU/100 mL, but any presence exceeds WHO and BDW drinking water standards (should be 0 CFU/100 mL). This indicates general microbial contamination, potentially from soil, vegetation, or human waste.

In summary, the overall water quality during the monsoon season indicates that the river system falling along the transmission line is largely pristine with excellent physical and chemical characteristics, such as neutral pH, low TDS, minimal suspended solids, and negligible heavy metal contamination, making it generally suitable for drinking and aquatic life. However, two major concerns emerged: biological contamination and localized nutrient enrichment. While most chemical parameters were within permissible limits, dissolved oxygen was suboptimal in upstream sites (W1–W4), and iron concentrations exceeded WHO standards across all sites, peaking at W10 due to monsoon-driven soil erosion. Phosphorus levels were significantly high in downstream locations (W6–W10), reflecting nutrient runoff from agriculture and organic matter decomposition, posing a risk of eutrophication in low-flow periods. Microbiological analysis revealed widespread fecal contamination, with E. coli present in seven out of nine sites and highest coliform counts at W10, indicating strong anthropogenic influence downstream. W3 and W8 were the only sites meeting microbiological standards, suggesting relatively undisturbed catchments. Overall, the water is chemically safe but microbiologically unsafe for direct consumption, requiring disinfection and filtration, while downstream nutrient enrichment and organic load necessitate continuous monitoring to prevent long-term ecological impacts.

Appendix 4-2. List of IBAT Red List species in the PA, BC, CF and project site

Table A3-2a: Presence of IBAT reported species in Protected Areas and Community Forests in the Project Area

IUCN Red List categories: CR - Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Near Threatened (NT), WCNP - Wangchuck Centennial National Park, PNP - Phrumsengla National Park, BC4 - Biological Corridor 4, CF1 - Garabling, CF2 - Phomrong, CF3 - Nangnang

#	*Scientific Name*	Common Name	IUCN	Elevation range (WCNP)	WCNP	PNP	BC4	CF1	CF2	CF3	Mammal survey	Bird survey
Mammalia												
1	*Manis pentadactyla*	Chinese Pangolin	CR									
2	*Moschus fuscus*	Black Musk Deer	EN									
3	*Moschus chrysogaster*	Alpine Musk Deer	EN		✓	✓						
4	*Cuon alpinus*	Dhole	EN	2000-3900	✓	✓	✓				✓	
5	*Moschus leucogaster*	Himalayan Muskdeer	EN	2900-4400			✓					
6	*Ailurus fulgens*	Red Panda	EN	3050-4000	✓	✓	✓					
7	*Trachypithecus geei*	Gee's Golden Langur	EN				✓					
8	*Panthera tigris*	Tiger	EN	2250-2950	✓	✓	✓					
9	*Trachypithecus pileatus ssp. tenebricus*	Tenebrous Capped Langur	EN		✓							
10	*Budorcas taxicolor*	Takin	VU	2250-3400	✓	✓						
11	*Capricornis sumatraensis*	Mainland Serow	VU	2400-3700								
12	*Ursus thibetanus*	Asiatic Black Bear	VU	2300-	✓	✓	✓	✓	✓	✓	✓	

#	***Scientific Name***	**Common Name**	**IUCN**	**Elevation range (WCNP)**	**WCNP**	**PNP**	**BC4**	**CF1**	**CF2**	**CF3**	**Mammal survey**	**Bird survey**
				3400								
13	*Arctictis binturong*	Binturong	VU									
14	*Rusa unicolor*	Sambar	VU	1600-3400	✓	✓	✓				✓	
15	*Panthera uncia*	Snow Leopard	VU		✓							
16	*Trachypithecus pileatus*	Capped Langur	VU	3000-3200	✓		✓					
17	*Lutrogale perspicillata*	Smooth-coated Otter	VU									
18	*Aonyx cinereus*	Asian Small-clawed Otter	VU			✓						
19	*Canis lupus ssp. chanco*	Himalayan Wolf	VU									
20	*Neofelis nebulosa*	Clouded Leopard	VU		✓	✓	✓					
21	*Catopuma temminckii*	Asian Golden Cat	VU		✓		✓					
22	*Panthera pardus*	Leopard	VU	1600-2400	✓							
23	*Lutra lutra*	Eurasian Otter	NT				✓					
24	*Naemorhedus goral*	Himalayan Goral	NT	2500-3500	✓		✓					
25	*Ratufa bicolor*	Black Giant Squirrel	NT		✓		✓					
26	*Panthera pardus ssp. fusca*	Indian Leopard	NT				✓					
27	*Petaurista nobilis*	Bhutan Giant Flying Squirrel	NT									
28	*Mustela altaica*	Altai Weasel	NT									
29	*Pteropus medius*	Indian Flying Fox	NT									

#	*Scientific Name*	Common Name	IUCN	Elevation range (WCNP)	WCNP	PNP	BC4	CF1	CF2	CF3	Mammal survey	Bird survey
30	*Pardofelis marmorata*	Marbled Cat	NT		✓		✓					
31	*Rousettus leschenaultii*	Leschenault's Rousette	NT									
32	*Macaca assamensis ssp. assamensis*	Assam Macaque	NT	1700-3000	✓							
33	*Macaca assamensis ssp. pelops*	Assam Macaque	NT									
34	*Macaca assamensis*	Assamese Macaque	NT		✓		✓					
35	*Ovis ammon*	Argali	NT									
Aves												
1	*Sarcogyps calvus*	Red-headed Vulture	CR									
2	*Gyps bengalensis*	White-rumped Vulture	CR									
3	*Ardea insignis*	White-bellied Heron	CR			✓						
4	*Falco cherrug*	Saker Falcon	EN									
5	*Haliaeetus leucoryphus*	Pallas's Fish-eagle	EN		✓	✓						
6	*Aquila nipalensis*	Steppe Eagle	EN									
7	*Calidris tenuirostris*	Great Knot	EN									
8	*Aquila heliaca*	Eastern Imperial Eagle	VU									
9	*Aceros nipalensis*	Rufous-necked Hornbill	VU			✓						
10	*Calidris ferruginea*	Curlew Sandpiper	VU									
11	*Calidris falcinellus*	Broad-billed Sandpiper	VU									
12	*Sitta formosa*	Beautiful Nuthatch	VU			✓						

#	*Scientific Name*	Common Name	IUCN	Elevation range (WCNP)	WCNP	PNP	BC4	CF1	CF2	CF3	Mammal survey	Bird survey
13	*Tragopan blythii*	Blyth's Tragopan	VU									
14	*Pluvialis squatarola*	Grey Plover	VU									
15	*Aythya ferina*	Common Pochard	VU									
16	*Sterna aurantia*	River Tern	VU									
17	*Gallinago nemoricola*	Wood Snipe	VU									
18	*Prinia cinereocapilla*	Grey-crowned Prinia	VU									
19	*Numenius arquata*	Eurasian Curlew	NT									
20	*Lophotriorchis kienerii*	Rufous-bellied Eagle	NT									
21	*Treron phayrei*	Ashy-headed Green-pigeon	NT									
22	*Calidris canutus*	Red Knot	NT									
23	*Apus acuticauda*	Dark-rumped Swift	NT									
24	*Arenaria interpres*	Ruddy Turnstone	NT									
25	*Calidris alpina*	Dunlin	NT									
26	*Psittacula alexandri*	Red-breasted Parakeet	NT									
27	*Gypaetus barbatus*	Bearded Vulture	NT									
28	*Aegypius monachus*	Cinereous Vulture	NT									
29	*Nisaetus nipalensis*	Mountain Hawk-eagle	NT									✓
30	*Arborophila mandellii*	Chestnut-breasted Partridge	NT			✓						
31	*Cyornis magnirostris*	Large Blue Flycatcher	NT									
32	*Calliope pectardens*	Firethroat	NT									
33	*Gyps himalayensis*	Himalayan Griffon	NT									✓

#	*Scientific Name*	Common Name	IUCN	Elevation range (WCNP)	WCNP	PNP	BC4	CF1	CF2	CF3	Mammal survey	Bird survey
34	*Ducula aenea*	Green Imperial-pigeon	NT									
35	*Grus nigricollis*	Black-necked Crane	NT		✓							
36	*Aythya nyroca*	Ferruginous Duck	NT									
37	*Stachyris humei*	Blackish-breasted Babbler	NT									
38	*Vanellus vanellus*	Northern Lapwing	NT									
39	*Vanellus duvaucelii*	River Lapwing	NT									
40	*Calidris ruficollis*	Red-necked Stint	NT									
41	*Limosa lapponica*	Bar-tailed Godwit	NT									
42	*Falco chicquera*	Red-headed Falcon	NT									
Amphibia												
1	*Amolops monticola*	Mountain Cascade Frog	EN									
Reptilia												
1	*Cuora mouhotii*	Keeled Box Turtle	EN									
2	*Ophiophagus hannah*	King Cobra	VU		✓							
3	*Oligodon juglandifer*	Walnut Kukri Snake	VU									
4	*Elaphe taeniura*	Cave Racer	VU									
5	*Varanus bengalensis*	Bengal Monitor Lizard	NT		✓							
6	*Lycodon gammiei*	Gammie's Wolf Snake	NT									
7	*Ptyas korros*	Javan Rat Snake	NT									
1	*Bhutanitis ludlowi*	Ludlow's Bhutan Glory	EN									
Plantae												

#	***Scientific Name***	**Common Name**	**IUCN**	**Elevation range (WCNP)**	**WCNP**	**PNP**	**BC4**	**CF1**	**CF2**	**CF3**	**Mammal survey**	**Bird survey**
1	*Ophiorrhiza longii*		CR									
2	*Onosma griersonii*		CR									
3	*Nardostachys jatamansi*	Indian Nard	CR		✓							
4	*Cheirostylis sherriffii*		CR									
5	*Ceropegia dorjei*		CR									
6	*Dactylorhiza hatagirea*	Salampanja	EN									
7	*Sloanea tomentosa*	XIn Ye Hou Huan Xi	EN									
8	*Phoebe bootanica*		EN									
9	*Magnolia rostrata*	Changhui Houpo	EN									
10	*Carex nigra subsp. drukyulensis*		EN									
11	*Trillium govanianum*	Himalayan Trillium	EN			✓						
12	*Neopicrorhiza minima*		EN		✓							
13	*Impatiens sikkimensis*	Sikkim Balsam	EN									
14	*Ceropegia bhutanica*		EN									
15	*Trillium tschonoskii*	Keun-yeon-yeong-cho	EN				✓					
16	*Androsace hemisphaerica*		EN		✓							
17	*Bistorta griersonii*		EN		✓							
18	*Canarium strictum*	Kunthirikkam	EN									
19	*Podophyllum hexandrum*	Himalayan Mayapple	EN									
20	*Fritillaria cirrhosa*	Yellow Himalayan Fritillary	VU									
21	*Impatiens pseudolaevigata*	The Kameng Balsam	VU									
22	*Corallodiscus cooperi*		VU		✓							

#	*Scientific Name*	Common Name	IUCN	Elevation range (WCNP)	WCNP	PNP	BC4	CF1	CF2	CF3	Mammal survey	Bird survey
23	*Cymbopogon bhutanicus*		VU									
24	*Paris polyphylla*	Love Apple	VU			✓	✓					
25	*Beilschmiedia clarkei*		VU									
26	*Bambusa clavata*		VU									
27	*Lindera melastomacea*		VU									
28	*Litsea panamanja*		VU									
29	*Cinnadenia paniculata*		VU									
30	*Rauvolfia serpentina*	Indian Snakeroot	NT									
31	*Thamnocalamus spathiflorus var. bhutanensis*		NT									
32	*Citrus latipes*	Khasi papeda	NT									
33	*Herminium pygmaeum*		NT									
34	*Kickxia papillosa*		NT									
35	*Calophyllum polyanthum*	Malampunna	NT									
36	*Pedicularis dhurensis*		NT		✓							
37	*Hymenidium pilosum*	shu mao leng zi qin	NT									
Fungi												
1	*Ophiocordyceps sinensis*	Chinese Caterpillar Fungus	VU		✓							
				Total	**29**	**17**	**18**	**1**	**1**	**1**	**2**	**47**

Sources: Management and Conservation Plans of WCNP (2022), PNP (2019) and BC4. Management Plans of Garabling CF (2024), Phromphong CF (2019), and Nangnang CF (2024). Biodiversity survey reports of the Project.

Table A3-2b: Bird species recorded during the two surveys

	Common name	Scientific name	IUCN Red List status	FNCA Schedule (Bhutan)	Data source
1	Ashy-throated Warbler	*Phylloscopus maculipennis*	LC	Not listed	Vantage Point Survey
2	Bar-throated Minla	*Actinodura strigula*	LC	Not listed	Vantage Point Survey
3	Beautiful Rosefinch	*Carpodacus pulcherrimus*	LC	Not listed	Biodiversity Survey
4	Black Bulbul	*Hypsipetes leucocephalus*	LC	Not listed	Biodiversity Survey
5	Black Eagle	*Ictinaetus malaiensis*	LC	Not listed	Biodiversity Survey
6	Black-faced Laughingthrush	*Trochalopteron affine*	LC	Not listed	Biodiversity Survey
7	Black-rumped Magpie	*Pica botanensis*	LC	Not listed	Vantage Point Survey
8	Blyth's Leaf Warbler	*Phylloscopus reguloides*	LC	Not listed	Biodiversity Survey
9	Blue Whistling Thrush	*Myophonus caeruleus*	LC	Not listed	Both surveys
10	Blue-fronted Redstart	*Phoenicurus frontalis*	LC	Not listed	Both surveys
11	Brown Dipper	*Cinclus pallasii*	LC	Not listed	Both surveys
12	Brown Parrotbill	*Cholornis unicolor*	LC	Not listed	Vantage Point Survey
13	Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	LC	Not listed	Vantage Point Survey
14	Collared Grosbeak	*Mycerobas affinis*	LC	Not listed	Biodiversity Survey
15	Common Kestrel	*Falco tinnunculus*	LC	Not listed	Both surveys
16	Common / Feral Pigeon	*Columba livia*	LC	Not listed	Both surveys
17	Crested Kingfisher	*Megaceryle lugubris*	LC	Not listed	Vantage Point Survey
18	Darjeeling Woodpecker	*Dendrocopos darjellensis*	LC	Not listed	Biodiversity Survey
19	Dark-breasted Rosefinch	*Procarduelis nipalensis*	LC	Not listed	Vantage Point Survey
20	Dark-rumped Rosefinch	*Carpodacus edwardsii*	LC	Not listed	Vantage Point Survey
21	Eurasian Jay	*Garrulus glandarius*	LC	Not listed	Vantage Point Survey
22	Eurasian Sparrowhawk	*Accipiter nisus*	LC	Not listed	Biodiversity Survey
23	Eurasian Tree Sparrow	*Passer montanus*	LC	Not listed	Vantage Point Survey
24	Eurasian Wren	*Troglodytes troglodytes*	LC	Not listed	Vantage Point Survey
25	Goldcrest	*Regulus regulus*	LC	Not listed	Vantage Point Survey
26	Great Cormorant	*Phalacrocorax carbo*	LC	Not listed	Biodiversity Survey
27	Green-backed Sunbird	*Aethopyga nipalensis*	LC	Not listed	Vantage Point Survey
28	Green-backed Tit	*Parus monticolus*	LC	Not listed	Both surveys
29	Grey Bushchat	*Saxicola ferreus*	LC	Not listed	Vantage Point Survey
30	Grey-backed Shrike	*Lanius tephronotus*	LC	Not listed	Both surveys
31	Grey Wagtail	*Motacilla cinerea*	LC	Not listed	Biodiversity Survey
32	Grey-crested Tit	*Lophophanes dichrous*	LC	Not listed	Both surveys
33	Himalayan Buzzard	*Buteo refectus*	LC	Not listed	Both surveys
34	Himalayan Griffon	*Gyps himalayensis*	NT	Not listed	Vantage Point Survey
35	Satyr Tragopan	*Tragopan satyra*	LC	Schedule I (Totally Protected)	Biodiversity Survey

	Common name	Scientific name	IUCN Red List status	FNCA Schedule (Bhutan)	Data source
36	Himalayan Monal	*Lophophorus impejanus*	LC	Schedule I (Totally Protected)	Biodiversity Survey
37	Himalayan Wood Owl	*Strix nivicolum*	LC	Not listed	Biodiversity Survey
38	Hodgson's Redstart	*Phoenicurus hodgsoni*	LC	Not listed	Both surveys
39	Hodgson's Treecreeper	*Certhia hodgsoni*	LC	Not listed	Vantage Point Survey
40	Large-billed Crow	*Corvus macrorhynchos*	LC	Not listed	Both surveys
41	Lemon-rumped Warbler	*Phylloscopus chloronotus*	LC	Not listed	Vantage Point Survey
42	Little Bunting	*Emberiza pusilla*	LC	Not listed	Biodiversity Survey
43	Little Forktail	*Enicurus scouleri*	LC	Not listed	Vantage Point Survey
44	Maroon-backed Accentor	*Prunella immaculata*	LC	Not listed	Vantage Point Survey
45	Mountain Hawk-Eagle	*Nisaetus nipalensis*	NT	Not listed	Vantage Point Survey
46	Olive-backed Pipit	*Anthus hodgsoni*	LC	Not listed	Both surveys
47	Oriental Skylark	*Alaudala gulgula*	LC	Not listed	Biodiversity Survey
48	Oriental Turtle-Dove	*Streptopelia orientalis*	LC	Not listed	Vantage Point Survey
49	Plain Mountain Finch	*Leucosticte nemoricola*	LC	Not listed	Both surveys
50	Plumbeous Redstart	*Phoenicurus fuliginosus*	LC	Not listed	Vantage Point Survey
51	Red Crossbill	*Loxia curvirostra*	LC	Not listed	Vantage Point Survey
52	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	LC	Not listed	Both surveys
53	Red-headed Bullfinch	*Pyrrhula erythrocephala*	LC	Not listed	Biodiversity Survey
54	Red-tailed Minla	*Minla ignotincta*	LC	Not listed	Vantage Point Survey
55	Ruddy Shelduck	*Tadorna ferruginea*	LC	Not listed	Biodiversity Survey
56	Rufous-breasted Accentor	*Prunella strophiata*	LC	Not listed	Both surveys
57	Rufous-fronted Tit	*Aegithalos iouschistos*	LC	Not listed	Both surveys
58	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	LC	Not listed	Vantage Point Survey
59	Rufous-vented Tit	*Periparus rubidiventris*	LC	Not listed	Vantage Point Survey
60	Rusty-flanked Treecreeper	*Certhia nipalensis*	LC	Not listed	Both surveys
61	Slaty-backed Forktail	*Enicurus schistaceus*	LC	Not listed	Biodiversity Survey
62	Southern Nutcracker	*Nucifraga hemispila*	LC	Not listed	Vantage Point Survey
63	Spotted Laughingthrush	*Ianthocincla ocellata*	LC	Not listed	Vantage Point Survey
64	Spotted Nutcracker	*Nucifraga caryocatactes*	LC	Not listed	Both surveys
65	Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*	LC	Not listed	Biodiversity Survey
66	Striped-throated Yuhina	*Yuhina gularis*	LC	Not listed	Biodiversity Survey
67	White Wagtail	*Motacilla alba*	LC	Not listed	Both surveys
68	White-browed Fulvetta	*Fulvetta vinipectus*	LC	Not listed	Both surveys
69	White-capped Redstart	*Phoenicurus leucocephalus*	LC	Not listed	Both surveys
70	White-collared Blackbird	*Turdus albocinctus*	LC	Not listed	Biodiversity Survey

	Common name	Scientific name	IUCN Red List status	FNCA Schedule (Bhutan)	Data source
71	White-throated Redstart	*Phoenicurus schisticeps*	LC	Not listed	Biodiversity Survey
72	White-throated Laughingthrush	*Ianthocincla albogularis*	LC	Not listed	Vantage Point Survey
73	Yellow-billed Blue Magpie	*Urocissa flavirostris*	LC	Not listed	Both surveys
74	Yellow-browed Tit	*Sylviparus modestus*	LC	Not listed	Vantage Point Survey

Appendix 4-3. Wobthang Transmission Line Wet Season Report

ROYAL UNIVERSITY OF BHUTAN

Environmental Services for 132 kV D/C Wobthang Solar Transmission Line Project

College of Natural Resources

August 03, 2025

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CHAPTER ONE

1. Summary

This biodiversity and environmental assessment were conducted along the proposed 132 kV double circuit Wobthang Transmission Line, which spans approximately 68 kilometers across Bumthang and Trongsa Dzongkhags in Bhutan. The project aimed to evaluate the environmental baseline conditions during the wet season, focusing on terrestrial and aquatic biodiversity, as well as physical and atmospheric parameters. A combination of field methods including vegetation plots, camera trapping, bird point counts, aquatic sampling, and environmental monitoring was applied across representative sites. Results showed high floristic diversity across forest types, with endemic and scheduled species. Air and noise quality remained within permissible limits except for elevated values near industrial zones. Water quality was generally good in terms of physicochemical properties, but several downstream sites showed high phosphorus and iron levels, with widespread microbiological contamination due to monsoon-driven runoff. Mammal activity was confirmed by direct and indirect signs, while avifauna were richly noted across habitats. However, limited species of herpetofauna were recorded. The study provides crucial recommendations for conservation-sensitive infrastructure planning and emphasizes the importance of site-specific mitigation for sustainable development.

CHAPTER TWO

2. Introduction

The Royal Government of Bhutan is currently pursuing a balanced path of sustainable development, integrating ecological conservation with necessary infrastructure expansion. One such strategic initiative is the construction of a 132 kV double circuit (D/C) transmission line linking the 108 MW Wobthang Solar Farm in Bumthang to the Mangdechu-Yurmoo Transmission Line in Trongsa Dzongkhag. Given the project's geographic extend spanning 68 kilometers across ecologically diverse terrain—an indepth biodiversity and environmental baseline study was deemed essential to inform project planning and impact mitigation.

The transmission line traverses through Tang, Ura, Chhoekhor, Chumig, Nubi, Langthel, and Drakteng Gewogs, encompassing a range of ecosystems from warm broadleaf to mixed conifer forests. These habitats are known to support high biological diversity and include several species of ecological, economic, and conservation importnace. Moreover, the area includes vital riverine corridors, steep mountain slopes, and community-managed forests, all of which are vulnerable to anthropogenic disturbance.

This study, conducted during the wet season, aimed assess baseline environmental conditions, with particular attention to biodiversity (flora, fauna, aquatic species), air and noise pollution levels, meteorological variables, and water quality. A multi-faceted approach was applied using systematic and purposive sampling methods tailored to each thematic component. For terrestrial biodiversity, vegetation plots, point counts, visual encounter surveys, and camera trapping were employed. Aquatic biodiversity was evaluated through fish and macroinvertebrate sampling along streams intersecting the transmission line. Water quality was examined using both field and laboratory analyses across 31 parameters, and meteorological and ambient air data were gathered using real-time digital sensors.

The findings of this study are critical in establishing an ecological reference point before project implementation. They not only help determine the current health of the ecosystem but also identify sensitive zones that require focused mitigation and conservation strategies. Additionally, the study aligns with Bhutan's national policies, such as the Environmental Assessment Act 2000, Forest and Nature Conservation Act 2023, and Bhutan's Biodiversity Action Plan, which call for evidence-based planning that minimizes negative impacts on biodiversity and natural resources.

CHAPTER THREE

3. Materials and Methods

3.1. Study Area

The study area for the 132kV D/C Wobthang Transmission Line Project spans approximately 68 kilometers, beginning at the 108 MW Wobthang Solar Farm in Bumthang Dzongkhag and connecting to the Mangdechu-Yurmoo Transmission Line in Trongsa Dzongkhag. It crosses diverse terrains, including forested landscapes, riverine ecosystems, and settlements, traversing Gewogs such as Tang, Ura, Chhoekhor, Chumig, Nubi, Langthel, and Drakteng (Figure 3.1). The area of influence (AoI) includes a 250-meter buffer zone on either side of the transmission line, incorporating a 27-meter right-of-way (ROW). Sampling sites included forested areas, water bodies, and wildlife habitats crucial for species migration and biodiversity conservation.

Key assessments in the study area focused on ecological and physical parameters, including biodiversity inventory, water quality, and atmospheric conditions. This study area, marked by its ecological significance and diverse geography, presents an opportunity to balance infrastructure development with environmental stewardship. Findings from the study will guide mitigation measures and contribute to sustainable development efforts in Bhutan.

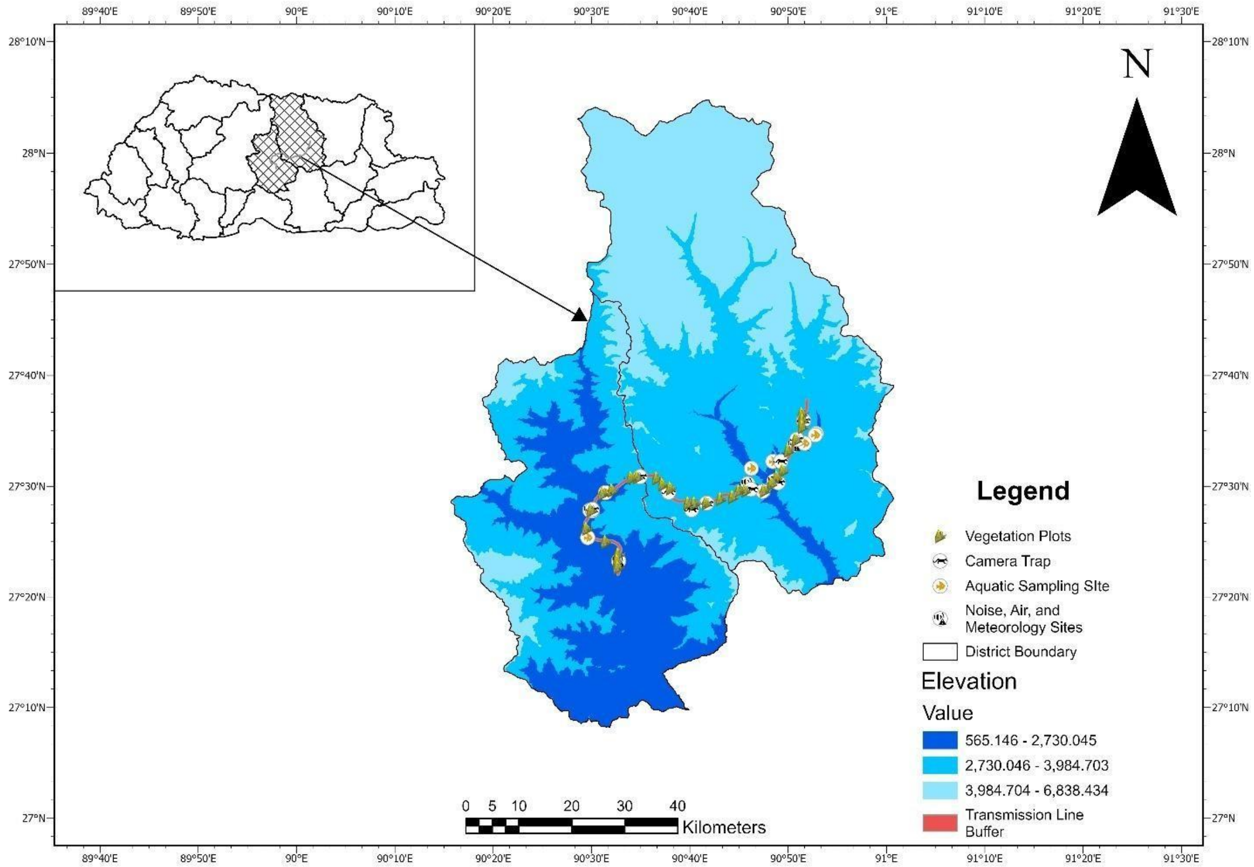

Figure 3.1: Study Area Representing the Vegetation Plots, Camera Trap Locations, Aquatic Sampling Sites, Noise, Air, and Meteorological Stations, and Transmission Line Buffer

3.1. Equipment Used

The materials required for data collection varied according to the type of sampling conducted. For environmental monitoring the air quality monitoring machine AQM 09 ((Oceanus, Henan, the People's Republic of China) was used. For vegetation sampling, equipment such as measuring tapes, diameter tapes, compass, GPS devices, and data sheets were used to record parameters including species composition, density, canopy cover, and other ecological variables. Likewise, for fish sampling, essential tools included a cast net with a 3-meter radius, spinner hook, seine net, and electro-shocker, as well as a flow meter for measuring water depth and velocity. Macroinvertebrate sampling used a kick net with a 25 cm × 25 cm frame and a 500 µm mesh, along with ethanol-filled containers for preserving specimens that cannot not be identified on-site. These materials were carefully chosen to ensure accuracy and efficiency in data collection across various aquatic habitats.

3.2. Sampling Design

3.2.1. Ambient Noise, Air Quality, Climate Meteorology

A purposive sampling design was adopted to assess ambient noise, air quality, and meteorological conditions across the Area of Influence (AoI) of the project. Monitoring stations were strategically selected to represent a range of land-use types, with emphasis on sensitive areas such as settlements and forest zones, as well as industrial and semiurban sites where applicable. The selected locations ensured adequate spatial coverage along the transmission line corridor and were chosen to capture potential variability in environmental conditions due to human activity, topography, and land-use patterns.

3.2.2. Terrestrial Biodiversity

The terrestrial biodiversity assessment for the 132 kV D/C Wobthang Transmission Line Project followed a systematic sampling design to ensure comprehensive data collection along the 68-kilometer alignment. A total of 30 sampling plots were established at intervals of approximately 2.34 kilometers, providing adequate spatial coverage and ecological representation. Plot locations were strategically selected based on the Terms of Reference (ToR), with an emphasis on ecologically sensitive areas, including diverse forest types and critical wildlife habitats. Each plot was surveyed for key parameters such as vegetation composition (including rare, endemic, and invasive species), habitat characteristics, and wildlife presence encompassing terrestrial mammals, birds, and herpetofauna. The surveys employed point count methods for avifauna, visual encounter surveys for herpetofauna, and camera trapping for terrestrial mammals. Camera traps were deployed at selected plots to record medium to large mammals, with placement based on signs of animal activity such as trails, scat, and tracks. The sampling approach was aligned with the national biodiversity assessment grid (4 × 4 km) established by the Department of Forest and Park Services (DoFPS, 2020), ensuring compatibility with existing national biodiversity datasets.

3.2.3. Aquatic Biodiversity

Sampling points for the aquatic biodiversity assessment were established at sites where the transmission lines crossed settlements and aquatic habitats. These locations were randomly chosen within predefined buffer zones along the transmission line corridors to provide representative spatial coverage. Sampling sites were selected to represent diverse habitat types (pools, riffles, runs) and ecological conditions, including upstream and downstream of the transmission line. Site selection prioritized ecological significance, accessibility, and habitats critical to vulnerable or endangered species. Of the ten proposed sampling sites, nine were accessible and included in the study, while one site was omitted due to inaccessibility. Key substrate composition and flow characteristics (river depth and velocity) were considered to ensure representative and comprehensive ecological assessment.

3.3. Data Collection Methods

3.3.1. Ambient Noise, Air Quality, Climate and Meteorology

To monitor noise and ambient air quality in the project area, a real-time ambient air quality monitoring system, AQM-09 (Oceanus, Henan, the People's Republic of China), was deployed across five strategically selected locations (Table 3.1), representing a mix of sensitive and industrial areas to ensure comprehensive spatial coverage and variability. The instrument is capable of simultaneously measuring particulate matter and gaseous pollutants, along with auxiliary environmental parameters such as ambient temperature, relative humidity, atmospheric pressure, wind direction, and wind speed. The AQM-09 is also integrated with a noise meter, enabling concurrent measurement of sound levels in decibels alongside air quality parameters. Noise monitoring was conducted over a 24-hour period, with measurements categorized into day (6:00 a.m. to 10:00 p.m.) and night (10:00 p.m. to 6:00 a.m.) intervals, in accordance with standard environmental assessment practices (National Environment Commission [NEC], 2020).

The device operates on the principle of light scattering to determine concentrations of particulate matter and utilizes electrochemical sensors for detecting gaseous pollutants. It is equipped with light-scattering diodes capable of measuring PM2.5, PM10, and total suspended particulates (TSP), and features pre-calibrated sensors for gaseous pollutants such as nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO).

Table 3.1: Ambient Noise and Air Quality Sampling Station Location Details

Sl. No.	Site Code	Date of Monitoring	Latitude	Longitude	Elevation
1	NA1	July 08, 2025	27.56233961	90.84364313	2808.80
2	NA2	July 10, 2025	27.50806837	90.80978459	2827.91
3	NA3	July 12, 202	27.50388024	90.76474474	2663.81
4	NA4	July 14, 2025	27.46390653	90.49728101	1918.30
5	NA5	July 16, 2025	27.387850	90.545917	2147.31

3.3.2. Terrestrial Biodiversity

3.3.2.1. Vegetation Data

Following DoFPS (2020) a major plot size of 400 m² (20 m × 20 m) was established at each site using nylon thread to sample trees and shrubs. Within the major plot, a minor subplot of 4 m^2 (2 m × 2 m) was established at the Southeast corner for collecting herbaceous vegetation data (Figure 3.2). Within the major plot, all tree species with a diameter at breast height (DBH) of ≥ 10 cm measured at 1.3 m height were recorded, along with their respective heights (Kaka et al., 2014). In addition to tree species, all shrub species representing various life forms were recorded, along with their respective heights. Within the 2 m × 2 m subplot, all herbaceous plant species were enumerated, and individual counts were recorded (Rabgay et al., 2020).

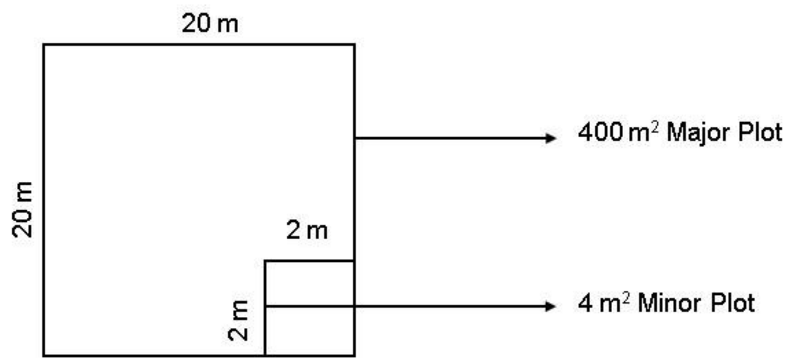

Figure 3.2: Vegetation Sampling Plot with Major Plot for Tree and Shrub sampling and Minor Plot for Herb Sampling

3.3.2.2. Terrestrial Mammals

To document terrestrial mammals, ten camera traps were deployed in forested areas following expert advice and insights from local ecological knowledge to capture real-time mammal activity, operating for approximately 13 trap nights each, totaling around 130 trap nights (Table 3.2). In addition to camera trap data, direct sightings and various wildlife signs, including pugmarks, hoof prints, droppings, scats, hairs, and burrows were recorded to understand mammal presence.

Table 3.2: Locations and details of camera traps used for terrestrial mammal monitoring

Sl. No.	Latitude	Lonngitude	Elevation (m asl)
1	27.59881	90.85966	3193
2	27.57044	90.84798	2984
3	27.53727	90.82041	2904
4	27.50531	90.81634	2769
5	27.49541	90.77034	2693
6	27.47444	90.69528	3014

7	27.464612	90.669406	3439
8	27.490831	90.630772	3236
9	27.514320	90.582333	3385
10	27.465172	90.501662	2079

3.3.2.3. Avifauna

Point count surveys were conducted to collect avifauna data within the vegetation plots. From the center of each 20 m × 20 m square vegetation plot, all birds seen or heard within fixed radius of 20 meters during a 20-minute period were recorded (Ralph et al., 1995; Vergara et al., 2010). Both visual and auditory detections were noted to maximize species identification. Conducting point counts from the center of established vegetation plots allowed direct correlation between bird presence and habitat characteristics measured within the plots (Kissling & Garton, 2006).

3.3.2.4. Herpetofauna

The herpetofauna survey, targeting reptiles and amphibians, was mainly carried out as a supplementary activity while accessing vegetation plots and surrounding areas. An opportunistic broad survey approach was used to locate and document herpetofauna within the sampling sites. Both transect walks and visual encounter surveys were conducted. Additionally, techniques such as rock rolling, vocalization monitoring, and targeted habitat searching were utilized. These methods involved carefully lifting and turning rocks to reveal concealed amphibians and reptiles, listening to their calls, and thoroughly exploring preferred habitats such as streams and ponds.

3.3.3. Aquatic Biodiversity

3.3.3.1. Fish Sampling

Fish sampling was conducted across a 300-meter stretch of the sampling site, encompassing various habitat types, including pools, riffles, and runs (Wangmo & Rai, 2019). The stretch was evenly divided into 150 meters upstream and 150 meters downstream of the designated sampling site (Figure 3.3). A combination of fishing gear was employed, including a cast net, spinner hook, gill net net, and electro-shocker, following a strict catch-and-release protocol to minimize harm to the fish population (Figure 3.4). No specimen was collected during the wet season survey.

For cast net sampling, a 3-meter radius net was thrown 30 times, with 15 throws upstream and 15 downstream within the designated sections. Gill nets were used at accessible sites to capture fish, targeting specific microhabitats, while rock-flipping and kick-sampling techniques were also employed to collect fish. Additionally, environmental parameters such as water depth and velocity were measured at each sampling location using a flow meter to provide site-specific contextual data (Figure 3.5).

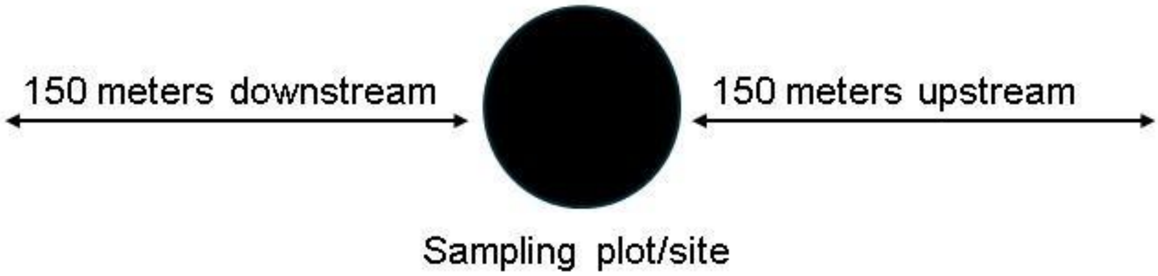

Figure 3.3: Fish Sampling Method Representing the Downstream and Upstream Sites

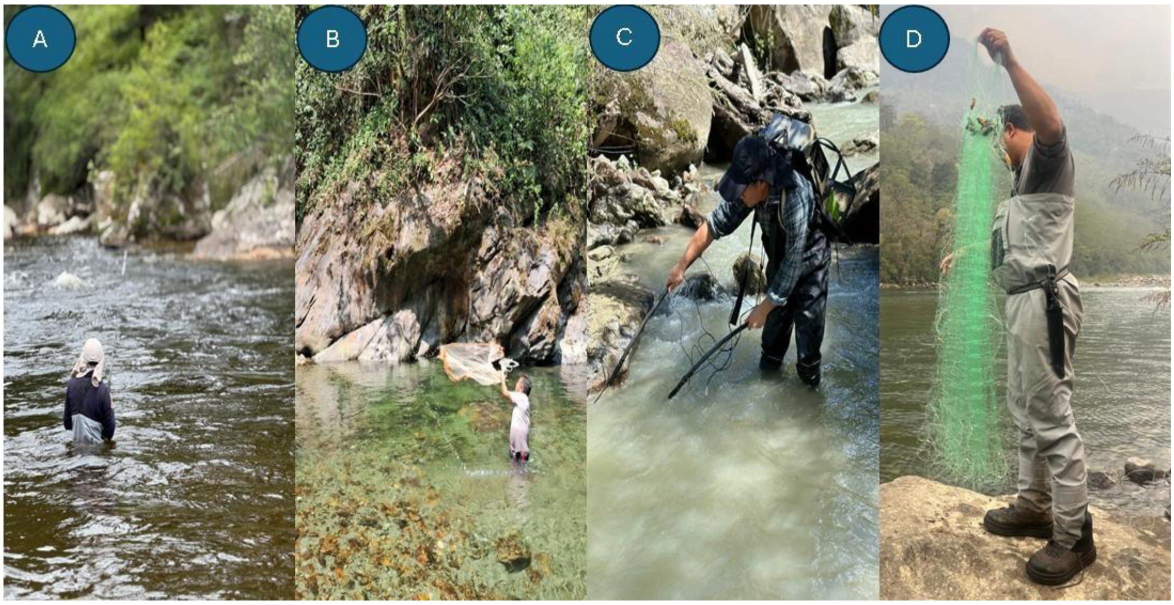

Figure 3.4: Different Fishing Method Employed in the Study, (a) Spinner and hook, (b) Cast Net, (c) Eectro Shocker, (d) Gill Net

Figure 3.5: Measurement of Environmental Parameters (Water Depth and Velocity) at Sampling Locations

3.3.3.2. Macroinvertebrate Sampling

To sample benthic macroinvertebrates, a multi-habitat sampling approach was applied. Microhabitat coverage, considering flow types at 5% intervals, was assessed within the 300-meter river stretch in wadable rivers, with twenty sub-samples proportionately collected from identified microhabitats. For non-wadable rivers, twenty samples were taken from the littoral sections of the same stretch. Kick nets (25 cm × 25 cm frame with a 500 µm mesh) were used to collect benthic samples by disturbing the river bottom to dislodge sediments and organisms, which were carried into the net by the water current (Figure 3.6). This method resulted in composite samples representing 1.25 m^2 of the riverbed surface. Most macroinvertebrate samples were identified up to the genus level on-site using standard identification references (Merritt et al., 2008; Thorp & Covich, 2010), while specimens that could not be identified were preserved in ethanol-filled containers labeled with the site code and sampling date for subsequent laboratory identification.

Figure 3.6: Macroinvertebrates Sampling Using Kick Net

3.3.4. Water Sampling

Water samples were collected and analyzed at the same locations where aquatic biodiversity surveys were conducted, allowing for direct correlation between physicochemical parameters and biotic communities. A total of 31 physicochemical water parameters were measured. Eleven parameters (pH, Temperature, Conductivity, Total

Dissolved Solids (TDS), Salinity, Turbidity, Dissolved Oxygen (DO), Biological Oxygen Demand, Total Coliform, Fecal Coliform, and *Escherichia coli* (*E. coli*) were tested on site, while water samples were collected using grab method for other parameters.

For total suspended solids (TSS), Chloride, Nitrate, Ammonia, Sulphate, Sodium, Potassium, and Fluoride, 500 mL of water were collected in clean polyethylene bottles without preservatives and refrigerated at 4°C (Zhang et al., 2017). For Iron, Manganese, Zinc, Copper, Calcium Hardness, Magnesium Hardness, Total Hardness, Mercury, Arsenic, and Cadmium, 250 mL of water were collected in acid-washed bottles and preserved with concentrated nitric acid (HNO_3) to maintain pH below 2. Similarly, for Chemical Oxygen Demand (COD), 250 mL of water was collected in acid-washed bottles, preserved with concentrated sulfuric acid (H_2SO_4) to pH < 2, and refrigerated at 4°C.

Similarly, for Total Orthophosphate, 250 mL of water was preserved with concentrated sulfuric acid (H_2SO_4) and stored in amber bottles in the dark to prevent photodegradation. Each sample bottle was clearly labeled with the sample ID, date and time of collection, preservation method, and targeted parameters. Samples were transported in coolers with ice packs to maintain a temperature of approximately 4°C and delivered to the Soil Air and Water Testing (SWAT) laboratory, College of Natural Resources, Royal University of Bhutan, for analysis (Table 3.3).

Table 3.3: Summary of Water Quality Parameters, Methods, Preservation, and Holding Time

Sl. No.	Parameter	Method / Instrument Used	Sample Volume	Storage Condition	Maximum Holding Time
1	pH	PCS Testr 35	On-site	Analyze immediately	15 minutes (max)
2	Temperature	PCS Testr 35		Analyze immediately	Instantaneous
3	Conductivity	PCS Testr 35		Analyze immediately	28 days (if cooled)
4	Total Dissolved Solids	PCS Testr 35		Analyze immediately	7 days
5	Salinity	PCS Testr 35		Analyze immediately	28 days
6	Turbidity	Nephelometric		≤6°C	48 hours
7	Dissolved Oxygen	Membrane Electrode		Analyze immediately	15 minutes (if unpreserved)
8	Biochemical Oxygen Demand (BOD)	Membrane Electrode		Analyze immediately	48 hours

9	Total Suspended Solids	Evaporating Method		≤6°C	7 days
10	Chloride	Argentometric		≤6°C	28 days
11	Nitrate	Jal Tara Test Kit		≤6°C	48 hours (unpreserved)
12	Ammonia	Phenate (4500-NH_3)		≤6°C, unpreserved or acidified	28 days (if acidified)
13	Sulphate	Turbidimetric		≤6°C	28 days
14	Sodium	Flame Photometer		≤6°C, acidify with HNO_3 (optional)	6 months (if acidified)
15	Potassium	Flame Photometer		≤6°C	6 months (if acidified)
16	Fluoride	Jal Tara test kit	500 mL	≤6°C	28 days

17	Iron (Fe)	Phenanthroline		pH < 2 with HNO_3, ≤6°C	6 months
18	Manganese (Mn)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
19	Zinc (Zn)	Spectrophotometric,		pH < 2 with HNO_3, ≤6°C	6 months
20	Copper (Cu)	UV/VIS Spectrophotometry		pH < 2 with HNO_3, ≤6°C	6 months
21	Calcium Hardness	EDTA Titrimetric	250 mL	≤6°C, acidified	6 months

22	Magnesium Hardness	EDTA Titrimetric		≤6°C, acidified	6 months
23	Total Hardness	EDTA Titrimetric		≤6°C, acidified	6 months
24	Mercury (Hg)	Colorimetric		pH < 2 with HNO_3, ≤6°C	28 days
25	Arsenic (As)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
26	Cadmium (Cd)	Colorimetric		pH < 2 with HNO_3, ≤6°C	6 months
27	Chemical Oxygen Demand (COD)	Dichromate		pH < 2 with H_2SO_4, ≤6°C	28 days (EPA)
28	Total Orthophosphate	Ascorbic Acid		pH < 2 with H_2SO_4,	28 days (EPA max)
				amber bottle, ≤6°C	
29	Total Coliform	Macconkey and Blood agar media and inoculation for 24 hours within 37°C	On-site /100 mL	≤10°C	24 hours
30	Fecal Coliform				
31	*E. coli*				

3.4. Data Analysis

Data was computed in Microsoft Excel and R software. Descriptive statistics were obtained to compare the results of different sites. Since there is no single diversity index more suitable than others, five commonly used diversity indices were tested for vegetation (tree, shrub, herb), (Kelzang et al., 2021; Morris et al., 2014). Shannon diversity index (Shannon & Wiener, 1949), Simpson's diversity index (Simpson, 1949), Pielou evenness index (*J*) (Pielou, 1966), Margalef's richness index

(Margalef, 1958), Menhinick index (D_{Mn}) (Menhinick, 1964), will be computed using the following formulae:

$H' = -\sum_{i=1}^{n} pi * lnpi$……………………………………………………………………….......... (1)

Where H'= Shannon diversity

p_i= The proportion of individuals belonging to the i^{th} species *ln*= Natural logarithm function

$D = 1 - \sum \frac{n\,i-1}{N(N-1)}$ ………………………………………………………………………………………… (2)

Where D = Simpson's diversity

n_i = The number of organisms that belong to species i N = The total number of organisms in the community

$J' = \frac{H'}{lnS}$……………………………………………………………………………………….. (3)

Where: J' = Pielous eveness index H'= Shannon Diversity Index.

S = Species richness

$D_{Mg} = \frac{(S-1)}{ln\,N}$……………………………………………………………………………………. (4)

Where: D_{MG}: Margalef's richness index

S = Species richness

N = Total number of individuals

$D_{Mn} = \frac{S^R}{\sqrt{n}}$………………………………………………………………………………………(5)

Where: D_{Mn} = Menhinick's index

S_R = species richness

N = Total number of individuals.

However, for fish and macroinvertebrates, only species diversity, species richness, and evenness were calculated. The Shannon diversity index (Shannon & Wiener, 1949) quantifies the uncertainty in predicting the species identity of a randomly chosen individual, with higher values (typically ranging from 1.5 to 3.5) indicating greater species diversity and more equitable abundance distributions. Similarly, Simpson's diversity index (Simpson, 1949) measures the probability that two randomly selected individuals belong to different species, where values closer to 1 denote higher diversity and values near 0 suggest dominance by a few species. The Pielou evenness index (Pielou, 1966) assesses the equitability of species distribution, ranging from 0 (highly uneven distribution) to

1 (perfect evenness). Margalef's richness index (Margalef, 1958) evaluates species richness relative to the logarithm of the sample size, with higher values indicating greater richness, particularly emphasizing the contribution of rare species. Lastly, the Menhinick index (Menhinick, 1964) standardizes species richness by the square root of the sample size, allowing for meaningful comparisons between samples of varying sizes. Together, these indices offer a comprehensive understanding of biodiversity by addressing different aspects of community composition and structure.

C HAPTER FOUR

4. Results and Discussion

4.1. Environmental Baseline

4.1.1. Air Quality

Air quality data collected from five sampling sites (NA1–NA5) indicate that concentrations of particulate matter (PM2.5, PM10, and total suspended particulates) were consistently low and well within the limits established by both the NEC (2020) and World Health WHO (2021) guidelines. The highest particulate levels were recorded at Site NA4, with PM2.5 at 3.6 µg/m³, PM10 at 5.2 µg/m³, and TSP at 8.5 µg/m³, all significantly below the respective standards (Table 4.1). This elevated concentration at NA4 could be attributed to its proximity to the Dzongkhalum, Trongsa which may influence local dust or emissions. All the sites reported undetectable levels of particulates. Gaseous pollutants such as nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) were below detection limits at all sites, while carbon monoxide (CO) was negligible, with only a trace concentration of 0.02 µg/m³ recorded at Site NA4. The overall low pollutant concentrations can be attributed in part to the sampling occurring during the wet season, which facilitates the removal of airborne particulates through precipitation and atmospheric cleansing processes. These findings suggest that the ambient air quality in the project area was good during the monitoring period, with minimal influence from industrial or combustion-related emissions.

Table 4.1: Concentrations of Particulate Matter (PM2.5, PM10, TSP) and Gaseous Pollutants (NO_2, SO_2, CO) at Five Monitoring Sites Compared with NEC and WHO Standards (µg/m³)

Parameters		$PM_{2.5}$	PM_{10}	TSP	NO_2	SO_2	CO

Unit		µg/m³					
Standards	NEC	60[a] 60[b]	75[a] 200[b]	100[a] 500[b]	15[a] 80[b]	30[a] 120[b]	1000[a] 5000[b]
	WHO	15	45	-	25	40	7
Sampling Sites	NA1	1	2	3.3	0	0	0
	NA2	1	2	4.6	0	0	0
	NA3	0	0	0	0	0	0
	NA4	3.6	5.2	8.5	0	0	0.02
	NA5	0	0	0	0	0	0

Note: $PM_{2.5}$ = Particulate Matter 2.5, PM_{10} = Particulate Matter 10, TSP = Total Suspended Particualtes, NO_2 = Nitrogen Dioxide, SO_2 = Sulphur Dioxide, CO = Carbon Monoxide.
NA1-NA5 = Noise and Air Monitoring sites 1 to 5,
- = No standard reference available [a] = Sensitive area (place like hospitals, schools, sensitive ecosystem) [b] = Industrial area
NEC = National Environment Commission Environmental Standards, 2020.
WHO = World Health Organization Global Air Quality Guidelines
The observations and air quality criteria is for 24 hours average

4.1.2. Water Quality

For the study, out of three water quality parameters *viz.,* biological, physical and chemical, the latter two were dealt with and studied in detail while only the microbiological parameters were studied for biological parameters. There were 31 water quality parameters studied from the water sampling sites. Under the physical parameters, pH, Temperature, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Salinity, Turbidity and Electrical Conductivity (EC) were studied. The chemical parameters included Dissolved Oxygen (DO), Total Hardness, Chloride (Cl), Ammonia (NH_3), Iron (Fe), Manganese (Mn), Copper (Cu), Magnesium (Mg), Fluoride (F), Nitrate (NO_3),

Phosphate (P), Potassium (K), Mercury (Hg), Arsenic (As), Zinc (Zn), Cadmium (Cd), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Sulphate (SO_4),

Sodium (Na) and Calcium (Ca). While under the microbiological parameters, Fecal Coliform, *Escherichia coli* and Total Coliform were taken into consideration.

Physical parameters

Overall, the water quality parameters across all sites during the monsoon season indicate excellent quality, within international and national standards. The water is soft, slightly acidic to neutral, and low in dissolved and suspended solids, which are characteristic of upland river systems with minimal anthropogenic influence. Slight turbidity exceedance at W10 likely results from increased sediment input due to monsoon runoff or localized erosion, which should be monitored. The low EC and TDS values confirm that the rivers are pristine and free from significant chemical contamination, making them suitable for drinking with minimal treatment (Table 4.2).

Table 4.2: Physical parameters for monsoon season and recommendations/limits

Parameters		**pH (scale)**	**Temp (°C)**	**TDS (mg/L)**	**TSS (mg/L)**	**Salinity (mg/L)**	**Turbidity (NTU)**	**EC (µS/cm)**
Standards	AWQC	6.5-8.5	-	500[1] 1500[2] 2100[3]	25[1] 100[2]	-	5[a]	800[1]
	BDW	6.5-8.5	-	-	-	-	5	-
	EPA	6.5-8.5[a]	25[a]	500[a] 1500[b]	50	<500 (Fresh water)	≤5[a]	2500[b]
	WHO*	6.5-8.5	-	1000	-	-	10[b]	1500
Sampling Sites	W1	7.12	17.1	19.1	6.89	18	1.07	26.7
	W2	7.5	17.3	12.9	4.61	14.3	1.28	18.9
	W3	6.95	19.2	20.2	5.19	19.2	1.29	28.7
	W4	6.69	16.4	22.1	10.67	15.9	3.22	22.1
	W5	6.95	17.2	26.8	3.46	22.3	5.74	38
	W6	7.22	14.7	31	4.46	23.8	6.74	44.2
	W7	7.05	15.4	22.4	5.46	26.9	7.74	38.4

	W8	7.07	16.8	34.9	6.46	27.3	8.74	48.8
	W10	7.09	15.5	17.3	8.46	16.4	10.74	23.5
Notes:								

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

1. pH

The pH across all sites ranged from 6.69 (W4) to 7.50 (W2). According to WHO, EPA, and BDW standards (6.5–8.5), all sites fall within the permissible range, indicating neutral to slightly acidic conditions at W4 and slightly alkaline at W2. These values suggest that the water is generally suitable for drinking and aquatic life without significant risk of acidity or alkalinity issues.

2. Temperature

The water temperature varied between 14.7°C (W6) and 19.2°C (W3). Although there is no explicit drinking water temperature standard, temperatures between 15–25°C are generally considered acceptable for human consumption and aquatic ecosystems. All sites fall within this acceptable range, indicating no thermal stress on aquatic organisms. 3. Total Dissolved Solids (TDS)

TDS ranged from 12.9 mg/L (W2) to 34.9 mg/L (W8), which is far below the WHO limit of 1000 mg/L and the EPA desirable limit of 500 mg/L. Such low concentrations indicate very soft water with minimal dissolved minerals. This suggests excellent water quality with no salinity concerns, making it ideal for drinking and irrigation.

4. Total Suspended Solids (TSS)

TSS values were between 3.46 mg/L (W5) and 10.67 mg/L (W4). While WHO and BDW do not provide specific limits, the Ambient Water Quality Criteria (AWQC) recommend a maximum of 25 mg/L. All sites are within this range, indicating low levels of suspended matter and good water clarity. W4 recorded the highest TSS but remains acceptable.

5. Salinity

The salinity levels ranged from 14.3 mg/L at W2 to 27.3 mg/L at W8, which are well below the maximum permissible limits specified by international and Bhutanese standards. According to the AWQC (2020) and EPA (2015) guidelines, no explicit salinity limit is set, but related parameters like TDS and electrical conductivity (EC) show values consistent with freshwater quality. The salinity values observed indicate that the water samples are fresh and unlikely to pose salinity-related issues for drinking or aquatic life. These low salinity levels correspond with low TDS and EC values, confirming minimal dissolved salts in the water. Overall, the salinity concentrations in the sampled water bodies are within acceptable ranges for both human consumption and ecological health, reflecting good water quality conditions in the surveyed locations.

6. Turbidity

Turbidity ranged from 1.07 NTU (W1) to 10.74 NTU (W10). WHO's permissible limit is 10 NTU. All sites are within the safe limit except W10 (10.74 NTU), which slightly exceeds the threshold, possibly due to localized sediment disturbance during monsoon runoff. Higher turbidity at W10 suggests increased particulate matter and may require monitoring for filtration purposes.

7. Electrical Conductivity (EC)

EC ranged from 18.9 µS/cm (W2) to 48.8 µS/cm (W8), significantly lower than the WHO permissible limit of 1500 µS/cm. This indicates very low mineralization and negligible salinity, making the water suitable for drinking, irrigation, and industrial use without scaling risks.

Chemical parameters

Overall, the chemical water quality in the study area during the monsoon season is largely within permissible limits for drinking and aquatic life, except for dissolved oxygen (DO) in some sites and iron (Fe) in all sites. Low DO in upstream sites (W1–W4) suggests reduced aeration during high flows, which could affect sensitive macroinvertebrates. High iron concentrations, especially at W10, likely result from monsoon-driven soil erosion and runoff from iron-rich geology. Hardness, chloride, ammonia, manganese, and fluoride remain within safe limits, confirming that the water is chemically suitable for most uses, with minimal treatment needed for Fe removal. Most nutrient and trace element concentrations are within safe limits, except phosphorus, which is alarmingly high at several sites (W6–W10). This suggests significant nutrient loading from agricultural runoff, soil erosion, and organic matter decomposition during monsoon floods. While low nitrate minimizes the immediate risk of eutrophication, elevated phosphorus could trigger algal blooms during low-flow periods. Mercury, arsenic, and zinc remain negligible, indicating no industrial or heavy metal contamination. Overall, phosphorus enrichment appears to be the major chemical concern in the monsoon season. All tested parameters—Cd, BOD, COD, SO_4^{2-}, Na, and Ca—are within permissible limits, indicating no heavy metal contamination and low to moderate organic load in the monsoon season (Table 4.3). However, sites W7–W10 show slightly higher BOD, likely from organic matter influx during heavy rains. Overall, the water remains of good chemical quality, with soft characteristics due to low hardness and major ions. The dominant concern remains organic load in downstream sites, which may affect oxygensensitive aquatic species.

Table 4.3: Chemical parameters for monsoon season and recommendations/limits

Parameters		**DO (mg/L)**	**Total Hardness (mg/L caco3)**	**Cl (mg/L)**	**NH_3 (mg/L)**	**Fe (ppm)**	**Mn (mg/L)**	**F (mg/L)**
Standards	AWQC	6[1] 4[2]	200[1]	50[1] 200[2]	0.05[1] 0.5[2]	0.05[1] 0.5[2]	0.05[1] 0.5[2]	0.05[1] 0.5[2]
	BDW	-	-	-	-	-	-	-
	EPA	8.5[a]	100[a] 500[b]	250[b]	0.3[b]	0.3[b]	0.3[b]	0.3[b]
	WHO*	-	500	250	1.5	1.5	1.5	1.5

Sampling Sites	W1	5.13	24.00	49.63	0.05	0.624	<0.001	0.200
	W2	5.12	40.00	24.82	0.03	0.703	<0.001	0.100
	W3	4.9	22.00	24.82	0.03	0.628	<0.001	0.200
	W4	5.89	24.00	49.63	0.03	0.491	<0.001	0.100
	W5	7.01	42.00	49.63	0.03	0.794	<0.001	0.300
	W6	6.8	48.00	49.63	0.03	1.794	<0.001	0.100
	W7	6.08	40.00	74.45	0.02	2.794	<0.001	0.100
	W8	6.01	56.00	99.26	0.03	3.794	<0.001	0.100
	W10	5.9	48.00	99.26	0.03	5.794	<0.001	0.100

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

8. Dissolved Oxygen (DO)

DO ranged from 4.9 mg/L (W3) to 7.01 mg/L (W5). According to AWQC, the desirable limit for aquatic life is ≥6 mg/L. Only W5, W6, W7, and W8 meet or approach this requirement, while

W1, W2, W3, W4, and W10 fall below the limit, indicating potential stress for sensitive aquatic species like mayflies and stoneflies. Lower DO levels during the monsoon may result from increased organic matter decomposition and reduced aeration due to high flow turbidity.

9. Total Hardness (as $CaCO_3$)

The total hardness levels, expressed as mg/L of $CaCO_3$, ranged from 22.00 mg/L (W3) to 56.00 mg/L (W8) across the sampling sites. These values were well below the WHO and EPA maximum permissible limit of 500 mg/L, indicating that the water is soft to moderately hard, with no adverse health implications. Water hardness in this range is not considered a health hazard; in fact, moderate hardness contributes essential minerals such as calcium and magnesium, which are beneficial to human health. Ecologically, such levels are ideal for aquatic life, supporting enzyme function and shell formation in invertebrates. Therefore, the observed hardness levels are safe for drinking and pose no ecological concern, although slightly higher values at W8 and W10 may influence taste or soap lathering but remain within acceptable limits.

10. Chloride (Cl^-)

Chloride levels varied from 24.82 mg/L (W2 & W3) to 99.26 mg/L (W8 & W10), remaining well below the WHO limit of 250 mg/L. Higher values at W7–W10 compared to upstream sites may reflect slight anthropogenic input or natural mineral weathering. All sites are safe for drinking and irrigation, with no risk of salinity issues.

11. Ammonia (NH_3)

Ammonia concentrations were consistently low across all sites (0.02–0.05 mg/L), which is within EPA and WHO limits (1.5 mg/L). These low levels indicate minimal organic pollution and healthy nitrogen cycling, likely due to well-oxygenated flow despite some sites having marginal DO.

12. Iron (Fe)

Iron showed significant variation, from 0.491 ppm (W4) to 5.794 ppm (W10). WHO and EPA recommend a maximum of 0.3 ppm, meaning all sites exceed permissible limits, with W10 showing the highest concentration. Elevated Fe during the monsoon likely results from soil leaching, erosion, and sediment inflow. This could cause staining and taste issues in drinking water and suggests a need for filtration if used domestically.

13. Manganese (Mn)

Manganese was below detection level (<0.001 mg/L) in all sites, well within the WHO limit of 0.1 mg/L. This indicates no contamination from Mn-bearing minerals or industrial sources.

14. Fluoride (F^-)

Fluoride concentrations ranged from 0.1 to 0.3 mg/L, well below the WHO limit of 1.5 mg/L. These levels suggest no risk of dental or skeletal fluorosis and indicate safe water for consumption.

Table 4.4: Chemical Parameters for Monsoon Season and Recommendations/Limits

Parameters		**NO_3 (mg/L)**	**P (ppm)**	**K (mg/L)**	**Mg (mg/L)**	**Hg (mg/L)**	**As (mg/L)**	**Zn (mg/L)**
Standards	AWQC	0.05[1] 0.5[2]	0.05[1] 0.5[2]	-	-	0.0005	0.01[1] 0.05[2]	0.2[1] 0.5[2]
	BDW	-	-	-	-	0.006	0.01	-
	EPA	0.3[b]	0.3[b]	-	-	0.001[b]	0.01[b]	1[b] (Fresh water)
	WHO*	1.5	1.5	1.5	50	0.001	0.01[a] 0.05[b]	3
Sampling Sites	W1	<10	0.04	3.6	8.00	<0.001	<0.02	<0.001
	W2	<10	0.05	1.8	30.00	<0.001	<0.02	<0.001
	W3	<10	0.04	2.7	8.00	<0.001	<0.02	<0.001
	W4	<10	0.05	3.4	18.00	<0.001	<0.02	<0.001
	W5	<10	0.03	2.7	36.00	<0.001	<0.02	<0.001
	W6	<10	1.03	1.6	40.00	<0.001	<0.02	<0.001

	W7	<10	2.03	1.3	36.00	<0.00 1	<0.02	<0.00 1
	W8	<10	3.03	0.1	46.00	<0.00 1	<0.02	<0.00 1
	W10	<10	5.03	3	46.00	<0.00 1	<0.02	<0.00 1

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

15. Nitrate (NO_3^-)

Nitrate levels were recorded as <10 mg/L at all sites. This is well below WHO's permissible limit of 1.5 mg/L and the EPA limit of 0.3 mg/L for freshwater ecosystems. These low levels indicate minimal agricultural runoff or sewage contamination during the monsoon season, possibly due to dilution from heavy rainfall. Low nitrate suggests low risk of eutrophication in these streams.

16. Phosphorus (P)

Phosphorus ranged from 0.03 ppm (W5) to 5.03 ppm (W10). WHO and EPA guidelines recommend a maximum of 0.3 mg/L (0.3 ppm), so W6 (1.03 ppm), W7 (2.03 ppm), W8 (3.03 ppm), and W10 (5.03 ppm) greatly exceed the permissible limits. High phosphorus levels in these downstream sites could be attributed to runoff from agricultural lands, organic matter decomposition, and soil erosion during the monsoon. Elevated P indicates a risk of nutrient enrichment and potential algal growth if flow conditions stabilize.

17. Potassium (K)

Potassium levels were generally low, ranging from 0.1 mg/L (W8) to 3.6 mg/L (W1), with no established WHO or EPA limits. These concentrations are typical for natural waters and do not pose any health risk. Variability likely reflects geological differences and leaches from soils.

18. Magnesium (Mg)

The magnesium concentrations across the sampling sites ranged from 8.00 mg/L (W1 and W3) to a high of 46.00 mg/L (W8 and W10). These levels fall well within the generally accepted natural background range for freshwater ecosystems and do not pose ecological risks, as magnesium is an essential nutrient for both aquatic flora and fauna. It plays a key role in enzyme activation, photosynthesis, and fish metabolism. No thresholds for ecological toxicity were breached. From a drinking water perspective, while BDWQS 2016 do not specify a permissible limit for magnesium, the WHO Guidelines for Drinking Water Quality suggest that magnesium concentrations below 50 mg/L are generally considered safe and do not present a health concern for most individuals. Therefore, based on existing international references and ecological tolerances, the magnesium levels observed at these sites are not only safe for human consumption but also environmentally benign. However, in cases such as W8 and W10 where the concentrations approach the upper informal limit (46 mg/L) (Table 4.4), regular monitoring is advisable, especially in areas with populations sensitive to water hardness or with pre-existing renal issues.

19. Mercury (Hg)

Mercury was below detection (<0.001 mg/L) at all sites, meeting the WHO and EPA limit of 0.001 mg/L. This suggests no contamination from industrial discharge or mining activities.

20. Arsenic (As)

Arsenic concentrations were also below detection (<0.02 mg/L) across all sites, complying with the WHO and EPA limit of 0.01 mg/L. This indicates the absence of geogenic arsenic contamination, which is a concern in some regions.

21. Zinc (Zn)

Zinc was below detection (<0.001 mg/L) at all sites, well within the WHO permissible limit of 3 mg/L and EPA's 1 mg/L for freshwater. This means no anthropogenic zinc input and safe levels for aquatic life and drinking purposes.

Table 4.5: Chemical Parameters for Monsoon Season and Recommendations/Limits

Parameters		Cd (mg/L)	BOD (mg/L)	COD (mg/L)	SO_4 (mg/L)	Na (mg/L)	Cu (mg/L)	Ca (mg/L)
Standards	AWQC	0.003[1]	2[1] 5[2] 50[3]	0.05[1] 0.5[2]	250[a] 400[b]	-	0.05[1] 0.01[2]	-
	BDW	-	-	-	-	-	-	-
	EPA	0.005[b]	10	0.3[b]	250[b]	-	0.005[a] 0.01[b]	-
	WHO*	0.003	6	1.5	250 500[b]	200	1	75
Sampling Sites	W1	<0.02	2.83	1.43	3.36	2.100	0.030	16.00
	W2	<0.02	3.14	2.83	2.10	2.600	0.030	10.00
	W3	<0.02	1.45	2.63	3.16	1.000	0.030	14.00
	W4	<0.02	0.46	4.07	2.90	1.400	0.030	6.00
	W5	<0.02	1.02	3.73	2.56	4.300	0.080	6.00
	W6	<0.02	1.46	6.61	2.18	2.600	0.080	8.00
	W7	<0.02	3.78	4.59	2.56	2.700	0.090	4.00
	W8	<0.02	3.57	8.50	3.57	2.600	0.090	10.00
	W10	<0.02	5.24	9.66	2.90	1.000	0.050	2.00

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

22. Cadmium (Cd)

Cadmium was below detection (<0.02 mg/L) in all sites. The WHO permissible limit is 0.003 mg/L, and EPA sets 0.005 mg/L. Although the reported detection limit is higher than the standards, the non-detection suggests cadmium is not a concern in these waters.

Its absence indicates no contamination from industrial sources or phosphate fertilizers.

23. Biochemical Oxygen Demand (BOD)

BOD ranged from 0.46 mg/L (W4) to 5.24 mg/L (W10). WHO recommends ≤6 mg/L for surface waters, while EPA suggests 10 mg/L as a desirable limit. All sites are within permissible limits, but W10 shows the highest BOD (5.24), indicating moderate organic pollution, likely from domestic waste or agricultural runoff during monsoon rains. Sites W7 and W8 (3.78–3.57 mg/L) also indicate organic load that could stress sensitive aquatic organisms.

24. Chemical Oxygen Demand (COD)

COD ranged from 1.43 mg/L (W1) to 9.66 mg/L (W10), all well below the WHO permissible limit of 250 mg/L and AWQC's guideline for good quality water (≤50 mg/L). These low values indicate limited industrial or chemical contamination, consistent with a rural watershed setting.

25. Sulfate (SO_4^{2-})

Sulfate levels ranged from 2.10 mg/L (W2) to 3.57 mg/L (W8), far below the WHO and EPA guideline of 250 mg/L. These values are typical of natural background concentrations and pose no health or environmental concerns.

26. Sodium (Na)

Sodium concentrations varied from 1.0 mg/L (W3, W10) to 4.3 mg/L (W5). No strict drinking water standards exist for sodium (except for taste concerns at >200 mg/L), so these levels are extremely low and safe, suggesting minimal contribution from urban or industrial effluents.

27. Copper (Cu)

The concentration of copper across the water samples from ranged from 0.030 mg/L to 0.090 mg/L, with the lowest values observed at W1–W4 (0.030 mg/L) and the highest at W7 and W8 (0.090 mg/L). While the BDWQS (2016) does not specify a limit for copper, international benchmarks provide context. The WHO guideline sets a health-based maximum of 2.0 mg/L, and the EPA drinking water Action Level is 1.3 mg/L, both of which are significantly higher than the concentrations observed at all sites. However, when referenced against the more stringent AWQC for high-quality source waters—0.05 mg/L for Class A waters—Cu levels at W5–W8 and W10 exceed this threshold, suggesting potential concern for direct abstraction without treatment. Despite this, from a drinking water safety perspective, all sites remain well within international safety limits, indicating that the copper concentrations present no significant health risk. Ecologically, such low levels of copper are unlikely to cause toxicity to aquatic organisms, though continuous monitoring is advisable for upstream catchments where values begin to approach Class A limits, particularly if the water body is intended for sensitive uses.

28. Calcium (Ca)

Calcium ranged from 2 mg/L (W10) to 16 mg/L (W1), which is well below the WHO limit of 75 mg/L for drinking water. These low levels indicate soft water, consistent with the geology of the region. Higher Ca in W1 (16 mg/L) could be due to localized carbonate rock influence.

Microbiological Parameters

Microbiological quality is the most critical concern during the monsoon season. E. coli presence in most sites confirms recent fecal contamination, while elevated fecal and total coliform counts at W5, W6, W7, and especially W10 suggest domestic sewage and agricultural runoff influence downstream (Table 4.6). Sites W3 and W8 are the only locations with zero coliforms, indicating relatively protected catchments. Direct consumption without treatment poses a high health risk, particularly for diarrheal and waterborne diseases. Boiling, chlorination, or advanced disinfection is essential before drinking.

Table 4.6: Microbiological Parameters for Monsoon Season and

Recommendations/Limits

Parameters		***E. coli***	**Fecal Coliform (CFU/100ml)**	**Total Coliform (CFU/100ml)**
Standards	AWQC	0	20[1] 2,000[2] 5,000[3]	50[1] 5,000[2] 10,000[3]
	BDW	0	0	-
	EPA	0	0	Not more than 5%
	WHO*	0	0	95% in sample
Sampling Sites	W1	Present	3	10
	W2	Present	5	25
	W3	Absent	0	0
	W4	Present	25	50
	W5	Present	100	300
	W6	Present	50	150
	W7	Present	40	100
	W8	Absent	0	0
	W10	Present	150	450

Notes:

STANDARDS*:* (AWQC: Ambient Water Quality Criteria, 2020; BDW: Bhutan Drinking Water Quality Standard, 2016; EPA Human Health Ambient Water Quality Criteria, 2015; WHO Guidelines for Drinking Water Quality, 2017).

*Maximum concentration limits

[1]Very Good, Drinking water source without conventional treatment, but after disinfection whenever necessary; [2]Good, Drinking water source with conventional treatment; [3]Moderate, Uses for irrigation, industrial cooling etc.

[a]Desirable limit; [b]maximum permissible limit

(-)No reference available

29. *E. coli*

E. coli was present in 7 out of 9 sites, except W3 and W8, which showed absence.

According to WHO, EPA, and BDW standards, the permissible limit for *E. coli* is 0 CFU/100 mL, meaning any presence is unsafe for drinking without treatment. The detection of E. coli at W1, W2, W4, W5, W6, W7, and W10 suggests recent fecal contamination, likely from domestic sewage, livestock runoff, or open defecation during heavy rains.

30. Fecal Coliform

Fecal coliform counts ranged from 3 CFU/100 mL (W1) to 150 CFU/100 mL (W10). WHO and EPA standards require 0 CFU/100 mL for drinking water, but AWQC allows up to 20 CFU/100 mL for high-quality sources and 5,000 CFU/100 mL for moderate use. W1 and W2 have relatively low levels (3–5 CFU/100 mL), while W10 (150 CFU/100 mL) indicates significant contamination. High counts at W4, W5, W6, and W7 point to stormwater or livestock contributions during the monsoon.

31. Total Coliform

Total coliform ranged from 10 CFU/100 mL (W1) to 450 CFU/100 mL (W10), well below AWQC's moderate-use threshold of 10,000 CFU/100 mL, but any presence exceeds WHO and BDW drinking water standards (should be 0 CFU/100 mL). This indicates general microbial contamination, potentially from soil, vegetation, or human waste.

In summary, the overall water quality during the monsoon season indicates that the river system falling along the transmission line is largely pristine with excellent physical and chemical characteristics, such as neutral pH, low TDS, minimal suspended solids, and negligible heavy metal contamination, making it generally suitable for drinking and aquatic life. However, two major concerns emerged: biological contamination and localized nutrient enrichment. While most chemical parameters were within permissible limits, dissolved oxygen was suboptimal in upstream sites (W1–W4), and iron concentrations exceeded WHO standards across all sites, peaking at W10 due to monsoon-driven soil erosion. Phosphorus levels were significantly high in downstream locations (W6–W10), reflecting nutrient runoff from agriculture and organic matter decomposition, posing a risk of eutrophication in low-flow periods. Microbiological analysis revealed widespread fecal contamination, with E. coli present in seven out of nine sites and highest coliform counts at W10, indicating strong anthropogenic influence downstream. W3 and W8 were the only sites meeting microbiological standards, suggesting relatively undisturbed catchments. Overall, the water is chemically safe but microbiologically unsafe for direct consumption, requiring disinfection and filtration, while downstream nutrient enrichment and organic load necessitate continuous monitoring to prevent long-term ecological impacts.

4.1.3. Noise

Noise levels were measured in A-weighted decibels [dB(A)] across five monitoring sites (NA1–NA5) during both daytime (6:00 a.m. to 10:00 p.m.) and nighttime (10:00 p.m. to 6:00 a.m.) and evaluated against NEC (2020). According to the standards, the maximum permissible noise levels are 55 dB(A) during the day and 45 dB(A) at night for sensitive areas, and 75 dB(A) during the day and 65 dB(A) at night for industrial areas (Table 4.7).

At Sites NA1, NA2, NA3, and NA5, both daytime and nighttime noise levels remained well within the prescribed limits for sensitive areas. Daytime noise levels ranged from 38 to 50 dB(A), while nighttime levels were between 30.8 and 42.6 dB(A). These values reflect relatively quiet ambient conditions, suitable for residential, institutional, or ecologically sensitive environments.

However, Site NA4 recorded significantly higher noise levels, with 67 dB(A) during the day and 60.3 dB(A) at night. These values remain within the NEC's permissible limits for industrial zones (75 dB(A) day / 65 dB(A) night), suggesting compliance with national standards. However, the relatively high values at this site, compared to others, may be attributed to its proximity to the Dzongkhalum, Trongsa, where infrastructure operations may contribute to ambient noise. Furthermore, high vehicular movement near Site NA4 likely adds to the elevated levels, particularly during the daytime.

Table 4.7: Day and Night Noise Levels [dB(A)] Recorded at Five Monitoring Sites Compared with NEC 2020 Standards for Sensitive and Industrial Areas

Noise		Day	Night
Unit	dB (A)		
Standards	NEC	55[a] 75[b]	45[a] 65[b]
Sampling Sites	NA1	41	34.4
	NA2	38	30.8

	NA3	50	42.6
	NA4	67	60.3
	NA5	46	39
Note: dB(A) = A-weighted decibels [a] = Sensitive area (place like hospitals, schools, sensitive ecosystem) [b] = Industrial area NA1-NA5 = Noise and Air Monitoring sites 1 to 5 NEC = National Environment Commission Environmental Standards, 2020			

4.1.4. Climate and Meteorology

Meteorological conditions recorded during the sampling period across five sites (NA1– NA5) showed notable spatial variation (Table 4.8). Ambient temperature ranged from 21.3°C at NA1 to a peak of 27.1°C at NA4, with the highest temperature likely influenced by industrial activity and lower vegetation cover at the site. Relative humidity varied between 43.6% (NA4) and 77% (NA2), indicating moderate to high moisture levels. Wind speeds were generally low, ranging from 0.10 m/s at NA5 to 0.59 m/s at NA2, suggesting limited atmospheric dispersion during the monitoring period. Rainfall was recorded as zero across all locations, as no precipitation occurred during the sampling timeframe. Atmospheric pressure varied between 72.2 mbar and 82.5 mbar, with higher values at site NA4 reflecting more stable weather conditions. Overall, the meteorological parameters during the monitoring period were relatively stable and dry, which is important for interpreting pollutant behavior in ambient air.

Table 4.8: Meteorological Parameters Recorded at Five Sampling Sites During the Monitoring Period

Parameters		**Temperature**	**Humidity**	**Wind**	**Rainfall**	**Pres**
Unit		°C	%	m/s	mm	mbar
Sampling Sites	NA1	21.3	69.1	0.36	0	72.5
	NA2	21.6	77	0.59	0	72.2
	NA3	22.7	58.1	0.13	0	75.4
	NA4	27.1	43.6	0.26	0	82.5
	NA5	23.6	67.3	0.1	0	79.9
Note: °C = Degree Celsius, % = Percent, m/s = meter per second, mm = millimeter, mbar = millibar NA1-NA5 = Noise and Air Monitoring sites 1 to 5						

4.2. Biodiversity Assessment

4.2.1. Flora

4.2.1.1. Forest Types and Floristic Composition

The proposed power transmission line transverses a mosaic of forest types with distinct plant assemblages, shaped by elevational differences, topography, and localized climatic conditions. The forest types vary from warm broad-leave forests in the Trongsa region (≈ 1,500 to 1,800 m asl), through mixed conifer and bluepine forest (≈ 2,500 to 2,800 m asl) in the mid elevation zones to fir and hemlock forest in the high mountain region towards Yotongla (≈ 3,200 m asl) (Figure 4.1).

Across these forest ecosystems, a total of 195 plant species encompassing trees, shrubs, herbs and epiphytes were recorded. Of these, 147 taxa were identified to the species level, and the remaining 48 taxa to the generic level (refer to Table xxx for detail species list). Each forest varies notably their canopy structure, canopy closure, floristic compositions and species richness (Table 4.9).

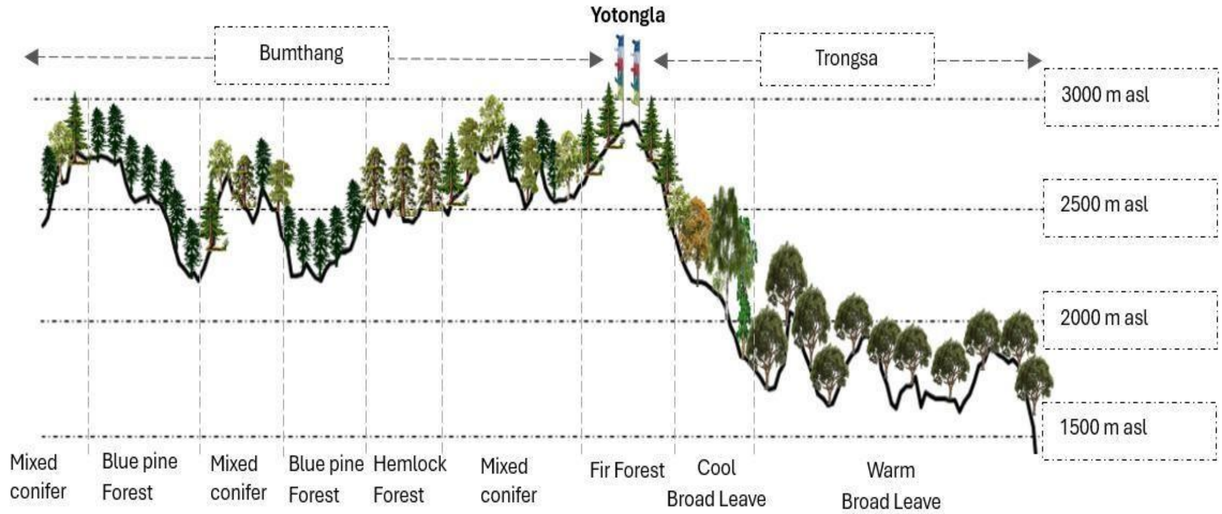

Figure 4.1: Forest Types Along the Transmission Line

1. Warm Broadleaf Forest

The warm broad leave forest was found between the altitude range of 1600−2400 m asl. This forest type shows variable canopy cover ranging from 5% to 91%. The dominant canopy species include *Rhus chinensis* (18)*, Quercus graffithii* (10)*, Eurya acuminata* (7)*, Lyonia ovalifolia* (7)*, and Rhododendron arboreum* (16). The understory vegetations were mostly composed of *Ageratina adenophora, Artemesia* spp*., Strobilanthus* spp*., Pilea sanguineae, Hydrocotyle himaliaca, and Oplismenus burmannii* and various ferns species. This forest type hosts the highest species richness after mixed conifer forest with a total of 99 species (Menhinick = 3.42), and exhibited high diversity Index (Shannon =

2.54, Simpson = 0.97, Pielou = 0.94), indicating a balanced and species-rich ecosystem. **2. Cool Broadleaf Forest**

Cool broad-leave forest was found between elevation range of 1900–2300 m asl, and it is characterized by medium to high canopy cover (53%−91%). The dominant tree species were *Alnus nepalensis* (5), *Lyonia ovalifolia* (8), *Brassaiopsis mitis* (4), *Quercus graffithii* (2), *Acer cappadocium*, and *Exbucklandia populenea*. The understories are mostly dominated by *Ageratina adenophora*, *Urtica* sp., *Artemesia* spp., *Buddleja paniculata*, *Viburnum mullaha*, *Enkainthes deflexus*, and *Symplocus* spp. The forest hosts high diversity of species (absolute = 76, Menhinick = 2.12) and exhibited the highest diversity indices (Shannon = 2.64, Simpson = 0.95, Pielou = 0.87).

3. Mixed Conifer Forest

The mixed conifer forest is generally considered as a transitional forest between broadleaf and coniferous forest, and they usually occur in mid altitude ranges. In the current study area, this forest type was found between 2800–3260 m asl with canopy cover ranging from 53%–90%. The dominant trees were *Tsuga dumosa* (26), *Pinus walliachina* (23) *Rhododendron arboreum* (28), *Populus rotundifolia* (6), and *Enkainthus deflexus* (6). The understories are mostly composed of *Daphne bholua*, *Rhododendron kesangiae*, *Yushania microphylla*, *Smilax* spp., and *Rubus fockeanus*. This forest type has comparatively lower species richness (absolute = 107, Menhinick = 2.54) and lower diversity indices (Shannon = 2.38, Simpson = 0.99, Pielou = 1.07).

4. Bluepine Forest

It is a forest that is predominated with blue pine and it the largest forest in terms of area. It occurred between the elevation range of 2650–3300 m asl and exhibited the highest canopy closure (avg = 67.3%). The dominant tree species are *Pinus wallachiana* (122), followed by *Salix wallichiana* (13), and *Lyonia ovalifolia* (2). Frequently, bluepine forest co-occur with understories species mostly composed of *Populus rotundifolia* (23), *Rosa macrophylla* (13), *Epipactis hellborine* (68), *Chimaphilia japonica* (51) and *Polygonatum sp*. (67). Compared to other forest types, bluepine forest has lower species richness (absolute = 76, Menhinick = 2.4), and diversity indices (Shannon = 2.24, Simpson = 0.97, Pielou = 0.95).

5. *Hemlock Forest*

The hemlock forest was restricted to only one plot along the entire transmission corridor at elevation of 3032 m asl, with canopy cover over 90%. The forest structure is quite unique in that the vegetation were pre-dominantly large trees with forest floor entirely covered with mosses and fallen debris. The dominant tree species were *Tsuga dumosa* (7), *Rhododendron barbatum* (3), *Rhododendron keysii* (2), *Gamblea ciliata* (2) and *Enkainthus deflexus*. The forest has the lowest species richness (absolute = 10, Menhinick = 1.04) and also exhibited the lowest vegetation indices (Shannon = 1.7, Simpson = 0.72, Pielou = 0.73).

6. Fir Forest

Similarly, fir forest was also restricted to one plot along the transmission corridor at an elevation of 3267 m als, with canopy cover of 61%. The dominate species were *Abies densa* (5), *Betula utilis* (3), *Tsuga dumosa* (1) and *Hydrangae heteromalla* (3) with patchy understory covered by *Senecio scandens*, *Smilax* spp., *Lindera heterophylla*, and *Neillea rubiflora*, and *Zanthoxylum bungaenum*. The forest has a total species richness of 21 (Menhinick = 1.7) and had the highest vegetation indices (Shannon = 2.7, Simpson =
0.92, Pielou = 0.89).

Table 4.9: Summary of Forest Types

Forest Types	**Elevation (m asl)**	**Dominant Species**	**Canopy Cover (%)**
Warm Broad Leave	1600–2400	*Rhus chinensis, Quercus graffithii, Eurya acuminata, Lyonia ovalifolia, Rhododendron arboreum*	5%-91%
Cool Broad Leave	1930–1300	*Alnus nepalensis*, *Lyonia ovalifolia*, *Brassaiopsis mitis*, *Quercus graffithii*, *Acer cappadocium*, *Exbucklandia populenea*.	53%-91%
Mixed Conifer	2800–3260	*Tsuga dumosa*, *Pinus walliachina, Rhododendron arboreum*, *Populus rotundifolia*, *Enkainthus deflexus*	5%-90% (avg. 66%)

Hemlock Forest	3032	*Tsuga dumosa*, *Rhododendron barbatum*, *Rhododendron keysii*, *Gamblea ciliata, Enkainthus deflexus*	90%
Blue Pine Forest	2650–3285	*Pinus wallachiana*, *Salix wallichiana*, *Lyonia ovalifolia, Populus rotundifolia*, *Rosa macrophylla*, *Epipactis hellborine*	30%-90% (avg. 67.3%)
Fir Forest	3267	*Abies densa*, *Betula utilis*, *Tsuga dumosa*, *Hydrangae heteromalla*, *Senecio scandens*, *Lindera heterophylla*	61%

Species Diversity by Plot

The species diversity and richness across the vegetation plots along the transmission line was evaluated using suit of diversity indices (Figure 4.2). These indices provide complementary insights into species richness, abundance, and their distribution. These insights can be particularly useful for assessing the ecological value of the area, and in predicting the potential impact of powerline development to the local biodiversity.

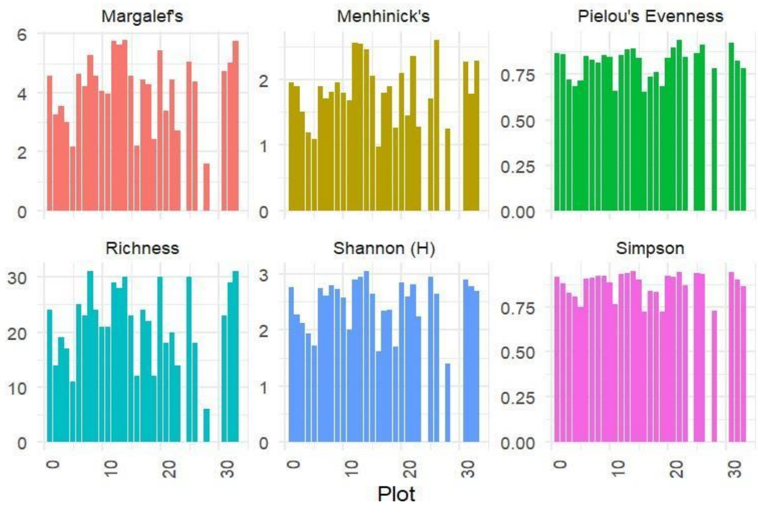

Figure 4.2: Plot Wise Diversity Indices

Overall, species richness ranged from 6 species in Plot 28 to 31 species in Plots 8 and 33. Plots with higher species richness were typically associated with mixed conifer and warm broad leave forest and lesser species richness with bluepine and hemlock forest types. However, Menhinick index (species richness adjusted for sample size), show considerable variation with highest values of 2.6 and 2.5 in plot 26 & 12 respectively, and the lowest values in plot 16 (0.98) & 5 (1.09) indicating species poor habitats.

The highest Shannon index was recorded in plot 14 (3.04) followed by plot 13 and plot 25 (2.95), and the lowest in plot 28 (1.4). Further, higher values (H' > 2.8) were observed in plots 12, 13, 14, 20, 25, and 31, which were associated with warm broadleaf and mixed conifer forest. Conversely, lower diversity indices were observed in plot 16, 19, and 28, which might reflect habitat simplification, species dominance or disturbance. Similarly, Simpson's Index showed that plots 14, 13, 22, and 25 exhibited high values (≥ 0.94), which indicates diverse species with near equal dominance.

Margalef's Index ranged from 1.59 in Plot 28 to 5.79 in Plot 14, with notably higher values in Plots 12, 14, 20, and 25. These plots represent floristically rich habitats and must be paid attention during development of powerline transmission. Pielou's Evenness Index, which measures uniformity of species, ranges from 0.65 in Plot 16 to 0.94 in Plot 22. Plots with high evenness reflect less-disturbed environments and lower evenness indicates disturbed areas or areas dominated by a few species.

Species of Conservation Importance

The key plant species observed during the survey, including those of conservation concern, endemism and ecological importance, are presented in Table 4.10. Among the identified species, few species are classified as "Least Concern" under IUCN Red List including *Abies densa*, *Alnus nepalensis*, *Rhododendron arboreum*, and *Tsuga dumosa*. This indicates that these species are widespread and are not currently under significant global threats.

However, 26 species are listed as "Scheduled" species under Forest and Nature Conservation Act of 2023. These species are not threatened globally nor regionally but they are recognized as nationally important, and thus require protection, management, and monitoring to ensure a healthy population in the wild.

Furthermore, *Rhododendron kesangiae,* an endemic species to Bhutan was also recorded during the survey. As a species with a highly confined geographic range, they are inherently vulnerable to habitat change, disturbance, and stochastic events. Therefore, this species requires careful protection during the development of transmission corridors.

Table 4.10: List of Species of Conservation Concern

Sl. No	Species Name	IUCN Status	FNCA	Remarks
1	*Abies densa*	Least concern	Schedule III	–
2	*Ageratina adenophora*	Not evaluated	Not listed	Invasive species
3	*Alnus nepalensis*	Least concern	Schedule III	–
4	*Astilbe rivularis*	Not evaluated	Schedule III	–
5	*Betual alnoides*	Not evaluated	Schedule II	–
6	*Daphne bholua*	Not evaluated	Schedule III	–
7	*Englehardia spicata*	Not listed	Schedule III	–
8	*Exbucklandia populnea*	Not listed	Schedule III	–
9	*Lindera heterophylla*	Not listed	Schedule III	–
10	*Lyonia ovalifolia*	Not listed	Schedule III	–
11	*Macaranga pustulata*	Not listed	Schedule III	–
12	*Picea spinolusa*	Not evaluated	Schedule III	–
13	*Pinus wallichiana*	Not evaluated	Schedule III	–
14	*Quercus graffithii*	Not evaluated	Schedule III	–
15	*Quercus lanata*	Not evaluated	Schedule III	–
16	*Quercus oxyodon*	Not evaluated	Schedule III	–

17	*Rhododendron arboreum*	Least concern	Schedule III	–
18	*Rhododendron barbatum*	Not evaluated	Schedule III	–
19	*Rhodedendron falconeri*	Not evaluated	Schedule III	–
20	*Rhododendron kesangiae*	Not evaluated	Schedule III	Endemic
21	*Rhododendron keysii*	Not evaluated	Schedule III	–
22	*Rhododendron triflorum*	Not evaluated	Schedule III	–
23	*Rhus chinensis*	Not evaluated	Schedule III	–
24	*Rhus wallichii*	Not evaluated	Schedule III	–
25	*Rubia cordifolia*	Not evaluated	Schedule III	–
26	*Tsuga dumosa*	Least concern	Schedule III	–
27	*Yushiana microphylla*	Not evaluated	Schedule III	–

4.2.2 Fauna

4.2.2.1. Terrestrial Mammals

A total of seven mammal species were documented during the terrestrial survey through a combination of camera trap images, indirect signs, and direct sightings (Table 4.11, Figure 4.3). Camera traps, deployed at ten locations, recorded four species from six functioning units: red fox (*Vulpes vulpes*), Asiatic black bear (*Ursus thibetanus*), wild boar (*Sus scrofa*), and barking deer (*Muntiacus vaginalis*). In addition to camera trap detections, indirect evidence (droppings) were recorded for Asiatic black bear and red fox, indicating their presence beyond direct captures. Signs of rooting and rubbing behavior were observed on pine trees and surrounding mud near wild boar activity areas (Figure 4.4c). Indirect evidence such as pellets and tracks also confirmed the presence of sambar deer (*Rusa unicolor*) and serow (*Capricornis thar*), species that typically inhabit rugged and less accessible areas. Additionally, opportunistic sightings of red fox and leopard cat (*Prionailurus bengalensis*) were made while moving between survey sites. The relatively low number of species recorded may be attributed to the short deployment period of camera traps and seasonal factors, as the survey was conducted in July, a period when dense vegetation and monsoon conditions may reduce animal movement or visibility (Caravaggi et al., 2017). Furthermore, most mammal species (*n* = 4) recorded fall under the "Least Concern" category and were primarily detected through camera trapping (Figure 4.3).

Table 4.11: List of Mammal Species Recorded During the Survey, along aithtTheir Detection Type, IUCN Red List Status, and FNCA Schedule Classification

Sl. No	Common Name	Scientific Name	Detection Type	IUCN Status	FNCA Schedule
1	Red Fox	*Vulpes vulpes*	Camera Trap and Direct Sighting	Least Concern	Schedule II
2	Asiatic Black Bear	*Ursus thibetanus*	Camera Trap	Vulnerable	Schedule II
3	Wild Boar	*Sus scrofa*	Camera Trap	Least Concern	Schedule III
4	Barking Deer	*Muntiacus vaginalis*	Camera Trap	Least Concern	Schedule III
5	Sambar Deer	*Rusa unicolor*	Indirect Signs	Vulnerable	Schedule II
6	Himalayan Serow	*Capricornis thar*	Indirect Signs	Near Threatened	Schedule II
7	Leopard Cat	*Prionailurus bengalensis*	Direct Sighting	Least Concern	Schedule II

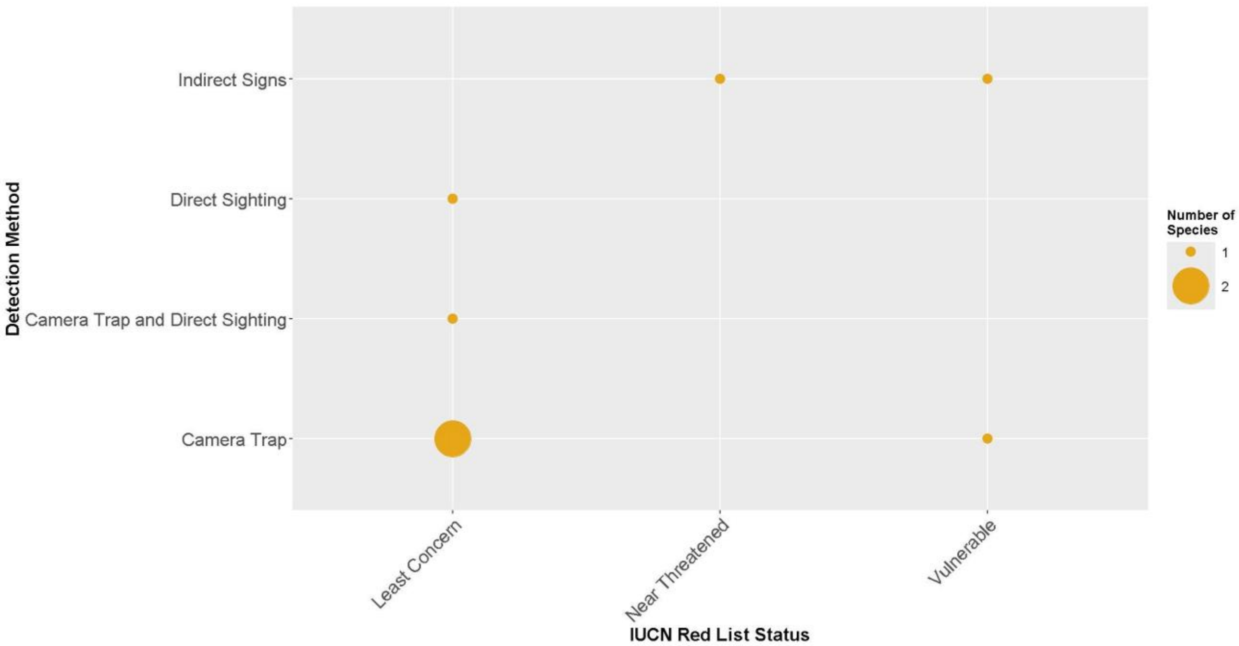

Figure 4.3: Bubble Chart Showing the Number ff Mammal Species Detected by Each Detection Method Across Different IUCN Red List Categories. The Size of the Bubble Represents the Number of Species Observed Per Combination.

Figure 4.4: Indirect Signs of Wild Mammals Recoded in the Study Area, (a) Scat of Red Fox, (b) Scat of Asiatic Black Bear, (c) Rubbing Evidence of Wild Boar, (d) Pallet of Sambar Deer, (e) Pallet of Himalayan Serow

4.2.2.2. Avifauna

A total of 108 bird species were recorded during the survey (Table 4.12). Among these, three species are classified as *Near Threatened (NT)* under the IUCN Red List, while the remaining 105 species are listed as *Least Concern (LC)*. The recorded diversity reflects a healthy and ecologically functional bird community.

A small number of high-flying bird species were observed during the survey (*n* = 5, 4.6%). These included raptors such as the Mountain Hawk Eagle (*Nisaetus nipalensis*) and the Himalayan Vulture (*Gyps himalayensis*), both of which are Near Threatened. Other high-flyers like the Common Buzzard and Himalayan Buzzard were also recorded. Despite their ecological significance, these high-flying birds represented less than 5% of the total recorded species, indicating that the area is not dominated by soaring or gliding birds.

Importantly, no major migratory pathways were detected during the survey. There was no evidence of large flocks or consistent directional movement that would indicate the presence of a migratory flyway. This suggests that the proposed transmission line corridor does not intersect with any known critical migratory routes, reducing the risk of large-scale migratory bird collisions.

However, the presence of three Near Threatened species—including the Mountain Hawk Eagle and Himalayan Vulture—does imply some conservation sensitivity. These species are known to occupy large territories and may occasionally traverse the height range of overhead lines. Therefore, localized mitigation is warranted, especially across open ridgelines or broad valleys where flight activity may be higher.

Table 4.12: List of bird species recorded during the survey, along with their scientific names and IUCN conservation status.

Sl. No.	Common Name	Scientific Name	IUCN	FNCA Schedule
1	Ashy Bulbul	*Hemixos flavala*	LC	
2	Ashy Drongo	*Dicrurus leucophaeus*	LC	
3	Ashy-throated Warbler	*Phylloscopus maculipennis*	LC	
4	Asian Barred Owlet	*Glaucidium cuculoides*	LC	Schedule III
5	Bar-throated Minla	*Actinodura strigula*	LC	
6	Bar-winged Flycatcher Shrike	*Hemipus picatus*	LC	
7	Bhutan Laughingthrush	*Trochalopteron imbricatum*	LC	
8	Black Bulbul	*Hypsipetes leucocephalus*	LC	
9	Black-chinned Yuhina	*Yuhina nigrimenta*	LC	
10	Black-crested Bulbul	*Rubigula flaviventris*	LC	

11	Black-faced Laughingthrush	*Trochalopteron affine*	LC	
12	Black-rumped Magpie	*Pica bottanensis*	LC	
13	Black-throated Tit	*Aegithalos concinnus*	LC	
14	Blue Whistling Thrush	*Myophonus caeruleus*	LC	
15	Blue-fronted Redstart	*Phoenicurus frontalis*	LC	
16	Blue-throated Barbet	*Psilopogon asiaticus*	LC	
17	Bronzed Drongo	*Dicrurus aeneus*	LC	
18	Brown Dipper	*Cinclus pallasii*	LC	
19	Brown Parrotbill	*Paradoxornis unicolor*	LC	
20	Chestnut-bellied Rock Thrush	*Monticola rufiventris*	LC	
21	Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	LC	
22	Chestnut-tailed Starling	*Sturnia malabarica*	LC	
23	Collared Owlet	*Taenioptynx brodiei*	LC	
24	Common Buzzard	*Buteo buteo*	LC	
25	Common Green Magpie	*Cissa chinensis*	LC	
26	Common Kestrel	*Falco tinnunculu*	LC	Schedul e III
27	Common Myna	*Acridotheres tristi*	LC	
28	Common Pigeon	*Columba livia*	LC	

29	Creasted Kingfisher	*Megaceryle lugubris*	LC	
30	Crimson Sunbird	*Aethopyga siparaja*	LC	
31	Crimson-browed Finch	*Carpodacus subhimachalus*	LC	
32	Dark-sided Flycatcher	*Muscicapa sibirica*	LC	
33	Eurasian Cuckoo	*Cuculus canorus*	LC	Schedul e III
34	Eurasian Jay	*Garrulus glandarius*	LC	
35	Eurasian Magpie	*Pica pica*	LC	
36	Eurasian Tree Sparrow	*Passer montanus*	LC	
37	Golden-bush Robin	*Tarsiger chrysaeus*	LC	
38	Great Barbet	*Psilopogon virens*	LC	
39	Green-backed Tit	*Parus monticolus*	LC	
40	Greenish Warbler	*Phylloscopus trochiloides*	LC	
41	Green-shrike babbler	*Pteruthius xanthochlorus*	LC	
42	Green-tailed Sunbird	*Aethopyga nipalensis*	LC	

43	Grey Treepie	*Dendrocitta formosae*	LC	
44	Grey-backed Shrike	*Lanius tephronotus*	LC	
45	Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	LC	
46	Grey-headed Woodpecker	*Picus canus*	LC	
47	Grey-hooded Warbler	*Phylloscopus xanthoschistos*	LC	
48	Grey-winged Black Bird	*Turdus boulboul*	LC	
49	Hill Partige	*Arborophila torqueola*	LC	
50	Himalayan Beautiful Rosefinch	*Carpodacus pulcherrimus*	LC	
51	Himalayan Buzzard	*Buteo refectus*	LC	
52	Himalayan Vulture	*Gyps himalayensis*	NT	Schedul e II
53	Hoary-throated Barwing	*Actinodura nipalensis*	LC	
54	Hodgson's Redstart	*Phoenicurus hodgsoni*	LC	
55	Kalij Pheasant	*Lophura leucomelanos*	LC	Schedul e III
56	Large Billed Crow	*orvus macrorhynchos*	LC	Schedul e III
57	Large Hawk-Cuckoo	*Hierococcyx sparverioides*	LC	
58	Long-tailed Shrike	*Lanius schach*	LC	
59	Mountain Hawk Eagle	*Nisaetus nipalensis*	NT	Schedul e III
60	Mrs. Gould's Sunbird	*Aethopyga gouldiae*	LC	
61	Nepal House Martin	*Delichon nipalense*	LC	
62	Olive-backed Pipit	*Anthus hodgsoni*	LC	
63	Orange-bellied Leafbird	*Chloropsis hardwicki*	LC	
64	Oriental Cuckoo	*Cuculus optatus*	LC	
65	Oriental Magpie Robin	*Copsychus saularis*	LC	
66	Oriental Sky Lark	*Alauda gulgula*	LC	
67	Oriental Turtle Dove	*Streptopelia orientalis*	LC	
68	Oriental White-eye	*Zosterops palpebrosus*	LC	
69	Plain Mountain Finch	*Leucosticte nemoricola*	LC	
70	Plumbeous water redstart	*Phoenicurus fuliginosus*	LC	

71	Red JungleFowl	*Gallus gallus*	LC	Schedule III
72	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	LC	Schedule III
73	Red-Tailed Minla	*Minla ignotincta*	LC	
74	Red-vented Bulbul	*Pycnonotus cafer*	LC	
75	River Lapwing	*Vanellus duvaucelii*	NT	Schedule III
76	Rufous Sibia	*Heterophasia capistrata*	LC	
77	Rufous-breasted Accentor	*Prunella strophiata*	LC	
78	Rufous-capped Babbler	*Cyanoderma ruficeps*	LC	
79	Rufous-fronted Tit	*Aegithalos iouschistos*	LC	
80	Rufous-gorgeted Flycatcher	*Ficedula strophiata*	LC	
81	Rufous-vented Yuhina	*Yuhina occipitalis*	LC	
82	Rufous-winged Fulvetta	*Schoeniparus castaneceps*	LC	
83	Russet Sparrow	*Passer cinnamomeu*	LC	
84	Rusty-cheeked Scimitar Babbler	*Erythrogenys erythrogenys*	LC	
85	Rusty-flanked Treecreeper	*Certhia nipalensis*	LC	
86	Scarlet Minivet	*Pericrocotus speciosus*	LC	
87	Snow Pigeon	*Columba leuconota*	LC	
88	Spotted Nutcracker	*Nucifraga caryocatactes*	LC	
89	Streaked Spinder Hunter	*Arachnothera magna*	LC	
90	Striated Laughingthrush	*Grammatoptila striata*	LC	
91	Stripe-throated Yuhina	*Yuhina gularis*	LC	
92	Verditer Flycatcher	*Eumyias thalassinus*	LC	
93	Whiskered Yuhina	*uhina flavicollis*	LC	
94	White Wagtail	*Motacilla alba*	LC	
95	White-browed Fulvetta	*Fulvetta vinipectu*	LC	
96	White-browed Scimitar Babbler	*Pomatorhinus schisticeps*	LC	
97	White-capped Water-redstart	*Phoenicurus leucocephalus*	LC	
98	White-collared Blackbird	*Turdus albocinctus*	LC	
99	White-crested Laughingthrush	*Garrulax leucolophus*	LC	
100	White-throated Bulbul	*Alophoixus flaveolus*	LC	
101	White-throated Fantail	*Rhipidura albicollis*	LC	

102	White-throated Laughingthrush	*Pterorhinus albogularis*	LC	
103	White-winged Grosbeak	*Mycerobas carnipes*	LC	
104	Yellow-bellied Fantail	*Chelidorhynx hypoxanthus*	LC	
105	Yellow-billed Blue Magpie	*Urocissa flavirostris*	LC	
106	Yellow-browed Tit	*Sylviparus modestus*	LC	
107	Yellowish-billed Bush Warbler	*Horornis acanthizoides*	LC	
108	Yellowish-billed Fantail	*Chelidorhynx hypoxanthus*	LC	

4.2.2.3 Herpetofauna

During the survey, only two species of herpetofauna—both listed as Least Concern on the IUCN Red List—were directly recorded. An individual of *Amolops* spp., a streamdwelling frog, was documented by the aquatic survey team in a mid-elevation stream habitat (Figure 4.5), which fell under the aquatic plot 07 (27.57934N 90.8810568E). Additionally, a false cobra/big-eyed bamboo snake (*Pseudoxenodon macrops*) was sighted opportunistically along a vegetation plot (27.573057N 90.849743E).

Figure 4.5: *Amolops* spp. Found along Mid-elevation Sream

4.2.3. Aquatic Life

4.2.3.1. Fish

Species Composition and Dominance

For the monsoon season, a total of 75 individuals of Salmo trutta were recorded from 10 sampling sites (Figure 4.6). *Salmo trutta* (Linnaeus, 1758), commonly known as Brown Trout, was the only species encountered during the monsoon season.

Owing to the lone species' presence in the monsoon season, the diversity indices such as species diversity, species evenness, and species richness were not reported. The study affirms that the species had 100% abundance in the sampling sites during the monsoon season owing to the higher altitude of the study site augmented by invasive nature of the fish which preys and competes with the native species.

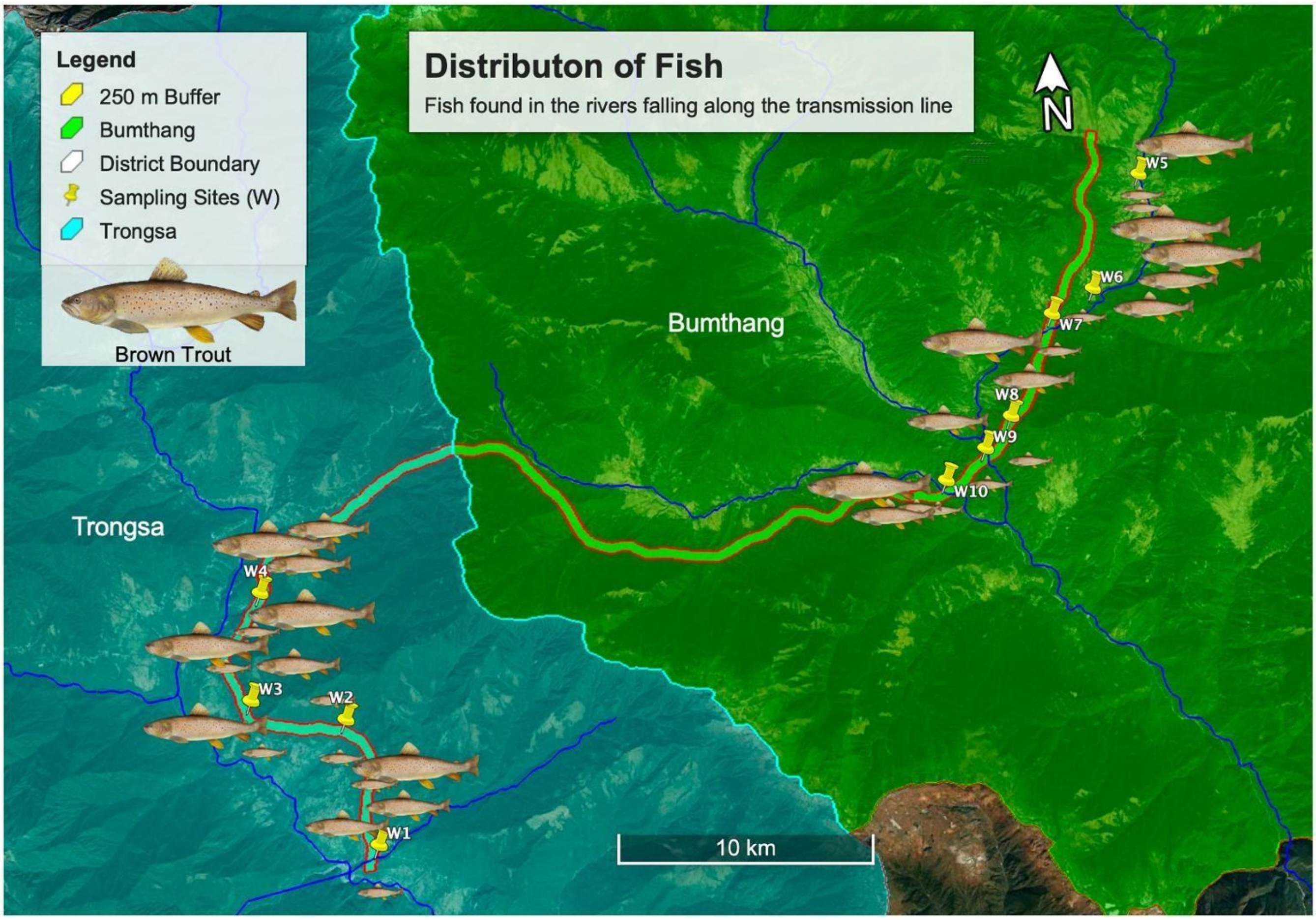

Figure 4.6: Occurrence of Brown Trout over all the Water Sampling Sites

Description of fishes in different sites Water Sampling Site 5

Table 4.13: Details of the Fish Found in Site 5 during Wet season

SN	Species	Habitat Substratum	Count	Depth (cm)	Velocity (m/s)	Latitude	Longitude
1	*Salmo trutta*	Big Stones	9	30	0.2	27.57876749	90.88111035
2	*Salmo trutta*	Big stone	8	47	0.4	27.57928879	90.88148691
3	*Salmo trutta*	Stones	7	27	0.1	27.57799300	90.88040492
4	*Salmo trutta*	Stones	3	41	0.3	27.57710112	90.87937579

Site 5 was in the river adjacent to Tang Central School, Bumthang and it did not fall directly under the 250m buffer of the transmission line. The site recorded 27 individuals of *Salmo* *trutta* across four microhabitats dominated by stone-based substrates. Depths ranged from 27–47 cm and velocities from 0.1–0.4 m/s, indicating variable hydraulic conditions. High abundance in big-stone substrates suggests these areas provide shelter and feeding opportunities. Despite structural habitat diversity, only one species was found, indicating low diversity but strong habitat specialisation. Site 5 showed a strong dominance of brown trout across all sampled stretches, suggesting this species' adaptability to coarse substrates and moderate flows. The complete absence of native species likely indicate s competition exclusion and physical barriers downstream, which restrict recolonization. The presence of various size classes suggests that this section may serve as an important growth and feeding ground for the species.

Figure 4.7: Site 5 recorded the highest catch (A) and had favourable habitat for the fish (B).

Water Sampling Site 6

Table 4.14: Details of the Fish Found in Site 6 During Monsoon Season

SN	Species	Habitat Substratum	Count	Depth (cm)	Velocity (m/s)	Latitude	Longitude
1	*Salmo trutta*	Boulder	1	41	0.7	27.56540604	90.86120284

Site 6 was located adjacent to the Forest Management Unit Office of Tang Gewog. The site had only one *Salmo trutta* associated with a boulder substrate at 41 cm depth and a relatively high velocity of 0.7 m/s. The low abundance could be linked to higher water turbulence, offering less favorable conditions for sustaining larger populations. However, boulder substrates may serve as transient habitats or resting points in high-energy flows. The low abundance at Site 6 may reflect limited cover availability and higher flow energy compared to Site 5. Nevertheless, the occurrence of brown trout demonstrates its capacity to occupy fast-flowing stretches, where most native species struggle to survive during monsoon.

Water Sampling Site 7

Table 4.15: Details of the Fish Found in Site 7 During Monsoon Season

SN	Species	Habitat Substratum	Count	Depth (cm)	Velocity (m/s)	Latitude	Longitude
1	*Salmo trutta*	Stones	2	54	0.1	27.53742753	90.80733561
2	*Salmo trutta*	Large stone	5	34	0.2	27.53733883	90.80713611
3	*Salmo trutta*	Small stones	7	21	0.3	27.53712831	90.80698823

Site 7 was located below the Mebartsho. We carefully selected this site to not disturb the sanctum of the sacred religious site. The site recoreded 14 individuals of *Salmo trutta* across three distinct substrate types. Depth varied from 21–54 cm with velocities of 0.1–0.3 m/s. The highest abundance was observed in small-stone habitats, possibly due to their role in offering shelter and invertebrate prey. Habitat complexity here appeared important for supporting trout populations. Site 7 revealed a higher diversity of microhabitats and a broad range of fish sizes, suggesting multi-functional habitat use by brown trout (feeding, shelter, and possibly juvenile rearing). Like other sites, the absence of native species reinforces the hypothesis that barrier effects downstream and interspecific competition prevents their establishment.

Figure 4.8: Site 7 recorded juvenile fish (A) and has coarse gravels to big stones favourable for fish (B).

Water Sampling Site 8

Table 4.16: Details of the Fish Found in Site 8 During Monsoon Season

SN	Species	Habitat Substratum	Count	Depth (cm)	Velocity (m/s)	Latitude	Longitude
1	*Salmo trutta*	Big boulder	2	83	0.4	27.52754711	90.77070428
2	*Salmo trutta*	Large boulder	2	59	0.4	27.52767609	90.77053338
3	*Salmo trutta*	Stone	8	22–65	0.6	27.53726246	90.80715226

Site 8 was also in the Tangchhu river towards the upstream of of the Chamkharchhu and Tangchhu confluence. The site recorded 12 individuals of *Salmo trutta* across boulder and stone substrates. Depth varied widely from 22–83 cm, and velocities were relatively high (0.4–0.6 m/s), suggesting this site represents a moderate to high-flow environment. Boulder habitats appear suitable for juvenile trout, providing cover from fast currents. Site 8 displayed the widest range of habitat complexity among the sampled sites, with varying depths and substrate sizes. The presence of very small individuals (4 cm) indicates successful recruitment, highlighting its ecological role as a nursery habitat for brown trout.

Figure 4.9: Site 8 was characterized by large boulders and pebbles habitat substratum.

Water Sampling Site 10

Table 4.17: Details of the Fish Found in Site 10 During Monsoon Season

SN	Species	Habitat Substratum	Count	Depth (cm)	Velocity (m/s)	Latitude	Longitude
1	*Salmo trutta*	Big stones	21	61	0.4	27.49205227	90.79004838

Site 10 was situated in Chamkharchhu, situated on a riverbank beneath the roadpoint. This roadpoint is approximately two kilometers from the Nangar-Ura bypass highway. The site recorded had 21 individuals of *Salmo trutta* in a deep pool-like habitat with big-stone substrates at 61 cm depth and 0.4 m/s velocity. This suggests a stable microhabitat likely preferred for feeding or resting during higher flows.

Sites with No Fish Encountered (Sites 1, 2, 3, 4, and 9)

During the monsoon sampling period, Sites 1, 2, 3, and 4 recorded no fish presence, primarily due to environmental and accessibility constraints. The high current velocity and increased turbulence during monsoon made sampling difficult, particularly in deeper sections of the river. Additionally, the riverbanks offered no significant signs of fish presence during field observations.

Figure 4.10: A: Site 1-Yurmochhu; B: Site 2- Bubja stream; C: Site 3- Dzongkhalum stream; D: Site 4- Telangangchhu

Further investigation revealed that Sites 2 (located in Bubja stream), 3 (Dzongkhalum stream), and 4 (Telangangchhu) were located upstream of waterfalls, creating natural barriers that likely prevent fish migration into these stretches. This geomorphological characteristic suggests that these sites may inherently have low fish diversity and abundance due to isolation.

Site 1 was in Yurmochhu river towards the downstream of the brigdge and upstream of the MHPA powerhouse. Although accessible, presented highly challenging conditions during monsoon, including strong currents and limited safe access points along the river stretch. Consequently, no fish were sampled. However, based on the habitat features, it is hypothesized that these stretches may support some fish species during more favorable flow conditions, which warrants post-monsoon sampling.

Figure 4.11: Water sampling site 9 was inaccessible.

Site 9, which was above 100-200 meters above the Chamkharchhu and Tangchhu confluence, was completely inaccessible because it falls between a deep bridge crossing with steep vertical drops to the river channel, making safe descent impossible. Even if descent were achieved, no suitable sampling zones were available. Therefore, this site could not be assessed during the current survey period.

Distribution pattern of fishes across sites and habitats

The distribution of *Salmo trutta* across the sampled sites revealed a highly uneven spatial pattern influenced by substratum composition, flow velocity, and water depth, which collectively shape habitat suitability. Across all accessible sites (5, 6, 7, 8, and 10), brown trout was the sole species recorded, with individuals representing multiple life stages, from fingerlings to adults, indicating successful recruitment and persistence in these reaches.

Site 5 exhibited the highest abundance and diversity in size classes, with total lengths ranging from 11 cm to 25 cm. The site was dominated by big stones and stones, with moderate depths (27–47 cm) and flow velocities between 0.1 and 0.4 m/s (Figure 4.12). These conditions are characteristic of transitional zones providing both velocity refugia and feeding opportunities. The presence of multiple size classes suggests this stretch functions as an important growth and foraging habitat for brown trout.

Site 6, by contrast, recorded only a single individual (21 cm), captured in a microhabitat dominated by large boulders at 41 cm depth and a relatively higher velocity of 0.7 m/s. This suggests that extreme hydraulic conditions, coupled with low habitat heterogeneity, may limit fish density at this site.

At Site 7, a total of 14 individuals were observed across substrata of stones to large stones, with depths varying from 21 cm to 54 cm and velocities ranging between 0.1–0.3 m/s. The range in sizes (8–22 cm) and habitat types indicates multifunctional habitat usage, supporting both juvenile and sub-adult stages. The low velocities and interstitial spaces among large stones likely serve as predator refugia and energyconserving zones.

Site 8 displayed the greatest habitat variability, ranging from big boulders to stonedominated sections, with depths extending from 22 cm to 83 cm and velocities from 0.4 to 0.6 m/s. The occurrence of very small individuals (as low as 4 cm) in combination with sub-adults up to 22 cm strongly suggests that Site 8 functions as a critical nursery habitat, providing microhabitats with stable cover and abundant drift for feeding.

Finally, Site 10 recorded 21 individuals, all juvenile, in habitats dominated by big stones, with deep pockets (61 cm) and moderate velocity (0.4 m/s). The low abundance, despite suitable conditions, may reflect connectivity limitations or competitive displacement from upstream habitats with better complexity.

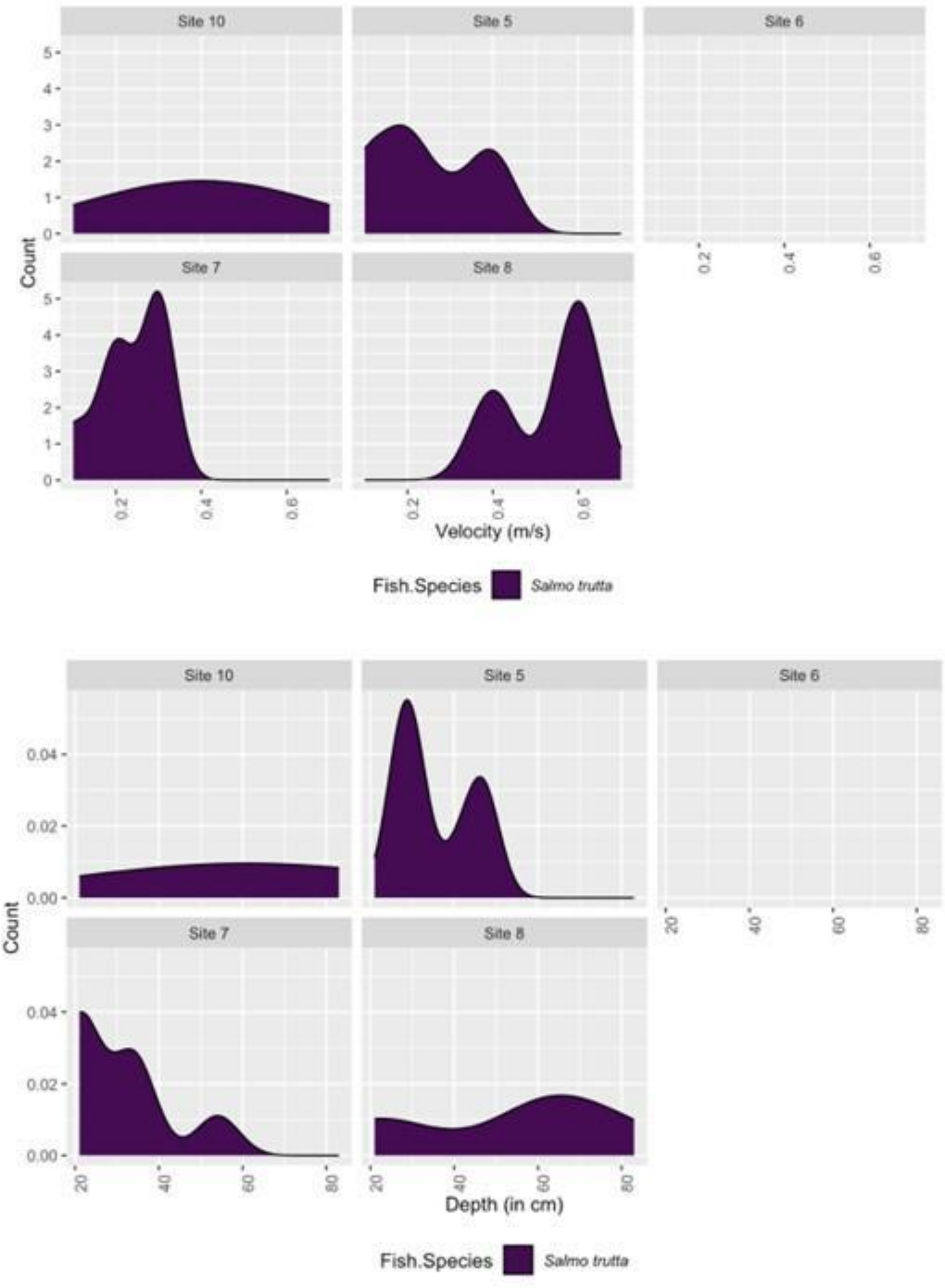

Figure 4.12: Distribution of Fish in Different Velocity and Depth Across Different Habitat Substratum

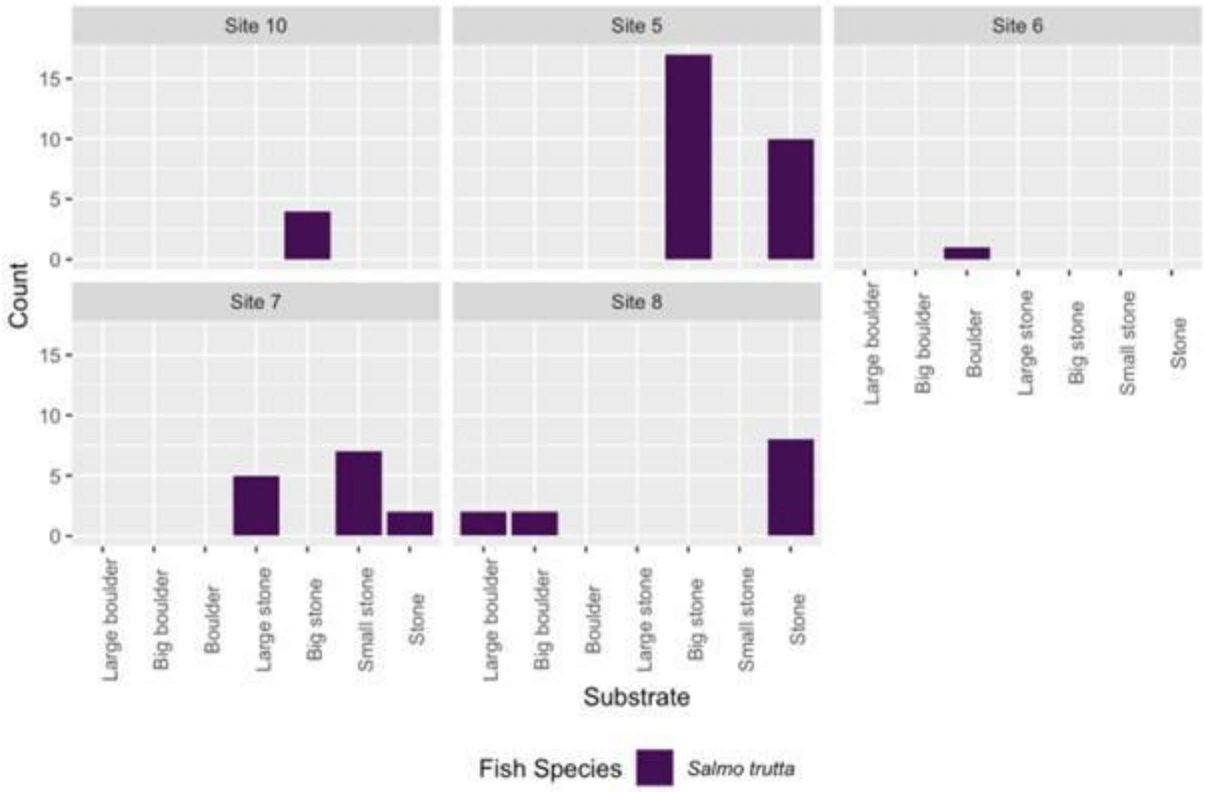

Figure 4.13: Distribution of Different Classes of Brown Trout Across Different Substratum

Migration behavior of brown trout

The migratory behavior of brown trout exhibits a high degree of flexibility. This species uses many life history strategies and has effectively adapted to a wide geographic range (anadromous and potamodromous). Its reproductive features have also showed a great deal of variety. For instance, the average spawning date and the length of the spawning period have both shown large latitudinal fluctuations, according to numerous publications. Brown trout also migrates across great distances for spawning and over short distances for feeding or wintering. Additionally, daily movement patterns also differ due to seasonal variations and population differences.

In general, the most important upstream movements of brown trout are linked to their search for adequate spawning sites. Their spawning period is usually in late fall between September to December. However, the dates and environmental triggers of the spawning movements in Bhutanese brown trout populations have not been sufficiently studied.

Brown trout is particularly vulnerable to a variety of anthropogenic disturbances, including changes in river flow and thermal conditions, because of their migratory patterns and reliance on environmental cues. The natural water regime can be changed by dams, weirs, and other river structures in addition to limiting or impeding the flow of freshwater creatures. By delivering lower mean flows during the winter and larger flows during the dry season (e.g., irrigation dams), daily rapid fluctuations in flow (e.g., hydropeaking in hydropower generation), or dampening flood peaks, flow management modulates inter- and intra-annual seasonality and variability (e.g. dams for flood control). The density, biomass, and species composition as well as daily fish behavior and the timing of spawning and migrating phases may all be impacted by these non-natural flow changes.

Table 4.18: IUCN Red List Status of the fish in the Project site: LC = Least Concern, H = Hill Stream, R = Riverine and MF = Migratory Fish.

SN	Order	Family	Species	IUCN Red List Status	Habitat		
					H	R	M.F
1	Salmoniformes	Salmonidae	*Salmo trutta*	LC	-	-	+

Description of fish

Salmo trutta Linnaeus, 1758

Common names: Brown trout, river trout.

Synonyms: *Salmo fario* Linnaeus, 1758; *Trutta fario* (Linnaeus, 1758).

Description: Dorsal-fin rays 7-3-4/7-11, pectoral 1/12, ventral 9, anal 3-4/7-10, and caudal 18-20. Body brown with shades of greenor bluish tinge, has red spots and and adipose fin.

Maximum length 40-100 cm. Maximum recorded weight 20 kg.

Distribution: Widely established in the cold-water bodies of the temperate region of Haa, Paro, Thimphu, Punakha, Gasa, Wangdue, Trongsa, and Bumthang.

Conservation status: Introduced sport species.

4.2.3.2. Macroinvertebrates

Species Composition and Dominance

For the monsoon season, a total of 2,006 individuals of macroinvertebrates were collected, representing 20 families under 10 orders (Table 4.19). Among the collected taxa, *Baetis* sp. from the Baetidae family was the most dominant species with a count of N = 1,060 and a Relative Abundance (RA) of 52.84%, followed by *Drunella* sp. from the Ephemerellidae family (N = 117, RA = 5.83%) and *Hydropsyche* sp. from the Hydropsychidae family (N = 116, RA = 5.78%).

The monsoon recorded overall species diversity *H'* = 1.92, species evenness E_H = 0.63, and species richness S_R = 6.06. The dominance of *Baetis* sp. suggests that monsoon conditions favored taxa adapted to high flow and well-oxygenated environments, which is consistent with typical mayfly ecology. The presence of other pollution-sensitive indicator species like *Heptagenia* sp. and *Rhyacophila* sp. further reflects good water quality and relatively stable habitat conditions during the monsoon season.

Table 4.19: Overall Species Diversity and Relative Abundance of Macroinvertebrates for Monsoon Season

SN	Order	Family	Genus	Count	RA
1	Diptera	Ceratopogonidae	Polycentropus	35	1.74%
2	Diptera	Chironomidae	Perla	66	3.29%
3	Ephemeroptera	Heptageniidae	Heptagenia	154	7.68%
4	Decapoda	Palaemonidae	Epeorus	39	1.94%
5	Diptera	Tabanidae	Rhyacophila	101	5.03%
6	Trichoptera	Limnephilidae	Brachycentrus	16	0.80%
7	Trichoptera	Hydropsychidae	Hydropsyche	116	5.78%
8	Coleoptera	Elmidae	Habrophlebia	67	3.34%
9	Ephemeroptera	Baetidae	Baetis	1,060	52.84%
10	Odonata	Gomphidae	Drunella	117	5.83%
11	Ephemeroptera	Ephemerellidae	Simulium	31	1.55%
12	Coleoptera	Dytiscidae	Lumbricus	8	0.40%
13	Plecoptera	Perlidae	Pelocoris	6	0.30%
14	Unidentified	Unidentified	Tabanus	5	0.25%
15	Trichoptera	Brachycentridae	Gomphus	2	0.10%
16	Trichoptera	Rhyacophilidae	Planaria	28	1.40%
17	Coleoptera	Dytiscidae	Agnetina	14	0.70%
18	Hemiptera	Naucoridae	Culicoides	60	2.99%
19	Haplotaxida	Lumbricidae	Chironomus	27	1.35%
20	Decapoda	Potamidae	Notonecta	9	0.45%
21	Coleoptera	Gyrinidae	Rhithrogena	45	2.24%
	Total			**2,006**	**100%**

Overall, mayflies (Ephemeroptera) were the most abundant across all sampled sites during the monsoon season, dominated by *Baetis* sp. This high abundance can be linked to their adaptation to flowing waters and high oxygen conditions typical during the monsoon period. Their presence indicates good water quality and stable habitat conditions. Additionally, other sensitive taxa such as *Heptagenia* sp. and *Drunella* sp. further confirm the ecological integrity of the streams during this season.

Table 4.20: Macroinvertebrates Found During the Monsoon Season

SN	Sampling Site	Common Name	Count	Longitude	Latitude
1	W1	Comb lipped caddisfly	8	27.4923052	90.7900878
2		Common stonefly	4	27.4923052	90.7900878
3		Common stonefly	10	27.4923052	90.7900878
4		Flat headed mayfly	6	27.4923052	90.7900878
5		Flat headed mayfly	3	27.4923052	90.7900878
6		Flat headed mayfly	11	27.4923052	90.7900878
7		Free living caddisfly	9	27.4923052	90.7900878
8		Free living caddisfly	6	27.4923052	90.7900878
9		Mountain casemaker caddisfly	4	27.4923052	90.7900878
10		Net spinning caddisfly	7	27.4923052	90.7900878
11		Prong gilled mayfly	4	27.4923052	90.7900878
12		Small minnow mayfly	14	27.4923052	90.7900878
13		Small minnow mayfly	54	27.4923052	90.7900878
14		Small minnow mayfly	37	27.4923052	90.7900878
15		Spiny crawler mayfly	6	27.4923052	90.7900878
16		Spiny crawler mayfly	9	27.4923052	90.7900878
17	W2	Blackfly	3	27.422793	90.4935215
18		Flat headed mayfly	17	27.422793	90.4935215
19		Flat headed mayfly	4	27.422793	90.4935215
20		Free living caddisfly	14	27.422793	90.4935215
21		Free living caddisfly	9	27.422793	90.4935215
22		Free living caddisfly	3	27.422793	90.4935215
23		Earthworm	1	27.422793	90.4935215
24		Net spinning caddisfly	11	27.422793	90.4935215
25		Prong gilled mayfly	13	27.422793	90.4935215
26		Small minnow mayfly	56	27.422793	90.4935215
27		Small minnow mayfly	71	27.422793	90.4935215
28		Small minnow mayfly	17	27.422793	90.4935215
29		Spiny crawler mayfly	7	27.422793	90.4935215
30	W3	common Stonefly	11	27.4631287	90.5015703
31		Creeping water bug	3	27.4631287	90.5015703
32		Flat headed mayfly	9	27.4631287	90.5015703

33		Flat headed mayfly	10	27.4631287	90.5015703
34		Flat headed mayfly	13	27.4631287	90.5015703
35		Free living caddisfly	8	27.4631287	90.5015703
36		Free living caddisfly	11	27.4631287	90.5015703
37		Free living caddisfly	4	27.4631287	90.5015703
38		Horsefly	1	27.4631287	90.5015703
39		Net spinning caddisfly	13	27.4631287	90.5015703
40		Clubtail dragonfly	2	27.4631287	90.5015703
41		Flatworm	11	27.4631287	90.5015703
42		Prong gilled mayfly	11	27.4631287	90.5015703
43		Prong gilled mayfly	21	27.4631287	90.5015703
44		Small minnow mayfly	2	27.4631287	90.5015703
45		Small minnow mayfly	39	27.4631287	90.5015703
46		Small minnow mayfly	14	27.4631287	90.5015703
47	W4	Comb lipped caddisfly	7	27.4902604	90.523485
48		Common stonefly	13	27.4902604	90.523485
49		Common stonefly	4	27.4902604	90.523485
50		Common stonefly	6	27.4902604	90.523485
51		Flat headed mayfly	3	27.4902604	90.523485
52		Free living caddisfly	10	27.4902604	90.523485
53		Net spinning caddisfly	3	27.4902604	90.523485
54		Flatworm	4	27.4902604	90.523485
55		Flatworm	1	27.4902604	90.523485
56		Small minnow mayfly	81	27.4902604	90.523485
57		Small minnow mayfly	97	27.4902604	90.523485
58		Small minnow mayfly	11	27.4902604	90.523485
59		Spiny crawler mayfly	3	27.4902604	90.523485
60	W5	Common stonefly	8	27.57934	90.8810568
61		Earthworm	3	27.57934	90.8810568
62		Flat headed mayfly	13	27.57934	90.8810568
63		Flat headed mayfly	16	27.57934	90.8810568
64		Flat headed mayfly	3	27.57934	90.8810568
65		Flatworm	5	27.57934	90.8810568
66		Flatworm	1	27.57934	90.8810568
67		Flatworm	1	27.57934	90.8810568
68		Horsefly	3	27.57934	90.8810568
69		Horsefly	1	27.57934	90.8810568
70		Mountain casemaker caddisfly	3	27.57934	90.8810568
71		Mountain casemaker caddisfly	3	27.57934	90.8810568
72		Net spinning caddisfly	11	27.57934	90.8810568

73		Net spinning caddisfly	2	27.57934	90.8810568
74		Non biting midge	17	27.57934	90.8810568
75		Non biting midge	4	27.57934	90.8810568
76		Non biting midge	5	27.57934	90.8810568
77		Small minnow mayfly	20	27.57934	90.8810568
78		Small minnow mayfly	21	27.57934	90.8810568
79		Small minnow mayfly	5	27.57934	90.8810568
80		Small minnow mayfly	14	27.57934	90.8810568
81		Small minnow mayfly	16	27.57934	90.8810568
82		Small minnow mayfly	4	27.57934	90.8810568
83	W6	Case making caddisfly	6	27.5644245	90.8612733
84		Common stonefly	4	27.5644245	90.8612733
85		Common stonefly	4	27.5644245	90.8612733
86		Earthworm	1	27.5644245	90.8612733

87		Flat headed mayfly	17	27.5644245	90.8612733
88		Flat headed mayfly	17	27.5644245	90.8612733
89		Flat headed mayfly	4	27.5644245	90.8612733
90		Flatworm	2	27.5644245	90.8612733
91		Net spinning caddisfly	9	27.5644245	90.8612733
92		Net spinning caddisfly	6	27.5644245	90.8612733
93		Predacious bug	4	27.5644245	90.8612733
94		Small minnow mayfly	29	27.5644245	90.8612733
95		Small minnow mayfly	16	27.5644245	90.8612733
96	W7	Black fly	17	27.57934	90.8810568
97		Comb lipped caddisfly	7	27.57934	90.8810568
98		Creeping water bug	3	27.57934	90.8810568
99		Earthworm	1	27.57934	90.8810568
100		Flat headed mayfly	8	27.57934	90.8810568
101		Flat headed mayfly	8	27.57934	90.8810568
102		Flat headed mayfly	7	27.57934	90.8810568
103		Flatworm	3	27.57934	90.8810568
104		Free living caddisfly	7	27.57934	90.8810568
105		Free living caddisfly	8	27.57934	90.8810568
106		Mountain casemaker caddisfly	3	27.57934	90.8810568
107		Net spinning caddisfly	11	27.57934	90.8810568
108		Net spinning caddisfly	5	27.57934	90.8810568
109		Non biting midge	17	27.57934	90.8810568
110		Non biting midge	6	27.57934	90.8810568
111		Predacious beetle	5	27.57934	90.8810568

112		Small minnow mayfly	71	27.57934	90.8810568
113		Small minnow mayfly	5	27.57934	90.8810568
114		Small minnow mayfly	16	27.57934	90.8810568
115		Small minnow mayfly	17	27.57934	90.8810568
116		Small minnow mayfly	4	27.57934	90.8810568
117		Small minnow mayfly	120	27.57934	90.8810568
118	W8	Black fly	5	27.5372571	90.8072067
119		Black fly	6	27.5372571	90.8072067
120		Comb lipped caddisfly	7	27.5372571	90.8072067
121		Common stonefly	6	27.5372571	90.8072067
122		Common stonefly	7	27.5372571	90.8072067
123		Common stonefly	3	27.5372571	90.8072067
124		Flat headed mayfly	6	27.5372571	90.8072067
125		Flat headed mayfly	8	27.5372571	90.8072067
126		Flat headed mayfly	3	27.5372571	90.8072067
127		Flat headed mayfly	11	27.5372571	90.8072067
128		Little stout crawler mayfly	10	27.5372571	90.8072067
129		Little stout crawler mayfly	4	27.5372571	90.8072067
130		Net spinning caddisfly	14	27.5372571	90.8072067
131		Prong-gilled mayfly	7	27.5372571	90.8072067
132		Small minnow mayfly	54	27.5372571	90.8072067
133		Small minnow mayfly	21	27.5372571	90.8072067
134		Small minnow mayfly	14	27.5372571	90.8072067
135		Small minnow mayfly	12	27.5372571	90.8072067
136		Spiny crawler mayfly	3	27.5372571	90.8072067
137	W10	Earthworm	2	27.5270233	90.7711176
138		Flat headed mayfly	3	27.5270233	90.7711176
139		Free living caddisfly	8	27.5270233	90.7711176
140		Free living caddisfly	4	27.5270233	90.7711176
141		Little stout crawler mayfly	31	27.5270233	90.7711176
142		Mountain casemaker caddisfly	3	27.5270233	90.7711176
143		Net spinning caddisfly	7	27.5270233	90.7711176
144		Net spinning caddisfly	10	27.5270233	90.7711176
145		Non biting midge	11	27.5270233	90.7711176
146		Non biting midge	27	27.5270233	90.7711176
147		Prong gilled mayfly	11	27.5270233	90.7711176
148		Small minnow mayfly	56	27.5270233	90.7711176
149		Small minnow mayfly	89	27.5270233	90.7711176
150		Small minnow mayfly	10	27.5270233	90.7711176
151		Small minnow mayfly	42	27.5270233	90.7711176

The sampled sites in the monsoon season show a dominance of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies**)**, commonly referred to as EPT taxa, across multiple locations such as W1, W2, W4, W7, and W10 (Table 4.20). These taxa are widely recognized as indicators of good water quality because they are sensitive to pollution and require well-oxygenated waters. Sites W4, W7, and W10 exhibit particularly high counts of small minnow mayflies and flat-headed mayflies, suggesting stable flow conditions and low organic pollution. The presence of free-living and casemaking caddisflies further supports this interpretation, as they thrive in clean, fast-flowing streams with good substrate diversity. However, occurrences of earthworms and nonbiting midges at W5 and W10 could indicate minor localized organic enrichment or sedimentation, possibly from riparian disturbances.

If the transmission line is constructed overhead, direct water quality impacts may be minimal since no chemical discharge is expected. However, construction-phase disturbances (soil erosion, vegetation clearance, accidental debris deposition) could degrade habitat conditions by increasing sediment load and reducing substrate complexity, critical for EPT taxa survival. Sites such as W4, W7, and W10 should be prioritized for protection, as they show high biodiversity and abundance of sensitive species. These areas serve as ecological hotspots and are more vulnerable to siltation or canopy loss. Maintaining riparian buffers, preventing soil disturbance near streambanks, and managing access routes are essential to preserve ecological integrity. Any decline in EPT diversity post-construction would indicate habitat degradation and loss of water quality resilience.

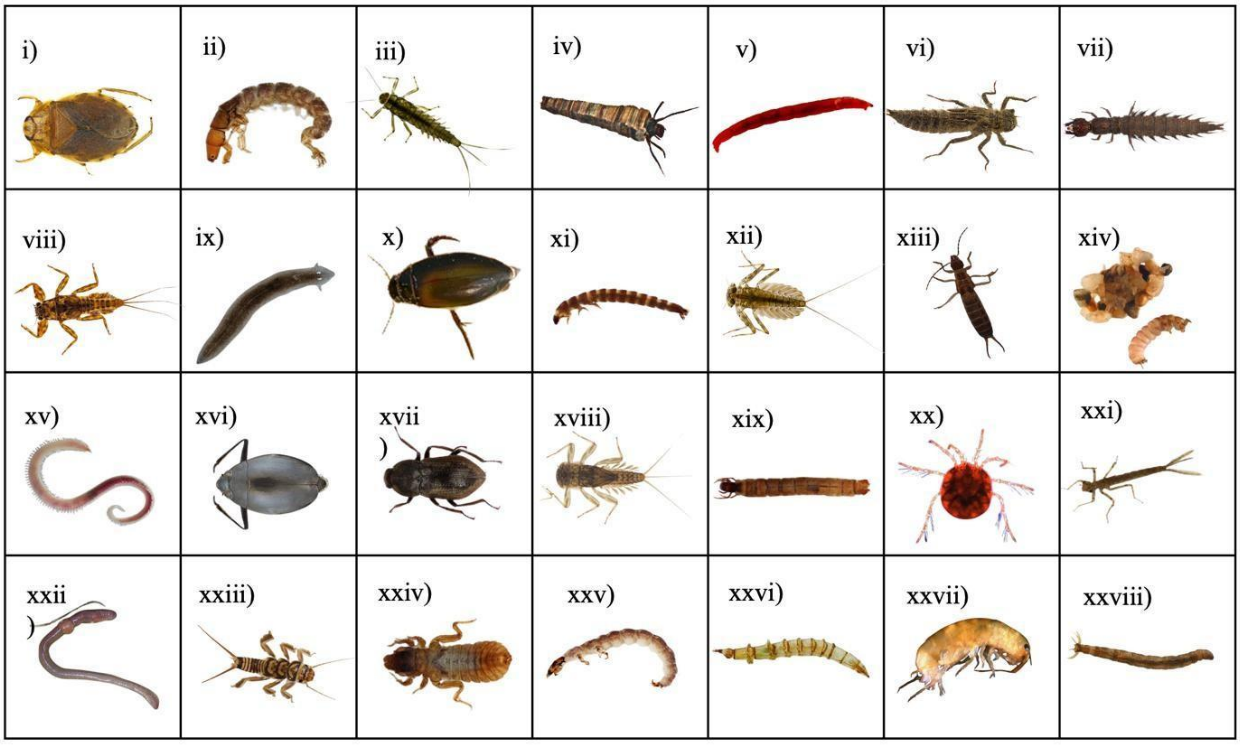

Figure 4.14: Macroinvertrebrates Found in the Study Area, *Ambrysus (i); Arctopsyche (ii); Baetis (iii); Brachycentrus (iv); Chironomus (v); Cordulegaster (vi); Corydalus (vii); Drunella (viii); Dugesia (ix); Dystiscus (x); Elmidae (xi); Epeorus (xii); Forficula (xi) xiii); Glossosoma (xiv); Glycera (xv); Gyrinus*

Distribution Pattern

The distribution pattern of macroinvertebrates across sites indicates a dominance of Ephemeroptera, particularly Baetidae (genus *Baetis*), which consistently recorded the highest abundance in multiple habitats such as riffles, runs, and pools (Figure 4.15). This taxon was especially dominant in riffles at sites W4, W7, and W10, suggesting a preference for fast-flowing, well-oxygenated habitats. Other Ephemeropteran families, including Heptageniidae (*Heptagenia*, *Epeorus*) and Leptophlebiidae (*Habrophlebia*), were also widely distributed but in lower densities compared to Baetidae. Trichoptera was the second most abundant order, with families Hydropsychidae (*Hydropsyche*) and Rhyacophilidae (*Rhyacophila*) occurring predominantly in runs and riffles, reflecting their affinity for moderate to high flow habitats suitable for case building and filter-feeding.

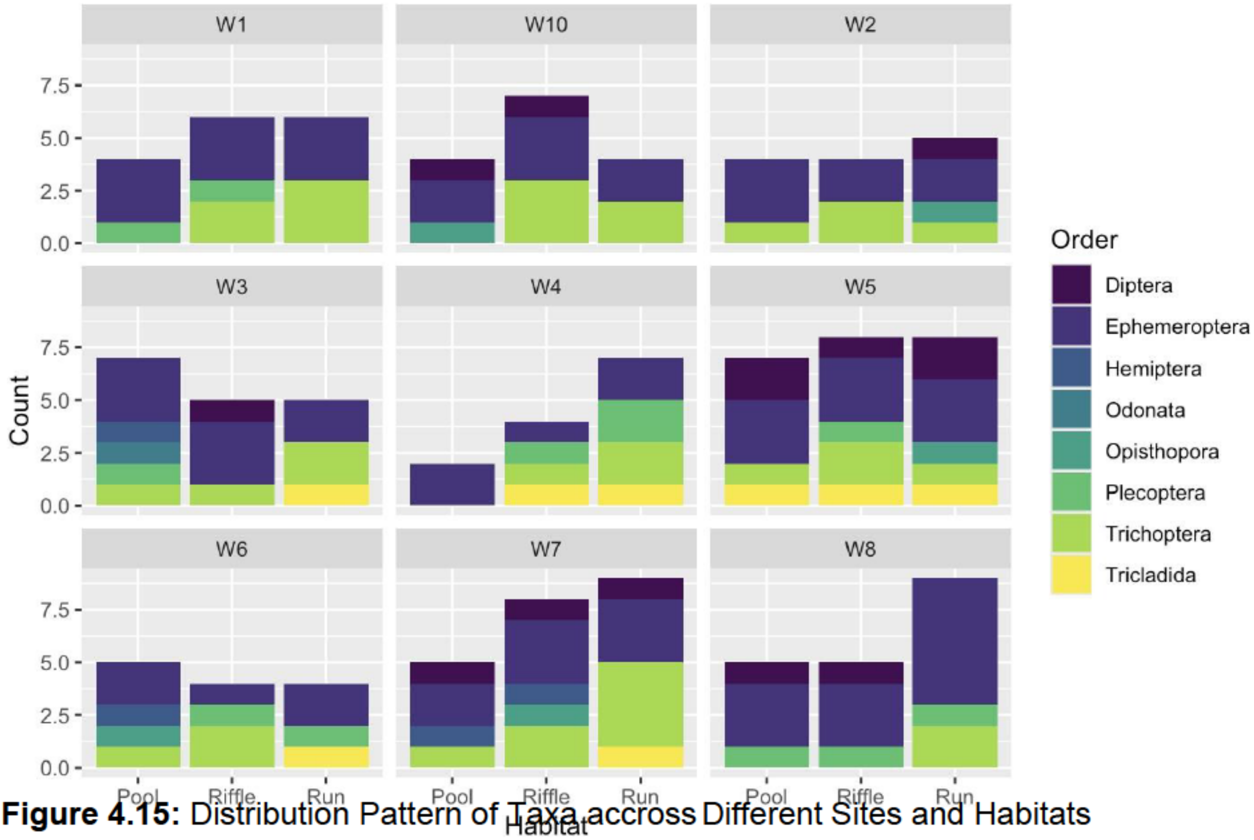

Figure 4.15: Distribution Pattern of Taxa accross Different Sites and Habitats

Plecoptera (Perlidae) was less widely distributed but present in riffles and runs, indicating their association with clean, cool water.

Habitat-specific distribution reveals that riffles supported the highest species richness and abundance across sites, particularly for sensitive taxa such as EPT taxa, which are indicative of good water quality. Runs exhibited moderate diversity, often dominated by Baetidae and Hydropsychidae, while pools supported relatively fewer individuals and a higher proportion of tolerant taxa such as Diptera (Simuliidae, Chironomidae) and Oligochaeta (Lumbricidae). Notably, Planariidae (flatworms) were present in multiple sites but mainly in runs, suggesting preference for slower currents compared to riffles. The distribution pattern overall suggests a gradient in community composition linked to habitat heterogeneity and flow conditions, with EPT taxa dominating high-flow habitats and tolerant taxa occupying low-flow or depositional habitats.

CHAPTER FIVE

5. Biodiversity Impact and Mitigation Measures

5.1. Terrestrial Biodiversity

5.1.1. Vegetation

The construction of infrastructure along the transmission line corridor is expected to cause impact to vegetation, primarily from vegetation clearance for transmission lines, and construction of temporary access road to build electric towers

5.1.1.1. Potential Impacts on Vegetation

The project development will require the removal of trees along the forested land, which may cause habitat loss & fragmentation, loss of biodiversity and increased risk of soil erosion and landslides, particularly in steep and unstable terrain. Furthermore, increased disturbance to wildlife is anticipated during construction activities and transport of materials to work sites. This may lead to abandonment of the habitats, especially by sensitive and elusive mammals and bird species.

5.1.1.2. Mitigation Measures

Tthe following mitigation measures are recommended to reduce ecological footprint of the transmission line and minimize impact to surrounding environment:

- Minimize vegetation removal in forest dominated by *R. kesangiae* by restricting only to the essential ROW clearance or restraining removal wherever possible.
- Controlling soil erosion during construction of temporary access roads.
- Schedule construction activities and material transportation to avoid critical wildlife breeding seasons.
- Establishing a robust environmental monitoring and evaluation plan to track vegetation recovery, erosion risks, and biodiversity changes throughout the project lifecycle.

5.1.2. Terrestrial Mammals

The monsoon season biodiversity assessment recorded seven mammal species along the 68 km transmission line corridor and its 250-meter buffer zone. These include both carnivores and herbivores, representing different trophic and habitat-use groups.

5.1.2.1. Potential Impacts on Terrestrial Mammals Potential

impacts on terrestrial mammals include:

- Disturbance due to construction activities, such as noise, machinery movement, and human presence.
- Temporary displacement from preferred habitats along the corridor.
- Habitat alteration due to vegetation clearance for tower footing and access routes.
- Increased edge effects and human access, which could increase the risk of opportunistic hunting or wildlife stress.

5.1.2.1. Mitigation Measures

To reduce impacts on mammal populations and maintain ecological function in the project area, the following measures are recommended:

- Limit vegetation clearance strictly to the required construction footprint. Retain understory and canopy vegetation near forest edges and water sources.
- Avoid peak activity periods of mammals by conducting high-disturbance activities (heavy excavation, machinery operation) during late morning to early afternoon, when most species are less active.
- Prohibit wildlife hunting through clear instructions to all workers and contractors. Signage should be placed at construction sites and camps, and compliance should be monitored by supervisors.
- Inspect open trenches or pits daily, especially in forested areas, to ensure no animals have become trapped overnight. If any mammals are found, safe release protocols should be followed.
- Manage food waste and other attractants in campsites and work zones to prevent attracting wildlife such as bears or wild boars. Waste should be securely stored and disposed of in designated pits away from forested areas.

- Restore disturbed areas post-construction using native vegetation, especially along wildlife movement zones. Replanting helps re-establish ecological connectivity and reduces erosion.
- Collaborate with local forest officials to support periodic field inspections and awareness activities related to mammal conservation during and after construction.

5.1.3. Avifauna

Although a very less (n = 5) high-risk raptors and vultures were directly observed during the monsoon-season survey, their presence cannot be ruled out entirely given the altitudinal range and habitat types along the proposed transmission line.

5.1.3.1. Potential Impacts on Avifauna

Potential impacts on avifauna include

- High-flying birds such as raptors are susceptible to mid-air collisions with transmission lines, especially during poor visibility conditions like fog or rain.
- Noise, human presence, and machinery movement during construction may disturb birds, causing temporary displacement from nesting or foraging habitats.
- Even localized vegetation clearance can fragment habitats or disrupt flight corridors commonly used by gliding and soaring birds.
- Post-construction human activity and altered landscapes may increase predator access, disturb normal bird behavior, or degrade nearby habitats.

5.1.3.2. Mitigation Measures

The following mitigation measures are recommended to reduce risks to high-flying birds during and after construction:

- Install bird flight diverters on top conductors, especially in sections passing over ridgelines, wide valleys, or river crossings. Marker balls can increase line visibility and help birds avoid collisions.
- Prioritize vertical line configurations over horizontal spans in sensitive sections where technically feasible, as vertical arrays reduce the overall collision risk zone.
- Schedule construction activities during daylight hours only, avoiding early morning and late evening when many high-flying birds are most active.

- Avoid placing towers on ridgeline peaks or at narrow ridge saddles, which are frequently used as updraft zones by soaring birds. If unavoidable, ensure diverters are installed at regular intervals along those sections.
- Maintain a buffer of vegetation in adjacent non-ROW areas to offer alternative perching and gliding zones, reducing attraction to tower structures.
- Monitor post-construction bird movement patterns for at least one full season to identify collision hotspots or areas of concern. Adaptive mitigation (adding diverters) can be applied based on observed patterns.
- Raise awareness among project personnel regarding possible bird collisions and establish a simple reporting mechanism for any carcass or injured bird sightings to facilitate response.

5.1.4. Herpetofauna

Although the monsoon survey recorded only two herpetofaunas there is high possibility that additional species inhabit the project area, particularly in the undisturbed forest patches and riparian zones. Herpetofauna are often cryptic, seasonal, and highly sensitive to environmental conditions, which may limit detectability during a single-season assessment.

The observed amphibian (*Amolops* spp.) is typically associated with fast-flowing, mid-elevation streams, while the snake was found in moist forest undergrowth. Both species are listed as Least Concern on the IUCN Red List, but their microhabitat specificity indicates vulnerability to disturbance.

5.1.4.1. Potential Impacts on Herpetofauna

Potential impacts on herpetofauna due to transmission line construction include:

- Habitat alteration and microclimate disruption from vegetation clearance, especially in humid understory and riparian habitats.
- Increased mortality risk during excavation, vegetation removal, and movement of heavy machinery.
- Fragmentation of moist ground and leaf-litter habitats, affecting amphibians and low-mobility reptiles.
- Loss of breeding microhabitats, especially during the monsoon.

5.1.4.2. Mitigation Measures

To safeguard both recorded and potentially unrecorded herpetofauna within the project corridor, the following mitigation measures are recommended:

- Avoid or minimize disturbance near moist zones, streams, and seasonal drainage lines. Maintain a buffer of natural vegetation around such features to preserve shade and humidity.
- Schedule vegetation clearance outside of peak amphibian breeding seasons, ideally avoiding June to August when activity is highest.
- Conduct pre-construction visual inspections in damp, shaded areas, under logs, rocks, and leaf litter. Any herpetofauna found should be safely relocated by trained personnel to suitable nearby habitats.
- Avoid the use of harmful chemicals (e.g., herbicides, pesticides) in and near forested or riparian sections during and after construction.
- Restore and revegetate disturbed riparian areas post-construction using native plant species to help recover microhabitat conditions suitable for amphibians and reptiles.
- Train workers and contractors to recognize and avoid harming herpetofauna. Awareness briefings or visual materials should be used to promote co-existence and prevent intentional killing of reptiles and amphibians.
- Install erosion and sediment control structures, such as silt fences or straw barriers, to prevent sediment inflow into stream habitats that may affect aquatic amphibians.

5.2. Aquatic Biodiversity

The construction and operation of the 132 kV D/C transmission line for the 108 MW Wobthang Solar Farm will traverse multiple river systems that support fish and macroinvertebrates. Based on the water quality analysis and aquatic biodiversity assessment across survey points, the following impacts and mitigation measures are identified:

5.2.1. Potential Biodiversity Impacts

1. Disturbance to Aquatic Habitats
    - Tower construction, road development, and vegetation clearing near rivers and tributaries can increase sediment runoff, leading to higher turbidity, as observed at W10 (turbidity = 10.74 NTU) and elevated Total Suspended Solids (TSS).

- Sedimentation reduces water clarity, clogs fish gills, disturbs macroinvertebrate habitats, and can impact sensitive species like Ephemeroptera (mayflies) that require high oxygen levels.

2. Water Quality Alterations

- The study showed low Dissolved Oxygen (DO) at upstream sites (4.9–5.9 mg/L), iron concentrations exceeding WHO limits across all sites (up to 5.79 ppm), and high phosphorus downstream (>5 ppm at W10). Construction activities could exacerbate these trends by increasing organic load and nutrient influx from disturbed soil and vegetation.

3. Impact on Fish Migration and Breeding

- Sediment plumes and chemical changes during peak construction could disrupt the spawning grounds of fish species. However, the most common fish encountered was brown trout, which is a non-native fish and is categorized as least concern as per IUCN Red List Category.

4. Cumulative Impacts

- The transmission line crosses multiple sub-catchments in Bumthang and Trongsa. Combined with other infrastructure projects, there is a risk of incremental degradation, impacting macroinvertebrate diversity and reducing resilience of river ecosystems including the defragmentation of habitats for the macroinvertebrates.

5.2.2. Mitigation Measures

1. Sediment and Erosion Control

- Install silt traps, check dams, and sediment barriers at tower sites near rivers.
- Schedule major earthworks in dry season to minimize runoff during heavy rains.
- Use bioengineering (vegetative stabilization) on exposed slopes immediately after construction.

2. Buffer Zone and Riparian Protection

- Maintain minimum 30 m no-construction buffer along riverbanks; where unavoidable, adopt riverbank stabilization measures (gabions, vegetated riprap).
- Prohibit machinery from washing or refueling near water bodies.

CHAPTER SIX

6. Conclusion

The environmental and biodiversity assessment of the Wobthang Transmission Line alignment reveals a landscape rich in biological and ecological diversity but equally susceptible to anthropogenic pressures, particularly during monsoonal periods. Ambient air and noise levels were largely within acceptable thresholds, except for Site NA4, which exhibited elevated noise due to proximity to industrial activity. Meteorological conditions remained stable throughout the sampling period, supporting the reliability of the environmental readings.

However, a notable concern arising from the study is the microbiological contamination of water sources. The widespread presence of *E. coli* and coliform bacteria, especially in downstream locations, signifies fecal pollution likely originating from open defecation, livestock intrusion, and runoff from human settlements. Such findings underscore the need for effective public health interventions, particularly in communities relying on these water bodies for domestic use.

The systematic evaluation conducted across the 68-kilometer corridor revealed that the area hosts a range of forest types, from warm broadleaf to high-elevation fir and hemlock forests, each supporting distinct and diverse flora. A total of 195 plant species were recorded, including Bhutan's endemic *Rhododendron kesangiae* and 26 scheduled species under the Forest and Nature Conservation Act of 2023. These findings highlight the ecological value of the area and the need for considerate conservation planning.

The terrestrial fauna survey, through camera traps and indirect evidence, confirmed the presence of seven medium- to large-sized mammals, while the avifaunal assessment revealed a diverse bird community tightly linked to vegetation composition. The herpetofauna, although opportunistically surveyed, added to the overall richness, particularly in moist, shaded areas. Aquatic biodiversity assessments further demonstrate healthy fish and macroinvertebrate populations upstream.

Considering these findings, it is imperative that project developers adopt stringent mitigation strategies to avoid or minimize ecological disruption. Recommendations include maintaining forest buffers, avoiding construction in floristically rich plots, implementing erosion control during construction, and providing wildlife crossings in key corridors. Equally important is continued environmental monitoring, especially for water quality and mammal movement patterns, to detect long-term changes and adapt management accordingly.

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Appendix 4-4 Wobthang Transmission line Dry Season Report DoFPS

BIODIVERSITY REPORT

Rapid Biodiversity assessment of the proposed Solar Transmission line for the Wobthang Solar Project

Phuensum Consultancy Services

Department of Forest and Park Services

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List of Acronyms

BA	Basal Area
CF	Community Forests
DBH	Diameter in Breast Height
EIA	Environmental Impact Assessment
FNCA	Forest and Nature Conservation Act
FNCRR	Forest and Nature Conservation Rules and Regulations
IUCN	International Union for Conservation of Nature
NWFPs	Non-Wood Forest Products
POWO	Plants of World Online
RBA	Rapid Biodiversity Assessment
RECOP	Regulation for Environmental Clearance of Projects
VES	Visual Encounter Surveys

EXECUTIVE SUMMARY

In accordance with the Environmental Assessment Act 2000 and Regulation for Environmental Clearance of Projects (RECOP 2016), a Rapid Biodiversity Assessment (RBA) was conducted as part of the Environmental and Social Impact Assessment (ESIA) to assess the forests resources, habitat type and biodiversity along the proposed 20 km Wobtahng-Garpang solar transmission line corridor and access road for transmission tower. The survey covered an systematic assessment of flora, avifauna, mammals, herpetofauna, and butterflies, following Bhutan's Biodiversity Monitoring and Social Survey Protocol (2020). Vegetation assessments encompassed tree, shrub, and ground/herb layers, with data analyzed using MS Excel and R software to estimate basal area, stem density, and species diversity using the Shannon–Wiener Diversity Index (H'), providing essential baseline information for informed decision-making and mitigation planning.

The vegetation along the corridor is predominantly mixed conifer and Blue Pine (*Pinus wallichiana*) forests. About 16.2% of the plot area falls inside the modified forest type and 83.8 % falls within the natural forest type. Tree diversity was low to moderate, with 14 species from nine families recorded across 33 plots, dominated by *Pinus wallichiana*, followed by *Tsuga dumosa* and *Hydrangea heteromalla*. Out of the 14 species, one is classified as Endangered, two as Vulnerable, one as Near Threatened, eight as Least Concern, and two have not yet been assessed by the IUCN. Canopy cover varied across plots, reflecting differences in forest structure and disturbance. Shrub diversity was high along the corridor, with 55 species from 22 families dominated by Rosaceae and Ericaceae, while diversity was comparatively lower along access roads due to disturbance. Herbaceous plants included 68 species from 34 families along the transmission line, dominated by Asteraceae, and 41 species from 21 families along access roads. Out of the 143 recorded shrub species, 1 species is classified as Endangered (EN), 1 as Vulnerable (VU), 38 as Least Concern (LC), and the remaining species are Not Evaluated (NE) according to the IUCN Red List. The assessment of tree regeneration recorded six species, predominantly *Pinus wallichiana*, with most individuals as seedlings under one year old, which shows healthy natural regrowth which is referred to as regeneration

The herpetofauna and butterfly survey documented three species of reptiles and amphibians (*Pseudoxenodon macrops*, *Scutiger bhutanensis*, *Asymblepharus sikkimensis*) and two butterfly species (*Colias croceus* and *Issoria lathonia*), all observed in forest habitats~~. ~~Among the recorded species, *Pseudoxenodon macrops* is classified as Least Concern (LC), *Scutiger bhutanensis* and *Asymblepharus sikkimensis* are categorized as Data Deficient (DD), while both butterfly species, *Colias croceus* and *Issoria lathonia,* are listed as Least Concern (LC) under the IUCN Red List

The bird survey recorded 46 species from 28 families, totaling 527 individuals, predominantly in Blue Pine and mixed-conifer forests. The Shannon-Wiener diversity index (H') of 2.8 and Pielou's evenness (J') of 0.75 indicate a diverse, balanced, and healthy bird community. Fringillidae had the highest number of individuals, while Muscicapidae exhibited the highest species richness. All species are classified as Least Concern under the IUCN Red List, with 11 species legally protected under FNCRR 2023. The survey confirms that the corridor supports a diverse and stable bird population, reflecting good habitat quality, ecosystem functioning, and overall biodiversity value.

CHAPTER 1: INTRODUCTION

1.1 Background

Recognizing the constitutional mandate to maintain at least 60% of forest cover for all the time to come, Bhutan continues to pursue development initiatives that balance economic progress with biodiversity conservation (MoEA, 2008). One such initiative is the construction of a transmission line for the 132 kilovolt (kV) Wobthang Solar Project designed to enhance the nation's energy and electrical transmission capacity while supporting regional development goals. Biodiversity assessment has been integrated into the project planning process as a critical tool for informed decision making.

As a part of this strategic initiative, the Government of Bhutan is undertaking the construction of a 132 kilovolt (kV) solar transmission line connecting Wobthang (Tang) to Garpang (Chamkhar) in Bumthang district, spanning approximately 20 kilometers with a 27-meter corridor opening. However, as per Bhutan's Environmental Assessment Act 2000 and its Regulation for Environmental Clearance of Projects (RECOP) 2016, a comprehensive Environmental Impact Assessment (EIA), hereafter referred to as ESIA is a mandatory prerequisite for obtaining an Environmental Clearance (EC). The Rapid Biodiversity Assessment (RBA) survey was conducted as a key component of the Environmental Impact Assessment (EIA) for the above proposed project.

The purpose and objective of RBA:

1. The survey aimed to assess and document biodiversity (flora, avifauna, mammal and other taxa like butterflies, reptiles and amphibians) within the proposed transmission line and access roads.
2. To quantify the forest resources that will be impacted, including an inventory of trees that may be required to remove.
3. Identify and document the presence of any rare, endemic, threatened, or vulnerable species as per the IUCN Red List and Bhutan's Forest and Nature Conservation Act 2023 and recommend appropriate threats mitigation measures to support environmentally sustainable project implementation.

4. Identification of forest coverage that is natural and modified within the proposed project.

This approach ensures that the Wobthang to Garpang transmission line project proceeds with full understanding of its implications to biodiversity ensuring such projects are implemented in harmony with Bhutan's conservation values.

1.2 Project Site

The proposed 132 kilovolt (kV) solar transmission line falls within Tang and Choekhor Gewogs which traverses through community owned Community Forests (CF) as shown in Figure 1. The area lies at an altitude range of 2500 m (Garpang) to 3000 m (Wobthang). Generally, the project site spans across diverse forest types, from mixed-conifer forests to sub-alpine and alpine scrublands. The region receives 1000 to 3000 ml of rainfall annually and has warmer temperate climatic conditions (FRMD, 2017).

Agriculture and livestock rearing are among the primary sources of livelihood of the people residing within the project area. Cash income is generated mainly through the sale of agricultural produce and dairy products such as milk, butter, and cheese playing a crucial role in household sustenance (WCNP, 2023; NSB, 2017). Fodder is cultivated on dry land, reducing the need to herd cattle into nearby forests. Within the project area, traditional forest use primarily includes the collection of fuelwoods, harvesting of timber for house construction and fencing materials, and limited grazing of domestic animals. In the predominantly coniferous forests, the collection of non-wood forest products (NWFPs) is relatively minor. In addition to timber, local communities also extract forest resources such as firewood, fodder, and small quantities of NWFPs to meet household needs (WCNP, 2023; NSB, 2017).

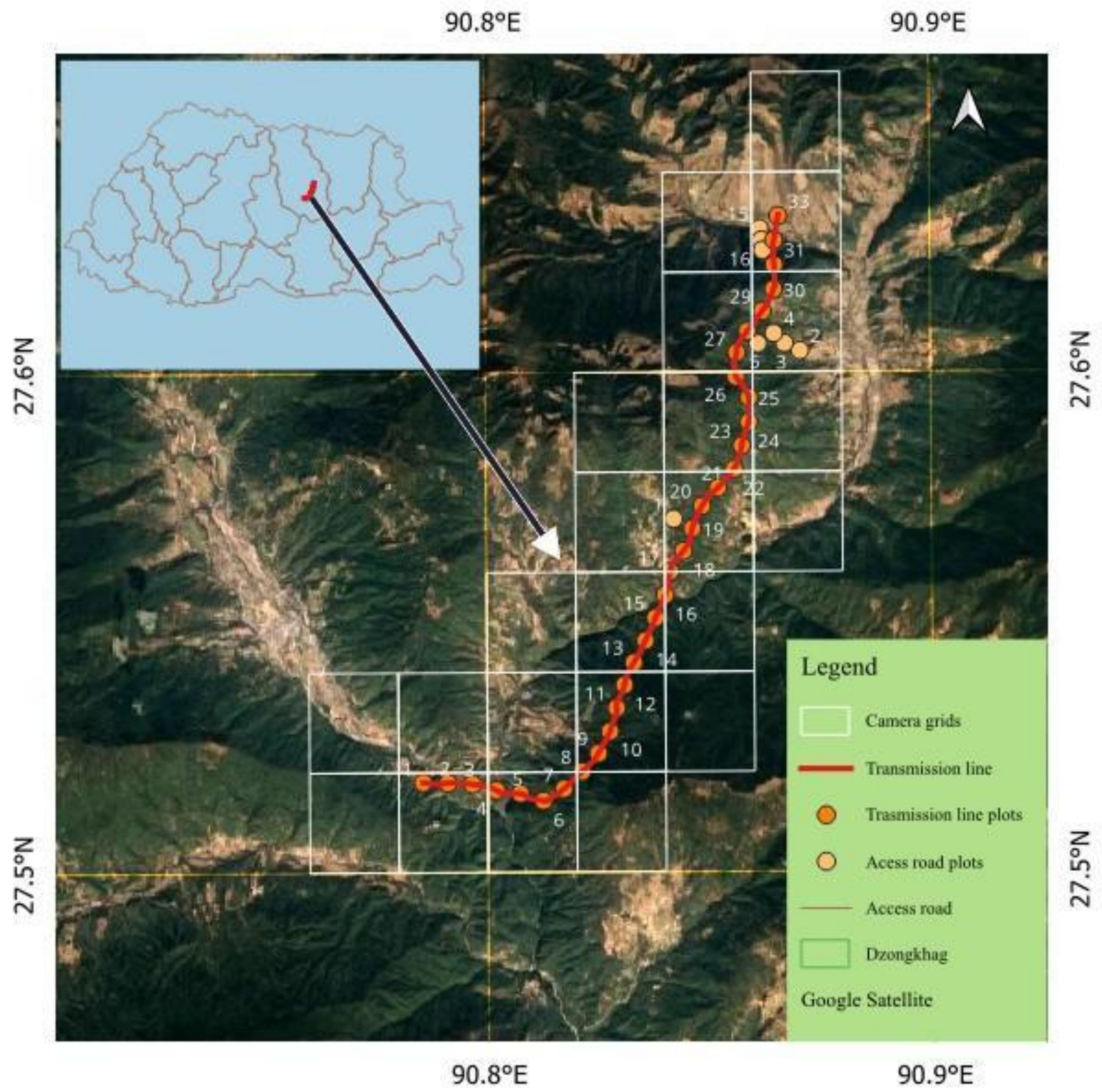

Figure 1. Survey area Map

CHAPTER 2: FLORAL DIVERSITY

Bhutan is a small, landlocked country covering an area of 38,394 square kilometers which makes less than 0.0075 percent of the Earth's surface, yet it is recognized as one of the biodiversity hotspot areas in the world. The country supports more than 5,600 species of seed plants, of which approximately 94 percent are native and 144 species are endemic to Bhutan (Yangzom and Long, 2015).

With Bhutan undergoing rapid growth in infrastructure and energy development, conducting floral surveys has become increasingly important for establishing baseline data, identifying and protecting high-value conservation areas, and monitoring shifts in plant diversity (Dorji et al., 2016). These surveys are vital for biodiversity conservation efforts and are integral to the Environmental Impact Assessment process, which aims to promote development that is environmentally sustainable and balanced with conservation goals (RGoB, 2014). Additionally, floral surveys support the development of a sustainable forest-based economy by aiding in the conservation of medicinal and non-wood forest products (NWFPS), thereby contributing to rural livelihoods and economic resilience (TEEB, 2010).

2.1. Methodology

2.1.1 Vegetation survey

A total of 41 plots were established (33 along the transmission line and 8 along access roads) using a systematic sampling with plots spaced 550 meters apart. The vegetation survey was conducted focusing on the three layers (Fig. 2, A & B): A. Tree layer, B. Shrub layer, and C. Ground/herb layer. Field data collection followed the standard guidelines outlined in Bhutan's Biodiversity Monitoring and Social Survey Protocol (2020). Within each sampling plot, data on trees and shrubs were gathered from randomly placed 50m x 50m plots. The regeneration, herbs, and ground layer assessments were carried out within 2m x 2m sub-plots established inside the larger tree/shrub plots.

All the woody species exceeding 1.3m height and 10 cm Diameter in Breast Height (DBH) were categorized as trees and plants between 0.5m and 5m in height were classified as shrubs or new growth of dominant species of the area (regeneration). The short, soft-stem plants ≤ 2m in heights were considered as herbs. The data collection on trees, shrubs, regeneration and herbs were recorded using the prescribed data sheets.

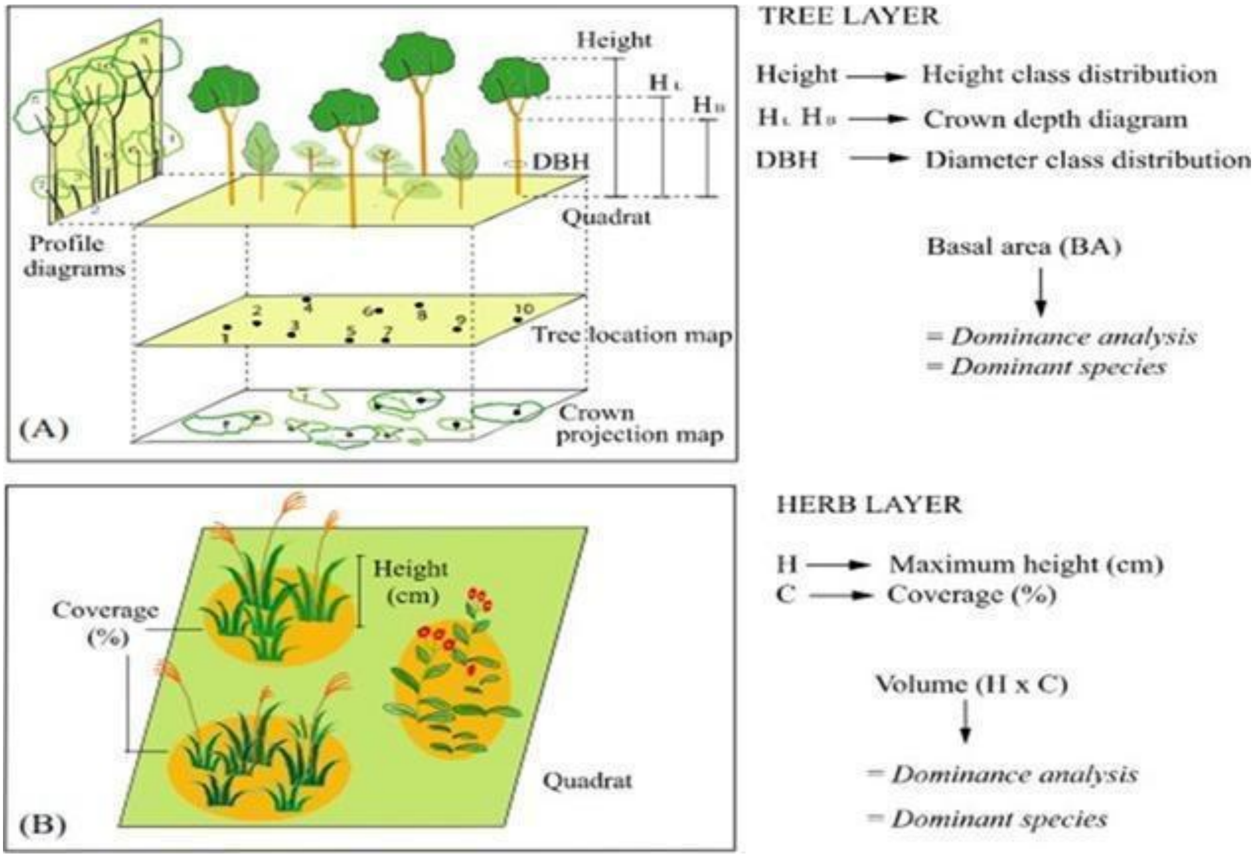

Figure 2. Vegetation survey method: (A) tree layer measurement (B) ground /herb layer measurement.

2.2 Data analysis

Data entry, sorting/cleaning, and basic analysis were conducted using pivot tables in MS Excel and R software. The basal area (BA, in cm²) was calculated to assess the proportion of space occupied by tree stems and stem density per plot was also calculated to estimate the number of trees that may need to be removed during the solar transmission line and access road construction. Species diversity and richness (the total number of different species) were determined using the Shannon-Wiener Diversity Index (H'). A higher H' value reflects greater species diversity, while a value of zero indicates the presence of only a single species. The index increases as both species richness and evenness improve.

$$H' = -\sum_{n=1}^{s} PilnPi$$

Where, H' = diversity index, Pi= ni/N, ni= number of individual types i, N=total number of individuals of all types and ln represents the natural logarithm.

2.2.3 Survey Equipment

Field equipment and materials such as a measuring tape, diameter tape, camera, vegetation survey forms/protocols, pen, pencil, knife, eraser, and a clipboard were materialized for the vegetation survey. Additionally, the mobile based application "SW map" was utilized to navigate and locate sampling plots.

2.3 Results

2.3.1 Tree diversity

The proposed transmission line from Wobthang to Garpang predominately falls under mixed-conifer and blue pine forests. Across 33 plots, 14 different species were recorded belonging to nine families. Most plots exhibit low to moderate diversity, indicating that tree species are largely dominated by a single species both in access road and transmission line. The dominant trees were *Pinus wallichiana* (*n=1602*) followed by *Tsuga dumosa* (*n=21*) and *Hydrangea heteromall* (*n=20*) for transmission line and similarly *Pinus wallichiana* (*n=283*) dominated the access road as well. Canopy cover showed considerable variation across plots, with the lowest value of 5% recorded at Nangnag and the highest value of 75% at Yerang.

The plot-wise Shannon Diversity analysis showed variation in tree diversity across the sample plots. Shannon diversity (H') and Simpson diversity (1–D) values range from very low in plots such as P5, P14, P17, and P22, (Figure 1) suggesting strong dominance by one or a few species and poor species evenness, to relatively high values in plots including P9, P13, P23, P27, and P31, which reflect higher species richness and more even distribution of tree individuals (Figure 3). Similarly, P15 and P16 showed the highest diversity for access roads (Figure 4). The results provide insights into species diversity, richness, and distribution, which are useful for assessing the biodiversity value of the area and for predicting the potential impacts of transmission line development on biodiversity. Overall, the findings indicate that the proposed transmission line and access road pass through sample plots that are predominantly dominated by single species.

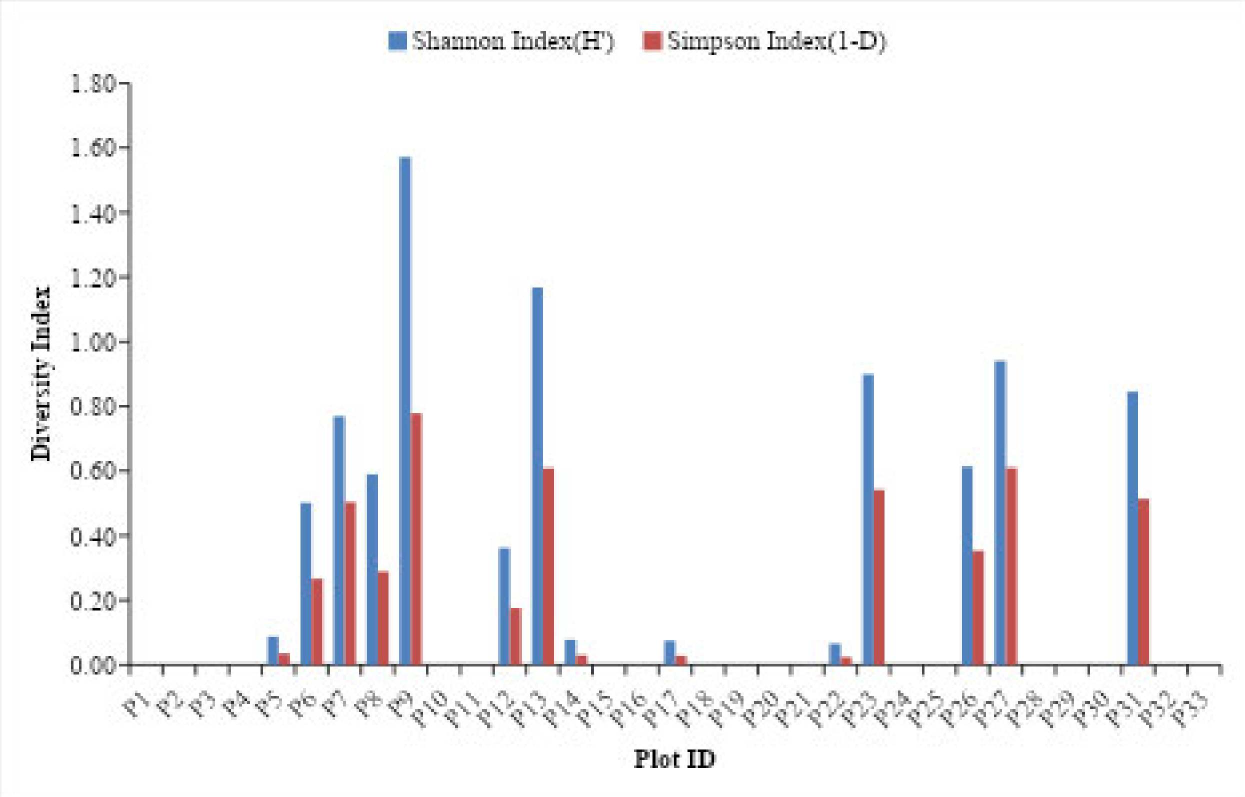

Figure 3. Shannon diversity (H') and Simpson diversity (1–D) variation across transmission lines.

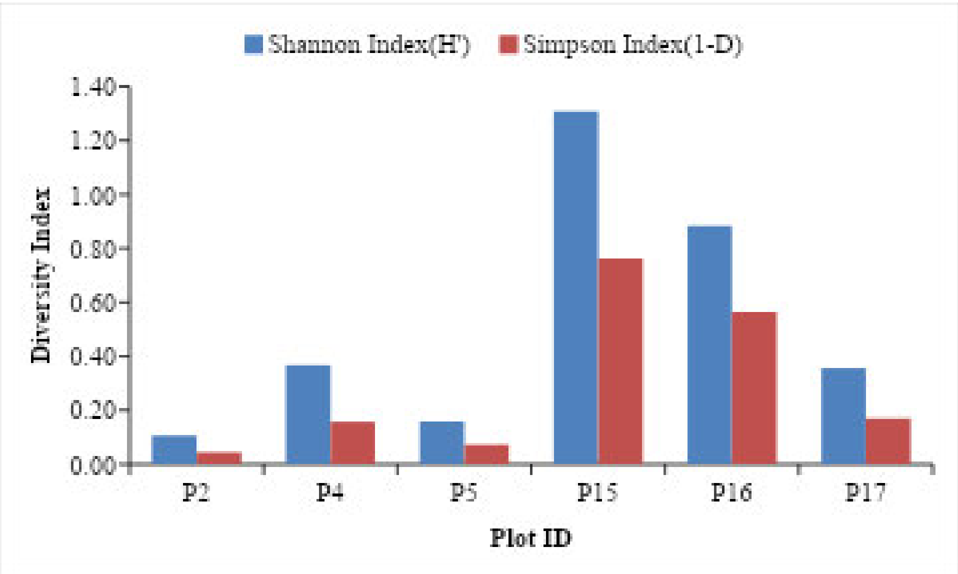

Figure 4. Graph showing Shannon diversity (H') and Simpson diversity (1–D) variation across access roads.

2.2.4 Shrubs Diversity

A total of 55 shrub species representing 22 different families were documented along the proposed transmission line. The most common families were Rosaceae with 12 species, and Ericaceae with 11 species. Families such as Aquifoliaceae, Asteraceae, Betulaceae, Buxaceae, Lamiaceae, Lauraceae, Smilacaceae, Symplocaceae, and Thymelaeaceae were less common, each represented by only one species. The highest species diversity was recorded in P 9 & P 11 (H'= 2.3) and the lowest species diversity was recorded in P 21 (H'= 0.5) as shown in Figure 5.

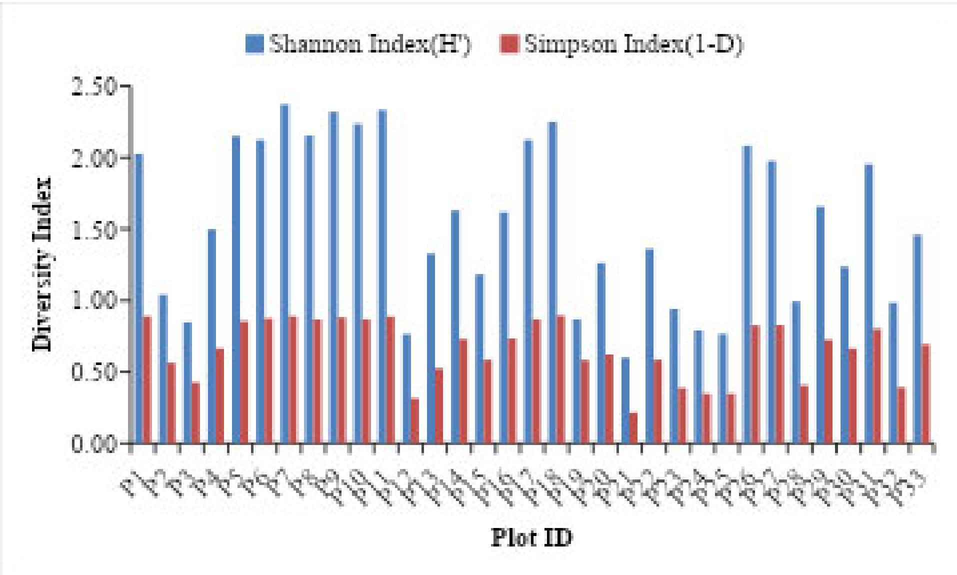

Figure 5. Shrubs diversity across Transmission line

A total of 27 shrub species from 14 plant families were documented along the access roads. The most dominant family was Rosaceae with 9 species. Less common families included Buxaceae, Caprifoliaceae, Fabaceae, Lauraceae, Poaceae, Salicaceae, Smilacaceae, and Thymelaeaceae, each represented by only one species. The highest species diversity was in P15 (H'=2.39) and low diversity in P 17 (H'=0.66) as shown in Figure 6.

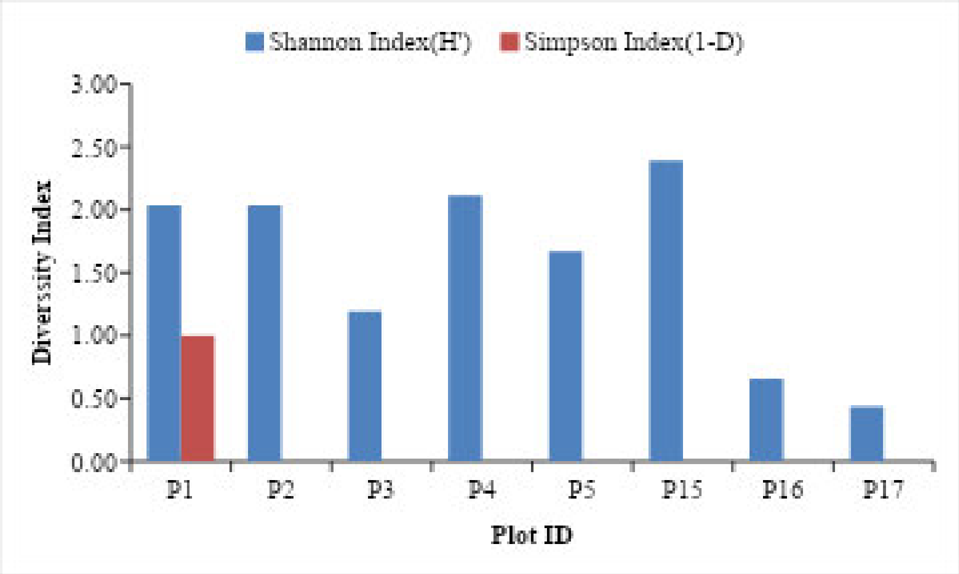

Figure 6. Shrubs diversity across access road.

2.2.5 Ground Vegetation

A total of 68 herbaceous plants, representing 34 different families were documented from 33 sample plots along the proposed transmission line. Asteraceae was the most dominant family with 14 species. Araliaceae, Asparagaceae, Campanulaceae, Caryophyllaceae, Dennestaedtiaceae, Dryopteridaceae, Hamiaceae, Juncaceae, Liliaceae, Lycopodiaceae, Ophioglossaceae, Oxalidaceae, Polygalaceae, Polypodiaceae, Pteridaceae, Saxifragaceae, Urtiaceae and Vitaceae were represented by a single species each, indicating lower dominance. The highest diversity was observed in sample plot 29 (H'=2.3) and lowest in sample plot 6 (H'=0.36) as shown in Figure 7.

A total of 41 herbaceous species, representing 21 different families, were documented along the proposed access roads. The family Asteraceae was the most dominant, comprising 10 species. Several other families, including Polypodiaceae, Plantaginaceae, Ophioglossaceae, Lycopodiaceae, Juncaceae, Hypericaceae, Geraniaceae, Fabaceae, Dernstaedtiaceae, Boraginaceae, Asparagaceae, and Apiaceae, were each represented by a single species, indicating lower levels of dominance. The highest diversity was observed in sample plot 15 (H'=1.93) and lowest in sample plot 17 (H'=1.31), Figure 8.

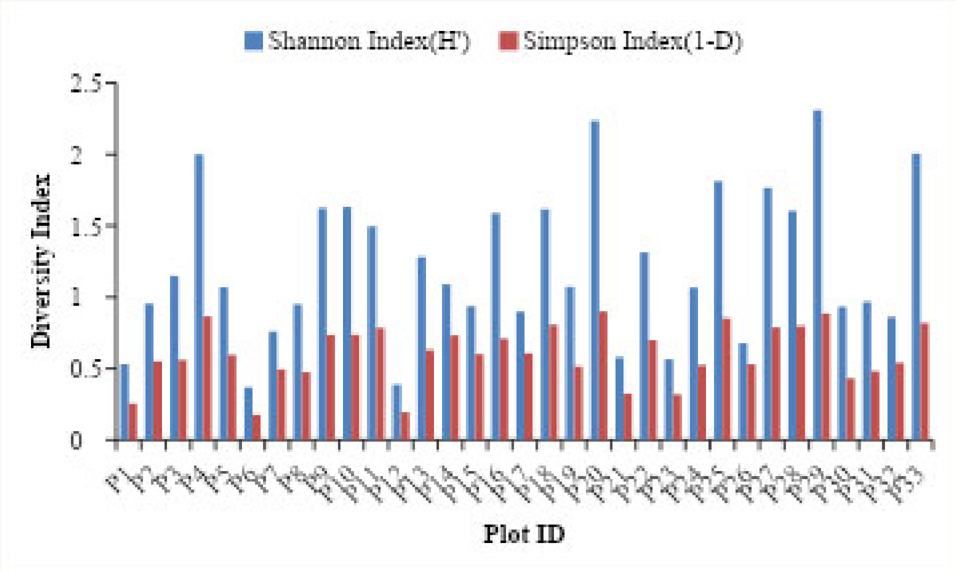

Figure 7. Herbs diversity across transmission line

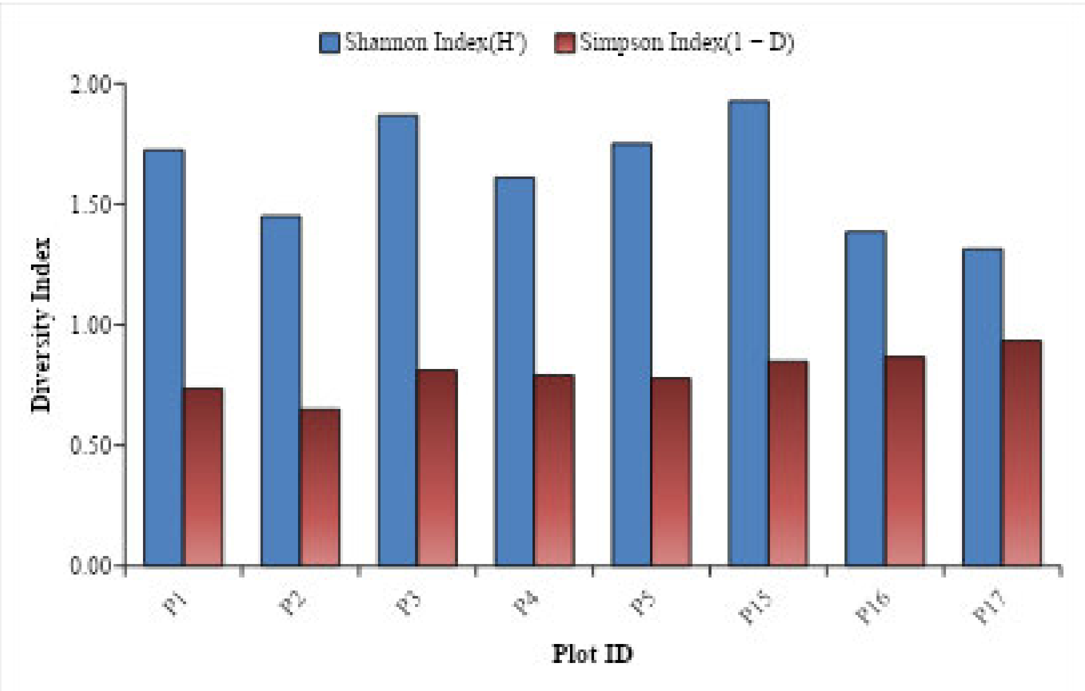

Figure 8. Herbs diversity across access roads.

2.2.6 Regeneration Structure of Forests according to Age and Height Classification

The survey recorded six regenerating species, with *Pinus wallichiana* being the dominant regenerating species (*n = 243*), followed by *Acer sp*. *(n = 12)*, *Taxus wallichiana* (*n = 9*), and *Picea brachytyla* (*n = 5*). In terms of age classes, 189 regenerating individuals were less than one year old, 131 were between one and two years old, and 33 were older than three years

(Figure 9). This age-class distribution indicates active regeneration, with most individuals occurring at the seedling stage, suggesting a good forest health, recovering naturally ensuring the continuity of the forest cover. The height of sapling was more between 1-30 cm followed by height class between 31-60 cm (Figure 10).

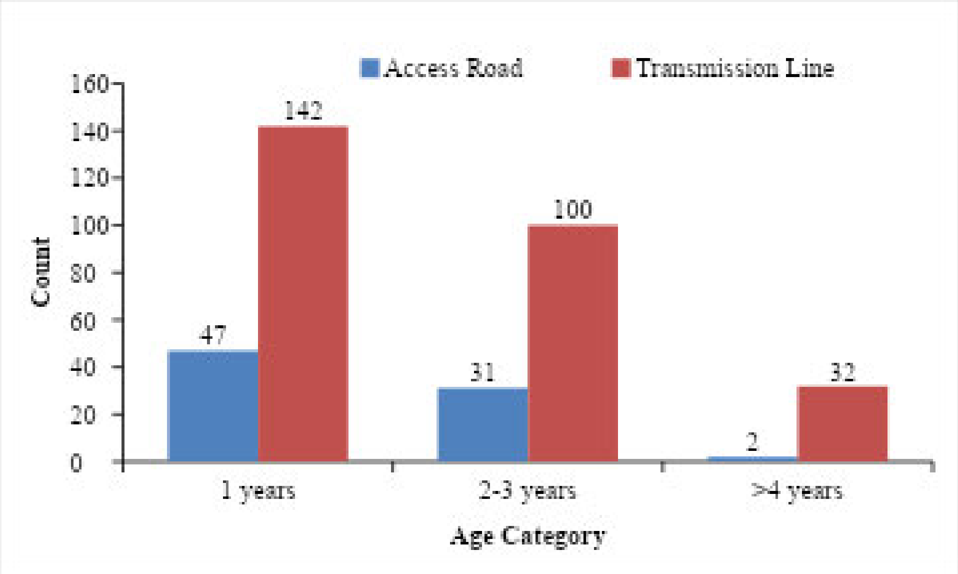

Figure 9. Regeneration age composition of access road and transmission line.

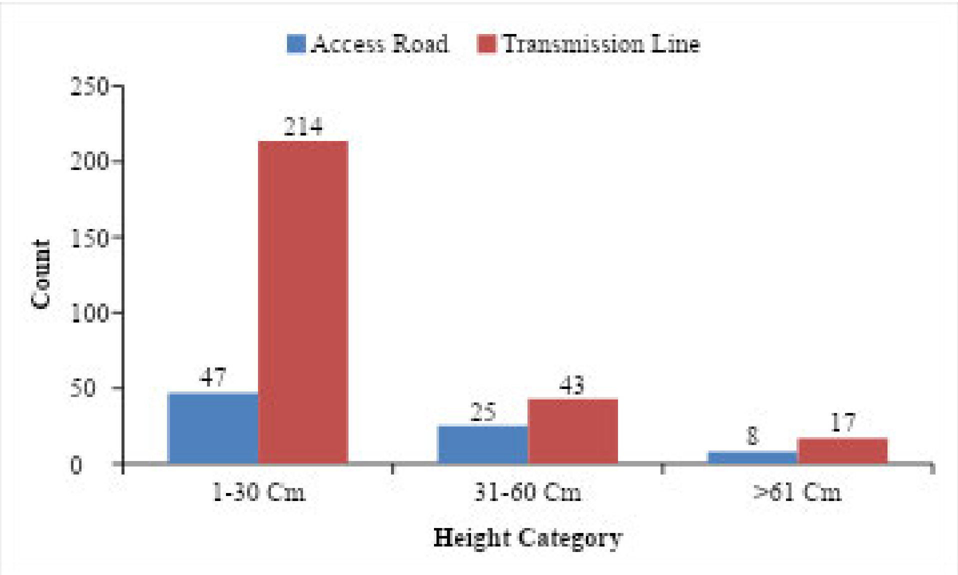

Figure 10. Height composition of access road and transmission line.

2.2.7 Tree species conservation importance in context to Bhutan

Key species recorded during the survey are presented in Table 1. Out of 14 different species, one species was classified as Endangered (EN), one Vulnerable (VU) and 12 species as Least Concern (LC) under the IUCN Red Listing category. All these species are listed under schedule II, III and special class timber under FNCA. These species are recognized as nationally prime timber resources, and thus it requires protection and management for the healthy forests.

Table 1. List of tree species under different schedule and IUCN Status

Sl.No	Scientific Name	Common / local Name	FNCA Schedule	IUCN Status
1	*Accer cappadocicum*	Maple, Chalam-Shing/Sermalingshing (Dzo), Kapasey (Lho)	II	Least Concern
2	*Acer sterculiaceum*	Maple, Chalam-Shing/Sermalingshing (Dzo), Kapasey (Lho)	II	Near Threatened
3	*Betula utilis*	Himalayan Birch, Taab (Dzo), chhar-shing (Sh)	II	Least Concern
4	*Pinus wallichiana*	Bluepine,Tongphu (Dzo), chang-shing (Sh), Dhubi (Lho)	II	Least Concern
5	*Corylus ferox*	Himalayan hazelnut	III	Least Concern
6	*Hydrangea heteromalla*	Not Evaluated	III	Least Concern
7	*Ilex dipyrena*	Not Evaluated	III	Least Concern
8	*Lyonia villosa*	Shajula-shing (Sh), Lek angeri(Lh)	III	Least Concern
9	*Malus baccata*	Not Evaluated	III	Least Concern
10	*Picea brachytyla*	Spruce, Bashing (Dzo), Kalo salla (Lh)	III	Vulnerable
11	*Populus rotundifolia*	Not Evaluated	III	Vulnerable
12	*Prunus rufa*	Not Evaluated	III	Not Evaluated
13	*Tsuga dumosa*	Hemlock, Sey shing(Dz), Tengre sallam(Lh),	III	Not Evaluated
14	*Taxus wallichiana*	Himalayan Yew, Ha-shing (Dzo), Keerang shing (Sh), Dhengre salla (Lho)	Special Class Timber	Endangered

2.2.8 Calculation of Stem Density and biodiversity impact.

Stem density was calculated by dividing the total number of trees enumerated within each plot by the plot's area, which is 0.25 hectares. This calculation facilitates the estimation of the total number of stems per hectare and allows projection across the entire proposed project area. The analysis of stem density along the solar transmission line indicates that Plot P20 recorded the highest density, with approximately 450 trees followed by P3 and P25 with 412 each. On average, about 309 trees per hectare are likely to be cleared along the proposed transmission line and access road. When extrapolated across the total project area of 46.9 ha, it is estimated that approximately 14366 trees and poles would be removed.

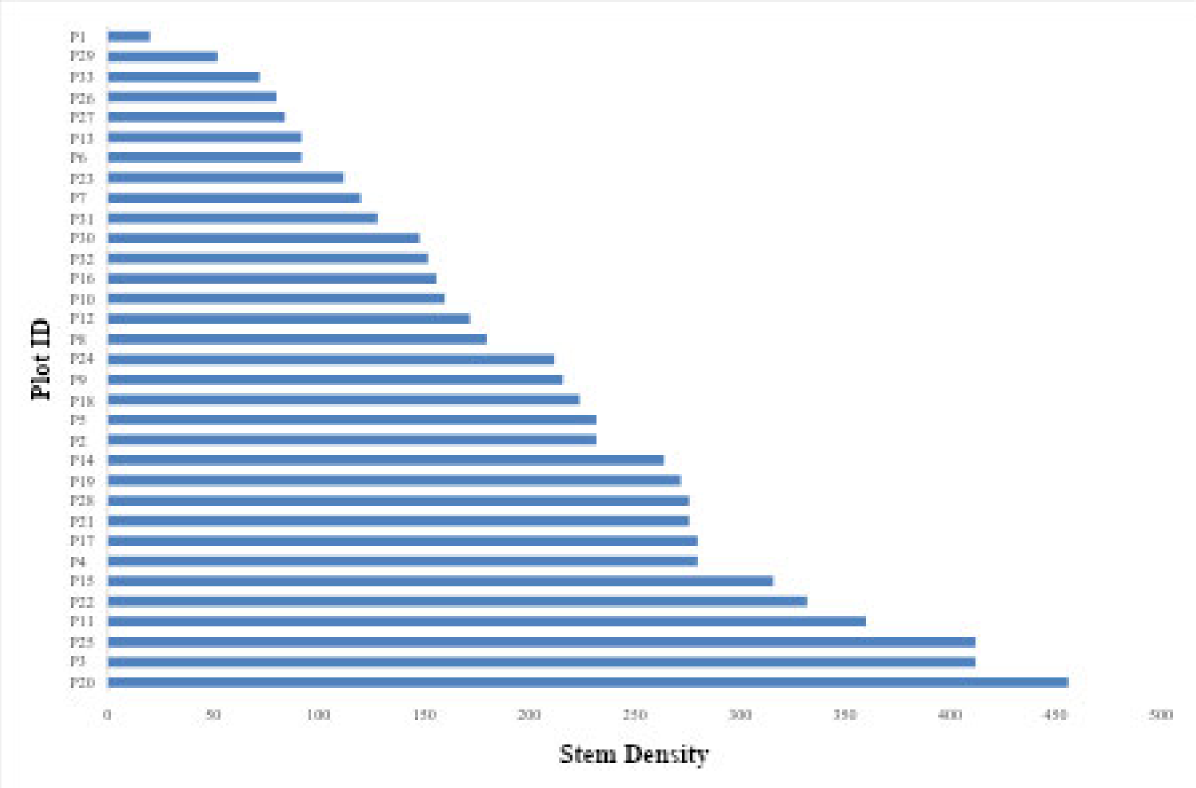

Figure 11. Stem density for transmission line.

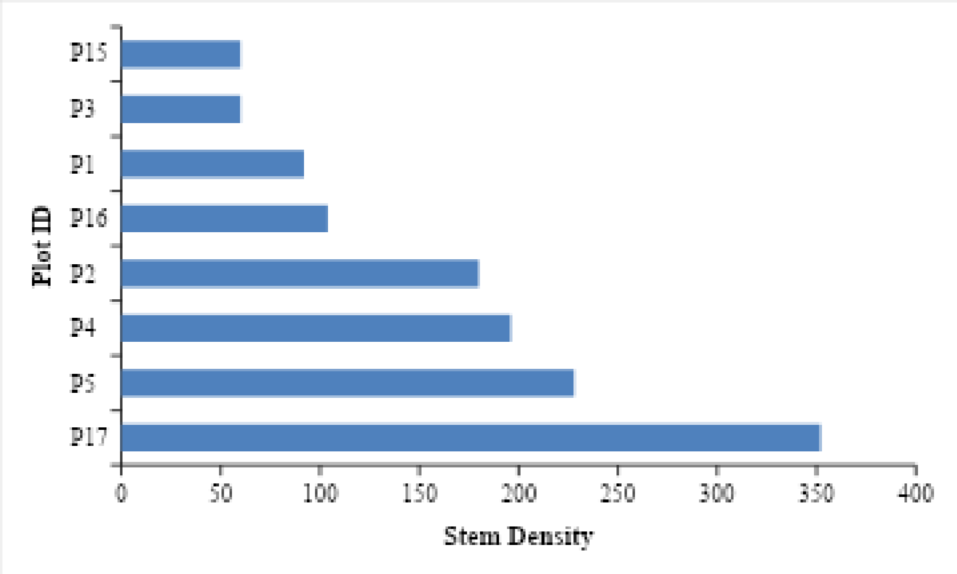

Figure 12. Stem density for access roads.

2.2.9 Comparative Analysis of Natural and Modified Forest Types

For the natural and modified forests type, we have conducted two kinds of assessment, one through study of forests types from the sample plots following criteria set in Annexure 7 and other through GIS analysis using Land Use and Land Cover 2020 data maintained by National Land Commission of Bhutan. The first assessment reveals a slightly larger proportion of the sampled area (Figure 13; Table 2), with 18 plots (54.55%), compared to natural habitats, which comprise 15 plots (45.45%). This suggests that anthropogenic influence is more prevalent within the proposed transmission line. Despite having fewer plots, natural habitats exhibit a lower mean canopy cover (39.4%), whereas modified habitats show a substantially higher canopy cover (60.6%). The higher canopy cover in modified areas reflect the dominance of dense, often mono-species stands resulting from regeneration following disturbance.

Table 2. Table showing natural and modified forest types and their mean canopy cover percentage based on plot-wise analysis

Habitat	Plots	Percentage (%)	Canopy cover (%)
Natural	15	45.45	39.4
Modified	18	54.55	60.6

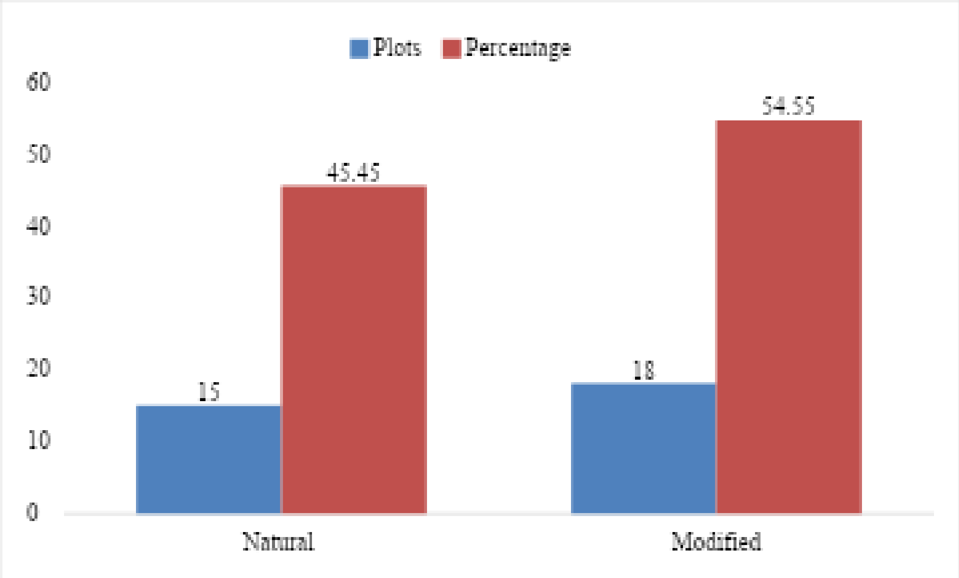

Figure 13. Natural and modified forest types

From the GIS analysis, 62 % of the Right of Way for access road have natural forests and only 38% was modified forests including agriculture land. In contrast to plot-wise assessment, GIS analysis revealed only 13% of transmission line as modified forests, with remaining 87% as natural forest (Figure 14). Overall, from GIS analysis reveals 44.8388 hectares of proposed area under natural forests, whereas only 8.6512 hectares as modified forests.

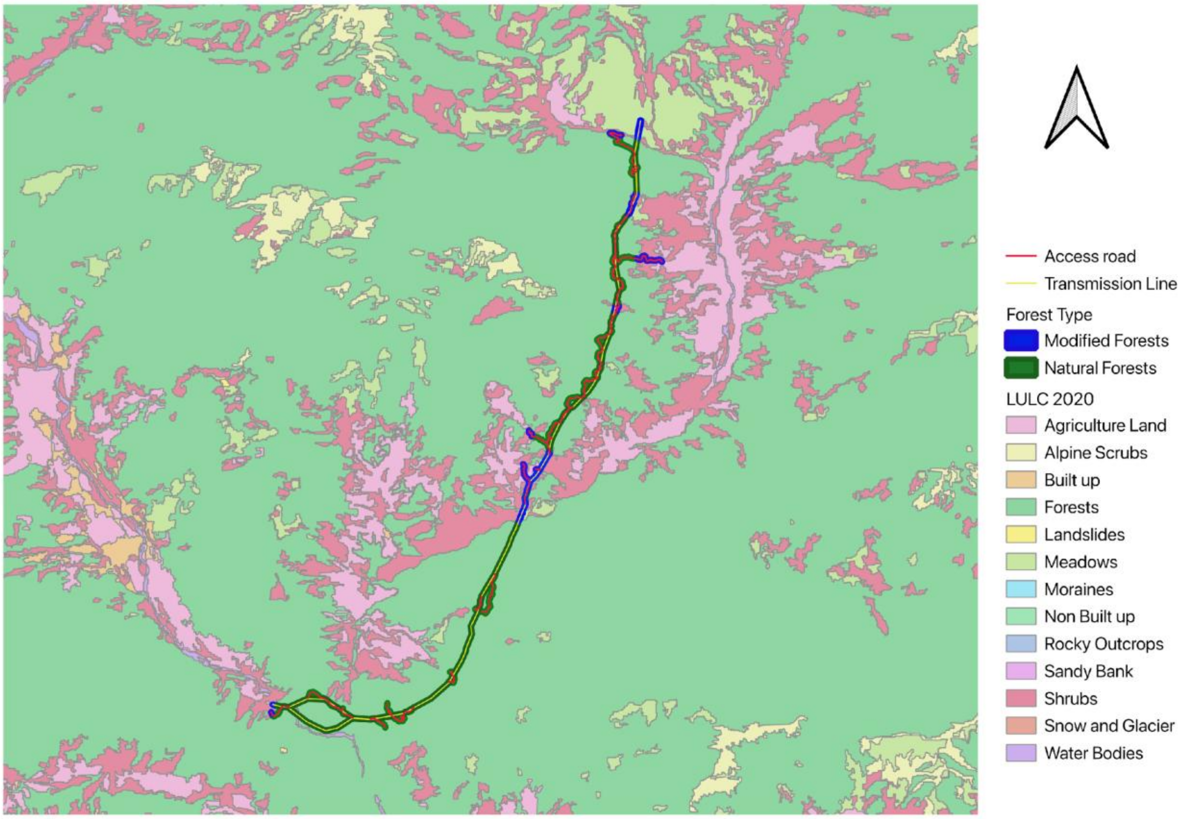

Figure 14. Forests type (natural and modified) based on Land Use Land Cover Map of Bhutan 2020.

2.2.10 Mitigation Measures

1. Implement effective soil erosion control measures during the construction of temporary access roads.

2. Establish a robust environmental monitoring and evaluation framework to track any encroachment and illegal activities during the project implementation.
3. Avoid removal of mature trees that are Endangered (*Taxus wallichiana*), Vulnerable (*Picea brachytyla*) under IUCN List where technically feasible and adopt selective pruning instead of clear felling.
4. Limit vegetation clearance strictly to the approved Right of Way (ROW) and access road width.

5. Linear clearing of vegetation may result in establishment and spread of invasive species, including bamboo and other unwanted species. Therefore, appropriate mitigation measures, such as regular monitoring and control of invasive species to minimize localized ecological impacts is highly recommended.

CHAPTER 3. HERPETOFAUNA AND LEPIDOPTERA DIVERSITY

3.1 Background

Herpetofauna, which includes amphibians and reptiles, are important components of natural ecosystems. They are highly sensitive to changes in temperature, moisture, and habitat conditions, making them good indicators of environmental health (Vitt & Caldwell, 2014). Amphibians play a vital role in controlling insect populations, while reptiles contribute to food web balance as both predators and prey. In Tang Valley in Bumthang, the distribution and diversity of herpetofauna are strongly influenced by altitude, climate, and habitat type (Stuart et al., 2004).

Butterflies are among the most well studied insect groups and are widely used as indicators of biodiversity and habitat quality. Their life cycle is closely linked to specific host plants and environmental conditions, making them sensitive to habitat disturbance and climate change (Bonebrake et al., 2010). Forests, grasslands, agricultural fields, and open landscapes found in Tang valley provide suitable habitats for a variety of butterfly species. The presence and diversity of butterflies often reflect the overall condition of vegetation and ecosystem stability (Kunte, 2000).

Wobthang, located in Bumthang District of central Bhutan, where the solar transmission line proposed is characterized by a cool temperate climate with conifer and mixed forests and cultivated land. These diverse habitats are likely to support a range of herpetofauna and butterfly species. However, information on these taxa from the Wobthang area remains limited compared to studies on birds and mammals.

The survey team carried out the opportunistic survey for herpetofauna and butterflies in the Wobthang area as a requirement for biodiversity assessment before venturing the solar project along the transmission line corridor.

3.2 Methodology

The herpetofauna and butterfly survey along the transmission line corridor along Wobthang to Garpang, was carried out using field methods recommended for biodiversity inventories.

3.2.1 Herpetofauna Survey

Herpetofauna were surveyed using Visual Encounter Surveys (VES) and systematic searches of likely hiding places such as under rocks, logs, and other ground cover. VES involves actively walking through the landscape and carefully scanning microhabitats where reptiles and amphibians may shelter, which is a widely applied method for sampling these groups during rapid biodiversity assessments (Heyer et al., 1994; Pinero et al., 2025).

Snake tongs and hooks were used to gently lift rocks and logs to locate cryptic animals without causing harm. Searches were conducted at suitable times of day and night to increase the chances of observing both diurnal and nocturnal species.

3.2.2 Butterfly Survey

Butterflies were surveyed primarily through visual observations and transect walks in flower rich and open areas such as the marshy landscape. Walking along the transect, observers recorded butterflies seen within a reasonable distance on both sides of the transect. This approach follows commonly used butterfly monitoring practices where observers count individuals while walking through suitable habitats (Royer, Austin & Newton, 1998). A Canon camera was used to photograph butterflies for later identification, which helps ensure accurate species identification when field conditions make quick identification difficult.

3.3 Data Collection and Identification

Herpetofauna and butterfly observations were recorded on standardized datasheets, including date, time, location, weather conditions, and habitat description. GPS units were used to georeference each encounter point. Photographs taken during the survey were later reviewed with reliable field guides to support accurate species identification. This combination of field expertise and photographic evidence improves the reliability of biodiversity records.

3.4 Results and Discussion

3.4.1. Herpetofauna diversity

During the survey along the Wobthang Solar Transmission Line area, three herpetofauna species were recorded. These included one snake, one lizard, and one toad. All the species were found in mixed conifer forest, showing that this habitat provides suitable living conditions for reptiles and amphibians.

Table 3. List of herpetofauna

Sl.No	Species	Common Name	Count	Habitat
1	*Pseduxenodon macrops*	False Cobra	1	Mixed Conifer
2	*Scutiger bhutanensis*	Bhutan Cat-eyed Toad	1	Mixed Conifer
3	*Asymblepharus sikimmensis*	Sikkimese Rock Skink	1	Mixed Conifer

The False Cobra (*Pseudoxenodon macrops*) was observed once. This snake usually lives in forest areas with leaf litter and ground cover. Its presence shows that the forest floor along the transmission line still has natural conditions needed for such species. One Bhutan Cat-eyed Toad (*Scutiger bhutanensis)* was also recorded. Toads need moist areas and are sensitive to environmental changes. Finding a toad indicates that the area has enough moisture and suitable shelter for amphibians.The Sikkimese Rock Skink (*Asymblepharus sikkimensis*) was found in rocky parts of the forest. This lizard uses rocks and forest ground for shelter and basking. Its presence shows that natural features like rocks and fallen logs are available in the area.

The low number of herpetofauna recorded during the survey may be due to several reasons. The survey was carried out during the winter season, when most reptiles and amphibians become inactive and remain in brumation, making them difficult to detect. In addition, the survey period was short, and the study was limited to the transmission line corridor. Therefore, it is possible that not all suitable habitats and areas were fully explored, and more species may be present in the area but were not observed during the survey.

3.4.2 Butterfly diversity

The butterfly survey in the Wobthang Solar Transmission Line area recorded two species with a total of five individual butterflies. The Clouded Yellow (*Colias croceus*) was the most common species with three individuals, while the Queen of Spain Fritillary (*Issoria lathonia*) was recorded with two individuals. Overall, butterfly numbers and species diversity were low during the survey.

The two butterfly species belonged to two families, namely Pieridae and Nymphalidae. This shows low family level diversity, indicating that only a small variety of butterflies was active or visible during the survey period. Both species were recorded from the Blue Pine Forest habitat. This habitat provides open spaces and sunlight, which are suitable for butterflies. However, limited flowering plants during the survey period may have reduced food availability, affecting butterfly presence and activity.

Table 4. List of butterflies

Sl.No	Species	Common Name	Family	Count	Habitat
1	*Colias croceus*	Clouded Yellow	Pieridae	3	Blue Pine Forest
2	*Issoria lathonia*	Queen of Spain Fritillary	Nymphalidae	2	Blue Pine Forest

The low butterfly diversity observed in the area may be due to several reasons. The survey was conducted during a cold season, when butterfly activity is generally low. The survey period was short and covered only areas along the transmission line corridor, so not all suitable habitats were explored. In addition, limited flowering plants, weather conditions, and time of observation may have further reduced butterfly sightings. Therefore, more butterfly species are likely present in the area but were not recorded during the survey.

More comprehensive data collection methods such as pitfall trapping, drift fences, cover boards, and nocturnal call surveys for amphibians were not employed in this study. Although these techniques are effective in improving detection rates and generating a more complete inventory of herpetofauna, their application requires longer survey periods, repeated sampling, increased manpower, and additional financial resources. Moreover, pitfall traps require daily monitoring to prevent mortality of captured animals and are particularly unsuitable during the winter season when herpetofaunal activity is extremely low.

It is also important to note that, historically, Bumthang District supports lower herpetofaunal diversity and population density compared to lower-altitude regions of Bhutan, due to its colder climate and high-elevation environment (NCD, 2024). Under such conditions, the expected encounter rate is naturally low, even with intensive sampling methods. Considering the limited timeframe, logistical and budgetary constraints, the winter season, and the inherently low herpetofaunal diversity and activity in high-altitude areas like Bumthang, the use of more intensive methods was not considered practically or scientifically efficient for this survey. Therefore, the assessment relied primarily on visual encounter surveys and opportunistic observations, which were more appropriate and proportionate to the ecological context and prevailing field conditions.

CHAPTER 4. AVIFAUNAL DIVERSITY

4.1 Background

Bhutan, cradled in the eastern Himalayas, is one of Asia's most significant places for bird diversity. Even though it is a small country, Bhutan has a remarkable variety of birds because of its wide range of altitudes, different climates, and strong commitment to protecting the environment. The land rises from the subtropical southern plains at about 97 meters above sea level (Namgyal et al.,2008; Nepal, 2022) to snowy high mountains over 7,570 meters in the north (Nepal, 2022). This creates many different habitats that support a large number of bird species (Inskipp, Inskipp, & Grimmett, 2016).

Bhutan lies where three different regions meet: the Indo-Malayan, Palearctic, and Sino-Himalayan zones. Because of this, tropical, temperate, and alpine birds all live in the country. More than 750 species of birds have been recorded in Bhutan, which is almost 8% of all the birds in the world (Grimmett et al., 2019). Currently, about 766 bird species are known in the country, and new records are added almost every year.

Bumthang, often called Deyzhi and known as the spiritual heartland of Bhutan, is also famous for its bird life. Its valleys, rivers, and forests support over 400 bird species (Exotic Birding LLC, n.d.). The mix of forests, meadows, and rivers provides homes for both birds that live there year-round and birds that come seasonally (Exotic Birding LLC, n.d.; HIDMC, n.d.).

In this area, pheasants like the Satyr Tragopan and Blood Pheasant live alongside Thrushes and Warblers, while migratory birds such as the wintering Black-necked Crane also visit (Exotic Birding LLC, n.d.). The birds of Tang, Choekhor, Ura and Chumey are an important part of Bhutan's natural heritage, attracting both scientists and bird watchers to explore and enjoy them (HIDMC, n.d.).

Tang Valley, one of Deyzhi's main valleys, is located at 2800-4000 meters above sea level and has rolling meadows, rivers, and temperate forests (Exotic Birding LLC, n.d.; HIDMC, n.d.). The valley is important for protecting high altitude ecosystems and the many birds that live there. At the same time, there is a need to improve local livelihoods through sustainable activities like eco-tourism, farming that protects the environment, and setting up solar panels, which give clean energy and reduce pressure on forests. The valley, made up of Blue Pine and mixed-conifer forests, was surveyed for biodiversity as part of the planning for the transmission line needed for the solar panel project.

4.2 Methodology

4.2.1 Study Area and Survey Design

The bird diversity of Tang Valley was surveyed along the proposed solar panel transmission line corridor. The survey was conducted along a 20 km stretch, following a transect line laid parallel to the transmission corridor. The survey area mainly comprises Blue Pine (Pinus wallichiana) forest with patches of mixed-conifer forest, representing typical high altitude conifer ecosystems of Bumthang.

4.2.2 Bird Survey Method

Birds were recorded using MacKinnon's listing method, a widely used rapid biodiversity assessment technique suitable for forest habitats. This method involves compiling a list of a fixed number of species encountered sequentially during a survey walk. In accordance with the Biodiversity Monitoring Protocols of Bhutan, a list size of 10 species was adopted, as the study area falls under conifer forest as per the Biodiversity Monitoring Protocol of Bhutan.

During the survey, all bird species detected through direct visual sightings, vocalizations (calls), and indirect evidence such as carcasses, feathers, and droppings were included. Each species was recorded only once within a single list, regardless of the number of individuals observed. However, the number of individuals encountered for each species was noted alongside the species name. Once a list of 10 different species was completed, a new list was started following standard MacKinnon's listing procedures. This approach allows for an assessment of species richness, relative abundance, and commonness of species across the survey area.

4.3 Species Identification and Documentation

Bird species were identified primarily based on the surveyors' field expertise. For species that could not be confidently identified in the field, standard bird field guidebooks were referred. Bird calls were identified using the Merlin Bird ID application and cross-checked with reference calls provided by Dr. Sherab to ensure accuracy. Nikon binoculars were used to observe birds at a distance.

Photographic evidence was collected whenever possible using a Canon 90D camera fitted with a 400 mm lens. However, due to distance, dense vegetation, or brief sightings, photographs could not be obtained for all species. All observations were systematically recorded using a pen and notebook during the survey.

4.4 Data Analysis

Bird diversity for the Wobthang Solar transmission line was analyzed using the Shannon-Wiener diversity index (H’), which describes both the number of bird species and their relative abundance in the study area. Bird records collected during field surveys were compiled into a species list with corresponding encounter frequencies. As the survey followed MacKinnon’s listing method, the frequency of each species across successive lists was used as a measure of relative abundance.

For each species, the proportion (pi) was calculated by dividing the number of times the species appeared in the lists by the total number of bird records. The Shannon-Wiener diversity index was then calculated using the following formula:

$$H^{'} = -\sum_{n=1}^{s} \quad PilnPi$$

Where, H’ = diversity index, Pi= ni/N, ni= number of individual types i, N=total number of individuals of all types and ln represents the natural logarithm.

Species evenness was calculated using Pielou’s Evenness Index as below:

$$J' = \frac{H'}{lnS}$$

Where H’ is the Shannon-Wiener diversity index and S is species richness. The resulting evenness value indicates the extent of dominance and distribution of bird species within the survey area.

4.4 Results and Discussions

4.4.1 Species Accumulation Curve

The species accumulation curve for birds shows a rapid increase in the number of species during the initial survey lists, indicating that a large proportion of common and easily detectable bird species were recorded early in the sampling period. This steep initial rise reflects high bird diversity and efficient survey coverage (Figure 15).

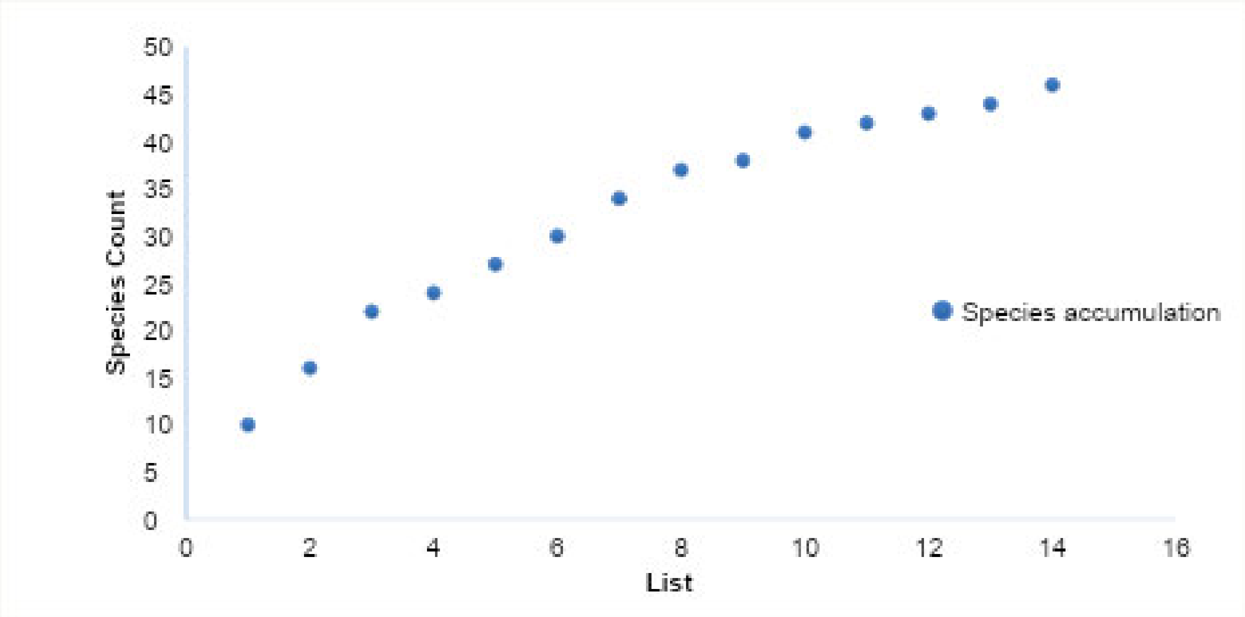

Figure 15. Species Accumulation Curve

As the sampling progressed, the rate of species addition gradually declined, suggesting that the most regularly occurring species had already been documented. Towards the later lists, the curve begins to level off indicating that additional sampling contributed few species. This pattern suggests that the remaining unrecorded species are likely rare, seasonal or less detectable.

The near asymptotic shape of the curve indicates that the bird survey effort was largely sufficient to capture the species richness of the Wobthang Solar transmission line corridor.

4.4.2 Species Diversity

The Shannon Diversity Index of 2.8 shows that the area has a high diversity of birds. Many different species are present, and no single species dominates, which means the bird population is healthy and balanced.

The forest is in good condition, with enough trees, shrubs, and ground vegetation to provide food, shelter, and nesting sites for birds. The variety of birds shows that there is enough food for different types, like insects, fruits, and seeds. Birds in this area help the forest by spreading seeds, pollinating plants, and controlling insects, which keeps the ecosystem healthy and balanced.

Overall, the Shannon index of 2.8 indicates that the forest and surrounding area are healthy, supporting a diverse and stable bird community, and that the ecosystem is functioning well.

4.4.3 Species Evenness

In the Wobthang transmission line corridor, the evenness index (Pielou's evenness, J') is 0.75. The value of the evenness index ranges from 0 to 1, where values closer to 1 indicate a more even distribution of individuals among species, and values closer to 0 indicate strong dominance by one or a few species.

An evenness value of 0.75 suggests that the bird community in the survey area is fairly evenly distributed. This means that although some species were recorded in higher numbers, many other species also contributed substantially to the total bird population. However, the distribution is not perfect even because a few species, such as the Plain Mountain Finch (191), were much more abundant than others.

The next group of relatively dominant species includes Rufous-breasted Accentor (26), White-browed Fulvetta (26), Large-billed Crow (20), Red-billed Chough (19), Russet Sparrow (18), and Common Pigeon (16). These species were recorded in moderate to high numbers and together form the core of the bird community. Their presence indicates that suitable feeding and nesting conditions are available across the study area.

Most of the remaining species, such as Green-backed Tit (12), Grey-crested Tit (12), Spotted Nutcracker (15), Striped-throated Yuhina (11), and Rusty-flanked Treecreeper (11), occurred in moderate numbers. These species help maintain overall evenness by contributing regularly to the total population without becoming overly dominant.

Several species, including Black Eagle, Brown Dipper, Himalayan Wood Owl, and Slaty-backed Forktail, were represented by only one or two individuals. These rare species reduce evenness slightly but are ecologically important, as their presence reflects habitat heterogeneity and availability of specialized microhabitats.

4.4.4 Species Richness

A total of 46 species belonging to 28 families composed of 527 individuals were recorded during the survey. This indicates moderate to high species richness, showing that the survey area supports a wide variety of bird species. The family Muscicapidae exhibited the highest species richness, indicating that this group is particularly well adapted to the local habitat conditions (Figure 16).

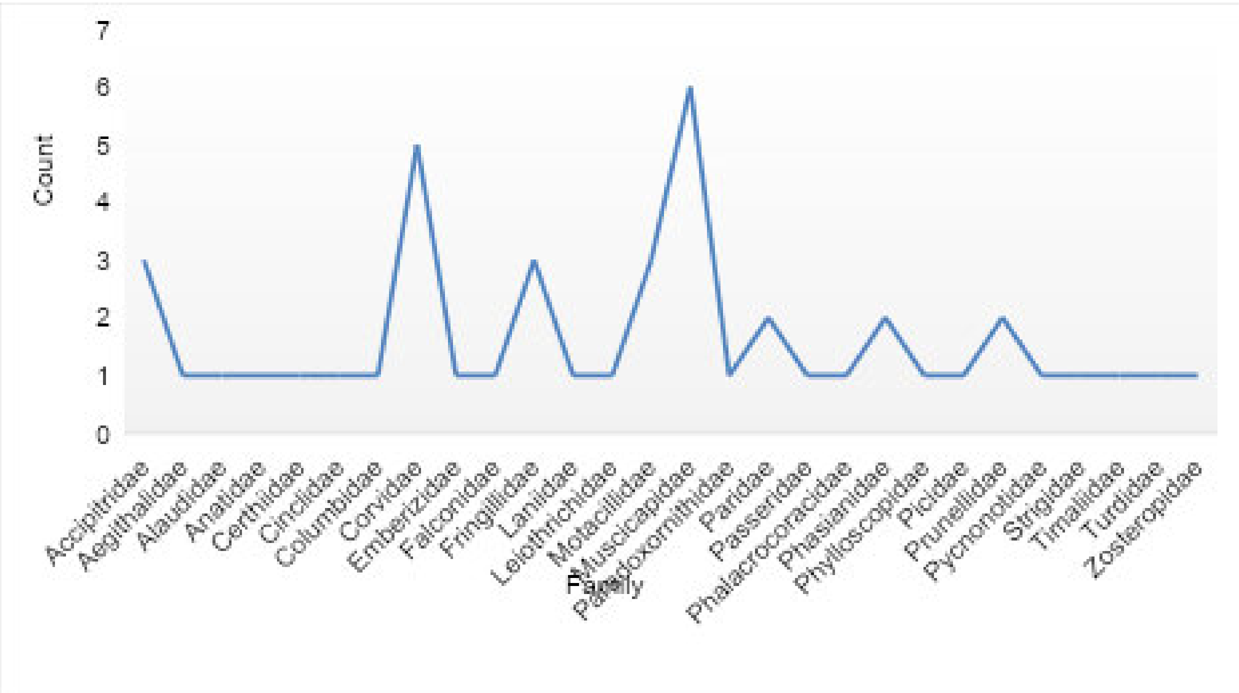

Figure 16. Family Diversity.

The Fringillidae family had the highest number of individual birds, indicating strong dominance in the community, followed by the Corvidae family (Figure 17).

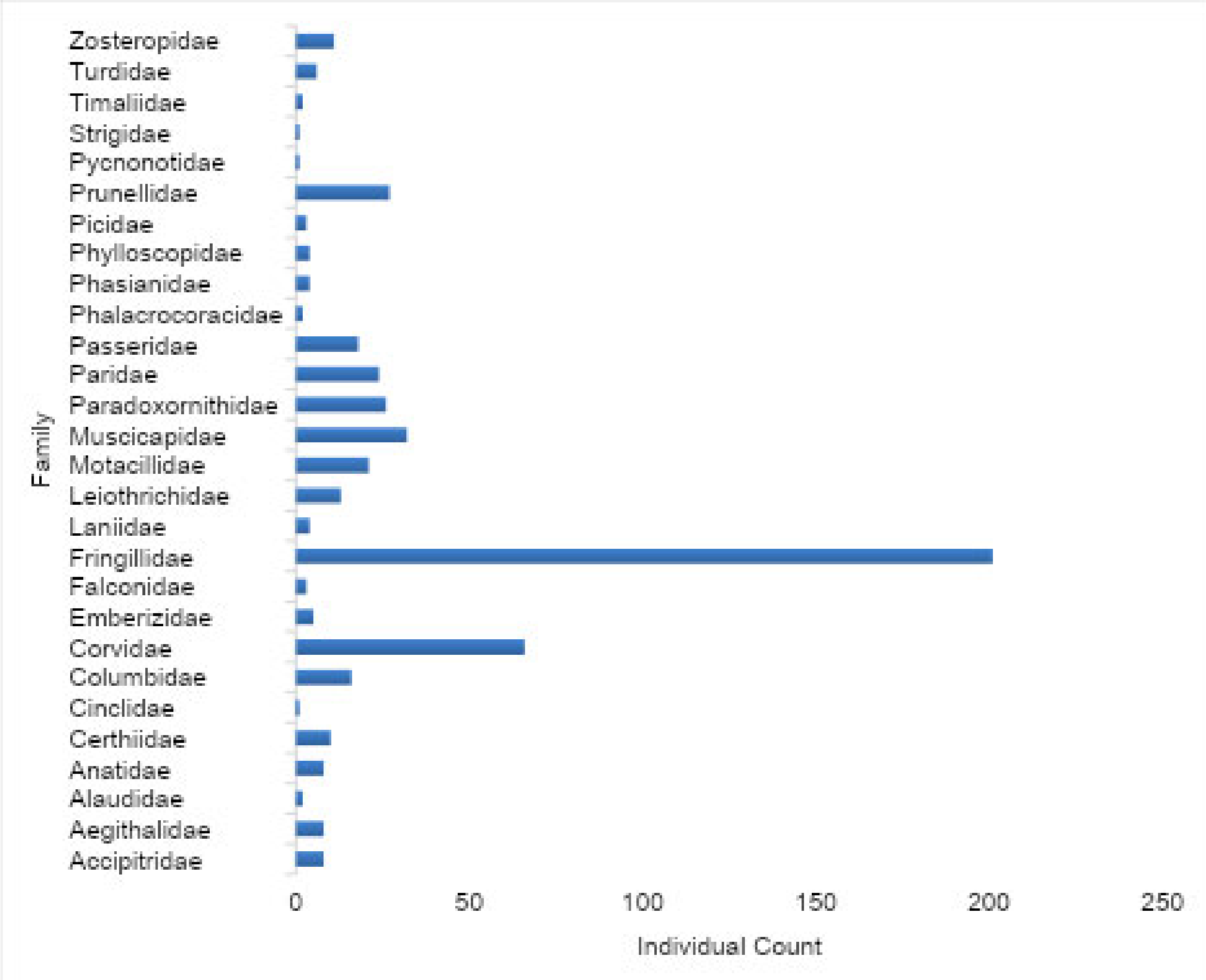

Figure 17. Family-wise species richness.

4.5 Conservation Status

All 46 bird species recorded in the survey area fall under Least Concern (LC) under IUCN category, meaning none of them are currently threatened with extinction. Despite this, under the FNCRR 2023, 11 species are legally protected: 2 species (4%) are listed under Schedule II and 9 species (20%) under Schedule III, while 0 species fall under Schedule I. The remaining 35 species (76%) are not scheduled. Although all birds are LC, about one quarter of the species receive legal protection as a preventive measure to regulate use and ensure their long-term conservation (Figure 18).

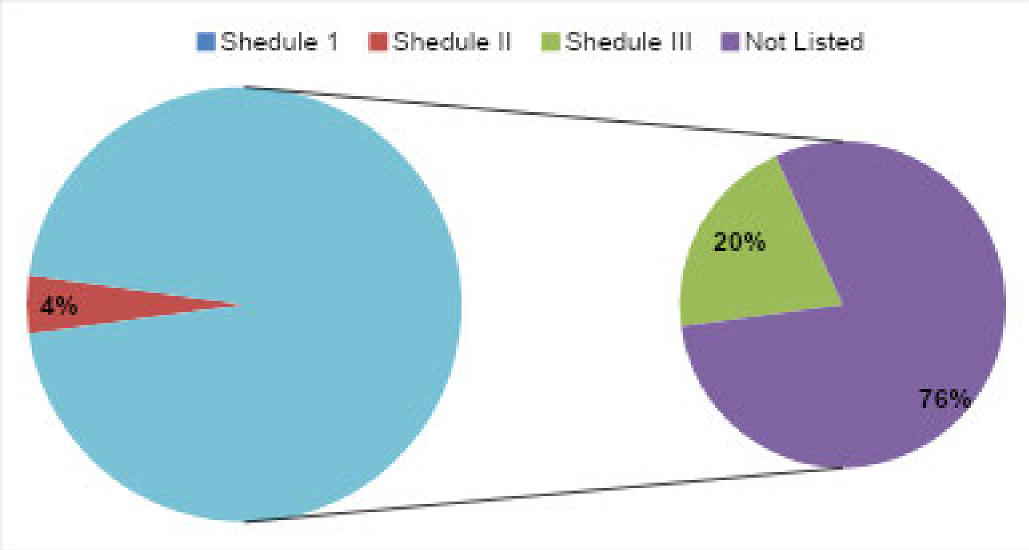

Figure 18. Conservation status of birds

4.6. Potential impact and mitigation plan

Potential Impact	Description	Mitigation / Management Measures
Habitat loss and vegetation clearance	Clearing of trees and shrubs along the transmission line corridor may reduce nesting, roosting, and foraging habitats for birds	● Limit vegetation clearance strictly to the approved right-of-way width ● Avoid cutting large trees where technically feasible ● Retain shrubs and ground vegetation wherever safety allows ● Restore disturbed areas through natural regeneration or plantation of native species
Disturbance during construction/poaching	Noise, movement of machinery, and human presence may disturb birds and alter their normal behavior	● Restrict construction activities to daylight hours ● Minimize unnecessary movement and noise ● Sensitize construction workers on wildlife protection and bird conservation
Impact on breeding activities	Construction during breeding season may disturb nesting and reduce breeding success	● Schedule major construction works outside the main breeding season (March–July) ● Prefer winter construction period when bird activity and breeding are minimal
Bird collision with transmission lines	Birds may collide with power lines, especially during low visibility conditions such as fog,	● Install bird flight diverters / bird reflectors on transmission lines ● Prioritize installation at valley crossings, forest edges, and open corridors ● Use high-visibility spiral markers or reflective devices

	snowfall, or at dawn and dusk	
Electrocution risk	Birds, especially raptors and large perching species, may be electrocuted if insulation is inadequate	● Ensure proper insulation of conductors and hardware ● Design pylons and poles to minimize exposed energized parts ● Avoid creating attractive perching points close to live components
Fragmentation of habitat	The corridor may divide forest patches and affect bird movement	● Maintain natural vegetation structure along corridor edges ● Encourage natural regeneration to reconnect habitats ● Keep corridor width minimal and consistent
Increased human access	Improved access along the corridor may increase disturbance or illegal activities	● Prohibit hunting, trapping, or harassment of birds by workers ● Include wildlife protection clauses in contractor agreements ● Regular supervision and enforcement
Long-term impacts during operation	Possible bird collision incidents after commissioning	● Conduct periodic monitoring for bird mortality ● Evaluate effectiveness of bird diverters ● Install additional mitigation if required

CHAPTER 5: Camera Trap Survey of Terrestrial Mammal Diversity

5.1. Introduction

The installation of high-voltage transmission lines (132 kV) constitutes a major form of linear infrastructure development with the potential to alter forest ecosystems. Although such infrastructure is critical for ensuring regional energy security, transmission line corridors typically require vegetation clearance, resulting in habitat fragmentation and pronounced edge effects that can influence the movement, behavior, and spatial distribution of forest-dwelling mammals (Fahrig, 2007). Linear clearings associated with roads and power transmission corridors are well documented to disrupt ecological connectivity and modify wildlife movement patterns, particularly in forested landscapes (Goosem, 2007).

In Bhutan's ecologically sensitive landscapes, where mammalian communities play essential roles in ecosystem functioning, including seed dispersal and top-down regulation of prey populations, understanding interactions between energy infrastructure and biodiversity is a key conservation priority. Situated within the Eastern Himalayan biodiversity hotspot, Bhutan supports mammalian assemblages of global conservation significance. The proposed *Wobthang–Garpang* transmission line corridor traverses forest habitats that sustain these species. Evidence from studies on linear infrastructure indicates that while some habitat-generalist mammals may utilize cleared rights-of-way (ROWs) for movement or foraging, forest specialists often perceive these open corridors as barriers, potentially leading to restricted movement, reduced habitat quality, and an increased risk of population isolation (Bennett, 1999; Science for Nature and People Partnership, 2023; Haddad et al., 2015).

To address these potential impacts, camera trapping has emerged as a robust, non-invasive method for monitoring mammalian diversity, particularly in remote and rugged terrain. Camera trap surveys provide continuous, time-stamped data that enable the assessment of species richness, occupancy, and temporal activity patterns, information that is critical for identifying wildlife movement routes and high-use crossing areas (Karanth et al., 2011; O'Connell et al., 2011). Studies conducted in mountainous and fragmented landscapes have demonstrated that camera trap data can reveal changes in animal behavior and space use in response to linear infrastructure, supporting evidence-based mitigation planning (Rajaratnam et al., 2016; Dutta et al., 2018).

Accordingly, a camera trap survey was conducted along the *Wobthang–Garpang* transmission line corridor to establish a baseline of mammalian diversity and to evaluate the spatial overlap between wildlife movement and proposed infrastructure. The documentation of species presence and activity patterns provides an empirical foundation for the identification of sensitive areas and the design of targeted mitigation measures, such as micro-siting of towers and the maintenance of habitat connectivity across the corridor (Bennett, 1999; IUCN, 2016).

Ultimately, this approach aims to ensure that energy development along the *Wobthang–Garpang* transmission line proceeds without undermining the ecological integrity and natural heritage of Bhutan's mammalian communities, in alignment with the national commitment to a "middle-path" approach to sustainable development (Gross National Happiness Commission, 2019). The findings from this assessment will directly inform project planning and implementation, supporting construction practices that minimize environmental impacts while balancing development objectives with long-term conservation goals (Bennun et al.2021; Science for Nature and People Partnership, 2023).

5.2. Methodology

5.2.1. Survey Design and Camera Trap Deployment

A rapid mammalian assessment was conducted using camera traps to evaluate the mammalian community along the proposed *Wobthang–Garpang* transmission line corridor. Cameras were deployed at 26 sites across 23 grids, each measuring 2 km × 2 km (Figure 19 and Table 5). Due to variations in terrain and the specific alignment of the transmission line, some grids required multiple camera units. Camera traps were positioned at varying distances from the transmission line, ranging from 0.05 km to 2.08 km, to capture mammalian activity both near and away from the corridor. To maximize detection probability, cameras were strategically placed along human and wildlife trails, with site selection informed by the presence of animal signs such as tracks, scat, or markings. Reconyx Hyperfire2 Professional models(23 units) were primarily used, supplemented by several Panthera V7 units(3units). All cameras were set to 'Rapid Fire' mode, capturing a sequence of five images per trigger at high sensitivity, ensuring detection of both small and large mammalian species.

Table 5. Camera trap stations with its geocoordinates.

TrapID	Latitude	Longitude	Installation	Retrieval
Wob_01	27.51789	90.77624	2025-12-14	2025-12-27
Wob_02	27.5248	90.77582	2025-12-13	2025-12-27
Wob_03	27.52568	90.792	2025-12-13	2025-12-26
Wob_04	27.51668	90.78962	2025-12-13	2025-12-27
Wob_04.1	27.50555	90.7858	2025-12-09	2025-12-27
Wob_04.2	27.51756	90.78735	2025-12-13	2025-12-27
Wob_05	27.51448	90.80265	2025-12-12	2025-12-26
Wob_05.1	27.51437	90.80256	2025-12-13	2025-12-21
Wob_06	27.50113	90.82121	2025-12-12	2025-12-26
Wob_07	27.52153	90.81278	2025-12-12	2025-12-26
Wob_08	27.52794	90.82235	2025-12-12	2025-12-25
Wob_08.1	27.52717	90.82149	2025-12-12	2025-12-25
Wob_09	27.52913	90.84207	2025-12-12	2025-12-25
Wob_10	27.5589	90.84432	2025-12-11	2025-12-23
Wob_12	27.5366	90.81202	2025-12-14	2025-12-26
Wob_13	27.57039	90.83083	2025-12-11	2025-12-25
Wob_14	27.57062	90.8457	2025-12-09	2025-12-23
Wob_15	27.5752	90.86678	2025-12-11	2025-12-25
Wob_16	27.59461	90.87043	2025-12-10	2025-12-24
Wob_17	27.58104	90.84367	2025-12-09	2025-12-23
Wob_18	27.58216	90.82991	2025-12-09	2025-12-23
Wob_19	27.60731	90.85414	2025-12-10	2025-12-24
Wob_20	27.60479	90.86509	2025-12-10	2025-12-24
Wob_21	27.62811	90.86451	2025-12-10	2025-12-24
Wob_22	27.62962	90.85213	2025-12-10	2025-12-24
Wob_23	27.64423	90.8686	2025-12-10	2025-12-24

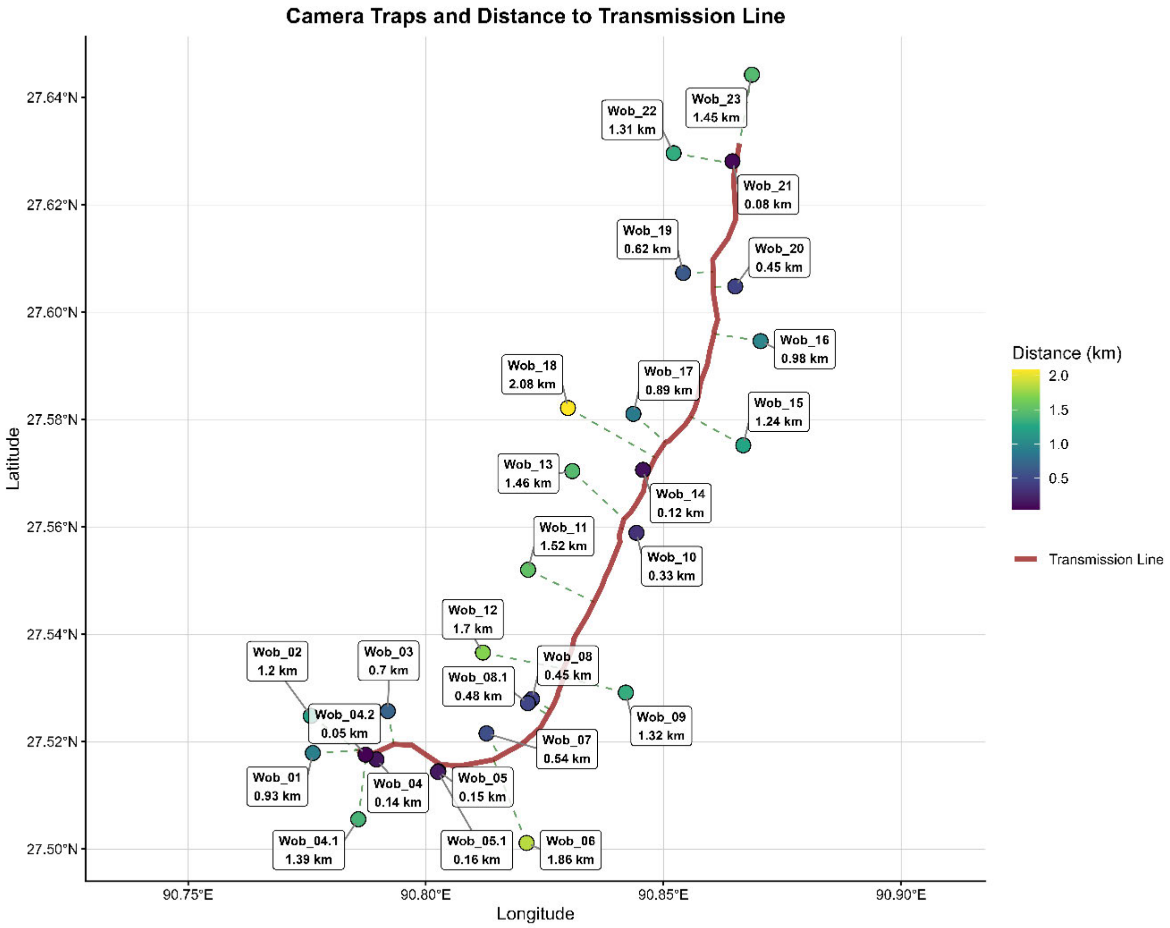

Figure 19. This map illustrates the systematic deployment of camera traps along the *Wobthang-Garpang* transmission line route.

5.3. Data analysis

5.3.1. Data Organization and Metadata Extraction

All captured images were retrieved from the SD cards and systematically organized. The primary directory was structured by Station ID, with sub-folders created for each identified species to facilitate a clear and auditable data hierarchy. The image dataset was processed using ***'Timelapse'*** software, which facilitated the efficient tagging of species and the automated extraction of metadata, including date, time, and temperature. The resulting data were exported into a CSV format to provide a structured database for subsequent quantitative analysis.

5.3.2. Species Identification

Species identification was performed using standardized field guides. Large mammals were identified to the species level due to their distinct morphological characteristics and the research team's familiarity with the local fauna. However, small mammals; specifically, rodents could not be identified to the species level in few instances due to poor image quality and rapid movement. Consequently, these were categorized at the order or family level (e.g., *Unknown rodent.*) to ensure the scientific accuracy of the dataset.

5.4. Result and discussion

5.4.1. Sampling Effort and Duration

The camera trapping survey was conducted, with deployment beginning on December 9, 2025, and retrieval completed by December 27, 2025. Each active station contributed 14.5 trap nights (average), resulting in a cumulative sampling effort of 378 trap nights across the study area (Table 6). A high success rate was maintained; however, one technical failure was recorded. Camera station Wob_011 malfunctioned shortly after deployment, and the data from this unit were excluded from the final analysis to maintain data consistency.

Table 6. Camera trap and its trap night (duration) along with number of species detected in it.

TrapID	Latitude	Longitude	Installation	Retrieval	Trap Nights	Species Richness
Wob_01	27.51789	90.77624	2025-12-14	2025-12-27	14	1
Wob_02	27.5248	90.77582	2025-12-13	2025-12-27	15	4
Wob_03	27.52568	90.792	2025-12-13	2025-12-26	14	6
Wob_04	27.51668	90.78962	2025-12-13	2025-12-27	15	2
Wob_04.1	27.50555	90.7858	2025-12-09	2025-12-27	19	5
Wob_04.2	27.51756	90.78735	2025-12-13	2025-12-27	15	2
Wob_05	27.51448	90.80265	2025-12-12	2025-12-26	15	1
Wob_05.1	27.51437	90.80256	2025-12-13	2025-12-21	9	1
Wob_06	27.50113	90.82121	2025-12-12	2025-12-26	15	2
Wob_07	27.52153	90.81278	2025-12-12	2025-12-26	15	2
Wob_08	27.52794	90.82235	2025-12-12	2025-12-25	14	1
Wob_08.1	27.52717	90.82149	2025-12-12	2025-12-25	14	4
Wob_09	27.52913	90.84207	2025-12-12	2025-12-25	14	3

Wob_10	27.5589	90.84432	2025-12-11	2025-12-23	13	2
Wob_12	27.5366	90.81202	2025-12-14	2025-12-26	13	3
Wob_13	27.57039	90.83083	2025-12-11	2025-12-25	15	4
Wob_14	27.57062	90.8457	2025-12-09	2025-12-23	15	4
Wob_15	27.5752	90.86678	2025-12-11	2025-12-25	15	2
Wob_16	27.59461	90.87043	2025-12-10	2025-12-24	15	3
Wob_17	27.58104	90.84367	2025-12-09	2025-12-23	15	2
Wob_18	27.58216	90.82991	2025-12-09	2025-12-23	15	3
Wob_19	27.60731	90.85414	2025-12-10	2025-12-24	15	1
Wob_20	27.60479	90.86509	2025-12-10	2025-12-24	15	2
Wob_21	27.62811	90.86451	2025-12-10	2025-12-24	15	3
Wob_22	27.62962	90.85213	2025-12-10	2025-12-24	15	5
Wob_23	27.64423	90.8686	2025-12-10	2025-12-24	15	3

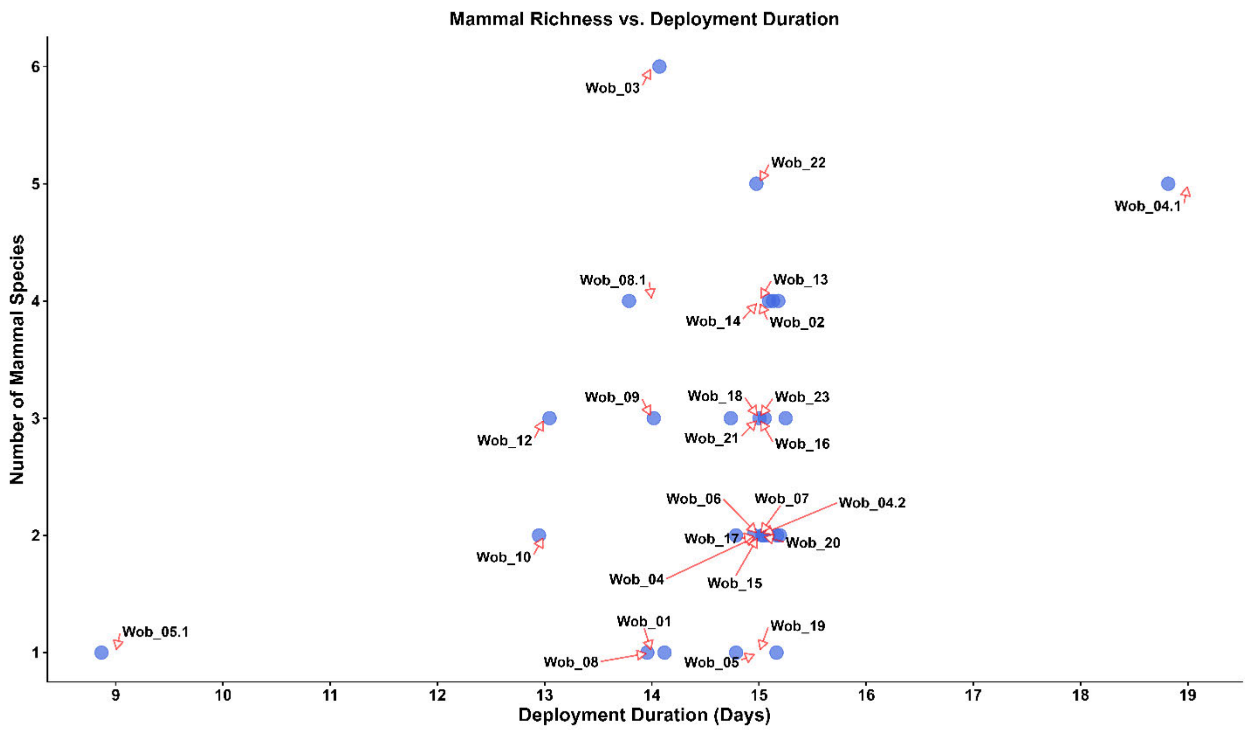

Figure 20. The plot shows the trap nights (deployment duration) for each camera trap and the number of species detected in it.

Figure 20 displays the cumulative number of mammal species detected relative to the sampling effort, measured in trap nights. To account for sites with shorter deployment periods and ensure a comprehensive biodiversity assessment, data from four additional camera traps (Wob_04.1, Wob_04.2, Wob_05.1, and Wob_08.1) were included in the analysis. The majority of the camera traps operated for a duration of 13 to 16 days, capturing the bulk of the species richness.

5.4.2. Species Accumulation Curve

To assess the completeness of the mammalian inventory, a Species Accumulation Curve was generated using R Software (Figure 21). The curve shows a distinct leveling off as it approaches the 26th sampling site, indicating that the sampling effort of 378 trap nights was sufficient to capture the majority of the species richness in the *Wobthang–Garpang* corridor. Since the curve reaches a clear level off, it can be concluded that the 23 grids (2km x 2km) and 26 deployment sites provided a statistically representative sample of the mammalian community. The rapid biodiversity assessment was successful in documenting the core terrestrial mammal fauna of the corridor within the designated timeframe.

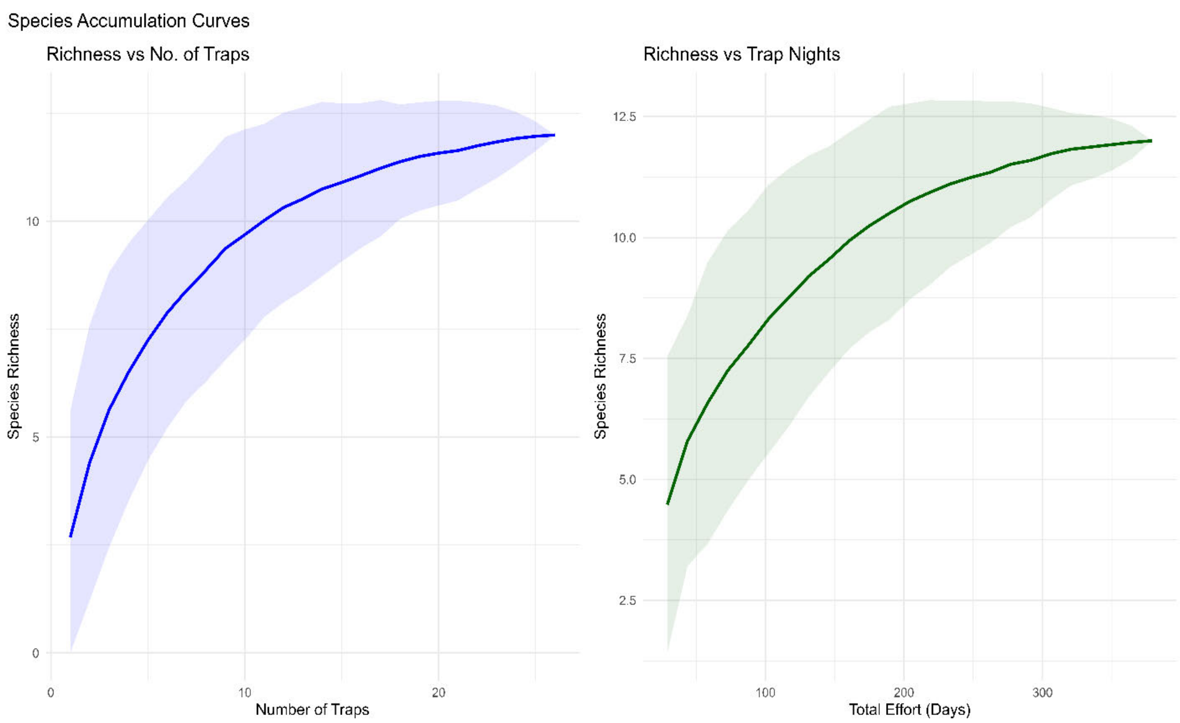

Figure 21. Species accumulation curve showing the relationship between cumulative species richness and sampling effort (Number of Traps and Trap Nights), with the curve approaching an asymptote as trap nights increase.

5.4.3. Terrestrial mammal abundance

5.4.3.1. Taxonomic Composition

Table. 7 List of mammals captured in the camera traps and their conservation status

Sl.no	Common name	Scientific name	Family	IUCN status	FNCA Schedule
1	Asiatic golden cat	*Catopuma temminckii*	Felidae	VU	II
2	Barking deer	*Muntiacus muntjak*	Cervidae	LC	III
3	Common leopard	*Panthera pardus*	Felidae	VU	II
4	Himalayan crestless porcupine	*Hystrix brachyura*	Hystricidae	LC	III
5	Himalayan serow	*Capricornis thar*	Bovidae	VU	II
6	Leopard cat	*Prionailurus bengalensis*	Felidae	LC	II
7	Red fox	*Vulpes vulpes*	Canidae	LC	II
8	Sambar	*Rusa unicolor*	Cervidae	VU	II
9	Squirrel	*Sciurus sp.*	Sciuridae	NA	III
10	Wild dog	*Cuon alpinus*	Canidae	EN	II

11	Wild pig	*Sus scrofa*	Suidae	LC	III
12	Yellow-throated marten	*Martes flavigula*	Mustelidae	LC	III

The camera trapping survey identified a diverse range of mammals categorized into 9 distinct families with 12 species (Figure 22 and Table 7). The distribution highlights a well-balanced ecosystem consisting of herbivores, carnivores, and omnivores.

b. **Dominant Families**

Felidae (3 species): This is the most represented family in the study area. The presence of three different wild cat species (Common Leopard, Asiatic Golden Cat and Leopard Cat) indicates a high trophic level and suggests that the corridor supports sufficient prey and cover for secretive predators

Canidae (2 species): Represented by species such as the Red Fox or Dhole, contributing to the predator-prey dynamics of the region.

Cervidae (2 species): Two deer species (Sambar and Barking Deer), representing a major component of the mammalian diversity along the transmission corridor.

b. Supporting Families

Other Families: Several families are represented by a single recorded species each, including Bovidae (Himalayan serow), Suidae (Wild Pigs), Mustelidae (Yellow-throated Marten), Hystricidae (Himalayan crestless porcupine), and Sciuridae (Squirrels).

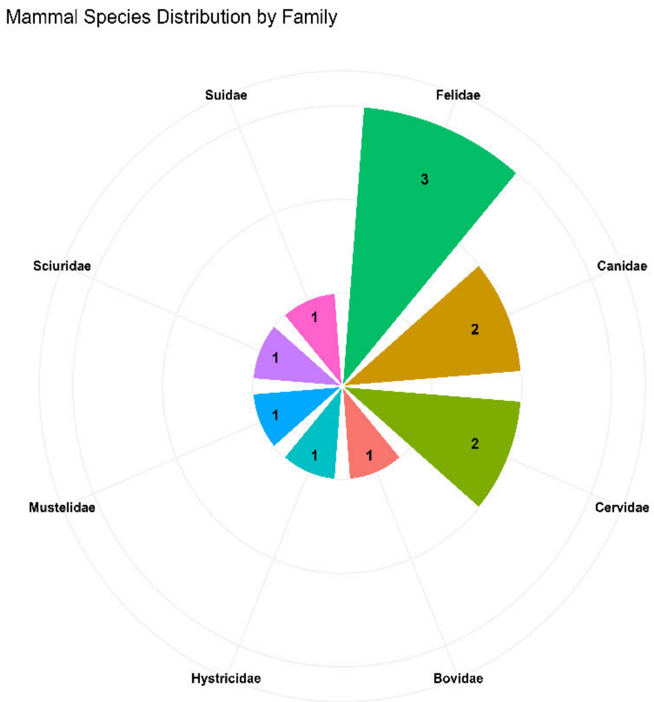

Figure 22. Different families of mammal detected from camera trap studies.

Ecological Significance: The high diversity of families (9 families) within a relatively small sampling area (26 sites) suggests that the proposed transmission line corridor between Wobthang and Garpang traverses a biologically rich landscape. The presence of specialized families like *canidae* and *Felidae* confirms the corridor serves as an active habitat for a wide spectrum of wildlife.

5.4.3.2. Species Richness and Site Highlights

The survey documented a clear gradient in biodiversity across the corridor.

Hotspot Identification: Wob-03 recorded the highest species richness among all 26 sites (Figure 23). This suggests that the area around Wob-03 may serve as a critical junction or refuge for multiple mammalian families, including both forest-interior specialists and wide-ranging carnivores.

Ecological Significance: In the context of Bhutanese high-altitude forests, sites with exceptionally high richness are often located near stable water sources or primary movement ridgelines (Penjor et al., 2021). Protecting the immediate environment around Wob-03 (camera trap installed along ridgeline) during the construction phase is paramount to maintaining local diversity.

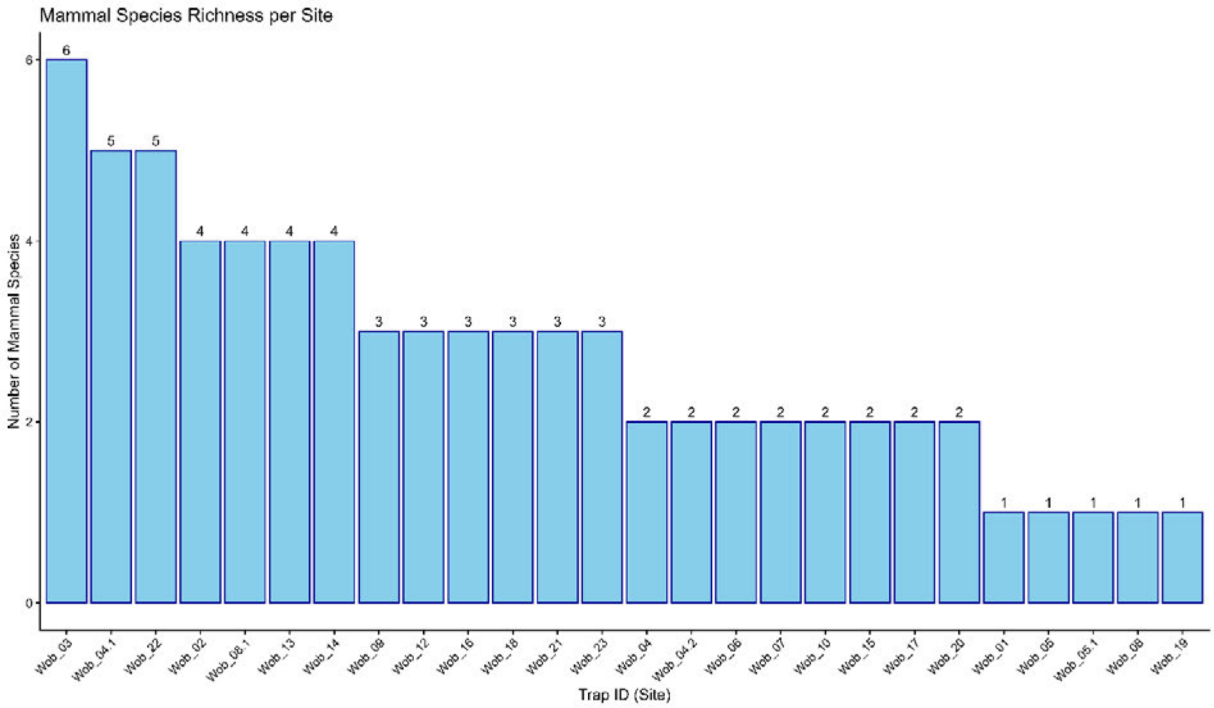

Figure 23. Species richness recorded across sampling stations, showing spatial variation in diversity across the surveyed landscape.

5.4.3.3. Relative Abundance and Community Structure

The community structure was evaluated using the Relative Abundance Index (RAI), calculated as detections per 100 trap nights (Figure 24).

Dominant Species: Sambar (*Rusa unicolor*) was found to be the most abundant species across the study area. As the most frequent detection, Sambar represents the primary biomass supporting the local carnivore guild.

Predator-Prey Implications: The high abundance of Sambar is a positive indicator of habitat quality. However, because large ungulates like Sambar are sensitive to poaching and human disturbance, their high density near the transmission line makes them vulnerable during the construction period.

Apex Predators: The presence of the Endangered Dhole and Vulnerable Common Leopard indicates that the prey base provided by Sambar is currently sufficient to support top-tier predators.

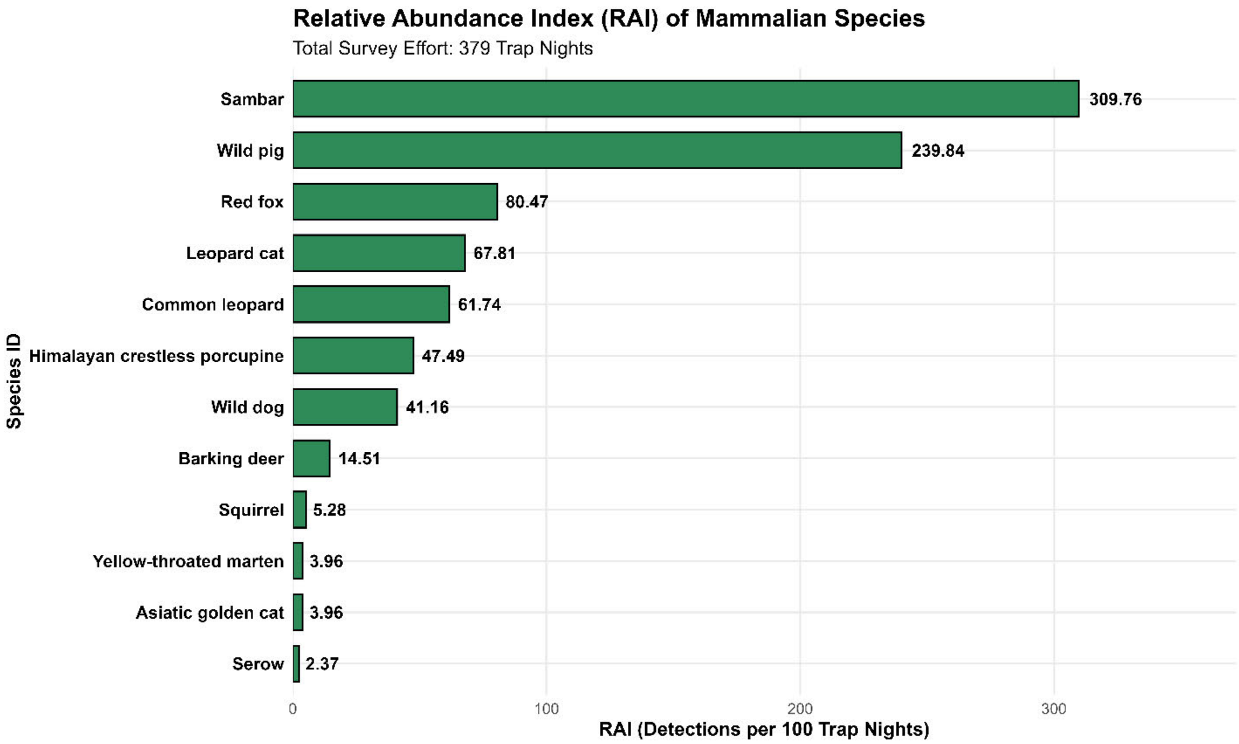

Figure 24. Relative Abundance Index (RAI) per species based on camera trap detections, highlighting variation in detection rates across the mammalian community.

5.4.3.4. Activity pattern of terrestrial mammal

Analysis of the camera trap records for the identified mammal species revealed highly specialized temporal niches. While overall activity was highest during the crepuscular and nocturnal periods, distinct species-specific patterns emerged, particularly in relation to human-dominated daylight hours (Figure 25).

a. Asiatic golden cat and **Wild dog** exhibited predominantly diurnal and crepuscular activity, with significant peaks between 7 AM and 10 AM, suggesting a preference for morning hunting windows.

b. Common leopard and **Leopard cat** shared a strong inclination toward nocturnal behavior; the Common leopard peaked sharply in the early morning hours (around 2 AM), while the Leopard cat was most frequently recorded during the late evening (8 PM to midnight)

c. Sambar and **Wild pig** displayed broad activity patterns but both showed a significant surge in the late afternoon and early evening, with Sambar activity peaking around 4 PM.

d. Red fox favored the transition into night, with its primary activity starting at dusk (7 PM) and continuing into the nocturnal hours and **Yellow-throated marten** demonstrated highly restricted temporal windows favoring the mid-afternoon.

e. Himalayan crestless porcupine remained strictly inactive during the day, emerging only after dark.

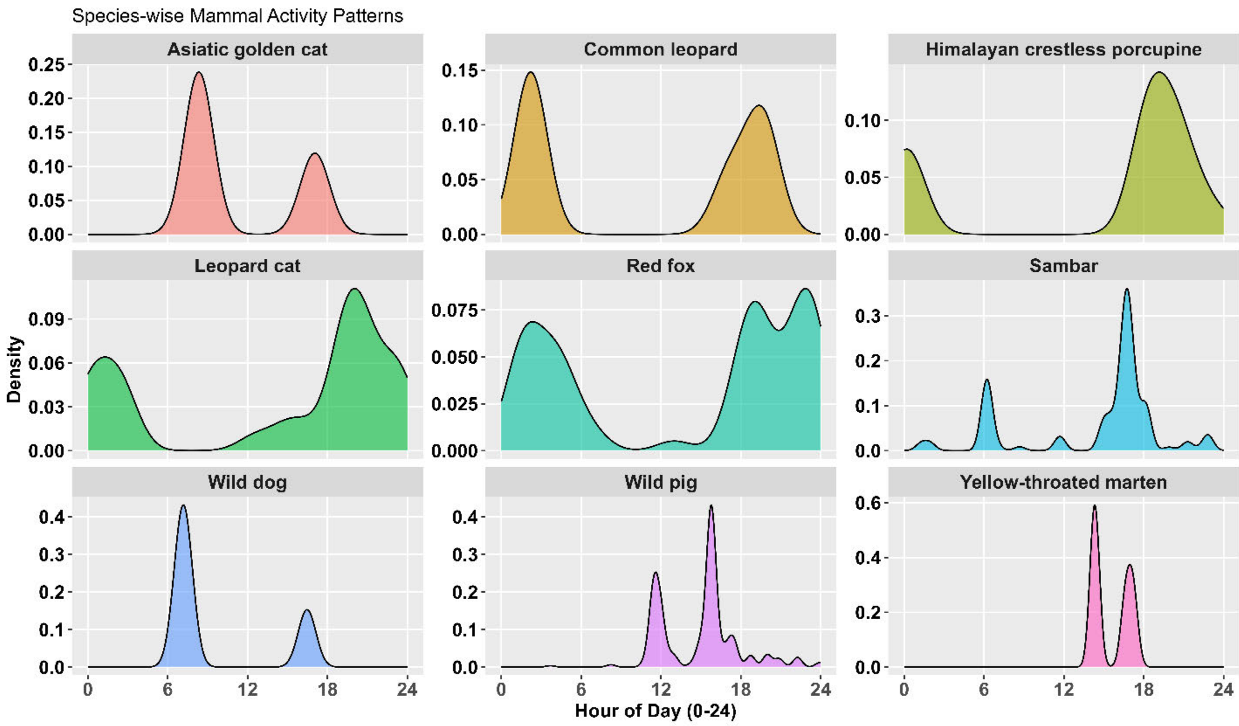

Figure 25. This figure presents the kernel density estimates of activity patterns over a 24-hour cycle for predators (e.g., Common leopard, Wild dog) and their primary prey base (e.g., Sambar, Wild pig).

5.4.4. Conservation Priority Heatmap

The analysis of the mammal conservation heatmap (Figure 26) reveals distinct spatial clusters of biodiversity and conservation priority across the study area. The spatial distribution indicates that while mammal activity is widespread, high-density "hotspots" are concentrated in specific ecological corridors, particularly where topographic features provide cover and connectivity.

Spatial Species Richness: The heatmap identifies a high concentration of wild mammal species in the central and northern sections of the study area (notably around stations Wob_03, Wob_22, and Wob_04.1). These areas support up to 5-6 independent wild species, serving as critical biodiversity nodes.

Threatened Species sites: Sites Wob_03 (0.7km from proposed transmission line) and Wob_14 (0.12km from the transmission) are high-priority conservation zones supporting threatened species such as the Dhole (EN), Common Leopard(VU), and Sambar(VU). As these areas likely represent essential movement corridors, they must be protected through careful transmission alignment and the avoidance of major habitat clearing to ensure continued connectivity for large carnivores and ungulates.

Distribution of Vulnerable Ungulates: Sambar and **Himalayan serow** show broad but patchy distributions, with high-intensity clusters in areas with less human interference. These "sites" on the heatmap indicate prime foraging and refuge habitats.

Predator-Prey Overlap: The spatial overlap between the Common leopard and its primary prey base (Sambar and Wild pig) is clearly visible in high-richness sites (eg. Wob_03), indicating functional predator-prey dynamics in the undisturbed forest patches.

Implications for Transmission Line Routing: The "High Wildlife Density Zone like Wob_03" identified on the map represents the location for mitigation. Tower placement and access road construction within these high-density zones should be strictly managed to prevent the permanent displacement of the Endangered Wild dog (Dhole) and the Vulnerable Common leopard.

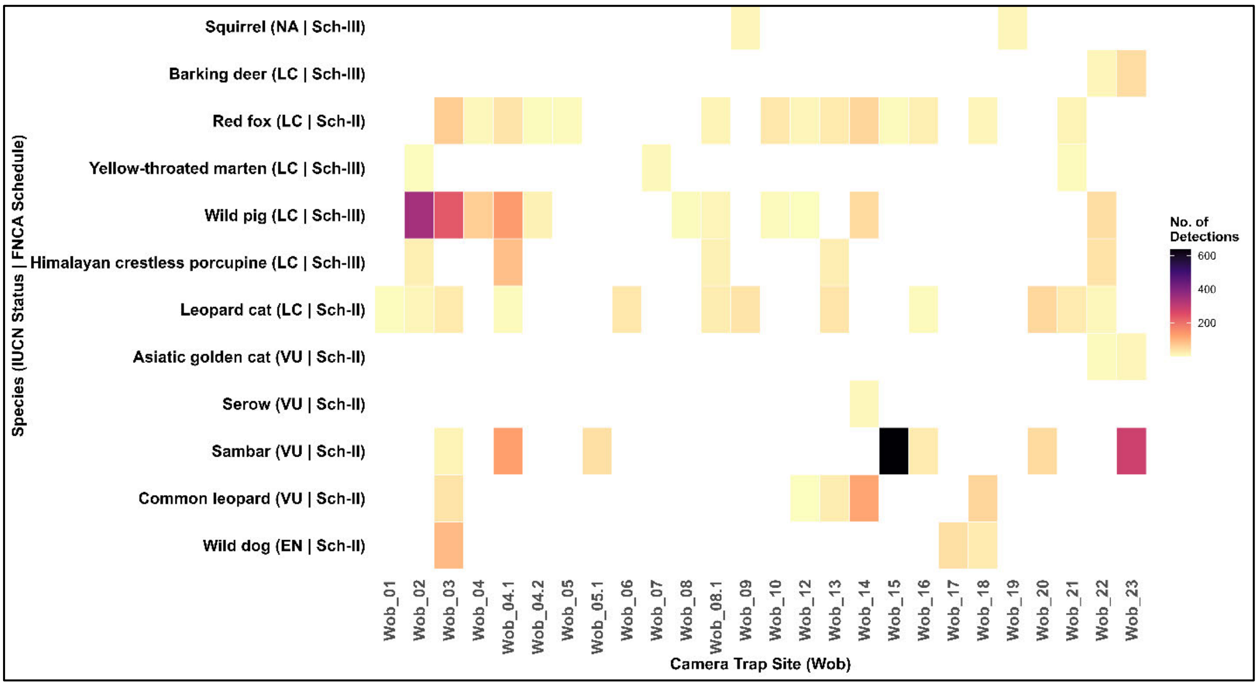

Figure 26. This heat map illustrates the spatial distribution of wild mammal species richness and detection frequency across the study area.

5.4.5. Top Predator Detection Comparison

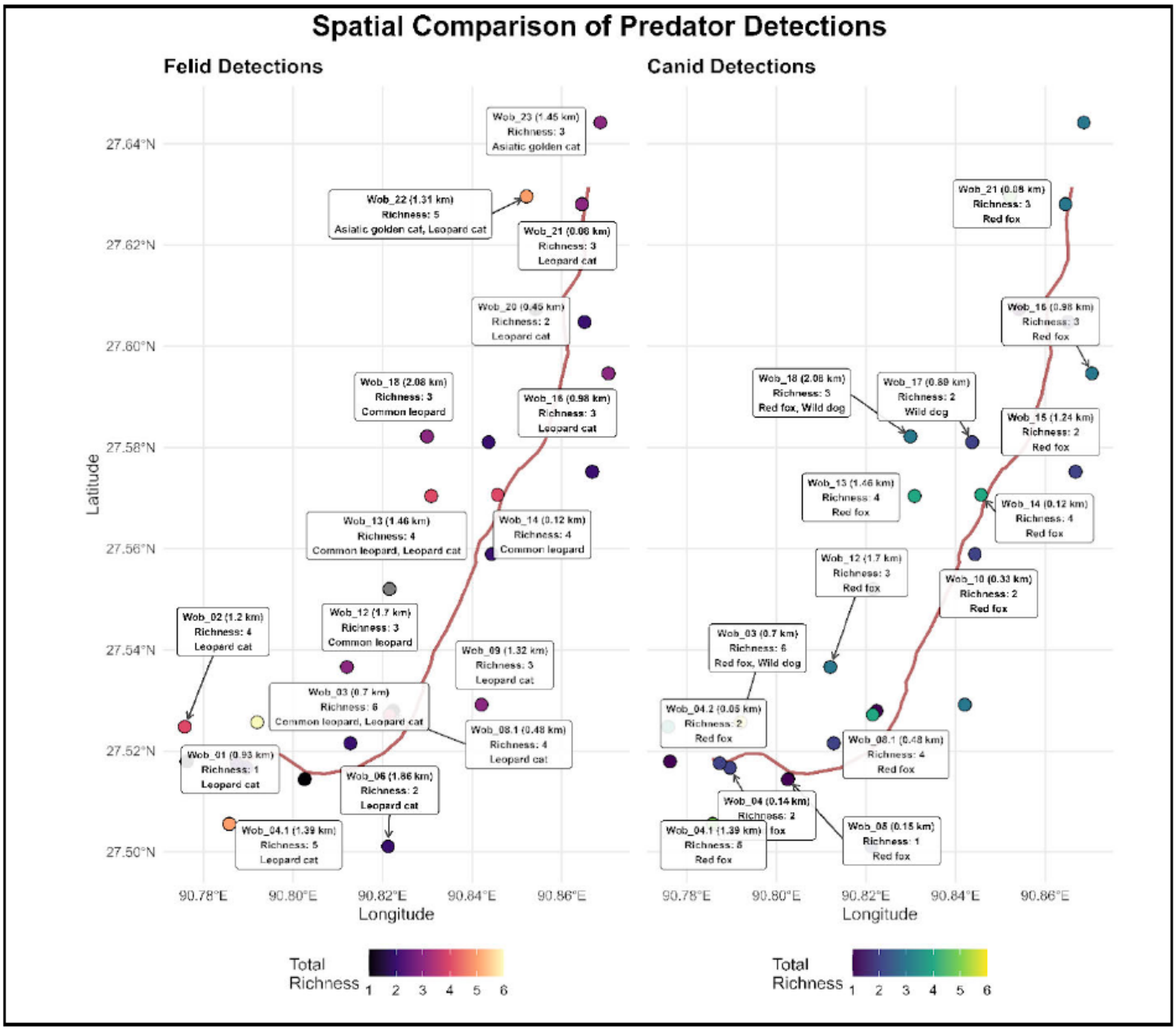

Figure 27. The map illustrates the felid and canid species detection comparison across the camera trap stations.

The predator detection comparison map (Figure 27) reveals a highly sensitive spatial distribution of carnivores, which has direct implications for the environmental management of the proposed transmission line. Correlating the data with conservation significance reveals the following insights:

5.4.5.1. Identification of High-Sensitivity Predator Sites

The map highlights significant clusters of predator activity, particularly at stations like Wob_03, Wob_18, and Wob_13. Wob_03 is a biodiversity node supporting four major predator species: the Wild Dog (Dhole), Common Leopard, Red Fox, and Leopard Cat. These sites likely serve as "hunting corridors" or "territorial overlaps." So, the linear clearing for transmission lines in these areas risks disrupting the fine balance between these predators or forcing them into closer proximity with human settlements.

5.4.5.2. Legal Protections: Schedule II Species

Five of the predators identified in these hotspots; the Wild Dog (EN), Common Leopard (VU), Asiatic Golden Cat (VU), Leopard Cat, and Red Fox, are protected under Schedule II of the Forest and Nature Conservation Act 2023. This status designates them as having the second highest degree of legal protection in the country under the Act (FNCA,2023). Any infrastructure project impacting these species must implement rigorous mitigation measures to avoid "taking" or significant habitat degradation. Transmission tower placement should avoid the high-intensity "red zones" shown on the map to remain compliant with FNCA, 2023 habitat protection mandates.

5.4.5.3. Fragmentation of Carnivore Corridors

Predators like the Common Leopard and Dhole rely on continuous forest cover for stealth and tracking prey. The creation of a broad, cleared "Right-of-Way" (ROW) for the transmission line acts as a physical and psychological barrier. For the Asiatic Golden Cat (detected at Wob_22), which is highly forest-dependent, the open gap under the power lines may isolate populations. Therefore, wherever the transmission line crosses known predator corridors (e.g., between Wob_03 and Wob_18), lower-growing scrub should be maintained to allow small-to-medium carnivores (Leopard cat, yellow-throated marten) to cross safely.

5.4.5.4. Human-Wildlife Conflict Risk (HWC)

The map shows high predator activity in specific terrain. Construction of access roads and camps in these zones increases the risk of HWC. Species like the Red Fox and Wild Dog can become attracted to construction camps if waste management is poor. Conversely, the high detection of Common Leopards suggests a risk of opportunistic attacks on camp pets (dogs) or livestock (ponies for construction material transportation) brought by workers.

5.4.5.5. Temporal-Spatial Construction Windows

By combining the predator comparison map (Figure 25) with previously analyzed activity patterns (Figure 24):

Since the Wild Dog is active in the morning and the Common Leopard at night, there is no "safe" time for continuous high-impact work in these sites. Construction at stations Wob_03 and Wob_18 should be limited to the "Mid-Day Window" (9:00 AM to 4:00 PM) to minimize stress during the primary hunting hours of these protected predators.

5.5. Recommendation

While none of the recorded species face critical threats globally, conservation measures are essential to mitigate potential impacts of *Wobthang-Garpang* transmission line. The following recommendations are proposed:

Table 7. Recommendation for mitigating impact on mammals.

Grid / Station	Potential Threat/Impact	Mitigation Measures Proposed	Responsible Party	Compliance Monitoring
Wob_03	Predator activity (Dhole, Common Leopard, Red Fox, Leopard Cat)	Avoid tower placement in high predator activity site; maintain vegetation islands; limit construction to 9:00 AM–5:00 PM; proper waste management at nearby camps	DGPC / DoFPS	DFO Bumthang
Wob_03	High mammal species richness (6 species)	Maintain corridor connectivity; micro-site towers to avoid core habitat; controlled noise during construction	DGPC	DFO Bumthang
Wob_14	Threatened species site (Dhole, Common Leopard, Sambar)	Avoid tower placement in this site; schedule construction outside peak activity hours; fencing and acoustic deterrents at nearby camps	DGPC / DoFPS	DFO Bumthang

Wob_18	Predator corridor (Common Leopard, Dhole)	Maintain some vegetation cover; avoid clearing continuous ROW; limit construction hours to 9:00 AM–5:00 PM	DGPC / DoFPS	DFO Bumthang
Wob_22	High species richness; forest-dependent small carnivores (Asiatic Golden Cat, Yellow-throated Marten)	Preserve low-growing scrub for crossing; minimize disturbance; controlled noise	DGPC	DFO Bumthang
Wob_13	Predator overlap zone	Avoid tower placement in these areas; monitor human-wildlife conflict; manage waste at camps	DGPC	DFO Bumthang
Peripheral/near settlements	Increased presence of domestic animals; low wild mammal activity	Waste management; fencing of camps; limit nocturnal work	DGPC	DFO Bumthang

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Annexure 1: Flora Check List

Sl.No	Species Name	Family	Habit	IUCN Status	Schedule (FNCA)
1	*Corylus ferox*	Betulaceae	Shrub/small tree	LC	III
2	*Ilex dipyrena*	Aquifoliaceae	Shrub/small tree	LC	III
3	*Lyonia villosa*	Ericaceae	Shrub/small tree	LC	III
4	*Malus baccata*	Rosaceae	Shrub/small tree	LC	III
5	*Populus rotundifolia*	Salicaceae	Shrub/small tree	LC	III
6	*Accer cappadocicum*	Sapindaceae	Tree	LC	III
7	*Acer campbellii*	Sapindaceae	Tree	LC	III
8	*Acer sterculiaceum*	Sapindaceae	Tree	LC	III
9	*Betula utilis*	Betulaceae	Tree	LC	III
10	*Hydrangea heteromalla*	Hydrangeaceae	Tree	LC	III
11	*Picea brachytyla*	Pinaceae	Tree	VU	III
12	*Pinus wallichiana*	Pinaceae	Tree	LC	II
13	*Populus ciliata*	Salicaceae	Tree	LC	III
14	*Prunus napaulensis*	Rosaceae	Tree	NE	III
15	*Prunus rufa*	Rosaceae	Tree	LC	III
16	*Sorbus* sp	Rosaceae	Tree	_	III
17	*Taxus wallichiana*	Taxaceae	Tree	EN	Special class
18	*Tsuga dumosa*	Pinaceae	Tree	LC	III
19	*Aster albescens*	Asteraceae	Shrub	NE	
20	*Berberis aristata*	Berberidaceae	Shrub	LC	III
21	*Berberis* sp	Berberidaceae	Shrub	_	_
22	*Borinda grossa*	Poaceae	Shrub	NE	III
23	*Coriaria nepalensis*	Coriariaceae	Shrub	NE	III
24	*Coriaria terminalis*	Coriariaceae	Shrub	NE	III
25	*Cotoneaster acuminatus*	Rosaceae	Shrub	NE	III
26	*Cotoneaster microphyllus*	Rosaceae	Shrub	NE	III
27	*Cotoneaster simonsii*	Rosaceae	Shrub	NE	III
28	*Daphne bholua*	Thymelaeaceae	Shrub	NE	III
29	*Elaeagnus parvifolia*	Elaeagnaceae	Shrub	NE	III
30	*Elsholtzia fruticosa*	Lamiaceae	Shrub	NE	III
31	*Enkianthus deflexus*	Ericaceae	Shrub	LC	III
32	*Euonymus frigidus*	Celastraceae	Shrub	LC	III
33	*Euonymus tingens*	Celastraceae	Shrub	LC	III

34	*Himalayacalamus falconeri*	Poaceae	Shrub	NE	III
35	*Hippophae salicifolia*	Elaeagnaceae	Shrub	NE	III
36	*Hypericum choisianum*	Hyericaceae	Shrub	NE	III
37	*Hypericum uralum*	Hyericaceae	Shrub	NE	III
38	*Jasminum humile*	Oleaceae	Shrub	NE	III
39	*Lespedeza* sp	Fabaceae	Shrub	_	_
40	*Leycesteria formosa*	Caprifoliaceae	Shrub	NE	III
41	*Ligustrum confusum*	Oleaceae	Shrub	LC	III
42	*Lindera* sp	Lauraceae	Shrub	_	III
43	*Lonicera angustifolia*	Caprifoliaceae	Shrub	NE	III
44	*Piptanthus nepalensis*	Fabaceae	Shrub	NE	III
45	*Prinsepia utilis*	Rosaceae	Shrub	NE	III
46	*Rhododendron arboreum*	Ericaceae	Shrub	LC	III
47	*Rhododendron arboreum* Subsp. *delavayi*	Ericaceae	Shrub	LC	III
48	*Rhododendron argipeplum*	Ericaceae	Shrub	LC	III
49	*Rhododendron cinnabarinum*	Ericaceae	Shrub	LC	III
50	*Rhododendron keysii*	Ericaceae	Shrub	NE	III
51	*Rhododendron lepidotum*	Ericaceae	Shrub	NE	III
52	*Rhododendron triflorum*	Ericaceae	Shrub	LC	III
53	*Rhododendron virgatum*	Ericaceae	Shrub	DD	III
54	*Rosa brunonii*	Rosaceae	Shrub	NE	III
55	*Rosa macrophylla*	Rosaceae	Shrub	NE	III
56	*Rosa sericea*	Rosaceae	Shrub	NE	III
57	*Rosa* sp	Rosaceae	Shrub	_	_
58	*Rubus biflorus*	Rosaceae	Shrub	NE	III
59	*Rubus* sp	Rosaceae	Shrub	_	_
60	*Salix* sp	Salicaceae	Shrub	_	_
61	*Sarcococca wallichii*	Buxaceae	Shrub	NE	III
62	*Smilax* sp	Smilacaceae	Shrub	_	III
63	*Spiraea canescens*	Rosaceae	Shrub	LC	III
64	*Spiraea micrantha*	Rosaceae	Shrub	NE	III
65	*Symplocos paniculata*	Symplocaceae	Shrub	LC	III

66	*Vaccinium nummularia*	Ericaceae	Shrub	NE	III
67	*Viburnum grandiflorum*	Viburnaceae	Shrub	NE	III
68	*Viburnum mullaha*	Viburnaceae	Shrub	LC	III
69	*Yushania microphylla*	Poaceae	Shrub	NE	III
70	*Agrimonia pilosa*	Rosaceae	Herb	LC	III
71	*Ainsliaea aptera*	Asteraceae	Herb	NE	III
72	*Anaphalis contorta*	Asteraceae	Herb	NE	III
73	*Anaphalis margaritacea*	Asteraceae	Herb	NE	III
74	*Anaphalis triplinervis*	Asteraceae	Herb	NE	III
75	*Artemisia vulgaris*	Asteraceae	Herb	LC	III
76	*Aster barbellatus*	Asteraceae	Herb	NE	III
77	*Aster neoelegans*	Asteraceae	Herb	NE	III
78	*Aster* sp	Asteraceae	Herb	_	_
79	*Astilbe rivularis*	Saxifragaceae	Herb	NE	III
80	*Astragalus* sp	Fabaceae	Herb	_	III
81	*Botrychium multifidum*	Ophioglossaceae	Herb	LC	III
82	*Bupleurum candollei*	Apiaceae	Herb	NE	III
83	*Campanula pallida*	Campanulaceae	Herb	NE	III
84	*Carex* sp	Cyperaceae	Herb	_	_
85	*Carpesium nepalense*	Asteraceae	Herb	NE	III
86	*Cephalanthera longifolia*	Orchidaceae	Herb	LC	III
87	*Chimaphila japonica*	Ericaceae	Herb	NE	III
88	*Cirsium* sp	Asteraceae	Herb	_	_
89	*Clinopodium umbrosum*	Lamiaceae	Herb	NE	III
90	*Clintonia udensis*	Liliaceae	Herb	NE	III
91	*Conyza* sp	Asteraceae	Herb	_	
92	*Cynoglossum furcatum*	Boraginaceae	Herb	NE	III
93	*Cyperus* sp	Cyperaceae	Herb	_	_
94	*Dipsacus inermis*	Caprifoliaceae	Herb	NE	III
95	*Dryopteris* sp	Dryopteridaceae	Herb	_	_
96	*Elatostema obtusum*	Urtiaceae	Herb	NE	III
97	*Fragaria nubicola*	Rosaceae	Herb	NE	III
98	*Galium aparine*	Rubiaceae	Herb	LC	III
99	*Gaultheria nummularioides*	Ericaceae	Herb	NE	III
100	*Gentiana capitata*	Gentianaceae	Herb	NE	III
101	*Geranium nepalense*	Geraniaceae	Herb	NE	III

102	*Geranium procurrens*	Geraniaceae	Herb	NE	III
103	*Halenia elliptica*	Gentianaceae	Herb	NE	III
104	*Hedera nepalensis*	Araliaceae	Herb	NE	III
105	*Hemiphragma heterophyllum*	Plantaginaceae	Herb	NE	III
106	*Hypericum japonicum*	Hypericaceae	Herb	NE	III
107	*Juncus inflexus*	Juncaceae	Herb	LC	III
108	*Juncus thomsonii*	Juncaceae	Herb	NE	III
109	*Lonicera acuminata*	Caprifoliaceae	Herb	NE	III
110	*Loniceria acuminata*	Caprifoliaceae	Herb	NE	III
111	*Lycopodium* sp	Lycopodiaceae	Herb	_	_
112	*Myriactis wallichii*	Asteraceae	Herb	NE	III
113	*Onosma paniculatum*	Boraginaceae	Herb	NE	III
114	*Onychium cryptgammoides*	Pteridaceae	Herb	NE	III
115	*Ophiopogon* sp	Asparagaceae	Herb	_	_
116	*Origanum vulgare*	Lamiaceae	Herb	LC	III
117	*Oxalis corniculata*	Oxalidaceae	Herb	NE	III
118	*Parthenocissus semicordata*	Vitaceae	Herb	NE	III
119	*Picris hieracioides*	Asteraceae	Herb	NE	III
120	*Plantago major*	Plantaginaceae	Herb	LC	III
121	*Polygala* sp	Polygalaceae	Herb	_	_
122	*Potentilla griffithii*	Rosaceae	Herb	NE	III
123	*Potentilla* sp	Rosaceae	Herb	_	_
124	*Primula capitata*	Primulaceae	Herb	NE	III
125	*Primula denticulata*	Primulaceae	Herb	NE	III
126	*Primula* sp	Primulaceae	Herb	_	_
127	*Prunella vulgaris*	Lamiaceae	Herb	LC	III
128	*Pteridium revolutum*	Dennestaedtiacea e	Herb	NE	III
129	*Pyrrosia* sp	Polypodiaceae	Herb	_	_
130	*Rubia cordifolia*	Rubiaceae	Herb	NE	III
131	*Rubus nepalensis*	Rosaceae	Herb	NE	III
132	*Satyrium nepalense*	Orchidaceae	Herb	NE	III
133	*Selinum* sp	Apiaceae	Herb	_	_
134	*Selinum wallichianum*	Apiaceae	Herb	NE	III
135	*Senecio scandens*	Asteraceae	Herb	LC	III
136	*Stellaria vestita*	Caryophyllaceae	Herb	NE	III
137	*Swertia* sp	Gentianaceae	Herb	_	_
138	*Trifolium dubium*	Fabaceae	Herb	LC	III

139	*Trifolium repens*	Fabaceae	Herb	LC	III
140	*Tripterospermum volubile*	Gentianaceae	Herb	NE	III
141	*Verbena officinalis*	Verbenaceae	Herb	NE	III
142	*Viola betonicifolia*	Violaceae	Herb	NE	III
143	*Viola biflora*	Violaceae	Herb	NE	III

Annexure 2. Bird Check List

Sl. No	Common Name	Scientific Name	Family	Count	IUCN Category
1	Beautiful Rosefinch	*Carpodacus pulcherrimus*	Fringillidae	3	LC
2	Black Bulbul	*Hypsipetes leucocephalus*	Pycnonotidae	1	LC
3	Black Eagle	*Ictinaetus malaiensis*	Accipitridae	1	LC
4	Black-faced Laughingthrush	*Trochalopteron affine*	Leiothrichidae	13	LC
5	Blue Whistling Thrush	*Myophonus caeruleus*	Muscicapidae	7	LC
6	Blue-fronted Redstart	*Phoenicurus frontalis*	Muscicapidae	5	LC
7	Blyth's Leaf Warbler	*Phylloscopus reguloides*	Phylloscopidae	4	LC
8	Brown Dipper	*Cinclus pallasii*	Cinclidae	1	LC
9	Collared Grosbeak	*Mycerobas affinis*	Fringillidae	5	LC
10	Common Kestrel	*Falco tinnunculus*	Falconidae	3	LC
11	Common Pigeon	*Columba livia*	Columbidae	16	LC
12	Darjeeling Woodpecker	*Dendrocopos darjellensis*	Picidae	3	LC
13	Eurasian Magpie	*Pica pica*	Corvidae	10	LC
14	Eurasian Sparrowhawk	*Accipiter nisus*	Accipitridae	2	LC
15	Great Cormorant	*Phalacrocorax carbo*	Phalacrocoracidae	2	LC
16	Green-backed Tit	*Parus monticolus*	Paridae	12	LC
17	Grey Wagtail	*Motacilla cinerea*	Motacillidae	2	LC
18	Grey-backed Shrike	*Lanius tephronotus*	Laniidae	4	LC
19	Grey-crested Tit	*Lophophanes dichrous*	Paridae	12	LC
20	Himalayan Buzzard	*Buteo refectus*	Accipitridae	5	LC
21	Himalayan Monal	*Lophophorus impejanus*	Phasianidae	2	LC
22	Himalayan Wood Owl	*Strix nivicolum*	Strigidae	1	LC
23	Hodgson's Redstart	*Phoenicurus hodgsoni*	Muscicapidae	10	LC
24	Large-billed Crow	*Corvus macrorhynchos*	Corvidae	20	LC
25	Little Bunting	*Emberiza pusilla*	Emberizidae	5	LC
26	Olive-backed Pipit	*Anthus hodgsoni*	Motacillidae	14	LC
27	Oriental Skylark	*Alauda gulgula*	Alaudidae	2	LC

28	Plain Mountain Finch	*Leucosticte nemoricola*	Fringillidae	191	LC
29	Red-billed Chough	*Pyrrhocorax pyrrhocorax*	Corvidae	19	LC
30	Red-headed Bullfinch	*Pyrrhula erythrocephala*	Fringillidae	2	LC
31	Ruddy Shelduck	*Tadorna ferruginea*	Anatidae	8	LC
32	Rufous-breasted Accentor	*Prunella strophiata*	Prunellidae	26	LC
33	Rufous-fronted Tit	*Aegithalos iouschistos*	Aegithalidae	8	LC
34	Russet Sparrow	*Passer cinnamomeus*	Passeridae	18	LC
35	Rusty-flanked Treecreeper	*Certhia nipalensis*	Prunellidae	11	LC
36	Satyr Tragopan	*Tragopan satyra*	Phasianidae	2	LC
37	Slaty-backed Forktail	*Enicurus schistaceus*	Muscicapidae	1	LC
38	Spotted Nutcracker	*Nucifraga caryocatactes*	Corvidae	15	LC
39	Streak-breasted Scimitar Babbler	*Pomatorhinus ruficollis*	Timaliidae	2	LC
40	Striped-throated Yuhina	*Yuhina gularis*	Zosteropidae	11	LC
41	White Wagtail	*Motacilla alba*	Motacillidae	5	LC
42	White-browed Fulvetta	*Fulvetta vinipectus*	Paradoxornithidae	26	LC
43	White-capped Water Redstart	*Phoenicurus leucocephalus*	Muscicapidae	5	LC
44	White-collared Blackbird	*Turdus albocinctus*	Turdidae	6	LC
45	White-throated Redstart	*Phoenicurus schisticeps*	Muscicapidae	4	LC
46	Yellow-billed Blue Magpie	*Urocissa flavirostris*	Corvidae	2	LC

Annexure 3. Birds Photos

White-browed Fulvetta

Blue-fronted Redstart

Himalayan Buzzard

Darjeeling Woodpecker

Beautiful Rosefinch

Oriental Skylark

Annexure 4. Herpetofauna and Lepidoptera Photos

False Cobra

Bhutan Cat-eyed Toad

Sikkimese Rock Skink

Clouded Yellow

Queen of Spain Fritillary

Annexure 5. Data Sheet Forms

Variables	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Site:					
District:					
Locality:					
Forest Type*:					
Date:					
Altitude:					
Slope (%):					
Aspect (°):					
Habitat (Natural/Modified)					
Canopy Cover**(%):					
Northing					
Easting					
***Subtorpical, Warm broad-leaved, Chir pine, cool broad-leaved, Evergreen oak, blue pine, spruce, hemlock, fir, juniper/rhodendron scrub, dry alpine scrub**					
****Open Forest:10-40% Moderately Desne Forest: 40-60% Dense Forest: 60-70% Very Dense Forest: 70-100%**					

Tree/Shrubs				
Location :		Plot No.		
Date :		Aspect (°)		
Altitude (m) :		Plot Size	**50x50m**	
Inclination (°) :		Recorder		
N:		E:		
Threshold: >1.3m, Ht= Height.				
Sp. No.	**Species name**	**DBH**	**Ht.**	**Status**

Data Form for recording regeneration status in the plot of 2x2 m	
Site:	

Plot ID:					
Locality:					
Recorder:					
Date:					
Sl.No.	Species	Count	Age	Height (cm)	Remarks

Data Form for recording ground vegetation in the plot of 2X2 m						
Site:						
Plot ID:						
Locality:						
Recorder:						
Date:						
Sl.No	Species	Count	Lifeform	Cover%	Height (cm)	Remarks

MacKinnon's Bird Listing

Grid ID:	Trans/Plot ID:	Date (YYYYMMDD):	Habitat:
Start Time:	End Time:	Weather:	List:
GPS Start:		GPS End:	Surveyor:

SlNo	Time (Hrs)	Species	Cluster Size				Altd. (m)	Evid.	Behv.	GPS Coordinate		Remark
			M	F	J	USex				Northing	Easting	
1												

Habitat Type: DTCF: dry temperate conifer forests (blue pine & spruce), MTCF: moist temperate conifer forest (hemlock, fir), SACF: subalpine conifer forest (juniper, rhodo & willow shrubs)
DCF: dry chirpine forest, CLUSTER SIZE: (M: male, F: female, J: juvenile, USex: Non dimorphic): Keep notes of threats (traps, snares, poaching), Remark: keep note of any special observations

Altd.: altitude, Evid.: evidence (o: observed, c: call, f: feather, db: dead body, d: dropping), Bevh.: behaviour (fd: feed, rt: rest, pn: preen, cs: courtship, fl: fly)

Annexure 6: Camera trap images of mammal species

Common Leopard

Asiatic Golden Cat

Leopard Cat

Wild Dog or Dhole

Sambar

Himalayan Serow

Wild Pig

Himalayan Crestless Porcupine

Yellow-throated Marten

Red Fox

Barking Deer

Squirrel

Annexure 7: Criteria for determining Natural and Modified Forests

1. **Natural Forest**

   A forest area is classified as Natural Forest when it meets most of the following criteria:

   a. ***Land-use History***
      - No documented or observable evidence of past agricultural cultivation, pasture, plantation forestry, or road construction.
      - No signs of historical terracing, plough lines, boundary bunds, grazing scars, or farm infrastructure.

   b. ***Stand Structure***
      - Uneven-aged stand structure with multiple canopy layers (seedlings, saplings, poles, mature trees).
      - Presence of natural gap dynamics and irregular tree spacing.

   c. ***Species Composition***
      - High native species diversity, including: broadleaf and/or conifer species typical of the local ecological zone.
      - Presence of shade-tolerant and late-successional species.
      - No dominance by a single planted species.

   d. ***Regeneration Pattern***
      - Predominantly natural regeneration.
      - Continuous recruitment of seedlings and saplings without evidence of systematic planting.

   e. ***Ecological Indicators***

      Presence of:
      - Deadwood (snags, fallen logs)
      - Leaf litter and humus layer
      - Forest-dependent fauna and flora
      - Intact soil structure with minimal compaction.

   f. ***Human Disturbance***
      - Limited to low-intensity, non-extractive use (e.g., occasional collection of NTFPs).

- No visible plantation rows, fencing, or artificial drainage.

2. **Modified Forest**

   A forest area is classified as Modified Forest when one or more of the following are evident:

*a. **Land-use History***

- Historical or physical evidence of:
- Agricultural farming
- Pasture or grazing lands
- Roads, settlements, or infrastructure
- Conversion followed by natural regeneration or reforestation.

*b. **Stand Structure***

Even-aged stands, often originating from:

- Single regeneration events
- Post-clearance regrowth
- Uniform spacing or linear patterns indicative of planting.

*c. **Species Composition***

- Low species diversity.
- Dominance of one or few species (monoculture or near-monoculture).
- Presence of planted or fast-growing species.

*d. **Regeneration Pattern***

- Regeneration largely influenced by planting or assisted natural regeneration.
- Limited structural complexity in understorey.

*e. **Ecological Indicators***

- Reduced deadwood and microhabitats.
- Altered soil profile (compaction, erosion, legacy agricultural soils).
- Simplified trophic structure.

*f. **Human Disturbance***

Clear evidence of past or ongoing management:

- Plantation boundaries
- Logging trails
- Old road alignments
- Grazing pressure

3. **Decision Rule (Operational Use)**

   For practical field application:

   Natural Forest: When ≥70% of observed indicators align with Natural Forest criteria and no strong evidence of past agriculture or plantation exists.

   Modified Forest: When any clear evidence of past agricultural use, pasture, road infrastructure, or plantation structure is present, regardless of current tree cover.

Appendix 4-5 Vantage Point Survey Report

VANTAGE POINT SURVEY REPORT

Wobthang- Garpang Transmission Line Project

27 January 2026

Contents

Tables

Figures

1. Introduction

1.1. Project Background

The Royal Government of Bhutan is proposing a 132-kilovolt (kV) transmission line linking Wobthang (Tang) to Garpang (Chamkhar) under the Bumthang district in central Bhutan. The line will extend for approximately 17.3 km and will require a corridor opening of about 27 m (13.5 m on either side of the centreline). To facilitate tower installation, stringing, and associated construction activities, temporary access roads will also be developed, comprising 29 separate road sections with a 3.5 m carriageway buffer and a combined length of approximately 19.1 km. The project is implemented by the Bhutan Power Corporation and supported by the Asian Development Bank.

In accordance with Bhutan's Environmental Assessment Act 2000[1] and the Regulation for Environmental Clearance of Projects (RECOP) 2016[2], the project must undergo a comprehensive Environmental and Social Impact Assessment (ESIA) as a prerequisite for obtaining Environmental Clearance. Rapid biodiversity surveys, including assessments of flora and fauna, have already been undertaken to inform the ESIA and identify priority biodiversity receptors within the project's area of influence.

Given that overhead transmission lines pose significant risks to large-bodied birds, particularly through collision and electrocution, additional targeted assessments were required to evaluate avian sensitivity along the alignment. This was especially important for species of conservation concern and those protected under Bhutan's national legislation. To address this need, a Vantage Point Survey was conducted in winter 2025 to document bird activity and flight behaviour along the project corridor and to support an evidence-based assessment of collision and electrocution risk.

1.2. The site

The proposed 132-kilovolt (kV) solar transmission line is located within Tang and Choekhor Gewogs in Bumthang District. The alignment traverses predominantly State Reserved Forests under the Bumthang Forest Division and intersects areas managed as community forests (CFs). The project area spans an elevational gradient of approximately 2,500 m above sea level (asl) near Garpang to about 3,000 m asl near Wobthang.

Ecologically, the corridor traverses a mosaic of high-elevation forest and scrub habitats, ranging from mixed conifer forests at lower elevations to subalpine communities and alpine scrublands at higher elevations. The region receives an estimated 1,000–3,000 mm of annual rainfall and is characterised by a warm-temperate climate.

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[1] Royal Government of Bhutan. 2000. Environmental Assessment Act. National Environment Commission, Thimphu. Bhutan

[2] National Environment Commission Secretariat. 2001.Regulation for the Environmental Clearance of Projects. Thimphu, Bhutan

Figure 1 Location of proposed 132 kV Transmission Line Corridor. Inset: Regional context showing proximity to protected areas and biological corridors. Main panel: Detailed site view with topographic features.

Methodology

Surveys were designed in line with the vantage point (VP) approach outlined by Scottish Natural Heritage (SNH, now known as NatureScot) for assessing the potential effects of onshore wind farms on birds. Survey design, field protocols, and interpretation were informed by the following NatureScot guidance document:

- Scottish Natural Heritage (2017). Recommended bird survey methods to inform the impact assessment of onshore wind farms. https://www.nature.scot/recommended-birdsurvey-methods-inform-impact-assessment-onshore-windfarms

1.3. Target species

Target species were defined as the priority birds surveyed in detail because they are most vulnerable to collision (and related transmission-line impacts) and/or have higher conservation or legal significance, and were considered likely to occur and be affected in the project area. In consultation with the Royal Society for the Protection of Nature and the Department of Forests and Park Services, the candidate target list was compiled from:

- Schedule I of the Forest and Nature Conservation Act 2023[3].
- red-listed birds of conservation concern identified through the Integrated Biodiversity Assessment Tool (IBAT) report from within 50 km of the project area (screened for relevance to local occurrence); and
- Birds of local conservation concern are likely to be affected by the transmission line.

[3] Royal Government of Bhutan. Forest and Nature Conservation Act of Bhutan 2023.

From this candidate list, species and groups with higher collision susceptibility and a greater likelihood of entering the risk zone were prioritised, including large-bodied birds (e.g., eagles and other raptors, cranes, storks), migratory species using seasonal corridors, and species with behaviours that increase risk (e.g., regular commuting between roosting and feeding areas, frequent ridge/valley crossings, flocking, low manoeuvrability, or reduced obstacle detection in low visibility). The target list is provided in Appendix 1. All other birds recorded during fieldwork were documented as secondary species, providing contextual information without reducing effort directed at target species.

1.4. Vantage Point Survey Methods

The VP survey was conducted over 5 days from December 13 to 17, 2025, due to time constraints. Over the 5 days, the VP survey covered the entire transmission line alignment, plus a 500 m buffer on either side. Because a VP can effectively cover up to 2 km, the alignment was divided into 2 km reporting units, with vantage points established at ~2 km intervals at locations providing clear, unobstructed views of the line and surrounding airspace. A total of 9 VPs were established (Table 1, Fig. 2).

Table 1 Details of vantage point locations used for bird flight activity monitoring along the 132 kV transmission corridor, including geographic coordinates, survey timing, and surrounding habitat characteristics.

Vantage Point	Latitude	Longitude	Dates	Time	Habitat
VP 1	27.63038	90.87026	14/12/2025	7 AM – 5 PM	Blue Pine Meadow
VP 2	27.61996	90.87205	15/12/2025	7 AM – 5 PM	Mixed Conifer Forest
VP 3	27.59361	90.86224	16/12/2025	7 AM – 5 PM	Mixed Conifer Forest
VP 4	27.57452	90.84935	17/12/2025	7 AM – 5 PM	Blue Pine Forest
VP 5	27.55901	90.84222	17/12/2025	7 AM – 5 PM	Blue Pine Forest
VP 6	27.54129	90.82239	16/12/2025	7 AM – 5 PM	Mixed Conifer Forest
VP 7	27.51773	90.81118	15/12/2025	7 AM – 5 PM	Blue Pine Forest
VP 8	27.51851	90.80123	14/12/2025	7 AM – 5 PM	Blue Pine Forest
VP 9	27.51819	90.79318	13/12/2025	7 AM – 5 PM	Blue Pine Forest

VPs were selected to maximise visibility and, where practicable, to keep the proposed key line section area within ~500 m to improve identification and estimation of flight height, direction, and crossing frequency. Sensitive features (e.g., roosts/nests/leks) were avoided, and observers did not position themselves on major flight corridors to minimise disturbance.

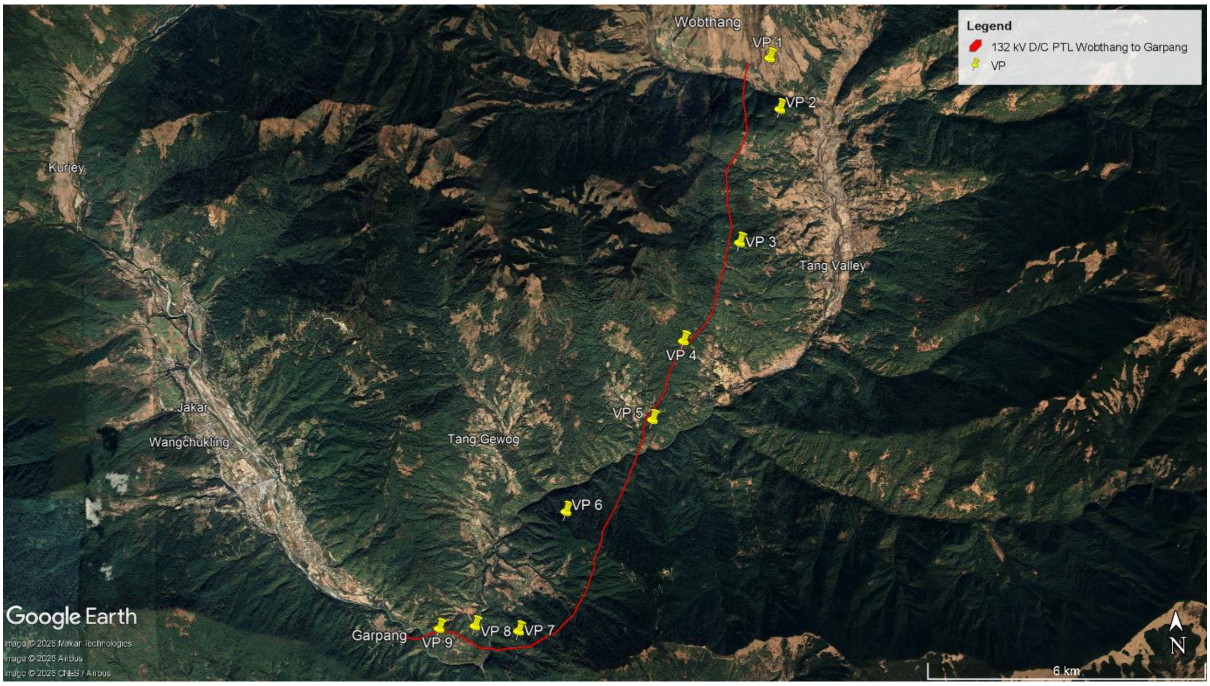

Figure 2 Vantage Point Survey Locations for Avifauna Impact Assessment. Proposed transmission corridor with established vantage points (VP1, VP2, etc.) for systematic bird flight activity monitoring.

Effort was distributed across daylight hours, with an emphasis on the periods from dawn to mid-morning and late afternoon to dusk, when commuting flights typically peak. Each VP was surveyed for ~9 hours/day, split into three 3-hour watches with ~30-minute breaks, and observer workloads were managed to reduce fatigue. Two observers were used, where possible, to alternate duties and improve detection/recording. Observations were conducted using binoculars (and an optional scope), a GPS device, a compass, and a map or tablet showing the alignment. Observers scanned up to a 180° arc, subdivided into two 90° sectors. Once a target bird was detected, it was tracked continuously until it landed or was lost from view. Detection time, flight duration and flight height were recorded using height bands relevant to the line risk zone (0–3 m, 3–25 m, 25–50 m, >50 m), with height recorded at detection and at 15-second intervals where feasible. Target-species tracking took priority over all other recordings.

Secondary species were recorded as supporting data using 5-minute activity blocks. If a target species was being tracked at the 5-minute mark, the summary was deferred and restarted after focal tracking ended.

Results

1.5. Target species

Nineteen bird species suspected to occur within the project area were included in the target species list (see Appendix 1). These species span IUCN conservation categories from Least Concern to Endangered and include taxa with movement strategies ranging from altitudinal migrants to full migrants. The list also includes species protected under Schedule II and III of Bhutan’s Forest and Nature Conservation Act (2023). Only three, which are all raptor species, were recorded during the vantage-point survey: Himalayan Griffon (*Gyps himalayensis*), a large-bodied vulture listed as Near

Threatened[4]; Mountain Hawk-Eagle (*Nisaetus nipalensis*), a large bird of prey listed as Near Threatened[5]; and Himalayan Buzzard (*Buteo refectus*), a medium–large raptor listed as Least Concern[6]. Overall, detections were dominated by Himalayan Griffon (4-7 individuals across multiple vantage points; 1,605 seconds of recorded flight), while Himalayan Buzzard and Mountain Hawk-Eagle were each recorded once (515 and 485 seconds, respectively) (Table 2). Across all observations, raptor activity was concentrated mainly in the mid–high (3025 m above ground) to high flight-height bands (50 m+), with limited low-height use (recorded only in one griffon observation and the buzzard record), suggesting that most movements occurred above the lowest height zone during survey periods.

Table 2 Summary of vantage-point survey detections of target species recorded at each vantage point, the number of individuals observed, total flight duration (s), and the proportion of flight time spent within low (0-3m), mid–high (3-25m), and high (50m+) height bands.

Species	Vantage point	Minimum no. of individuals	Total flight duration (secs)	Time proportion across heights
Himalayan Griffon	VP1	7	485	13.40% (low), 18.56 % (mid-high), 68.04% (high)
Himalayan Griffon	VP3	5	600	100% (mid-high)
Himalayan Griffon	VP4	4	155	100% (high)
Himalayan Griffon	VP6	4	365	100% (high)
Himalayan buzzard	VP9	3	515	24.27(low), 54.37 (mid-high), 21.36 (high)
Mountain Hawk Eagle	VP7	1	485	100% (high)

1.6. Secondary species

Across the nine vantage points, 50 secondary bird species were recorded. Species richness was highest at VP5 (20 species) and VP6 (19), followed by VP2 (18) and VP9 (17) (see Appendix 2). The lowest richness was observed at VP4 (9). The most widespread species were the Yellow-billed Blue Magpie (*Urocissa flavirostris*), recorded at all nine vantage points, and the Chestnut-crowned Laughingthrush (*Trochalopteron erythrocephalum*), recorded at eight, indicating a core set of common montane birds occurring consistently across the survey area. Several other species were also broadly distributed, including Blue Whistling Thrush (*Myophonus caeruleus*), Green-backed Tit (*Parus monticolus*), Spotted Nutcracker (*Nucifraga caryocatactes*), Large-billed Crow (*Corvus macrorhynchos*), and Red-billed Chough (*Pyrrhocorax pyrrhocorax*), reflecting frequent use of the surrounding forest–edge and open-

[4] BirdLife International. 2021. Gyps himalayensis. The IUCN Red List of Threatened Species 2021: e.T22695215A204643889. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T22695215A204643889.en. Accessed on 26 January 2026.

[5] BirdLife International. 2021. *Nisaetus nipalensis*. *The IUCN Red List of Threatened Species* 2021: e.T22696153A200288705. https://dx.doi.org/10.2305/IUCN.UK.2021-3.RLTS.T22696153A200288705.en. Accessed on 26 January 2026.

[6] BirdLife International. 2024. *Buteo refectus*. *The IUCN Red List of Threatened Species* 2024: e.T22734099A263610727. https://dx.doi.org/10.2305/IUCN.UK.2024-2.RLTS.T22734099A263610727.en. Accessed on 26 January 2026.

slope habitats. Overall, the secondary assemblage is dominated by species assessed as Least Concern on the IUCN Red List, with a small number of taxa variably assessed or not evaluated in some sources.

1.7. Target Species Summary

1.7.1. Himalayan Griffon (*Gyps himalayensis*)

The Himalayan Griffon (also referred to as the Himalayan vulture/griffon vulture) is a large soaring raptor and is listed as Near Threatened on the IUCN Red List, making it a priority target species for collision-risk interpretation in mountain wind/powerline settings. The species is a full migrant and is protected under Schedule II of Bhutan's Forest and Nature Conservation Act 2023.

During the vantage survey, Himalayan Griffons were recorded on four occasions across VP1, VP3, VP4, and VP6, with group sizes ranging from 4 to 7 individuals (a maximum of 7 in a single observation). Across all events, flight activity was dominated by the mid–high (25–50 m) and high (>50 m) height bands; only at VP1 were birds briefly noted at very low height (0–3 m) early in the event before gaining altitude and remaining predominantly in higher airspace thereafter (Fig. 4-5).

1.7.2. Himalayan Buzzard (*Buteo refectus*)

The Himalayan Buzzard is a medium-to-large raptor listed as Least Concern on the IUCN Red List; however, it remains relevant to collision-risk screening because it is a diurnal raptor that uses open airspace. It was recorded once, on 13 December 2025 at VP9, with three individuals observed for approximately 9–10 minutes. The bird was first recorded at low to mid height (3–25 m), then spent most of the observation period in the mid to high band (25–50 m), before shifting into the high band (>50 m) near the end of the event (Fig. 4-5).

1.7.3. Mountain Hawk-Eagle (*Nisaetus nipalensis*)

The Mountain Hawk-Eagle is a large, forest-associated raptor listed as Near Threatened on the IUCN Red List and is a full migrant. It was recorded once during the vantage survey, on 15 December 2025 at VP7, with one individual observed for approximately 9–10 minutes. All observations during this event were in the high flight band (>50 m), indicating use of the upper airspace rather than low-level flight (Fig. 4-5).

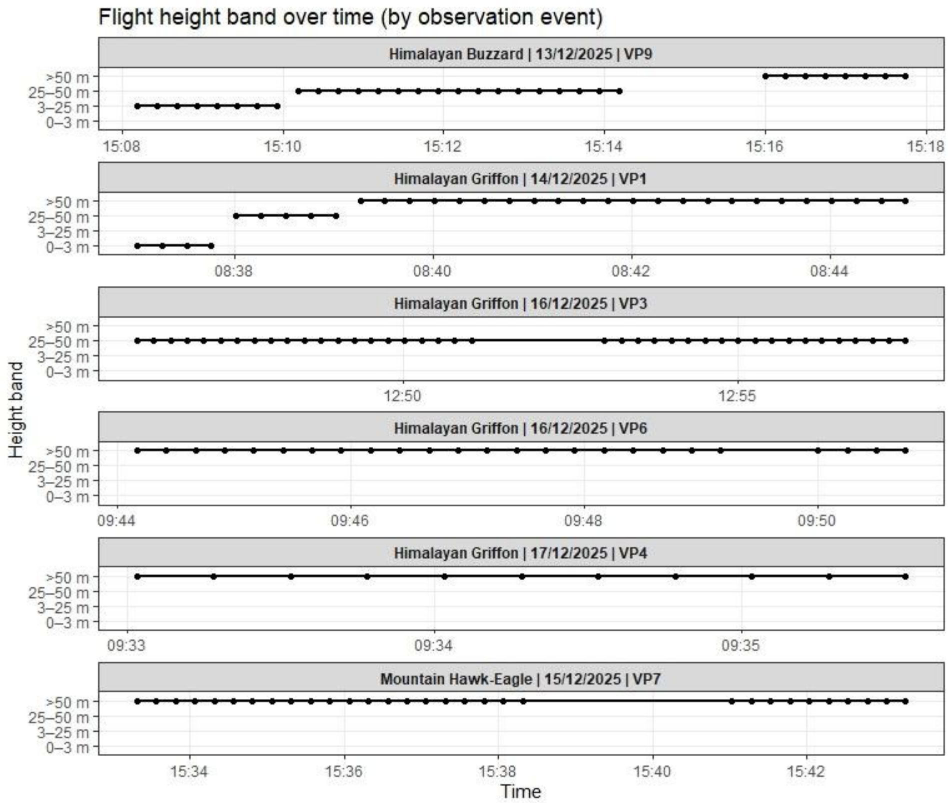

Figure 4 Flight height distributions by species and time of day from vantage point surveys along the 132 kV transmission corridor.

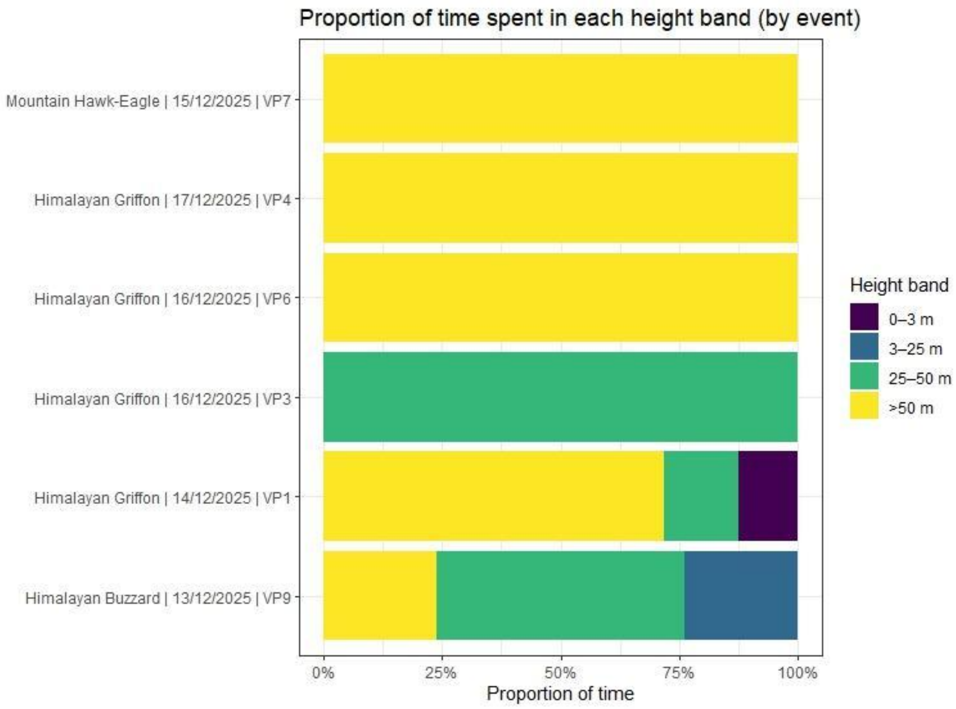

Figure 5 Proportion of observation time spent at each collision risk height category

2. Conclusions and Recommendations

The vantage survey was conducted over five days (13–17 December 2025) and recorded three raptor species, ranging from medium to large: Himalayan Griffon, Mountain Hawk-Eagle, and Himalayan Buzzard. Of these, the Himalayan Griffon and Mountain Hawk-Eagle are Near Threatened, while the Himalayan Buzzard is Least Concern. Himalayan Griffons were recorded most frequently and across a wider area of the project landscape, with detections at VP1, VP3, VP4 and VP6, and group sizes ranging from 4 to 7 individuals. In contrast, the Himalayan Buzzard and Mountain Hawk-Eagle were each recorded once (VP9 and VP7, respectively). While repeated griffon detections suggest the area may be used regularly, potentially due to suitable soaring conditions, habitat features, or nearby roosting areas, interpretation should be cautious because the survey window was short and detections may also reflect short-term factors, such as food availability, during the survey period. No consistent congregation site was identified during the survey.

In addition to the target species, 50 secondary bird species were recorded across the nine vantage points, indicating that the broader area supports a diverse range of small- to medium-sized birds; most secondary species are classified as Least Concern globally. Given the limited temporal coverage, further seasonal and longer-term surveys are recommended to better characterise the presence of target species, flight activity, and any seasonal peaks (including breeding periods) that may not have been captured by the survey.

For the proposed 132 kV overhead transmission line with towers, the principal avifaunal impact pathway is expected to be collision with overhead wires, particularly at spans crossing open airspace (e.g., ridgelines/saddles, valley pinch-points, and drainage crossings) and where birds move through the corridor at conductor height. The risk of electrocution is generally low on transmission towers due to larger clearances; however, it should still be checked and managed at any terminal structures, substations, or ancillary lower-voltage components associated with the project. Accordingly, mitigation should prioritise reducing collision risk through micro-siting to avoid high-risk flight corridors where practicable, and by installing bird flight diverters/line markers on priority spans (especially at crossings and other identified high-risk features). This should be supported by post-construction monitoring (targeted carcass searches/incident reporting) and an adaptive management approach, so additional marking or other measures can be implemented if bird mortality is detected, particularly for Near Threatened species.

3. Appendix

Appendix 1. Target species list

Common Name	Scientific Name	IUCN category	Global Population trend	Movement pattern	FNCA 2023 protection status
Pallas's Fish-eagle	*Haliaeetus leucoryphus*	EN	Decreasing	Full Migrant	Schedule II
Steppe Eagle	*Aquila nipalensis*	EN	Decreasing	Full Migrant	Schedule II
Rufous-bellied Eagle	*Lophotriorchis kienerii*	NT	Decreasing	Not a Migrant	NA
Bearded Vulture	*Gypaetus barbatus*	NT	Decreasing	Not a Migrant	Schedule II
Mountain Hawk-eagle	*Nisaetus nipalensis*	NT	Decreasing	Full Migrant	NA
Himalayan Griffon	*Gyps himalayensis*	NT	Decreasing	Full Migrant	Schedule II
Black-necked Crane	*Grus nigricollis*	NT	Stable	Altitudinal Migrant	Schedule II
Ferruginous Duck	*Aythya nyroca*	NT	Decreasing	Full Migrant	Schedule III
Northern Lapwing	*Vanellus vanellus*	NT	Decreasing	Full Migrant	Schedule III
River Lapwing	*Vanellus duvaucelii*	NT	Decreasing	Not a Migrant	Schedule III
Eastern Imperial Eagle	*Aquila heliaca*	VU	Decreasing	Full Migrant	NA
Common Pochard	*Aythya ferina*	VU	Decreasing	Full Migrant	Schedule III
Wood Snipe	*Gallinago nemoricola*	VU	Decreasing	Full Migrant	Schedule III
Himalayan Buzzard	*Buteo refectus*	LC	Unknown	Not a Migrant	NA
Himalayan Monal	*Lophophorus impejanus*	LC	Decreasing	Altitudinal Migrant	Schedule II
Eurasian Sparrowhawk	*Accipiter nisus*	LC	Stable	Full Migrant	Schedule III
Great Cormorant	*Phalacrocorax carbo*	LC	Increasing	Full Migrant	Schedule III
Ruddy Shelduck	*Tadorna ferruginea*	LC	Increasing	Full Migrant	Schedule III
Ibisbill	*Ibidorhyncha struthersii*	LC	Unknown	Altitudinal Migrant	Schedule III

Appendix 2: Details of secondary species recorded during the vantage survey (VP = Vantage Point)

Species	**Scientific name**	**IUCN category**	**Total VPs**	**VPs_present**
Yellow-billed Blue Magpie	*Urocissa flavirostris*	LC	9	VP1, VP2, VP3, VP4, VP5, VP6, VP7, VP8, VP9
Chestnut-crowned Laughingthrush	*Trochalopteron erythrocephalum*	LC	8	VP1, VP2, VP3, VP4, VP5, VP6, VP7, VP8
Blue Whistling Thrush	*Myophonus caeruleus*	LC	7	VP1, VP2, VP3, VP4, VP5, VP6, VP8
Green-backed Tit	*Parus monticolus*	LC	7	VP2, VP3, VP4, VP5, VP6, VP8, VP9
Large-billed Crow	*Corvus macrorhynchos*	LC	7	VP2, VP3, VP4, VP6, VP7, VP8, VP9
Spotted Nutcracker	*Nucifraga caryocatactes*	LC	7	VP2, VP3, VP4, VP5, VP6, VP7, VP8
Grey-backed Shrike	*Lanius tephronotus*	LC	6	VP1, VP5, VP6, VP7, VP8, VP9
Red-billed Chough	*Pyrrhocorax pyrrhocorax*	LC	6	VP1, VP2, VP5, VP6, VP8, VP9
Black-rumped Magpie	*Pica bottanensis*	NE	5	VP1, VP2, VP5, VP8, VP9
Blue-fronted Redstart	*Phoenicurus frontalis*	LC	4	VP1, VP5, VP6, VP9
Common Kestrel	*Falco tinnunculus*	LC	4	VP5, VP6, VP8, VP9
Olive-backed Pipit	*Anthus hodgsoni*	LC	4	VP1, VP3, VP8, VP9
Grey-crested Tit	*Lophophanes dichrous*	LC	3	VP2, VP4, VP6
Maroon-backed Accentor	*Prunella immaculata*	LC	3	VP3, VP4, VP9
Plain Mountain Finch	*Leucosticte nemoricola*	LC	3	VP1, VP3, VP9
Rufous-breasted Accentor	*Prunella strophiata*	LC	3	VP3, VP5, VP6
Spotted Laughingthrush	*Ianthocincla ocellata*	LC	3	VP1, VP2, VP6
White Wagtail	*Motacilla alba*	LC	3	VP7, VP8, VP9
White-browed Fulvetta	*Fulvetta vinipectus*	LC	3	VP1, VP2, VP6
White-throated Laughingthrush	*Pterorhinus albogularis*	LC	3	VP1, VP2, VP5
Ashy-throated Warbler	*Phylloscopus maculipennis*	LC	2	VP6, VP7
Eurasian Jay	*Garrulus glandarius*	LC	2	VP1, VP6
Eurasian Tree Sparrow	*Passer montanus*	LC	2	VP1, VP9
Eurasian Wren	*Troglodytes troglodytes*	LC	2	VP3, VP7
Grey Bushchat	*Saxicola ferreus*	LC	2	VP2, VP5
Hodgson's Redstart	*Phoenicurus hodgsoni*	LC	2	VP4, VP9
Red Crossbill	*Loxia curvirostra*	LC	2	VP8, VP9
Red-tailed Minla	*Minla ignotincta*	LC	2	VP2, VP6

Rufous-vented Tit	*Periparus rubidiventris*	LC	2	VP2, VP7
Bar-throated Minla	*Actinodura strigula*	LC	1	VP6
Brown Dipper	*Cinclus pallasii*	LC	1	VP5
Brown Parrotbill	*Paradoxornis unicolor*	LC	1	VP5
Crested Kingfisher	*Megaceryle lugubris*	LC	1	VP5
Dark-breasted Rosefinch	*Procarduelis nipalensis*	LC	1	VP1
Dark-rumped Rosefinch	*Carpodacus edwardsii*	LC	1	VP5
Feral Pigeon	*Columba livia*	LC	1	VP8
Goldcrest	*Regulus regulus*	LC	1	VP2
Green-backed Sunbird	*Aethopyga nipalensis*	LC	1	VP6
Himalayan Beautiful Rosefinch	*Carpodacus pulcherrimus*	LC	1	VP7
Hodgson's Treecreeper	*Certhia hodgsoni*	LC	1	VP2
Lemon-rumped Warbler	*Phylloscopus chloronotus*	LC	1	VP7
Little Forktail	*Enicurus scouleri*	LC	1	VP5
Oriental Turtle-Dove	*Streptopelia orientalis*	LC	1	VP9
Plumbeous Redstart	*Phoenicurus fuliginosus*	LC	1	VP5
Rufous-fronted Tit	*Aegithalos iouschistos*	LC	1	VP7
Rufous-gorgeted Flycatcher	*Ficedula strophiata*	LC	1	VP2
Rusty-flanked Treecreeper	*Certhia nipalensis*	LC	1	VP7
Southern Nutcracker	*Nucifraga hemispila*	LC	1	VP9
White-capped Redstart	*Phoenicurus leucocephalus*	LC	1	VP5
Yellow-browed Tit	*Sylviparus modestus*	LC	1	VP7

CRITICAL HABITAT ASSESSMENT

Wobthang to Garpang Transmission Line Project

23/01/2026

Contents

1. INTRODUCTION

1.1. Purpose of the study

This document presents the Critical Habitat Assessment (CHA) for a proposed 132 kV double-circuit transmission line linking the 108 MW Wobthang Solar PV project in Bumthang to the Mangdechhu–Yurmoo Transmission Line in Trongsa Dzongkhag. The project includes a 17.3 km transmission line corridor with a 27 m right-of-way (13.5 m on either side) and 19.1 km of access roads across 29 discrete segments (not continuous), with a 3.5 m carriageway buffer. The study is financed by the Asian Development Bank.

The project is expected to comply with ADB's Safeguard Policy Statement (SPS) and, where applicable, the more recent Environmental and Social Standard 6 (ESS6) under ADB's Environmental and Social Framework (ESF). ESS6 emphasises maintaining the core ecological functions of habitats and the biodiversity they support, recognising that biodiversity underpins ecosystem services valued by people and that biodiversity loss can reduce the delivery of those services.

The purpose of this critical habitat assessment is to confirm whether critical habitat or priority biodiversity features occur within the project's area of influence (AOI). As per the ESS6, priority biodiversity features (PBF) *are a subset of biodiversity that is particularly irreplaceable or vulnerable. These features provide indicators of importance, sensitivity, and value and encompass (i) threatened ecosystems, (ii) geographically-restricted ecosystems,(iii) threatened species, (iv) geographically-restricted species, (v) geographically-restricted assemblages; (vi) aggregations of migratory or congregatory species; (vii) areas associated with key evolutionary processes, or (viii) ecological function and connectivity that are vital to maintaining the viability of biodiversity described in this paragraph. Priority biodiversity features may be present in any category of habitat*."

Specifically, the CHA will:

- Identify priority biodiversity features that could trigger critical habitat (e.g., Critically Endangered (CR), Endangered (EN), and Vulnerable (VU) species as listed on the IUCN Red List, key habitats, Key Biodiversity Area (KBA), corridors, migratory/congregatory species).
- Define the Area of Assessment (AOA) for each biodiversity feature. As per the ESS6, *"AOAs are the spatial units within which the presence of critical habitat qualifying features is evaluated. They should include all areas subject to direct, indirect, and cumulative impacts from the project. The spatial scale should reflect the ecological characteristics of the species or ecosystems of concern—such as home range size, dispersal capacity, or migratory behavior—and be supported by expert input and scientific literature."*

- Determine whether each biodiversity feature meets the ESS6 thresholds by assessing its presence, abundance, distribution, and ecological use within its defined Area of Assessment

1.2. Project setting and ecological baseline

The proposed Wobthang–Garpang 132 kilovolt (kV) solar transmission line is located in Bumthang District, within Tang and Choekhor Gewogs, and traverses the state reserved forests, including Community Forests (Fig. 1). The alignment spans a montane elevational gradient from approximately 2,500 m at Garpang to 3,000 m at Wobthang. The region experiences warm-temperate climatic conditions with a strong monsoonal influence, receiving an estimated 1,000–3,000 mm of rainfall annually. These climatic and topographic conditions support predominantly forested ecosystems, with localised openings and short riparian sections embedded within the broader forest matrix.

The corridor passes primarily through conifer-dominated habitats typical of Bhutan’s mid- to high-elevation landscapes, with Blue Pine (*Pinus wallichiana*) and mixed-conifer forests forming the dominant cover along both the transmission line and associated access roads. Non-forest habitats occur only as small, localised inclusions (e.g., shrublands, meadow openings, and riverine features), indicating that the project is largely a forest-based development and that forest-dependent biodiversity is therefore a key ecological receptor.

Vegetation along the corridor is characterised by a tree layer dominated by *P. wallichiana*, with associated species including *Tsuga dumosa* and *Hydrangea heteromalla*. Forest structure varies spatially in response to stand condition and disturbance history, while diverse understorey communities contribute to habitat complexity, including species-rich shrub layers (notably Rosaceae and Ericaceae) and herbaceous assemblages commonly dominated by Asteraceae. Regeneration is evident across parts of the corridor, with recruitment dominated by *P. wallichiana* seedlings, consistent with ongoing natural regeneration and forest recovery processes.

Faunal records further indicate that the corridor supports intact, forest-associated communities across multiple taxa, consistent with good habitat quality and functioning ecosystem processes. Few Black-necked Cranes, a Near Threatened species, are observed in Wobthang, but the population is small (less than 1% of the cranes visiting Bhutan each year). The diversity of birds and mammals, together with forest-dependent herpetofauna and butterflies, suggests that the alignment traverses ecologically meaningful conifer forest habitat with a relatively intact trophic structure.

Figure 1 Map showing the proposed transmission line alignment, with an inset indicating the project location within Bhutan.

2. ASSESSMENT METHODOLOGY

2.1. Overview

To ensure a robust and comprehensive assessment, the CHA follows a staged process:

- Initial screening: Undertake stakeholder consultations and a targeted desk review using key sources such as the IUCN Red List of Threatened Species, Integrated Biodiversity Assessment Tool (IBAT) report, and the World Database of Key Biodiversity Areas (KBAs).
- Targeted field surveys: Collect and validate field data to confirm the presence, distribution, and habitat use of priority biodiversity features, using appropriate surveys (e.g., habitat surveys and targeted surveys for birds, bats, fish, invertebrates, and reptiles).
- Critical habitat determination:
  - o Define the Area of Assessment and
  - o Evaluate the area against the applicable Critical Habitat criteria.

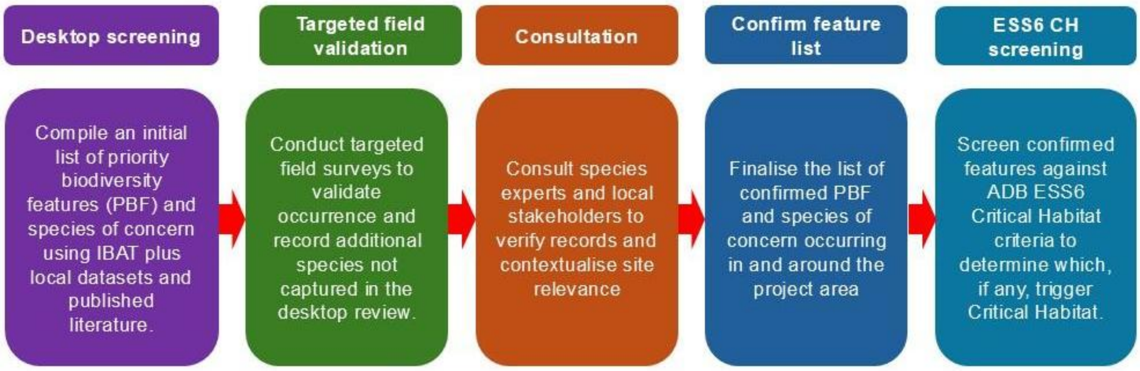

Figure 2 Key stages of the Critical Habitat Assessment (CHA) undertaken for the project.

2.2. Literature Review

To support the CHA and characterise baseline conditions, a targeted literature review was undertaken. Key project-related information was drawn from relevant reports, articles, and books, supplemented by online databases and official reference sources, including:

- Integrated Biodiversity Assessment Tool (IBAT) report
- Field surveys and verification data (e.g., habitat surveys and targeted surveys for birds, fish, bats, invertebrates, and reptiles)
- Forest and Nature Conservation Act (2023)
- IUCN Red List of Threatened Species
- BirdLife International Important Bird and Biodiversity Areas (IBAs)
- World Database of Key Biodiversity Areas (KBAs)

2.2.1. Summary of Integrated Biodiversity Assessment Tool (IBAT) report

The IBAT screening for a 50 km radius around the project footprint identified 1,087 assessed species across major taxonomic groups (Table 1). Birds represent the largest component (542 species; ~50%), followed by plants (243; ~22%), mammals (106; ~10%), invertebrates (93; ~9%), reptiles (55; ~5%), amphibians (43; ~4%), and fungi (5; <1%) (see table 1). No fish were reported in the IBAT output for this 50 km search area.

Across all taxa, the IBAT list includes 76 threatened species, including 9 Critically Endangered (CR), 29 Endangered (EN), and 38 Vulnerable (VU). An additional 48 species are listed as Near Threatened (NT), while 935 species are Least Concern (LC). Data Deficient (DD) listings total 28 species, concentrated primarily in plants (20) and invertebrates (3), with smaller contributions from amphibians (2), mammals (2), and reptiles (1); birds and fungi have no Data Deficient species in the IBAT results.

By broad group, mammals contribute the highest number of threatened species among vertebrates (22 threatened: 1 CR, 8 EN, 13 VU), whereas birds include 18 threatened (3 CR, 4 EN, 11 VU) but dominate overall richness. Plants include 29 threatened species (5 CR, 14 EN, 10 VU) and account for most of the uncertainty in the screening output via Data Deficient taxa. Overall, the IBAT results indicate that the 50 km landscape supports a diverse species assemblage with a substantive conservation signal driven by threatened taxa across multiple groups, particularly plants, mammals, and birds.

Table 1 Summary of taxa reported from IBAT

Group	Critically Endangered	Endangered	Vulnerable	Near Threatened, Least Concern, Data Deficient	Total
Mammals	1	8	14	84	106
Reptiles	0	1	3	51	55
Fish	0	0	0	0	0
Birds	3	4	11	524	542
Amphibians	0	1	0	42	43
Invertebrate	0	1	0	92	93
Plants	5	14	10	214	243
Fungi	0	0	1	4	5
Total	9	29	38	1011	1087

2.2.2. Ecologically sensitive areas

IBAT also screens for ecologically sensitive areas, including Protected Areas and Key Biodiversity Areas, within user-defined buffer distances. Within a 5 km radius of the project site, IBAT identified two Protected Areas (Fig. 3a):

- *Phrumsengla National Park, IUCN Category II*
  Phrumsengla National Park (PNP) covers 906.654 km² and safeguards extensive, high-value forest ecosystems, including some of Bhutan's last remaining stands of cool-temperate broadleaved forests and old-growth fir. These habitats are ecologically significant for maintaining landscape connectivity, protecting watersheds, and preserving ecosystem integrity in the eastern-central Himalaya.

  PNP spans a pronounced environmental gradient, ranging from approximately 850 m above sea level in the south to over 4,500 m in the north. This elevational range supports a complete sequence of Bhutan's major vegetation zones, from subtropical broadleaf forest through warm- and cool-temperate broadleaf forests, temperate coniferous forests, subalpine conifer forests, and alpine meadows above 4,200 m.

  The park is a major repository of floral diversity, with more than 1,000 plant species recorded, including 154 medicinal plants, and is particularly important for conserving large tracts of East Himalayan Silver Fir Forest and extensive cool broadleaved forests. Faunal diversity is similarly high: 69 mammal species have been recorded, including priority species such as the Royal Bengal Tiger (*Panthera tigris*), Red Panda (*Ailurus fulgens*), and Musk Deer (*Moschus spp*), together with other notable taxa (e.g., Himalayan Black Bear (*Ursus thibetanus*), Common Leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), and Golden Cat (*Catopuma teminckii*)). Avifaunal diversity is exceptional, with 378 bird species recorded, including three VU, six NT, and eight restricted-range species. Species of conservation interest include the Chestnut-breasted Partridge (*Arborophila mandellii*), Rufous-necked Hornbill (*Aceros nipalensis*), and Beautiful Nuthatch (*Sitta formosa*). The park also supports amphibians, reptiles, fish, and a diverse butterfly fauna, reinforcing its role as a multi-taxa biodiversity stronghold and a key conservation landscape in central and eastern Bhutan.

- *Wangchuck Centennial National Park, IUCN Category II*
  Wangchuck Centennial National Park (WCNP), gazetted on 10 June 2008, is Bhutan's largest and newest protected area (4,914 km²) and forms a core component of a connected north–central conservation landscape linking Jigme Dorji National Park to the west and Bomdeling Wildlife Sanctuary to the east via biological corridors. The park spans an exceptional altitudinal gradient (reported up to approximately 1,350–7,500 m a.s.l.), encompassing warm broadleaf forests in lower valleys through temperate and subalpine zones to alpine meadows, scree, and permanently snow- and glacier-dominated environments; around 85% of the park remains snow-covered for roughly four winter months. This elevational breadth and high landscape integrity underpin WCNP's ecological significance as a "water tower" supporting major

headwaters and regulating hydrological processes across river systems critical to downstream ecosystems and national hydropower generation.

Biodiversity values are high and supported by recent assessments and historical records, with the park recording 693 vascular plant species, 44 mammal species, 251 bird species, 246 butterfly species, and five fish species. WCNP is a habitat for charismatic and ecologically important predators and high-elevation fauna (including tigers and snow leopards (*Panthera uncia*), and the Tibetan wolf (*Canis lupus chanco*)). WCNP also supports high-value alpine meadow ecosystems that sustain culturally and economically important non-timber resources, notably Cordyceps (*Ophiocordyceps sinensis*) and other medicinal and ethnobotanical plants.

The IBAT also identified other sites of biodiversity importance, listed below (Fig. 3b):

- *Phrumsengla National Park*
  Phrumsengla National Park (KBA ID: 15202) is also a confirmed Key Biodiversity Area in Bhutan. The site is a terrestrial system spanning a very broad elevational range (about 600–4,500 m). Its most recent assessment was completed in 2005, and it is designated as a legacy site, recognised through the 2005 CEPF Ecosystem Profile for the Eastern Himalayas Hotspot as meeting one or more established global biodiversity-importance criteria. Reported habitat composition includes forest, grassland, and shrubland, each comprising roughly one-third of the site, with KBA classification noted as Global/Regional.

- *Bumthang wetlands*
  Bumthang wetlands (KBA ID: 15206) is a confirmed Key Biodiversity Area in Bhutan, covering approximately 119.6 km² and centred at 27.6000°N, 90.7167°E. The site spans freshwater and terrestrial systems at high elevation (about 3,000–3,400 m) and has substantial protected area coverage (68.12%). Its most recent assessment was completed in 2005, and it is designated as a legacy site, recognised through the 2005 CEPF Ecosystem Profile for the Eastern Himalayas Hotspot as meeting one or more established global biodiversity-importance criteria. Reported habitat composition is evenly split between “Artificial – Terrestrial” (50%) and inland wetlands (50%), with KBA classification noted as Global/Regional.

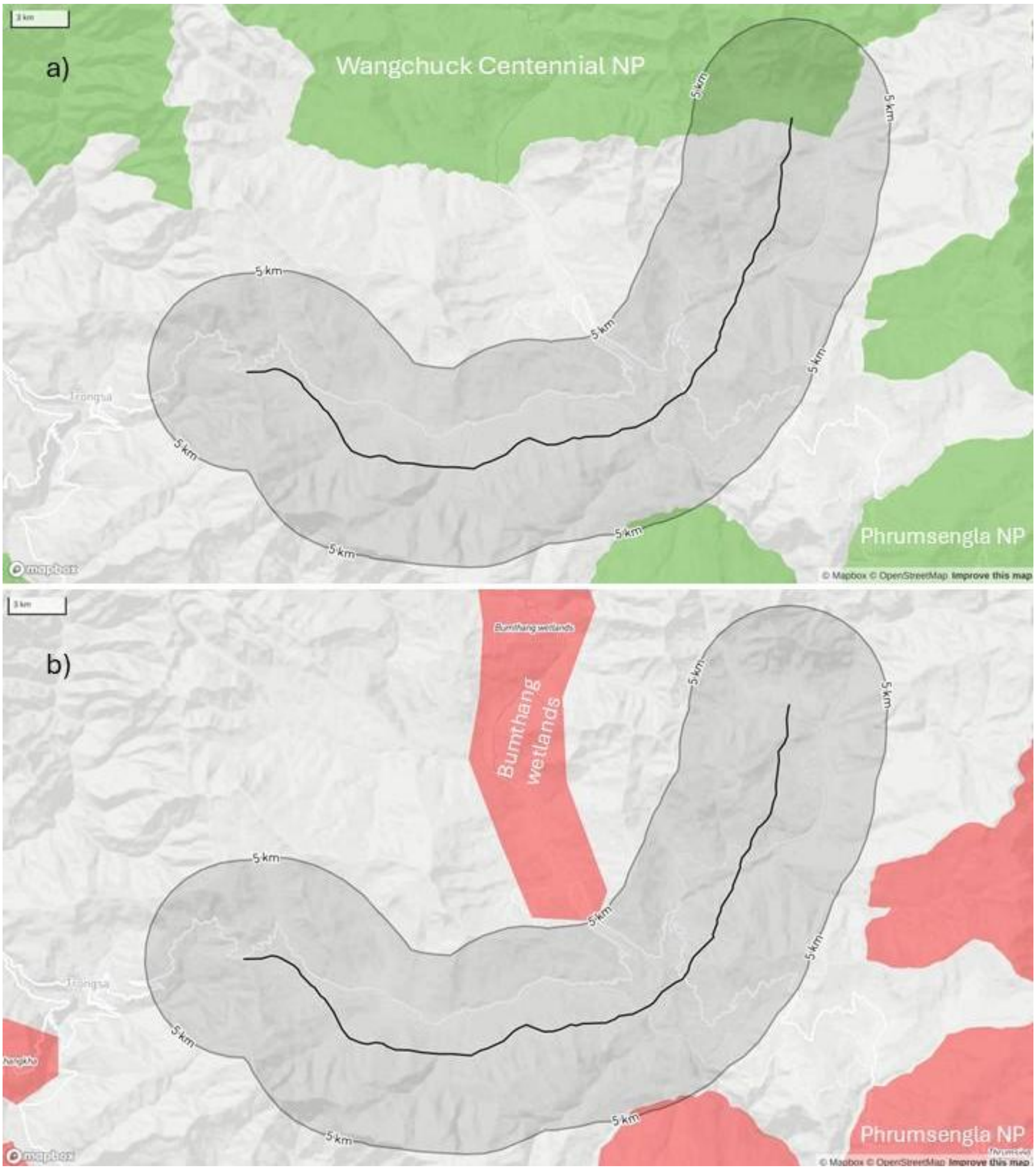

Figure 3 a) Wangchuck Centennial National Park and Phrumsengla National Park (PNP) are two protected areas found within 5km of the project. b) Two Key Biodiversity Area Bumthang wetlands and PNP are also recorded in the proximity.

2.3. Results from the targeted field surveys

Field surveys were undertaken to establish baseline conditions for flora and fauna within the project's area of influence. For this assessment, the Area of Influence (AOI) was defined as a 2 km buffer on either side of the proposed transmission line alignment. A wet-season survey was conducted in summer 2025 by the College of Natural Resources, and a dry-season survey was conducted in December 2025 by the Department of Forests and Park Services. Both surveys adhered to the guidelines outlined in the Biodiversity Monitoring Protocol of Bhutan (DoFPS, 2020).

During the wet-season survey, 195 plant species, including trees, shrubs, and herbs, were recorded. 7 species of mammals, 108 species of birds, 2 species of herpetofauna, 1 species of fish, and macroinvertebrates were collected, representing 20 families under 10 orders.

During the dry-season survey, 14 tree species, 55 shrub species, 68 herbaceous species along the transmission line and 41 along access roads, 3 herpetofauna species (reptiles/amphibians), 12 species of mammals, 2 butterfly species, and 46 bird species were recorded.

2.4. Stakeholder consultations

Stakeholder consultations have been conducted and remain ongoing. As additional information relevant to the CHA becomes available, this report will be updated accordingly. Consultations to date have included:

- Nature Conservation Division (NCD), Department of Forests and Park Services, DoFPS
    - Sonam Wangdi, Chief Forestry Officer
    - Lungten Dorji, Sr. Forestry Officer
    - Tshering Zam, Principal Forestry Officer
    - Chimmi Dorji, Deputy Chief Forestry Officer
    - Rinchen Dorji, Sr. Forestry Officer
    - Choney Yangzom, Dy. Chief Forestry Officer
- Territorial Forest Division, Bumthang, and Wangchuck Centennial National Park, DoFPS
    - Chief Forestry Officer
    - Karma Wangdi, Dy. Chief Forestry Officer

2.5. Assessment methodology

2.5.1. Determination of the Area of Assessment (AOA)

Areas of Assessment (AOA) were delineated to provide an ecologically defensible spatial unit for evaluating biodiversity features and potential critical habitat qualifying features, consistent with ADB ESS6. The workflow was designed for a linear infrastructure context and intended to capture areas potentially affected by direct, indirect, and cumulative impacts, including fragmentation, barrier effects, and edge-related change.

To align the assessment extent with landscape structure and define a defensible limit for project impacts, the CHA spatial scope was delineated using watershed polygons and defined as the Project Landscape Unit (PLU). Watersheds intersecting the combined project corridor (transmission line alignment and proposed access road) were selected as initial units, expanded to include directly adjacent watershed units, and merged into a single assessment polygon. All subsequent habitat mapping and connectivity analyses were constrained within this assessment extent.

For each biodiversity feature, potential habitat was mapped using ecological filters based on the best available national datasets and feature-specific requirements. Within the assessment extent, habitat was defined by selecting suitable land-cover classes (e.g., forest, shrubland, alpine scrub, meadow), restricting to relevant forest subtypes where applicable, and applying the feature's elevation range using a national DEM. Slope and aspect were also applied as feature-specific filters to further refine suitable habitat, as these terrain attributes are known to influence habitat use. The resulting layer represents areas that meet land cover, forest-type (if relevant), elevation, and terrain requirements within the defined assessment boundary.

To avoid overestimating suitable habitat in modified areas, disturbed land covers (built-up and non-built-up) were treated as avoidance zones and buffered using feature-specific distances. These buffered disturbance areas were excluded from the suitable habitat layer before delineating habitat patches, with buffers applied consistently across features to improve efficiency.

Refined habitat was converted into discrete patches and processed to represent ecologically relevant habitat networks by reducing artificial fragmentation and applying minimum patch-size rules, while retaining smaller "stepping-stone" patches that contribute to connectivity. Patches were then grouped into connected networks based on the defined connectivity distance. Only networks connected to the project corridor (and, where relevant, to protected areas or biological corridors) were retained for assessment.

2.5.2. Assessment of Critical Habitat criteria

The ESS6 defines critical habitat as "*a subset of natural and modified habitats, comprising areas of highest biodiversity value of significant importance to one or more types of priority biodiversity features*".

Table 3 summarises the threshold values used to identify Critical Habitat under ESS6. These thresholds provide an objective basis for evaluating whether biodiversity features within the area of assessment meet the criteria for Critical Habitat designation.

Table 3 Thresholds for critical habitat determination as per ESS6

Criterion	Threshold for critical habitat
1. Threatened ecosystems	**(i)** Areas representing ≥5% of the extent of occurrence (EOO) of an ecosystem type meeting the criteria for globally EN or CR on the IUCN Red List of ecosystems; or (ii) Other areas not yet assessed by IUCN but determined to be of high priority for conservation by regional or host country systematic conservation planning; or

	(iii) Free-flowing rivers shorter than 500 km recognized as ecologically significant
2. Geographically restricted ecosystems	(i) Areas representing ≥20% of the EOO of any ecosystem type
3. Threatened species	(i) Areas that support globally important concentrations of a globally EN or CR species (≥0.5% of the global population AND ≥5 reproductive units of a CR or EN species). (ii) Areas that support globally important concentrations of a globally Vulnerable species, the loss of which would result in the change of its status to EN or CR, and meet the thresholds in 3(i), or (iii) As appropriate, areas containing important concentrations of a nationally or regionally listed EN or CR species, where national/regional assessments have adhered to IUCN guidance.
4. Geographically restricted species	(i) Areas that regularly hold ≥10% of the global population size AND ≥10 reproductive units of a geographically-restricted species. (ii) For terrestrial vertebrates and plants, a restricted-range species is defined as those species that have an EOO of less than 50,000 square km (km^2). (iii) For marine systems, restricted-range species are provisionally considered those with an EOO of less than 100,000 km^2. (iv) For coastal, riverine, and other aquatic species in habitats wholly ≤200 km width (for example, rivers), restricted-range is defined as having a global range of ≤500 km linear geographic span (i.e., the distance between likely occupied locations furthest apart).
5. Geographically restricted assemblages	Areas that regularly: (i) Hold ≥0.5 of global population size of each of several ecoregion-restricted species in a taxonomic group: ≥5 species or 10% of the species restricted to ecoregion, whichever is larger. (ii) Hold ≥5 reproductive units of ≥5 bioregion-restricted species of 30% of the bioregion-restricted species known from the country, whichever is larger, within a taxonomic group; or (iii) Are part of the globally most important 5% of occupied habitat for ≥5 species within a taxonomic group.
6. Aggregations of migratory or congregatory species	(i) Areas known to sustain, on a cyclical or otherwise regular basis, ≥1% of the global population of a migratory or congregatory species at any point of that species' lifecycle; or (ii) Areas that predictably support ≥10% of the global population of a species during periods of environmental stress

7. Areas associated with key evolutionary processes	No quantitative threshold; should be identified in consultation with experts.
8. Ecological function and connectivity vital to maintaining the viability of biodiversity described above	No quantitative threshold; should be identified in consultation with experts.

3. CRITICAL HABITAT ASSESSMENT

3.1. Screening priority biodiversity features for CHA

In the initial screening phase, priority biodiversity features (PBFs), including species of conservation concern, were identified using the IBAT report, the IUCN Red List of Ecosystems, and the Key Biodiversity Area (KBA) framework. The IBAT reported a total of 1087 species occurring within 50 km of the project site and 2 sites of ecological importance (both KBAs) within 5 km of the project site. IBAT outputs were used to compile all globally threatened taxa (IUCN CR, EN and VU) and other relevant PBF (e.g., restricted-range and endemic species) reported within a 50-km search radius of the project footprint. In addition to taxa returned by IBAT, IUCN VU species not captured in the IBAT query were retained in the longlist as a precautionary measure, recognising that localised pressure and project-related residual impacts can increase extinction risk and may contribute to future uplisting under the IUCN Red List framework. In addition, the targeted biodiversity list was used to supplement the baseline by identifying species that may be present but were not captured through the initial IBAT screening.

The compiled list consisted predominantly of terrestrial species recorded. Wet-season aquatic sampling was undertaken at locations where the transmission line crosses settlements and aquatic habitats (e.g., streams and rivers); however, no species of conservation concern were detected.

The longlist was then refined through a spatial likelihood-of-occurrence screening (Table 4). Species distribution data and range maps from the IUCN Red List were intersected with the project footprint and AOI to determine range overlap. Species lacking spatial overlap with the project footprint were screened out as unlikely to occur in the project landscape. Occurrence likelihood for the remaining taxa was subsequently triangulated using multiple independent evidence streams, including:

(i) results from two-season (wet and dry) biodiversity surveys conducted by the College of Natural Resources and the Department of Forests and Park Services in 2025

(ii) Vantage survey conducted along the proposed transmission line to assess collision risks for the project, conducted during the winter of 2025

(iii) species inventories and key habitat information from community forest management plans for three nearby community forests, namely Gyalyon khar, Garabling & Phomrong Community Forests

(iv) eBird and iNaturalist platforms

These data sources were used to corroborate presence/absence, refine habitat associations, and strengthen the evidence base for the final shortlist of candidate species expected to occur within or proximal to the project area.

Table 4 Screening species for CHA

Sl	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
Amphibians						
1	*Amolops marmoratus*	Marbled Sucker Frog	LC	Criterion 4	Unlikely	Its occurrence in Bhutan is uncertain
2	*Amolops monticola*	Mountain Cascade Frog	EN	Criterion 3(i), 4	Unlikely	Its occurrence in Bhutan is uncertain
3	*Megophrys parva*	Concave-crowned Horned Toad	DD	Criterion 4	Unlikely	Its occurrence in Bhutan is uncertain
4	*Scutiger bhutanensis*	Bhutan Snow Toad	DD	Criterion 4	Unlikely	The species range within Bhutan does not overlap with the project site.
Birds						
1	*Aquila nipalensis*	Steppe Eagle	EN	Criterion 3(i)	Unlikely	The species range within Bhutan does not overlap with the project site.
2	*Ardea insignis*	White-bellied Heron	CR	Criterion 3(i)	Unlikely	The species range within Bhutan does not overlap with the project site.
3	*Calidris tenuirostris*	Great Knot	EN	Criterion 3(i)	Unlikely	The range overlaps with the project site. Sightings in Bhutan are sporadic and often associated with specific wetland sites. They are vagrant.
4	*Falco cherrug*	Saker Falcon	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
5	*Fulvetta ludlowi*	Brown-throated Fulvetta	LC	Criterion 3(i)	Unlikely	The range overlaps the project site. However, this species is currently known

SI	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
						only from eastern Bhutan, namely Mongar and Trashigang.
6	*Gyps bengalensis*	White-rumped Vulture	CR	Criterion 3(i)	Unlikely	The range overlaps with the project site, but the bird is primarily known from lowlands, with no recent published records from Bhutan.
7	*Haliaeetus leucoryphus*	Pallas's Fisheagle	EN	Criterion 3(i)	Unlikely	The range overlaps the project site. However, the species is known to occur mainly along the four major river basins, namely the Puna Tsangchu, Mangechu, Kurichu, and Drangme Chhu, with most records reported from Punakha and Wangdue.
8	*Prinia cinereocapilla*	Grey-crowned Prinia	VU	Criterion 4	Unlikely	The range does not overlap with the project site
9	*Sarcogyps calvus*	Red-headed Vulture	CR	Criterion 3 (i)	Unlikely	The range overlaps with the project site. However, the species is rare in Bhutan and is primarily found in the subtropical lowlands and foothills of southern Bhutan, generally occurring at elevations below 2,500 m. The species has been previously recorded in Royal Manas National Park.
10	*Spelaeornis caudatus*	Rufous-throated Wren-babbler	LC	Criterion 4	Unlikely	The range does not overlap with the project site
11	*Tragopan blythii*	Blyth's Tragopan	VU	Criterion 4	Unlikely	The range does not overlap with the project site
12	*Trochalopteron imbricatum*	Bhutan Laughingthrush	LC	Criterion 4	Confirmed	Detected during wet season survey August 2025

SI	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
Insects						
1	*Aeshna shennong*		DD	Criterion 4	Unlikely	Its occurrence in Bhutan is uncertain
2	*Bhutanitis ludlowi*	Ludlow's Bhutan Glory	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence
3	*Coeliccia svihleri*	-	LC	Criterion 4	Unlikely	The range does not overlap with the project site
4	*Huosoma tinctipenne*	-	LC	Criterion 4	Unlikely	The range overlaps with the project site. However, during the detailed aquatic survey carried out during the season, the species was not detected within the project's Aoi. There is only one record of the species, from the north of Bumthang.
5	*Megalestes gyalsey*	-	DD	Criterion 4	Unlikely	The range does not overlap with the project site
Plants						
1	*Carex nigra subsp. drukyulensis*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
2	*Cheirostylis sherriffii*		CR	Criterion 3(i)	Unlikely	The range does not overlap with the project site
3	*Dactylorhiza hatagirea*	Salampanja	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence

SI	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
4	*Trillium govanianum*	Himalayan Trillium	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence
5	*Trillium tschonoskii*	Keun-yeonyeong-cho	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence
6	*Androsace hemisphaerica*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
7	*Bistorta griersonii*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
8	*Canarium strictum*	Kunthirikkam	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
9	*Ceropegia bhutanica*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
10	*Ceropegia dorjei*	-	CR	Criterion 3(i)	Unlikely	The range does not overlap with the project site
11	*Impatiens sikkimensis*	Sikkim Balsam	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
12	*Magnolia rostrata*	Changhui Houpo	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
13	*Nardostachys jatamansi*	Indian Nard	CR	Criterion 3(i)	Unlikely	The range overlaps with the project site. However, the species is commonly found at higher altitudes and randomly distributed throughout its prime habitat, which ranges from 3871 m to 4864m.
14	*Neopicrorhiza minima*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site

SI	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
15	*Onosma griersonii*	-	CR	Criterion 3(i)	Unlikely	The range does not overlap with the project site
16	*Ophiorrhiza longii*	-	CR	Criterion 3(i)	Unlikely	The range does not overlap with the project site
17	*Phoebe bootanica*	-	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
18	*Podophyllum hexandrum*	Himalayan Mayapple	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence.
19	*Sloanea tomentosa*	XIn Ye Hou Huan Xi	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
Mammals						
1	*Ailurus fulgens*	Red Panda	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence.
2	*Anourosorex schmidi*	Giant Mole Shrew	DD	Criterion 4	Unlikely	The range does not overlap with the project site
3	*Cuon alpinus*	Dhole	EN	Criterion 3(i)	Confirmed	Range overlaps with project site, recorded in the Gyalyon khar, Garabling & Phomrong CF
4	*Manis pentadactyla*	Chinese Pangolin	CR	Criterion 3(i)	Unlikely	The range does not overlap with the project site
5	*Moschus chrysogaster*	Alpine Musk Deer	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence.
6	*Moschus fuscus*	Black Musk Deer	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site,

Sl	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
						but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence.
7	*Moschus leucogaster*	Himalayan Muskdeer	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
8	*Panthera tigris*	Tiger	EN	Criterion 3(i)	Unlikely	The species' range overlaps the project site, but it was not recorded in either wet- or dry-season surveys, and nearby community forest management plans do not report its presence.
9	*Trachypithecus geei*	Geei's Golden Langur	EN	Criterion 3(i), 4	Unlikely	The range does not overlap with the project site
10	*Trachypithecus pileatus ssp. tenebricus*	Tenebrous Capped Langur	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site
11	*Ursus thibetanus*	Asiatic black bear	VU	Criterion 3(i)	Confirmed	Range overlaps with project site, recorded in the Gyalyon khar, Garabling & Phomrong CF.
12	*Rusa unicolor*	Sambar deer	VU	Criterion 3(i)	Confirmed	Range overlaps with project site, recorded in the Gyalyon khar, Garabling & Phomrong CF. Detected during the dry and wet season surveys of 2025.
13	*Capricornis sumatraensis*	Serow	VU	Criterion 3(i)	Confirmed	Confirmed during the 2025 dry-season survey using camera traps
14	*Catotpuma temminckii*	Asiatic golden cat	VU	Criterion 3(i)	Confirmed	Confirmed during the 2025 dry-season survey using camera traps
15	*Panthera pardus*	Common leopard	VU	Criterion 3(i)	Confirmed	Confirmed during the 2025 dry-season survey using camera traps
Reptiles						

SI	Scientific Name	Common Name	IUCN status	CHA criteria (ESS6)	Potential occurrence in the AOI	Remarks
1	*Cuora mouhotii*	Keeled Box Turtle	EN	Criterion 3(i)	Unlikely	The range does not overlap with the project site

The CHA screening process has identified the following species likely to occur in the project's area of influence and merited evaluation against the ESS6 CHA criteria:

- Mammals: Asiatic wild dog, Asiatic black bear, sambar deer, serow, Asiatic golden cat, and leopard
- Birds: Bhutan laughing thrush

3.2. Critical habitat assessment of screened species

3.2.1. Criterion 1. Threatened ecosystems

The project area lies within Biome T2: Temperate–boreal forests and woodlands under the IUCN Global Ecosystem Typology, and more specifically within functional group T2.1: Boreal and temperate high montane forests and woodlands. At the national scale, this functional group in Bhutan represents approximately 0.027–0.033% of the global occurrence for these ecosystem types, which is well below the ≥5% of global extent-of-occurrence (EOO) threshold used to indicate a potentially significant contribution toward triggering Criterion 1 (Threatened ecosystems) under ADB ESS6.

The IUCN also maintains the Red List of Ecosystems (RLE), a globally recognised framework for assessing ecosystem collapse risk based on both spatial decline and functional degradation. However, no RLE assessments are currently available for Bhutan, and there are no national designations of threatened ecosystems that would allow this ecosystem to be classified as threatened at the country level. In addition, the broader landscape encompassing the project area is not identified as a nationally or internationally prioritised ecosystem conservation area based on currently available information. Accordingly, on the basis of (i) the very small proportion of global occurrence represented nationally, and (ii) the absence of any recognised threatened-ecosystem listings for Bhutan, the project area is not considered to trigger ADB ESS6 Criterion 1 for threatened ecosystems.

3.2.2. Criterion 2. Geographically restricted ecosystems

The IUCN Red List of Ecosystems (RLE) provides the global standard for determining ecosystem collapse risk, including "restricted geographic distribution" (Criterion B), but as mentioned previously, no RLE assessments are currently available for Bhutan, and there are no nationally adopted threatened-ecosystem listings applicable to this assessment.

On the basis of currently available information, the project area is not identified within a formally designated threatened or geographically restricted ecosystem under recognised global frameworks (RLE/KBA), and therefore ESS6 Criterion 2 is not triggered on ecosystem grounds, noting that this conclusion should be revisited if national RLE or finer-scale ecosystem assessments become available.

To assess the Critical Habitat Assessment criteria, population estimates were used wherever available. Where robust population data were lacking, the Extent of Occurrence (EOO) was applied as a proxy to screen for potential critical habitat triggers.

3.2.3. Criterion 3. Threatened species

Leopard *Panthera pardus*

The common leopard is widespread across Bhutan. Globally, the leopard population is estimated to be approximately 131,300 individuals. In Bhutan, the 2021-2022 national tiger survey data indicate approximately 319 leopards nationwide (Karma Choki, *unpublished*), which is insufficient to meet Criterion 3 even at the national level.

The global EOO is estimated at 1,116,442 km^2 for the Indian subspecies, which is also the one found in Bhutan (*P. p. fusca*) (Shivajumar et al., 2025). The AOA for the species was determined to be 1511.25 km^2 (Fig. 1), which is 0.13% of the global EOO, and hence does not trigger the CH designation.

Sambar Deer *Rusa unicolor*

Sambar deer is a widely distributed ungulate in Bhutan's tiger landscapes, occurring from the southern foothills to mid- and high-elevation forests. In Royal Manas National Park, pellet-group surveys found sambar sign to be the most abundant ungulate record, with most detections concentrated below 1,000 m above sea level (a.s.l.), indicating strong use of lowland subtropical habitats. In central Bhutan, camera-trapping in Biological Corridor No. 8 (linking Jigme Singye Wangchuck NP and Wangchuck Centennial NP) documented sambar across ~2,085–3,900 m, within a corridor spanning 1,850–4,180 m. In Phrumsengla National Park, plot-based assessments revealed peak use at elevations of 2,356–2,680 m, with a preference for cool broadleaved forests. Notably, livestock grazing and timber extraction were negatively associated with occurrence.

The global EOO is estimated to be 6,336,171 km^2 (Timmins et al., 2015). The AOA for the species was determined to be 1951.73 km^2(Fig. 2), which is 0.03% of the global EOO. Hence, it does not trigger the designation as a Critical Habitat.

Asian golden cat *Catopuma temminckii*

The Asiatic golden cat is an elusive felid of Bhutan's forested landscapes, notable for its exceptional coat colour polymorphism. Camera-trap studies in Bhutan have documented up to 10 distinct colour morphs, including golden, grey, melanistic, and multiple spotted/patterned forms, highlighting Bhutan as an important stronghold for the species. Typically solitary and largely nocturnal, the Asiatic golden cat occupies a broad ecological niche, ranging from subtropical forests to rugged high-elevation habitats above 3,000 m, where it preys on birds, reptiles, and small mammals. Despite this apparent ecological flexibility, it remains vulnerable to habitat loss and degradation, which can reduce prey availability and increase landscape fragmentation.

In Bhutan, the Asiatic golden cat has been reported from nine protected areas and has also been recorded outside the protected-area network, including Thimphu, Sarpang, Gedu, and Trashigang Territorial Forest Divisions, indicating a wider distribution across managed forest landscapes. The species has recently been listed as Vulnerable (downlisted from Near Threatened) due to global population declines. However, it remains geographically widespread, with a global Extent of Occurrence (EOO) estimated at 5,697,094 km² (Peterson et al., 2025). The Area of Assessment (AOA) for the species is estimated at 1032.11 km² (Fig. 3; ≈approximately 0.02% of global EOO), which is below the 0.5% screening threshold; therefore, it does not trigger Critical Habitat designation under this range-based criterion.

Asiatic wild dogs *Cuon alpinus*

Asiatic wild dogs or Dholes have been recorded nationwide, occurring across all 20 districts and within every protected area and biological corridor in Bhutan (Thinley et al., 2021). Their distribution spans a pronounced elevational gradient from 110 m a.s.l. in Royal Manas National Park (RMNP) in the southern foothills to 4,980 m a.s.l. in Jigme Dorji National Park (JDNP) in the upper Himalayas and includes a wide range of habitat types, from subtropical forests at low elevations to alpine meadows in the highlands.

Globally, the dhole is listed as Endangered, with an estimated <2,500 mature individuals remaining. Despite this threatened status, it remains geographically widespread, with a reported global EOO of 3,444,034 km² (Kamler et al., 2015).

National population estimates are currently unavailable; therefore, EOO was used as a proxy to screen for potential Critical Habitat triggers. The AOA for the species with respect to the project is estimated at 1638.83 km² (Fig. 4), representing approximately 0.04% of the global EOO. This is well below the 0.5% threshold typically used to trigger Critical Habitat designation based on a proportion of global range. Accordingly, the dhole does not meet the screening criteria for Critical Habitat within the AOA.

Asiatic black bear *Ursus thibetanus*

The Asiatic black bear is among Bhutan’s largest carnivores, reaching approximately 200 kg and up to ~190 cm in body length. The species is considered widespread across the country and, in some areas (e.g., Gasa and Bumthang), is regarded as a pest due to frequent interactions with people (NCD, 2023). Although a robust national population estimate is not yet available, increasing reports of sightings, conflict incidents, and rescue cases suggest the population is at least stable and may be increasing.

In Bhutan, Asiatic black bears occupy a wide range of habitats and elevations from subtropical forests in the southern lowlands (~100 m a.s.l.) to subalpine and alpine zones exceeding 5,000 m in the north, though they are most commonly associated with temperate forests in central and western Bhutan. The species is legally protected as schedule II species under Bhutan's Forest and Nature Conservation Act (2023).

The species' global EOO is estimated at 3,748,479 km² (Garshelis et al., 2020). The AOA was determined at 2826.49 km² (Fig. 5; 0.07% of the global EOO), which is well below the relevant screening threshold for Critical Habitat triggers based on range proportion.

Serow *Capricornis sumatraensis*

The serow was recorded at the project site during the camera trap survey conducted in winter 2025. There is no solid global estimate for the mainland serow population. In Bhutan's Jigme Singye Wangchuck National Park, situated within 10 km of the project site, the density was estimated at 0.36 individuals per km² based on 2010 data (Wang et al., 2011).

In the absence of recent global abundance figures, we relied on EOO data from the IUCN Red List. The global EOO is estimated at 3,511,389 km² (Phan et al., 2020), with the AOA representing only about 0.01% (408.89 km², Fig. 6)—well below the 0.5% threshold. Therefore, Criterion 3 is not met, and no further assessment under this criterion is necessary.

Figure 4 (a) Global distribution of the leopard

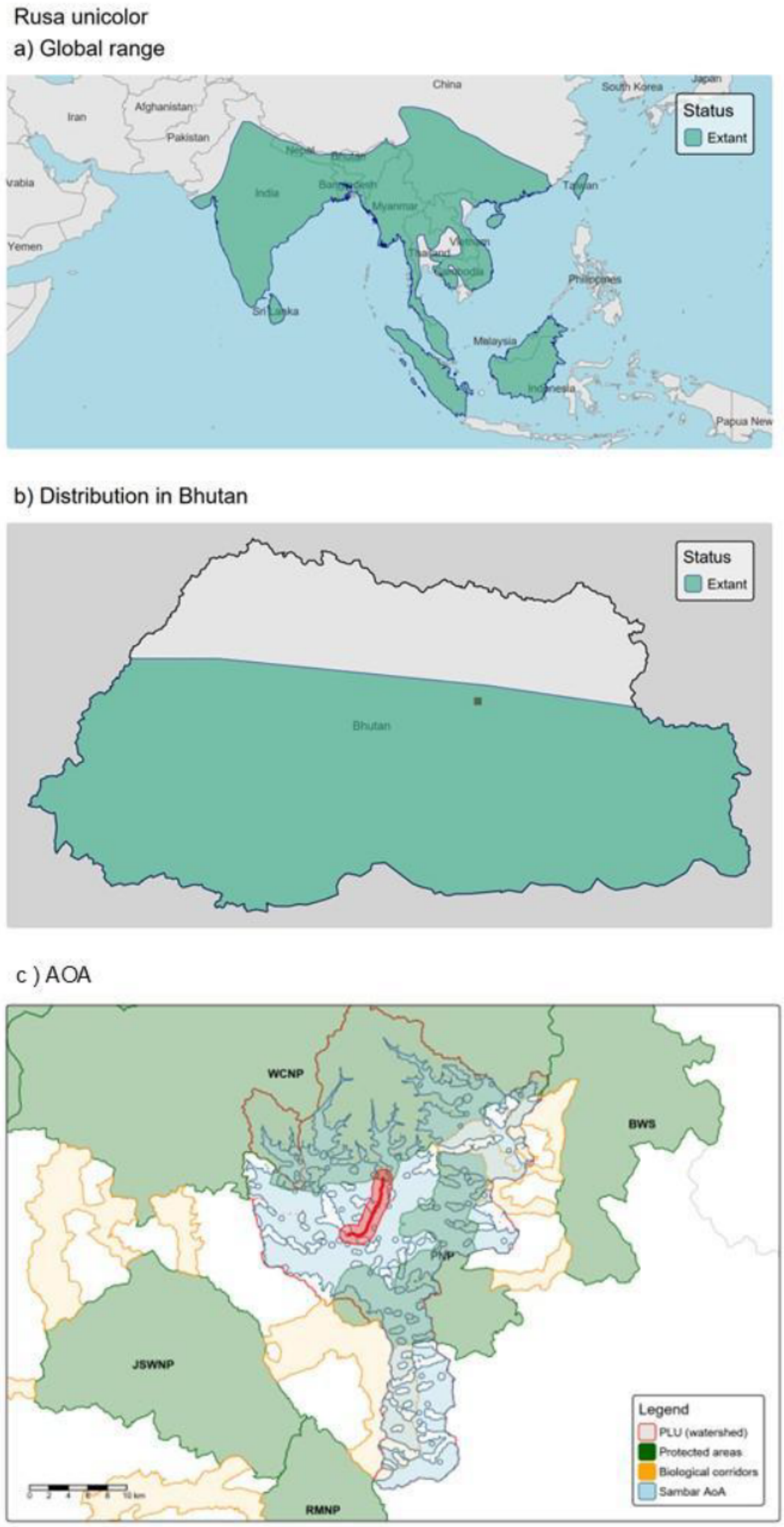

Figure 5 (a) Global distribution of the sambar, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

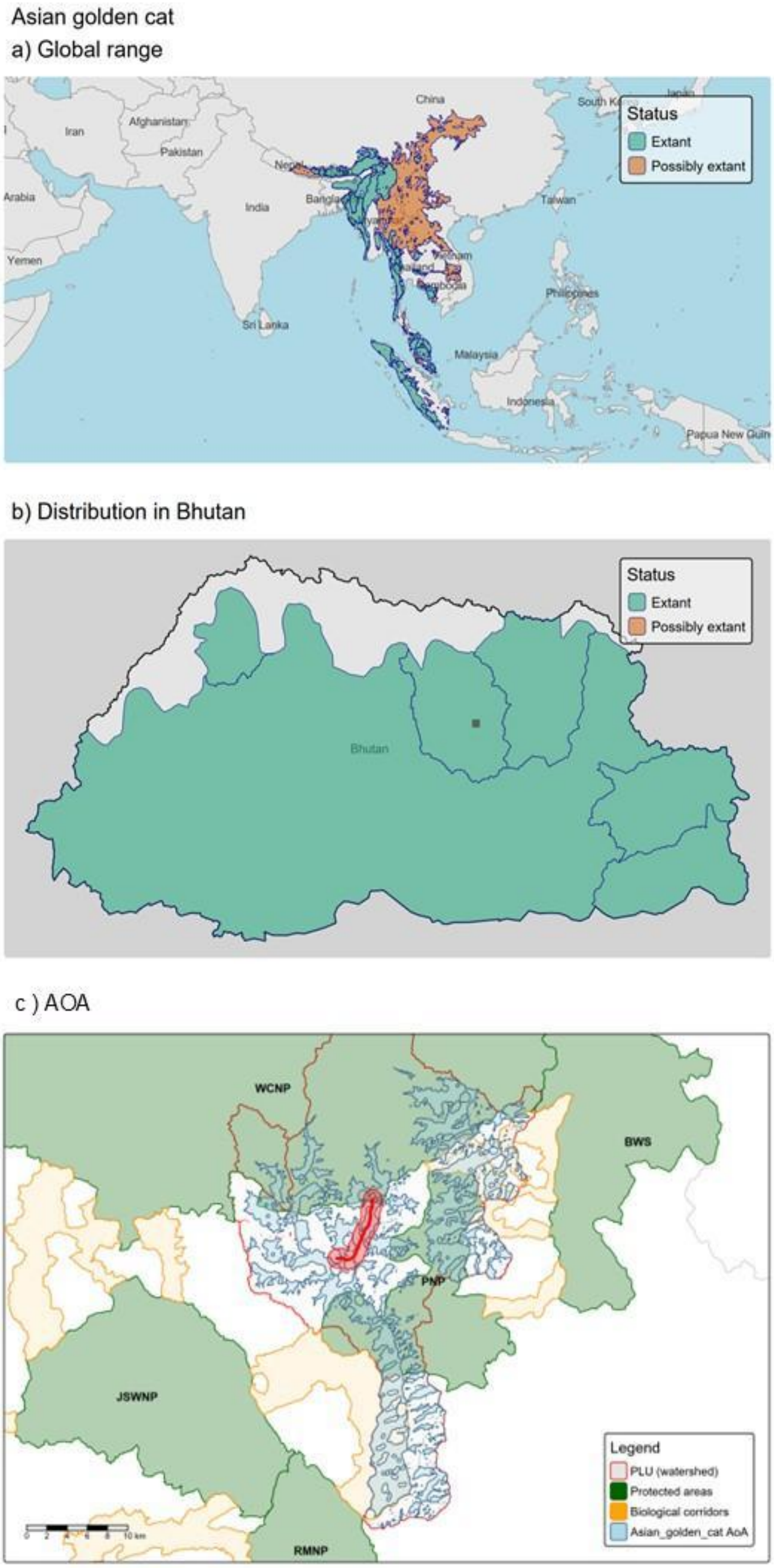

Figure 6 (a) Global distribution of the golden cat, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

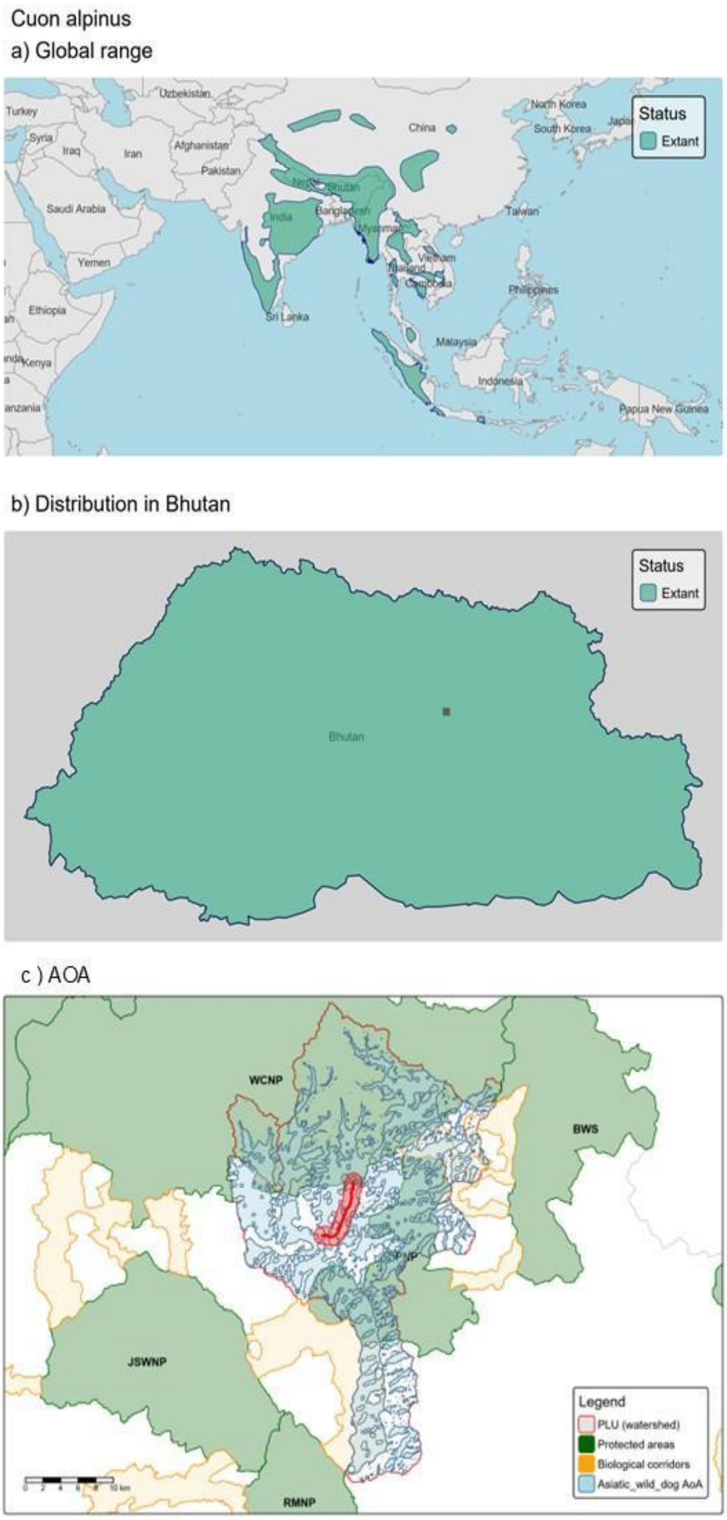

Figure 7 **(**a) Global distribution of the wild dogs, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

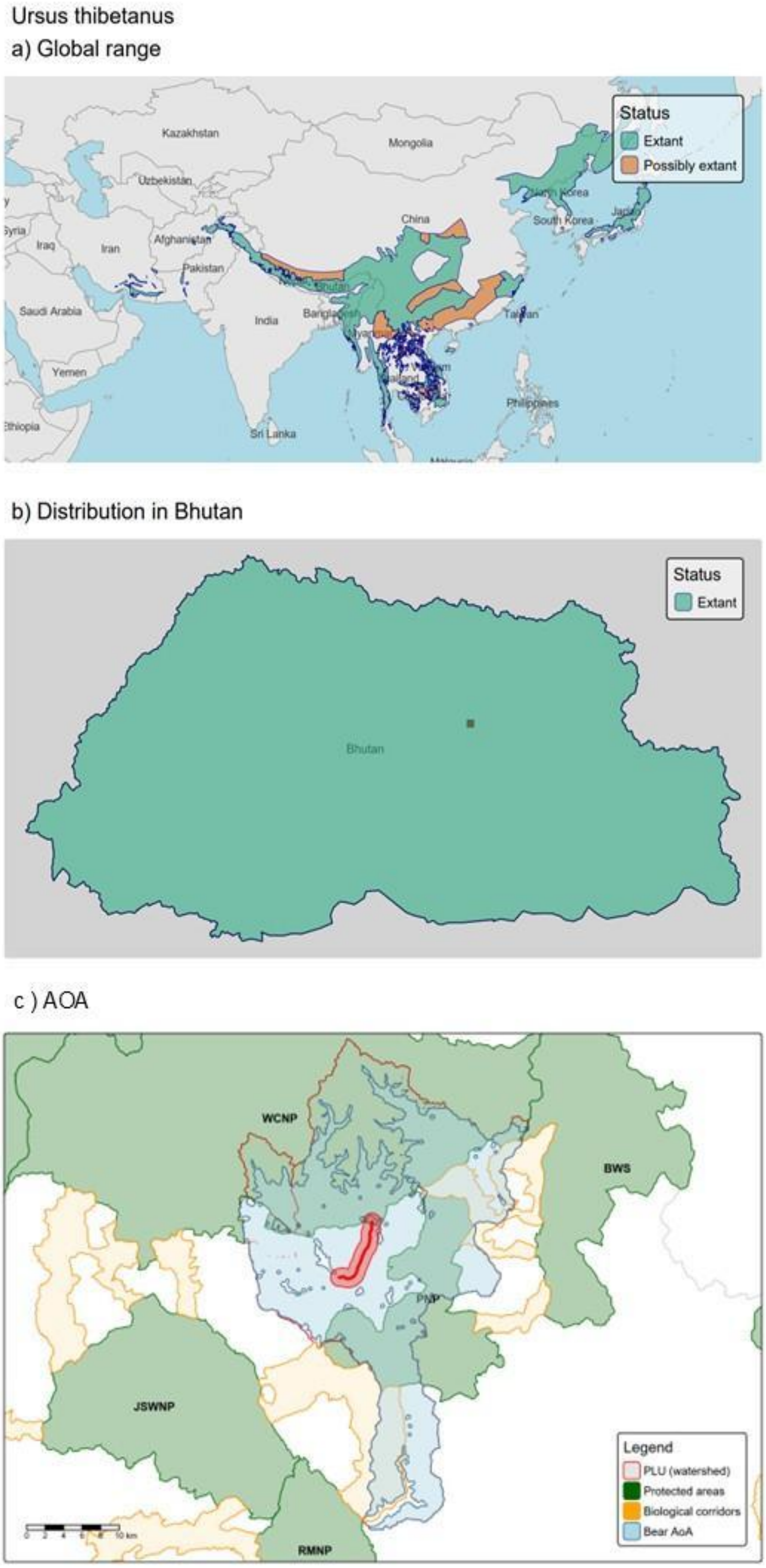

Figure 8 (a) Global

distribution of the leopard, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

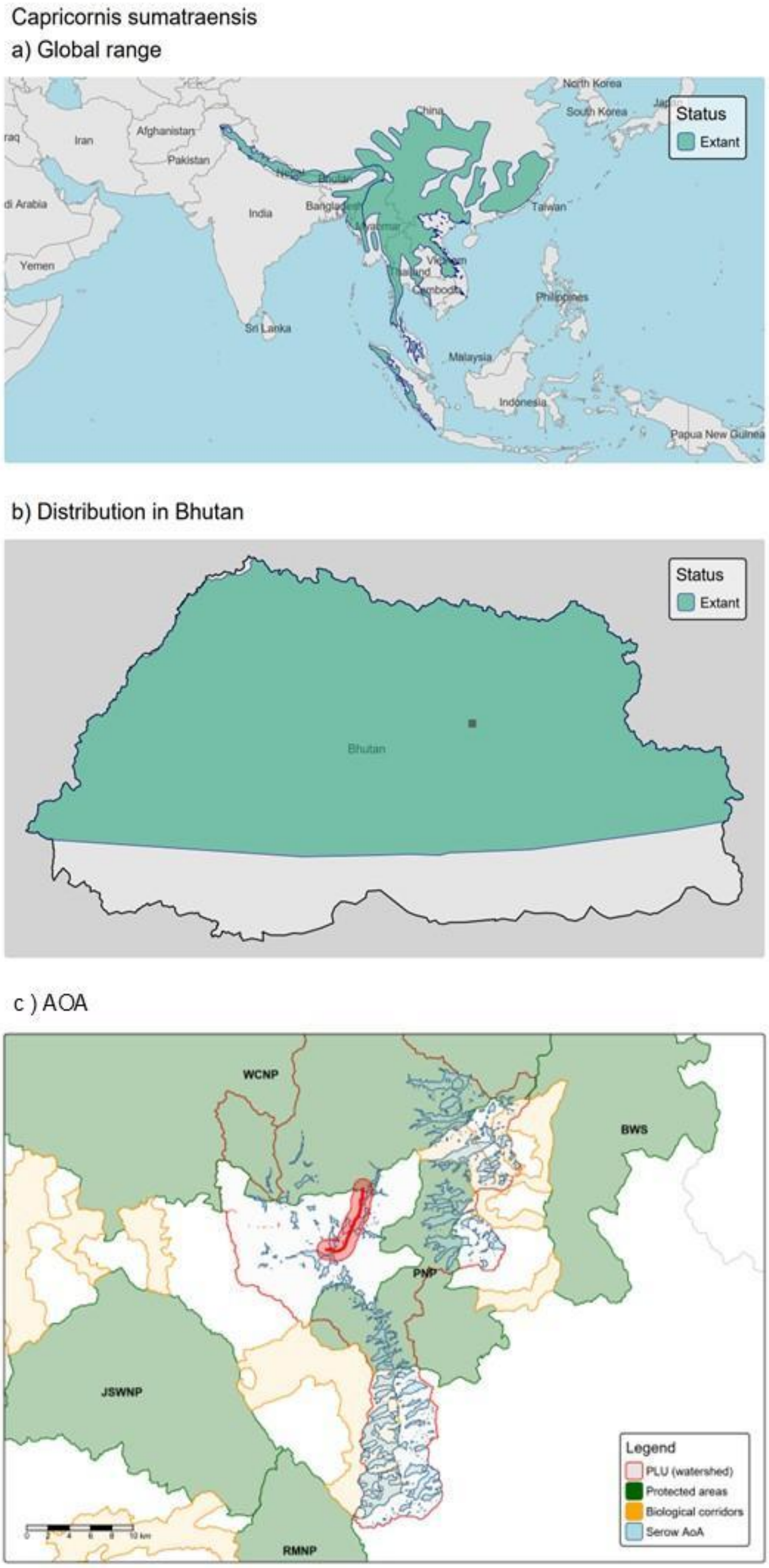

Figure 9 (a) Global distribution of the serow, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area

of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

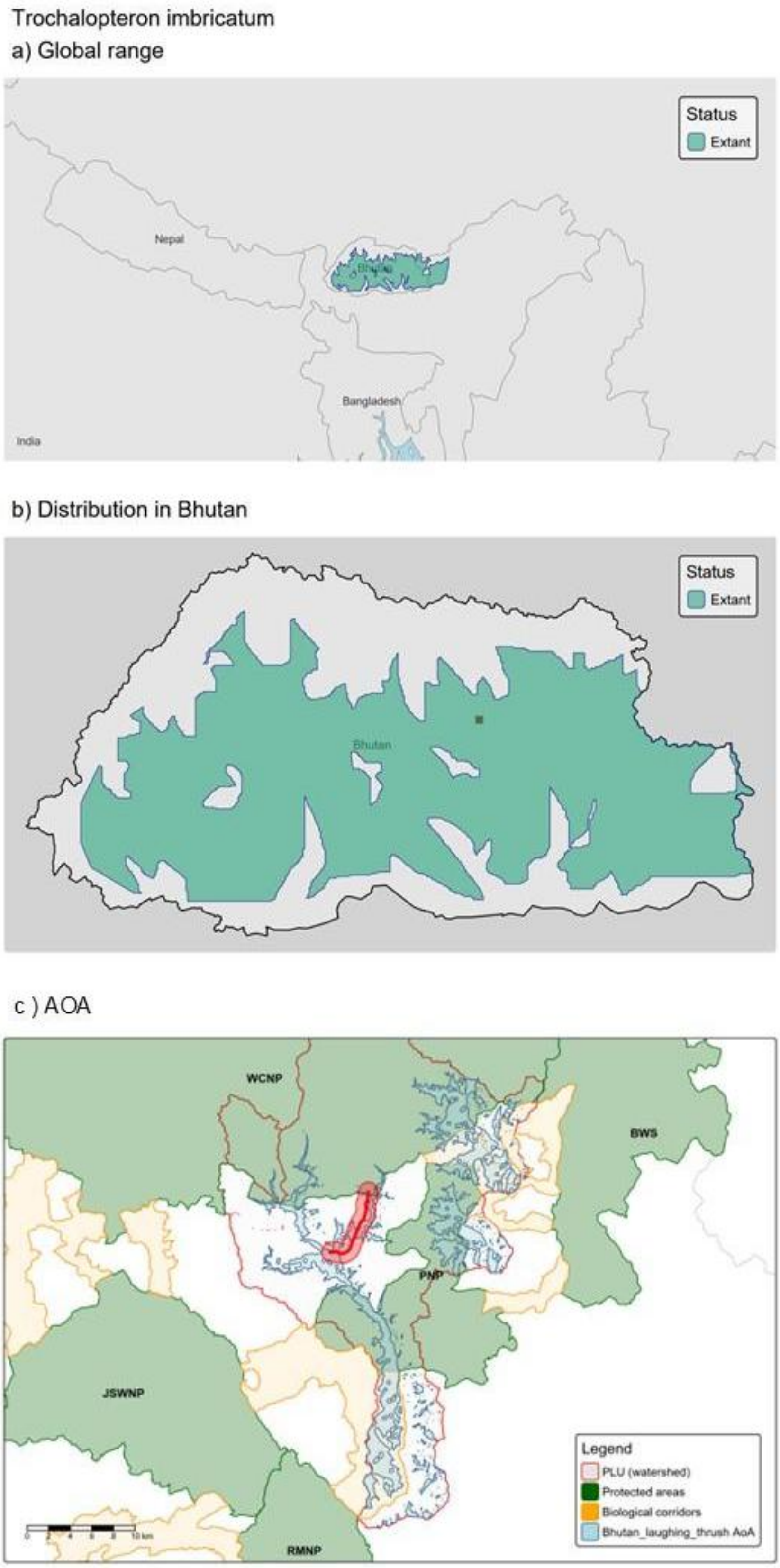

Figure 10 (a) Global distribution of the Bhutan laughingthrush, showing the species' mapped global range; (b) distribution within Bhutan, with the project location indicated by a red point; and (c) the Area of Assessment (AOA) delineated in accordance with ADB ESS6. The proposed transmission line (TL) alignment is shown in red, and the light-red 2 km buffer indicates the project AOI.

3.2.4. Criterion 4. Geographically restricted species

Bhutan Laughingthrush *Trochalopteron imbricatum*

The Bhutan Laughingthrush is endemic to the eastern Himalayas, with its core range in Bhutan and extending into parts of [redacted] (India). It is currently listed as Least Concern on the IUCN Red List and is considered to have a stable population trend. The species is typically recorded between 1,400 and 2,400 m elevation, and its Global EOO is estimated at 38,600 km² (Birdlife International, 2020).

Robust population estimates are not available at either national or global scales. In the absence of population size data, we used EOO as a proxy to screen potential Critical Habitat triggers. The defined AOA for this species is 559.65 km² (Fig. 7), representing approximately 1.4% of the global EOO. Given the species' broad distribution and the limited proportion of its range captured within the AOA, it is highly unlikely that the AOA would support ≥10% of the global population (or any equivalent threshold that would trigger Critical Habitat based on population concentration). Accordingly, the Bhutan Laughingthrush is screened out and should be excluded from further critical habitat assessments.

3.2.5. Criterion 5. Geographically restricted assemblages

Surveys identified one range-restricted species, the Bhutan Laughingthrush, in the project's area of influence; however, the AOA for the species encompasses only a small portion of its global range/EOO, indicating that the project area does not support a globally significant proportion of its distribution. In addition, spatial screening against national KBA datasets and the World Database of Key Biodiversity Areas indicates that the project area lies outside all mapped KBAs; while two international KBAs occur in the broader region, the project footprint and area of influence are located outside their boundaries. Accordingly, the project does not trigger the "geographically restricted biodiversity / recognised priority site" components of CHA screening on the basis of currently available information and the defined area of influence.

3.2.6. Criterion 6. Aggregations of migratory or congregatory species

ADB ESS6 Criterion 6 is triggered only where a site is known to sustain, on a cyclical or otherwise regular basis, at least 1% of the global population of a migratory or congregatory species at any point in its lifecycle (e.g., breeding, wintering, staging/stopover, moult, or communal roosting). Accordingly, the assessment focuses on whether the project's area of influence functions as a regularly used concentration area, rather than on whether migratory species are simply present.

Desktop screening (IBAT/literature) and targeted surveys confirmed 67 bird species with migratory behaviour in and around the project area, comprising 30 full migrants and 37 altitudinal migrants, and except for two, which are NT, the rest are all LC. These species are primarily associated with Blue Pine and mixed-conifer habitats along the corridor, with only limited riverine and open habitats present. The migratory species assemblage is dominated by forest and edge species, which are expected to occur as dispersed individuals or small groups within suitable habitat rather than as high-density aggregations.

Critically, there is no evidence that the project area of influence regularly supports site-based concentrations plausibly consistent with the ≥1% global population threshold. Field observations did not identify features typically associated with congregatory triggers (e.g., large wetlands or lakes supporting mass waterbird aggregations, large breeding colonies, or persistent communal roosts), and detections were consistent with a local forest bird community distributed across available habitat. While some full migrant species can congregate under suitable conditions (e.g., waterbirds, some raptors), the habitats within the corridor are limited in extent and do not represent known, repeatedly used congregation nodes at a scale commensurate with the criterion threshold.

On this basis, the project area is best characterised as supporting migratory species occurrence rather than a regularly used migratory bottleneck, staging area, or congregatory site. Therefore, ADB ESS6 Criterion 6 is not triggered for avifauna within the project area of influence.

3.2.7. Criterion 7. Areas associated with key evolutionary processes

Field surveys and spatial screenings confirm that the project footprint does not overlap with areas known for key evolutionary processes, such as refugia, hybrid zones, or centres of endemism. The alignment remains outside all protected areas, Bhutan’s Biological Corridors, and global KBAs. Furthermore, the absence of lekking, roosting, or breeding concentrations suggests the site is not essential for maintaining unique lineages or exceptional genetic diversity. While the project spans a 2,500–3,000 m elevation range where evolutionary gradients exist, the narrow, linear footprint does not fragment habitat blocks or impede local adaptation, as the surrounding landscape remains dominated by continuous, intact montane forest.

Consequently, the project area is not considered a site associated with any key known evolutionary processes, and Criterion 7 is not triggered.

3.2.8. Criterion 8. Ecological function and connectivity that are vital to maintaining the viability of biodiversity described above

The project footprint is located outside protected area boundaries and does not intersect Bhutan's mapped Biological Corridors, which are designated to facilitate movement between protected areas. The footprint also does not coincide with known regional connectivity pinch-points: no major river or wetland crossings occur within the alignment, and there are no ridge saddles or valley bottlenecks that would be expected to concentrate wildlife movement through the project area. The surrounding landscape is dominated by continuous forest, providing multiple alternative movement routes around the footprint.

From a functional perspective, the site supports routine ecological processes typical of the surrounding forest matrix (e.g., local dispersal, foraging movements, and gene flow). However, based on the spatial context and field survey findings, the project area is not considered a critical linkage required to maintain the viability of the biodiversity values described above at a landscape or national scale; no lek, roost, colony, or breeding concentration sites were identified during surveys. Given that the project is a transmission line, it is unlikely to fully obstruct or sever wildlife movement; potential impacts on connectivity are therefore expected to be limited to localised disturbance, temporary avoidance during construction, and incremental edge effects along access tracks and work areas, rather than permanent loss of landscape permeability

4. CONCLUSION

A Critical Habitat Assessment is undertaken to determine whether the project may affect Critical Habitat as defined under ADB ESS6 and to identify any Priority Biodiversity Features (PBFs) that require explicit assessment and management in the EIA. The CHA for the proposed Wobthang–Garpang transmission line was completed to evaluate potential impacts from construction and operation of the alignment and associated temporary works (including access construction) within a landscape dominated by continuous montane forest. The project footprint and defined area of influence are outside protected areas and outside Bhutan's mapped Biological Corridors, and no major movement pinch-points (river/wetland crossings or ridge-saddle bottlenecks) occur within the footprint.

Baseline biodiversity conditions were established using a desk-based screening (including IBAT) and targeted field surveys, supplemented by IUCN Red List range information and expert consultation. The initial desk screening identified 1,087 species within 50 km of the project area and two protected areas within 5 km of the project site. From this baseline, receptors were screened for CHA assessment, as they are reasonably expected to occur regularly within the project area and are of conservation concern under ADB ESS6 (e.g., globally threatened species, restricted-range species, and other PBFs). Following this screening and reassessment against the ESS6 quantitative criteria, seven species (six globally threatened and one range-restricted) were taken forward for detailed evaluation.

Reassessment of these receptors against the ESS6 Critical Habitat thresholds confirmed that none of the seven species qualify as a Critical Habitat feature for the project area. The range-restricted Bhutan laughingthrush population in the project AOI is unlikely to exceed 10% of its global population, and the project area does not overlap any national KBAs; two international KBAs occur in the broader region, but the project footprint and area of influence lie outside their boundaries. Ecosystem screening under the IUCN Global Ecosystem Typology indicates the project occurs within broad temperate–boreal montane forest types, and no threatened or geographically restricted ecosystem types were identified for the footprint or area of influence (noting that Bhutan does not yet have IUCN RLE assessments).

Accordingly, no CHA triggers are confirmed for this project under ADB ESS6, and Critical Habitat is not present within the assessed footprint based on currently available evidence. The next step is for all screened-in receptors to remain Priority Biodiversity Features and to be carried forward into the EIA impact assessment and mitigation design. Should the EIA identify measurable residual impacts to any PBF, the project will be required to demonstrate No Net Loss (NNL) for those features; if any Critical Habitat trigger were identified in future (e.g., through new data or design changes), this would require application of the Net Gain (NG) requirement and the associated ESS6 Critical Habitat management measures.

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Appendix 5-1. Administrative Clearance for the Project - Tang Gewog

དཔལ་ལྡན་འབྲུག་གཞུང་། བུམ་ཐང་རྫོང་ཁག་བདག་སྐྱོང་།

Royal Government of Bhutan
TANG GEWOG Administration, Bumthang

Ref. No. TG/ADM-10/2024-2025/ 251

Date: 09th June 2025

Administrative Approval

As per letter no. BPC/CD/EG&SS/TLP/2025/24 dated on June 8, 2025 the Gewog Administration, Tang hereby accorded Administrative approval to Bhutan Power Corporation Limited for the Installation of 132KV D/C Wobthang Transmission line for power evacuation for the upcoming Wobthang Solar Farm at Tang Gewog, Bumthang.

However, the installation work should pursue the clearance if needed from the competent authorities and nearby Community by the proposer itself.

Thanking you

Yours' sincerely

Gup
Gewog Administrati
Tang, Bumth

Ugyen Nima
Gup, Tang Gewog.

Copy

1. **Office file.**

Appendix 5-1b. Administrative Clearance for the Project and Consent from Project Affected Persons- Tang Gewog

དཔལ་ལྡན་འབྲུག་གཞུང་། བུམ་ཐང་རྫོང་ཁག་བདག་སྐྱོང་།

Royal Government of Bhutan
TANG GEWOG Administration, Bumthang

Ref. No. TG/ADM-10/2024-2025/ 2166 **Date: 26th November 2025**

Administrative Approval

As per letter no. BPC/CD/EG&SS/TLP/2025/101 dated on November 17, 2025 the Gewog Administration, Tang hereby accorded Administrative approval to Bhutan Power Corporation Limited for the Installation of 132kV Wobthang Garpang Transmission line and access road for the upcoming Wobthang Solar Farm at Tang Gewog, Bumthang.

However, the installation work should pursue the clearance if needed from the competent authorities and nearby Community by the proposer itself.

Thanking you

Yours' sincerely

Gup
Gewog Administration
Tang, Bumthang

Ugyen Nima
Gup, Tang Gewog.

Gup Gewog Administration
Tang. Bumthang

Copy

1. Office file.

Public Consultation Report/ No-Objection Certificate (NOC)

BPC

Date, Venue & Time:

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
1	Chungdu Dema	520/ Ka-3-250	Pangshing/ Tang	—	—					1
2.	Pema Wangmo	53 Ka-3-177	Joke/ Tang							2
3.	Pema (10103001375) (17431854)	Ka-3-94/ 274	NangNang/ Tang.	—	—			16.103A		3
4.	Pema Norbu (11513001770) (17717531)		Pangshing/ Tang					16.0 Acres		4

Public Consultation Report/ No-Objection Certificate (NOC)

BPC

Date, Venue & Time:

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
1.	Galey Wangchuk	~~866~~ 66/ Ka-1-866	Chamkhar/ Choekhor					3 Acres		

Appendix 5-2. Administrative Clearance for the Project - Choekhor Gewog

དཔལ་ལྡན་འབྲུག་གཞུང་།
སྐྱིད་འོག་བདག་སྐྱོང་།
ཆོས་འཁོར་ བུམ་ཐང་།
CHOEKHOR GEWOG

Choekhor/Admin-01/2025-2026/141 **Dated: 05/12/2025**

The **Manager**
Bhutan Power Corp Ltd
Bumthang

Sub: **Administrative clearance for 132kv Wobthang- Garpang Transmission**

Sir/Madam,

This has reference to your application **BPC/CD/EG&SS/TLP/2025/102** dated 12th Nov 2025 seeking administrative clearance for realignment of 132kV Wobthang-Garpang transmission line route. In this regard, gewog is pleased to accord administrative clearance for such realignment based on following terms;

1. *This clearance shall be valid upon acquiring clearances from other relevant agencies.*
2. *This clearance shall be valid for one year from the date of issue.*

Yours sincerely,

(Sangla)

Gup
Choekhor Gewog
Bumthang

Sangla, Gup : 77299781 sangla5534@gmail.com Namgyel Tshering, GAO: 17613653 ntshering@bumthang.gov.bt Kencho Norbu, Mangmi: 17366311 knorbu3721@gmail.com Luda Wangdi: (Sr.ES I- Agriculture) Mob:17649772 lwangdi@moal.gov.bt Leki Tshering: (LS II) Mob: 77239288 gawatshewang@gmail.com

Appendix 5-2b. Administrative Clearance for the Project - Choekhor Gewog

རྒེད་འོག་བདག་སྐྱོང་།
ཆོས་འཁོར་ བུམ་ཐང་།
CHOEKHOR GEWOG

Choekhor/Admin-02/2024-2025/ 315

June 10, 2025

The Manager
Bhutan Power Corporation
Thimphu

Sub: Administrative Clearance

Sir/Madam,

This has reference to your letter no: BPC/CD/EG&SS/TLP/2025/25 dated 08.06.2025 seeking administrative clearance for the 132kVD/C Wobthang solar farm Transmission Line alignment from at Kikila, Choekhor Gewog.

In this regard, administrative clearance is hereby accorded in your favor to proceed with the aforementioned projedct based on following terms:

1. *This clearance shall remain valid upon acquiring all the relevanct clearances*
2. *Transmission line must within the buffer survey line displayed to the gewog*
3. *This clearance shall be valid for one year from the date of issue.*

Thanking you in advance for your kind compliance as always

Yours sincerely,

(Sangla)

Gup
Choekhor Gewog
Bumthang

Sangla, Gup : 77299781 Namgyel Tshering, GAO: 17613653 Kencho Norbu, Mangmi: 17366311
Kencho Dema: (Sr.ES I- Agricultu[redacted]r. ES- Livestock: 17670965

Appendix 5-4 Consent from Project Affected Persons

Tang Gewog

Public Consultation Report/ No-Objection Certificate (NOC)

Date, Venue & Time: 9/06/2022 - Tang Gewog Office - 12:00 PM

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
1	Dorji Wangmo	40/ Ka-3-181	Bongshing/ Tang	Re-aligned	Lands to be re-aligned	Re-alignment decided	—	> 22acre	Farming.	

Public Consultation Report/ No-Objection Certificate (NOC)

Date, Venue & Time: 9/06/2023 - Tang Gewog Office - 12:00 PM

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
1	Dorji Wangmo	40/ KA-3-181	Rangthang/ Tang	Re-aligned	Line to be re-aligned	Re-alignment decided	—	>2 acre	Farming.	

Public Consultation Report/ No-Objection Certificate (NOC)

Date, Venue & Time: 9/06/2023 - Tang Gewog Office - 12:00 PM

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
1	Dorji Wangmo	40/ KA-3-181	Rangthang/ Tang	Re-aligned	Line to be re-aligned	Re-alignment decided	—	>2 acre	Farming.	

Public Consultation Report/ No-Objection Certificate (NOC)

BPC

Date, Venue & Time:

SN	Name of the Project Affected Individual (PAI), CID no/ Contact no.	Thram no./ House no.	Village/ Gewog	Compensation	Issues Raised/ Discussion	Decision Taken	Unresolved Issues (If any)	Total Land Holding (Acres)	Household Earning/ Source of Income	Signatures
	Sonam Dorji 10103001674 17644867	314	Pangshing Tang	Realignment	Expressed apprehension over the long term impact and disruption it may cause by the power line. The discussion explored various compensation mechanism	After through deliberation & reflection, the resolution was reached to realign the plot boundary to minimize land impact.		0.48 acres out of which 0.05 acres (approximately) was affected.	Salary	10/06/25

NO OBJECTION CERTIFICATE (NOC)

(For Project Affected Persons – PAPs)

Project: 132 kV D/C Wobthang Transmission Line Project

Proponent: Bhutan Power Corporation Limited (BPC)

Location: Bumthang

We, the undersigned landowners/legal representatives, hereby declare that:

1. We have been fully informed about the 132 kV D/C Wobthang Transmission Line Project.
2. We clearly understand the project scope and implications.
3. We voluntarily give our no objection for the project implementation.

Details of the Consent Providers:

Name	CID No.	Plot No.	Landowner/Representative		Relationship to owner	Contact No.	Signature	Date Signed
			Owner	Representative				
Dorji Wangmo	10103001575	TNH-3039 TMG-3747	☑	☐		17870904		9/6/2025
			☐	☐				
			☐	☐				

NO OBJECTION CERTIFICATE (NOC)

(For Project Affected Persons – PAPs)

Project: 132 kV D/C Wobthang Transmission Line Project

Proponent: Bhutan Power Corporation Limited (BPC)

Location: Bumthang

We, the undersigned landowners/legal representatives, hereby declare that:

1. We have been fully informed about the 132 kV D/C Wobthang Transmission Line Project.
2. We clearly understand the project scope and implications.
3. We voluntarily give our no objection for the project implementation.

Details of the Consent Providers:

Name	CID No.	Plot No.	Landowner/Representative		Relationship to owner	Contact No.	Signature	Date Signed
			Owner	Representative				
Sonam Dorji	10103001674	JNG-3004	☑	☐		17644867	[signature]	10/6/2025
			☐	☐				
			☐	☐				

Attestation:

I hereby confirm that all above signatures were obtained voluntarily after proper consultation and explanation of the project details.

Name: Susmita Subba

Designation: AEO

Signature: [signature]

Date: 9/06/2025

Appendix 5-5. Clearance from Bhutan Civil Aviation Authority

༄༅།། འབྲུག་ཞི་བའི་མཁའ་འགྲུལ་དབང་འཛིན།
གཞི་རྟེན་མཁོ་ཆས་དང་སྐྱེལ་འདྲེན་ལྷན་ཁག། དཔལ་ལྡན་འབྲུག་གཞུང་།

Bhutan Civil Aviation Authority
Ministry of Infrastructure & Transport
Royal Government of Bhutan

BCAA/AGA/CLEARANCE/06/1476

27th June, 2025

The Manager
Bhutan Power Corporation Limited
Thimphu: Bhutan

Subject: **Obstacle clearance**

With reference to your letter No. BPC/CD/EG&SS/TLP/2025 dated April 10, 2025, regarding the request for verification of the transmission line route at Bumthang, the Bhutan Civil Aviation Authority (BCAA) has reviewed the proposed power transmission line route using the submitted Google KMZ file. Based on our assessment, we confirm that the proposed route does not pose any significant obstruction to flight operations at Bumthang Domestic Airport. Accordingly, BCAA has no objection to the construction of the power transmission line along the proposed alignment.

However, please ensure that the height of each tower is maintained in accordance with the submitted specifications (38m). Additionally, all towers located along the flight route must be clearly painted in a visible color and fitted with obstruction beacon lights at the highest point.

Note:
This clearance is granted solely with respect to obstacle clearance for flight operations. Approvals pertaining to structural specifications, construction permits, and other related matters must be obtained from the concerned Dzongkhag Administration and relevant authorities.

Thank you

Sincerely,

(Kinley Wangchuk)
Director

Post Box: 1229 **Tel:** Pabx: +975-8-271347 **Director:** 271910 **PA:** 272828 **Accounts:** 272656
FSD: 272396 **ANAD:** 271911 **Fax:** +975-8-271909 **Email:** bcaa@bcaa.gov.bt

Appendix 5-6 Stakeholder Consultation with Forest Officials, CFO

ATTENDANCE SHEET FOR OFFICIALS PRESENT DURING COSULTATION MEETING

Venue: Chamkhar; CFO Office

Date: 8/01/2026

Time: 2:00 pm.

SN	Name	Designation	Department/ Office	Signature
	Yeshi Wangchuk	GO.	EGSS.	
	AARON SEXTON	ENU	ADB	
	NARGIS HALIMOVA	Social Spce	ADB	

ATTENDANCE SHEET FOR OFFICIALS PRESENT DURING COSULTATION MEETING

Venue: Chamkhar; CFO Office.

Date: 8/01/2026

Time: 2:00 pm

SN	Name	Designation	Department/ Office	Signature
1.	Pankey Dukpa	Chief Forestry Officer, Bumthang	DFO, Bumthang	
2	Nado	Principal Forestry Officer	WCNP	
3	Kishan Dahal	AEO	EGSS; BPC	
4.	Tshewang Choden	AEO	EGSS, BPC	

Appendix 5-7. Forest Clearance

དངུལ་རྩིས་ལྷན་ཁག།
Department of Revenue and Customs
Ministry of Finance
Royal Government of Bhutan

BHUTAN
Believe

Revenue Money Receipt

Payer Name : Bhutan Power Corporation Limited

Receipt No. : PR250617552829

Payment Received Date : 17-06-2025

Transaction ID : 516822874825

Payment Advice No. : PA250617866061

Bank Name : Bank of Bhutan

Beneficiary Bank ID : BEI0000162

Sl. No.	Account Head Name	Account Head Code	Amount
1	Forest Clearance & Service Fees	1460307	358.00
	Grand Total		BTN 358.00

Amount in Words : BTN Three Hundred Fifty Eight Only

Disclaimer : This is a computer generated receipt.

Appendix 5-8 Phomrong Record of Discussion & NOC

Record of Discussions

Community Forestry Management Group (CFMG) consultation meeting for proposed Wobthang Solar Project Transmission Line

Date: 18th April 2025

Location: Bepzur, Tang Gewog

Time: 01: 00 PM

Participants: Members of Phomrong Community Forest Management Group (CFMG)

Participants

1. Mr. Jigme Sonam, BPC
2. Ms. Susmita Subba, BPC
3. Mr. Rinchen
4. Mr. Tshering Tenzin
5. Mrs. Phuntsho Wangmo
6. Mrs. Tshering Dema

1. Welcome and Introduction

The meeting was convened by Bhutan Power Corporation Limited (BPC). Mr. Jigme Sonam and Ms. Susmita Subba formally welcomed the participants and provided a brief overview of the meeting's objectives and structure. The primary purpose of the consultation was to share information with the Community Forest Management Group (CFMG) and seek their clearance for the proposed 108 MW Wobthang Solar Project.

The consultation focused on the following key components:

- Focus group discussion on the proposed transmission line project.
- Analysis of alternative route options and associated implications.
- Discussion on compensation modalities.
- Open floor for questions and responses.
- Concluding remarks and endorsement of clearance.

2. Presentation on Proposed 132 kV Transmission Line Project

The project information was presented verbally in Dzongkha, considering the language preferences of the majority of the CFMG members. The main messages conveyed included:

- Project Name: 108 MW Wobthang Solar Project

- Transmission Line: 132 kV Double Circuit (D/C) from Wobthang Solar Farm to LILO at existing 132 kV S/C Mangdechu-Yurmoo TL
- Coverage: Gewogs of Tang, Chhoekhor, Chhume, Ura, Nubi, Dragteng, and Langthil
- Length: Approximately 67.8 km
- Estimated no. of towers: Approx. 208 (excluding new alignments).

Objectives of the Project:

- Evacuation of generated solar power.
- Enhanced power supply reliability in the eastern region.
- Facilitation of broader socio-economic development activities.

3. Analysis of Alternative Options

The team explained that various alternative routes for the transmission line were explored. After thorough assessment, the most feasible and acceptable option was to route through the Community Forest (CF). The discussion included details on the length of the transmission line that falls within the CF, the approximate acres that would require clearing, and the number of towers to be installed in these areas.

<table>
<tr><th>SN.</th><th>Dzongkhag</th><th>Gewog</th><th>CF</th><th>Approx. Line Length (km)</th><th>Towers in CF (nos.)</th></tr>
<tr><td rowspan="7">1</td><td rowspan="7">Bumthang</td><td rowspan="2">Tang</td><td>Garabling</td><td>0.615</td><td>1</td></tr>
<tr><td>Phomrong</td><td>1.950</td><td>6</td></tr>
<tr><td rowspan="5">Chhume</td><td>Nangar Chithuen</td><td>1.085</td><td>2</td></tr>
<tr><td>Beethang Phendey</td><td>0.740</td><td>1</td></tr>
<tr><td>Phurjoen Lothuen Rawang</td><td>0.262</td><td>2</td></tr>
<tr><td>Domkhar Zingbi</td><td>0.625</td><td>2</td></tr>
<tr><td>Domkhar Duegang</td><td>0.130</td><td>0</td></tr>
<tr><td rowspan="8">2</td><td rowspan="8">Trongsa</td><td rowspan="4">Dragteng</td><td>Taktse CF Dursaluem</td><td>0.760</td><td>3</td></tr>
<tr><td>Eusa Barpo</td><td>0.075</td><td>1</td></tr>
<tr><td>Changray</td><td>0.500</td><td>2</td></tr>
<tr><td>Samcholing Narbangshong</td><td>0.350</td><td>1</td></tr>
<tr><td rowspan="4">Langthil</td><td>Samcholing Shangthong Tengsa</td><td>1.941</td><td>6</td></tr>
<tr><td rowspan="3">Yoenlin Thenzin</td><td>0.235</td><td>2</td></tr>
<tr><td colspan="2">OR</td></tr>
<tr><td>0.290</td><td>1</td></tr>
</table>

4. Pros and Cons Discussion

The pros and cons of the project were presented for discussion. The benefits included enhanced reliability of power supply on a national level, a reduction in blackout occurrences, increased employment opportunities, and local economic development. Conversely, the potential drawback includes loss of trees.

5. **Compensation**

In discussing compensation, the team reassured the participants that commercial royalties for any trees felled would be paid in accordance with the Royalty on Forest Produce 2006 manual. And if the community required the felled timber, it could be handed over accordingly.

6. **Question and Answer Session**

A question-and-answer session followed, during which the CFMG members voiced their concerns, suggestions, and inquiries about the project. Detailed notes on the feedback received during this session were documented separately for further consideration and action.

7. **Concluding Remarks**

In closing, the team invited affected CF members to participate in a detailed review of how the proposed transmission line alignment would impact the CF. The team extended their gratitude to all members for their active participation throughout the meeting. After the discussions, the transmission line alignment maps were reviewed, and all present members signed the No-Objection Form, indicating their agreement and clearance for the project, based on the understanding reached during the meeting.

Questions and Answer Session

CF Clearance Summary				
S. No	Name of the CF	Clearance carried out during period	Feedback/Issues/Concerns/Queries	Responses
1	Garabling	18th April, 2025	Confirmation sought on the no. of towers within the CF.	Only one transmission tower falls in the CF
			Query on the extent of forest clearing	Approximately 4 acres of clearing will be required (approx. 600 m length and 27 m row)
			CFMG members indicated that while they are not against the project, they request additional land as compensation for the area lost	Provision of additional land is not possible. Compensation will be provided in the form of rates prescribed for standing basis. Additionally, felled trees may be handed over to the community if required.
			Concern that trees in the past were not handed over to the community after clearing.	Such instances occurred when clearing was done in a State Reserved Forest (SRF) and not within the CF, which is why the community was not entitled to the felled trees.
			Suggestion that CFMG members be allowed to conduct tree felling and clearing themselves. This would ensure minimal disturbance to areas beyond the Right of Way (RoW) and avoid over-clearing	If the CFMG is willing to carry out the clearing, this can be permitted subject to agreement with the contractor. The wage rate and responsibilities should be mutually agreed upon between the contractor and the CFMG members.
			Request for accountability in case of accidental damage to trees beyong the buffer, penalties will be applied as per CFMG rules. If CFMG members are involved in the clearing, they will bear the responsibility for any such damage.	
2	Phomrong	18th April, 2025	Query on the extent of forest clearing	Approximately 13.4 acres of clearing will be required (approx. 2 km length and 27 m row)
			Concern that the transmission line may cross a sacred or spiritual area, commonly known as "Pho Lha." Based on the confirmation, the CFMG members agreed that the clearance shall be granted by the four heads of the CFMG if the line does not cross the Pho Lha.	A BPC representative was sent along with the CF ranger to evaluate the alignment and it was confirmed that the line does not pass through the sacred area.
			CFMG requested that members be allowed to undertake the felling work and that BPC facilitate discussions with the contractor.	The request has been acknowledged. BPC will communicate with the contractor to ensure negotiations are held, ensuring mutual benefit for both parties.

Community Forestry Management Group (CFMG) clearance

The Community Forestry Management Group (CFMG) members of ....Phomreng...(name of CFMG) would like to issue this clearance to **Bhutan Power Corporation Limited (BPC)** for the purpose of .... measuring......................acres/meters with a Right of Way (RoW) measuring......................meters that falls within/runs through our Community Forest.

Both the parties are to abide by the following terms and conditions:

1. The CFMG members will not request for extension of the CF area taken by the BPC for the above purpose.

2. The CFMG will extract the timbers and other forest produces falling inside the area required for the above purpose and utilize as per the CF management plan only after the forest produces are handed over to the members by the concerned forest office.

3. BPC will pay the commercial royalty for trees need to be felled as per the Royalty on Forest Produce 2006 manual on rates prescribed for **standing basis** inside the area required for the above purpose.

4. The forest produce that are not covered in the CF management plan will be disposed off by the concerned forest office as per the provisions of the prevailing forest acts and regulations.

Accorded to the Bhutan Power Corporation Limited on ...18/04/2015....(Insert Date) in presence of the following CFMG members;

No.	Name	Role	CID Number	Signature

1	Rinchen	Chairperson/ Thrizin	
2	Tshering Tenzin	CF - forest Ranger	
3	Phurbho Wangmo	Dungchen	
4	Tshering Dema	Accountant	

Registration form for people who attend the Cl

Date	18/04/2025	in Chiwog	Bepzur	Gewog
No.	Names	Age	Sex	Occupation
1	Rinchen	47	M	Chairperson
2	Tshering Tenzin	60	M	Farming
3	Kinphuntsho Wangmo	30	F	Dungchen
4	Tshering Dema	28	F	Accountant
5	Susmita Subba	25	F	AEO, BPC
6	Jigme Sonam	30	M	AEO, BPC
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				

The sheet summarizing people who attend the consulation No			2	in Chiwog	Bepzur	Gewog	Tang
	Total number of people attending			Age				Remarks
	Female	Male	Total	15-25	26-35	36-60	>60	
Count (no.)	2	2	4					
Percentage (%)	50	50	100	0	2	2	0	
Youngest age:	28	47						
Oldest age:	30	60						

Appendix 5-8b. Phomrong CF Record of Discussion and Clearance

Record of Discussions

Stakeholder Consultation with Phomrong Community Forest Management Group (CFMG)

Date: 01.12.2025

Location: Bepzur Chiwog, Tang Gewog

Time: 5:00 PM

Participants:

- **Bhutan Power Corporation Limited (BPC):**
  1. Mr. Yeshi Wangchuk, Environment Officer
  2. Mr. Kamal Bahun, Section Officer
  3. Mr. Kinga Tenzin, Section Officer
  4. Mr. Kishan Dahal, Assistant Environmental Officer
  5. Ms. Tshewang Choden, Assistant Environment Officer
  6. Ms. Ganga Devi Monger, Assistant Environment Officer
- **Phomrong CFMG:**
  1. Mr. Rinchen, Chairperson, Phomrong CFMG
  2. Ms. Tshering Dema, Accountant, Phomrong CFMG
  3. Ms. Phuntsho Wangmo, Secretary, Phomrong CFMG

1. Presentation on proposed Access Road for 132 kV DC Wobthang- Garpang Transmission Line Project.

The project information was presented verbally in Dzongkha, considering the language preferences of the majority of the CFMG members. The main messages conveyed included:

- **Project Name:** Construction of 132 kV D/C Wobthang- Garpang Transmission Line Project.
- **Transmission Line:** 132 kV Double Circuit (D/C) Power Transmission line from 108 MW Wobthang Solar Farm to 33/11 kV Substation at Garpang.
- **Coverage:** Choekhor and Tang Gewog, Bumthang
- **Length:** Approximately 18 Km
- **Total length (Access Road):** Approx. 22 Km
- **Estimated no. of towers:** Approx. 57

S. N	Gewog Under Bumthang	Approx. Line Length (KM)	Approx. Line Length (KM) of Access Road in Phomrong CF	No. of Towers in Phomrong CF	No. of Towers in state Forest Land (SFRL)
1	Tang	16	0.64	6	45
2	Choekhor	2			5
	Total	**18**			**50**

2. **Compensation**

In discussing compensation, the team reassured the participants that commercial royalties for any trees felled would be paid in accordance with the Royalty on Forest Produce 2006 manual. And if the community required the felled timber, it could be handed over accordingly.

3. **Discussion**

A question-and-answer session followed, during which the CFMG members voiced their concerns, suggestion and inquiries about the project. Detailed notes on the feedback received during this session were documented separately for further consideration and action.

Concluding Remarks

In conclusion, the team invited the affected CF members to undertake a detailed review of the potential impacts of the proposed transmission line alignment on the CF. The team expressed appreciation to all participants for their active engagement throughout the meeting. Following the discussions, the transmission line alignment maps were reviewed, and all members present signed the No-Objection Form, thereby indicating their agreement and clearance for the project, based on the shared understanding established during the meeting.

CF Clearance Summary

SN	Name of CF	Clearance carried out during period	Feedback/Issues/concerns/queries	Responses and discussion
1	Phomrong	1st December 2025	How would the compensation be made?	Commercial royalties for felled trees will be paid in accordance with the Royalty Produce 2006 Manual. If the community requires the felled timber, it may be handed over to them accordingly as per the rules. However, as per the NOC clause, no extension of the CF area will be provided for the land taken for the project.
			The farm road leading to Dorjitse Monastery was fully funded by the local community, who regard it as their private road. According to their road regulations, all users are required to pay Nu. 1,500 per trip. However, they noted that if the contractor agrees to maintain the road up to the project area, the trip charges will be waived. They proposed two conditions: 1. Payment of Nu. 1,500 per trip; or 2. Maintenance of the farm road up to the project site if the road is significantly damaged during construction.	The team clarified that road maintenance is outside the scope of BPC and is the responsibility of the contractor. Once the work is awarded, BPC will inform and instruct about the village road regulation to the Contractor. The community may enter into a formal agreement with the contractor regarding road maintenance and to address any issues that may arise.

Rinchen
CF Chairperson.

Community Forestry Management Group (CFMG) clearance

The Community Forestry Management Group (CFMG) members of Phomrong CF.. (name of CFMG) would like to issue this clearance to **Bhutan Power Corporation Limited (BPC)** for the purpose of .... measuring.....................acres/meters with a Right of Way (RoW) measuring.....................meters that falls within/runs through our Community Forest.

Both the parties are to abide by the following terms and conditions:

1. The CFMG members will not request for extension of the CF area taken by the BPC for the above purpose.

2. The CFMG will extract the timbers and other forest produces falling inside the area required for the above purpose and utilize as per the CF management plan only after the forest produces are handed over to the members by the concerned forest office.

3. BPC will pay the commercial royalty for trees need to be felled as per the Royalty on Forest Produce 2006 manual on rates prescribed for **standing basis** inside the area required for the above purpose.

4. The forest produce that are not covered in the CF management plan will be disposed off by the concerned forest office as per the provisions of the prevailing forest acts and regulations.

Accorded to the Bhutan Power Corporation Limited on 01/12/2025.....(Insert Date) in presence of the following CFMG members;

No.	Name	Role	CID Number	Signature
1	Rinchen	Thrizin	10103001792	[signature]
2	Phuntsho Wangmo	Drungchen	10103001692	[thumbprint]
3	Tshering Dema	Accountant	10103001784	[signature]
4	Karpo Drukpa	Member	12001001695	[signature]
5	Karma Dorji	〃		[thumbprint]

6	Pema Choden	Member		
7	Sonam Choden	11		
8.	Lham Dorji			
9.	Minjur			
10.	Tshering Choden			
11.	Pema ~~Choden~~ Yangden			
12.	Yangchen			
13.	Pema Chorzom			Jaugs
14.	Tshering Dema			
15.	Tshering Choden			
16.	Kuenzang ~~Yangden~~ ~~Choden~~ Choden			
17.	Sangaymo			
18.	Dechen Tshomo			
19.	Deki Yangzom			
20.	Lhendup Dolker			
21.	Sangay Pelmo			
~~22.~~	~~Deki Sonam~~			
22.	Kencho Thinley			

Chairperson
Phomdrong Community Forest
Rinchen
Bumthang

Rinzin
(Thrizin)

Tshering Dema
(Accountant)

ATTENDANCE SHEET FOR OFFICIALS PRESENT DURING COSULTATION MEETING

Venue: Phongrong Village.

Date: 05/12/2025

Time: 5:00PM

SN	Name	Designation	Department/ Office	Signature
1	Yeshi Wangchuk	EO	Egss, CD, BPC	
2	Kinga Tenzin	SO (Survey)	"	
3	Ganga Devi Monger	AEO	"	
4	Kishan Dahal	AEO	"	
5	Tshewang choden	AEO	"	
6	Kamal Bahun	SO (Survey)	"	

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Phongrong Village.

Date: 07/12/2020

Time: 5:00pm.

BPC

SN	Name & ID Card	Village/Gewog	Signature	Remarks
1	Rinchen	Phomrong / Tang		
2	Phuntsho Dzangmo	"		
3	Tshering Dema	"		
4	Karpo Dukpa	"		
5	karma Dorji	"		
6	Pema Choden			
7	Sonam Choden			
8.	Cham Dorji			
9.	Minjur			
10.	Tshering Choden			
11.	Pema ~~Choden~~ Yangdon			
12.	Yangchen			
13.	Pema Chonzom			
14.	Tshering Dema			
15.	Tshering Choden			
16.	Kuenzang Choden			
17.	Sangaymo			
18.	Dechen Tshomo			

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Phomrong Village

Date: 01/12/2015

Time: 5:10 pm.

SN	Name & ID Card	Village/Gewog	Signature	Remarks
19.	Deki Yungzom	Phomrong/Hay.	19	
20.	Lhendup Dolker	"	20	
21.	Sangay Pelmo	"		
~~22.~~	~~Deki Sonam~~			
			22 21	
22.	Deki Sonam	"		
23.	Kencho Thinley.	"	23	

Appendix 5-9.Garabling CF Record of Discussion and Clearance

Record of Discussions

Community Forestry Management Group (CFMG) consultation meeting for proposed Wobthang Solar Project Transmission Line

Date: 18th April 2025

Location: Tandingang, Tang Gewog

Time: 10: 30 AM

Participants: Members of Garabling Community Forest Management Group (CFMG)

Participants

1. Mr. Jigme Sonam, BPC
2. Ms. Susmita Subba, BPC
3. Mrs. Lham Choden
4. Mr. Pema Wangda
5. Mr. Dechen Dorji
6. Mr. Rinchen Tshering
7. Mr. Sangay Tenzin
8. Mr. Dorji (A)
9. Mr. Dorji (B)
10. Mrs. Sangay Dema
11. Mr. Sonam Tshering
12. Mr. Rinchen
13. Mr. Nidup Dorji
14. Mr. Sonam Chojey
15. Mr. Sonam Tobgay
16. Mr. Sangay Chophel
17. Mr. Sangay Dorji
18. Mr. Sonam Gyeltshen
19. Mr. Leki Dorji
20. Mr. Rinchen Phuntsho
21. Mr. Yeshi
22. Mr. Pema Lethro
23. Mr. Tashi Lhendup
24. Ms. Pema Zangmo

1. Welcome and Introduction

The meeting was convened by Bhutan Power Corporation Limited (BPC). Mr. Jigme Sonam and Ms. Susmita Subba formally welcomed the participants and provided a brief overview of the meeting's objectives and structure. The primary purpose of the consultation was to share information with the Community Forest Management Group (CFMG) and seek their clearance for the proposed 108 MW Wobthang Solar Project.

The consultation focused on the following key components:

- Focus group discussion on the proposed transmission line project.
- Analysis of alternative route options and associated implications.
- Discussion on compensation modalities.
- Open floor for questions and responses.
- Concluding remarks and endorsement of clearance.

2. Presentation on Proposed 132 kV Transmission Line Project

The project information was presented verbally in Dzongkha, considering the language preferences of the majority of the CFMG members. The main messages conveyed included:

- Project Name: 108 MW Wobthang Solar Project
- Transmission Line: 132 kV Double Circuit (D/C) from Wobthang Solar Farm to LILO at existing 132 kV S/C Mangdechu-Yurmoo TL
- Coverage: Gewogs of Tang, Chhoekhor, Chhume, Ura, Nubi, Dragteng, and Langthil
- Length: Approximately 67.8 km
- Estimated no. of towers: Approx. 208 (excluding new alignments).

Objectives of the Project:

- Evacuation of generated solar power.
- Enhanced power supply reliability in the eastern region.
- Facilitation of broader socio-economic development activities.

3. Analysis of Alternative Options

The team explained that various alternative routes for the transmission line were explored. After thorough assessment, the most feasible and acceptable option was to route through the Community Forest (CF). The discussion included details on the length of the transmission line that falls within the CF, the approximate acres that would require clearing, and the number of towers to be installed in these areas.

SN.	Dzongkhag	Gewog	CF	Approx. Line Length (km)	Towers in CF (nos.)
1	Bumthang	Tang	Garabling	0.615	1
			Phomrong	1.950	6

		Chhume	Nangar Chithuen	1.085	2
			Beethang Phendey	0.740	1
			Phurjoen Lothuen Rawang	0.262	2
			Domkhar Zingbi	0.625	2
			Domkhar Duegang	0.130	0
2	Trongsa	Dragteng	Taktse CF Dursaluem	0.760	3
			Eusa Barpo	0.075	1
			Changray	0.500	2
			Samcholing Narbangshong	0.350	1
		Langthil	Samcholing Shangthong Tengsa	1.941	6
			Yoenlin Thenzin	0.235	2
				OR	
				0.290	1

4. **Pros and Cons Discussion**

The pros and cons of the project were presented for discussion. The benefits included enhanced reliability of power supply on a national level, a reduction in blackout occurrences, increased employment opportunities, and local economic development. Conversely, the potential drawback includes loss of trees.

5. **Compensation**

In discussing compensation, the team reassured the participants that commercial royalties for any trees felled would be paid in accordance with the Royalty on Forest Produce 2006 manual. And if the community required the felled timber, it could be handed over accordingly.

6. **Question and Answer Session**

A question-and-answer session followed, during which the CFMG members voiced their concerns, suggestions, and inquiries about the project. Detailed notes on the feedback received during this session were documented separately for further consideration and action.

7. **Concluding Remarks**

In closing, the team invited affected CF members to participate in a detailed review of how the proposed transmission line alignment would impact the CF. The team extended their gratitude to all members for their active participation throughout the meeting. After the discussions, the transmission line alignment maps were reviewed, and all present members signed the No-Objection Form, indicating their agreement and clearance for the project, based on the understanding reached during the meeting.

Questions and Answer Session

CF Clearance Summary				
S. No	**Name of the CF**	**Clearance carried out during period**	**Feedback/Issues/Concerns/Queries**	**Responses**
1	Garabling	18th April, 2025	Confirmation sought on the no. of towers within the CF.	Only one transmission tower falls in the CF
			Query on the extent of forest clearing	Approximately 4 acres of clearing will be required (approx. 600 m length and 27 m row)
			CFMG members indicated that while they are not against the project, they request additional land as compensation for the area lost	Provision of additional land is not possible. Compensation will be provided in the form of rates prescribed for standing basis. Additionally, felled trees may be handed over to the community if required.
			Concern that trees in the past were not handed over to the community after clearing.	Such instances occurred when clearing was done in a State Reserved Forest (SRF) and not within the CF, which is why the community was not entitled to the felled trees.
			Suggestion that CFMG members be allowed to conduct tree felling and clearing themselves. This would ensure minimal disturbance to areas beyond the Right of Way (RoW) and avoid over-clearing	If the CFMG is willing to carry out the clearing, this can be permitted subject to agreement with the contractor. The wage rate and responsibilities should be mutually agreed upon between the contractor and the CFMG members.
			Request for accountability in case of accidental damage to trees beyong the buffer, penalties will be applied as per CFMG rules. If CFMG members are involved in the clearing, they will bear the responsibility for any such damage.	
2	Phomrong	18th April, 2025	Query on the extent of forest clearing	Approximately 13.4 acres of clearing will be required (approx. 2 km length and 27 m row)
			Concern that the transmission line may cross a sacred or spiritual area, commonly known as "Pho Lha." Based on the confirmation, the CFMG members agreed that the clearance shall be granted by the four heads of the CFMG if the line does not cross the Pho Lha.	A BPC representative was sent along with the CF ranger to evaluate the alignment and it was confirmed that the line does not pass through the sacred area.
			CFMG requested that members be allowed to undertake the felling work and that BPC facilitate discussions with the contractor.	The request has been acknowledged. BPC will communicate with the contractor to ensure negotiations are held, ensuring mutual benefit for both parties.

Community Forestry Management Group (CFMG) clearance

The Community Forestry Management Group (CFMG) members of ……………………Gorakling………………………………………………………… (name of CFMG) would like to issue this clearance to **Bhutan Power Corporation Limited (BPC)** for the purpose of ……………………………………………………………………………………… measuring…………………acres/meters with a Right of Way (RoW) measuring…………………meters that falls within/runs through our Community Forest.

Both the parties are to abide by the following terms and conditions:

1. The CFMG members will not request for extension of the CF area taken by the BPC for the above purpose.

2. The CFMG will extract the timbers and other forest produces falling inside the area required for the above purpose and utilize as per the CF management plan only after the forest produces are handed over to the members by the concerned forest office.

3. BPC will pay the commercial royalty for trees need to be felled as per the Royalty on Forest Produce 2006 manual on rates prescribed for **standing basis** inside the area required for the above purpose.

4. The forest produce that are not covered in the CF management plan will be disposed off by the concerned forest office as per the provisions of the prevailing forest acts and regulations.

Accorded to the Bhutan Power Corporation Limited on …18/04/2025…(Insert Date) in presence of the following CFMG members;

No.	Name	Role	CID Number	Signature

The sheet summarizing people who attend the consulation No			1	in Chiwog	Tandingang	Gewog	Tang
	Total number of people attending			Age			
	Female	Male	Total	15-25	26-35	36-60	>60	Remarks
Count (no.)	4	18	22	0	5	13	4	
Percentage (%)	18.18	81.82	100.00	0.00	22.73	59.09	18.18	
Youngest age:	30	28						
Oldest age:	55	76						

Appendix 5-9b.Garabling CF Record of Discussion and Clearance

Record of Discussions

Stakeholder Consultation with Garabling Community Forest Management Group (CFMG)

Date: 22.11.2025

Location: Tandigang Chiwog, Tang Gewog

Time: 6:30 PM

Participants:

- **Bhutan Power Corporation Limited (BPC):**
  1. Mr. Yeshi Wangchuk, Environment Officer
  2. Mr. Kamal Bahun, Section Officer
  3. Mr. Kinga Tenzin, Section Officer
  4. Mr. Kishan Dahal, Assistant Environmental Officer
  5. Ms. Tshewang Choden, Assistant Environment Officer
  6. Ms. Ganga Devi Monger, Assistant Environment Officer
- **Forest Range Office, Tang Beat Office**
  1. Namkha Wangdi, Forest Ranger, Tang Beat Office
- Garabling CFMG:
  1. Mr. Pema Wangdi, Chairperson, Garabling CFMG
  2. Mr. Sonam Gyeltshen, Accountant, Garabling CFMG
  3. Mr. Nidup Dorji, Secretary, Garabling CFMG

***Members- List Attached**

Consent for Photo, Video, and Voice Recording

BPC team solicited and received consent of the participants for photo, video and voice recording during the meeting. No objection was raised.

1. Welcome and Introduction

The meeting was convened by Bhutan Power Corporation Limited (BPC). BPC team formally welcomed the participants and provided a brief overview of the meeting's objectives and structure. The primary purpose of the consultation was to share information with the

Community Forest Management Group (CFMG) and seek their clearance for the proposed 132 kV D/C Wobthang- Garpang Transmission line Project.

The consultation focused on the following key components:

- Focus group discussion on the proposed transmission line project.
- Discussion on compensation modalities.
- Open floor for questions and responses.
- Concluding remarks and endorsement of clearance.

2. Presentation on Proposed Access Road for Wobthang to Garpang Transmission Line

The project information was presented verbally in Dzongkha, considering the language preferences of the majority of the CFMG members. The main messages conveyed included:

- **Project Name:** Construction of 132 kV D/C Wobthang- Garpang Transmission Line Project.
- **Transmission Line:** 132 kV Double Circuit (D/C) Power Transmission line from 108 MW Wobthang Solar Farm to 33/11 kV Substation at Garpang.
- **Coverage:** Choekhor and Tang Gewog, Bumthang
- **Length:** Approximately 18 km
- **Total length (Access Road):** Approx. 22 Km
- **Estimated no. of towers:** Approx. 57

S. N	Gewog Under Thimphu	Approx. Line Length (KM)	No. of Towers in state Forest Land (SFRL)
1	Tang	16	45
2	Choekhor	2	5
	Total	**18**	**37**

3. Compensation

In discussing compensation, the team reassured the participants that commercial royalties for any trees felled would be paid in accordance with the Royalty on Forest Produce 2006 manual. And if the community required the felled timber, it could be handed over accordingly.

4. Question and Answer Session

A question-and-answer session followed, during which the CFMG members voiced their concerns, suggestion and inquiries about the project. Detailed summary discussion during this session as shown in table below.

5. Concluding Remarks

The team invited the affected CF members to conduct a detailed review of the potential impacts of the proposed transmission line alignment on the CF. Appreciation was extended to all participants for their active engagement throughout the meeting. Following the discussions, the transmission line alignment maps were reviewed. During the review, CFMG members suggested an alternative route along the existing grazing land, as the proposed alignment appeared steep and included multiple sharp turns, which could hinder the transportation of materials. In conclusion, the CFMG members marked the suggested route on Google Maps and team planned to survey it the following day, together with the Tandigang Chiwog Tshogpa and the Garabling CFMG Chairperson.

CF Clearance Summary					
SN	Name of CF	Clearance carried out during period	Feedback/Issues/concerns/queries	Responses and discussion	Outcomes
1	Garabling	22nd November 2025	CFMG members suggested an alternative route via the side with the bridge connection, as the proposed alignment was steep and included multiple turning points, which could hinder transportation of materials and more forest coverage.	The BPC team said that the suggested route is significantly longer than the proposed alignment and passes through a larger forested area. This could affect Forest Clearance approval if the forest coverage exceeds 40%, which needs to be taken into consideration. Additionally, the access road should be aligned as close as possible to the tower points and follow the shortest feasible distance to minimize impact. The team informed that alternative options was also explored such as using a ropeway for material transportation, in case the proposed route was found to be not feasible.	The BPC team and the members of Garabling CF agreed to conduct a joint site survey for the proposed access road route identified during the consultation.
			There have been changes in the CF area. The updated CF now covers a smaller area, and the suggested route primarily falls within the SRFL, with only a small portion of the access route passing through the CF area.	The team will validate the data of updated CF area and make the necessary changes.	

Tashi Chewdup
Tandigang Tshogpa.

Pema Wangdi (chairperson)
Garabling CF

Namkha Wangdi
Forest Range II
O/O. Tang.

Record of Discussions

Follow-Up Meeting with Garabling Community Forest Management Group (CFMG)

Date: 25.11.2025

Venue: Tangdigang Chiwog, Tang Gewog

Time: 5:30 PM

Participants: List Attached.

CF Clearance Summary					
SN	Name of CF	Clearance carried out during period	Feedback/Issues/concerns/queries	Responses and discussion	Outcomes
			CFMG members suggested an alternative route via the side with the bridge connection, as the proposed alignment was steep and	The BPC team said that the suggested route is significantly longer than the proposed alignment and passes through a larger forested	The joint survey was conducted on 23rd November. During the assessment, it was observed

1	Garabling	25th November 2025	included multiple turning points, which could hinder transportation of materials and more forest coverage.	area. This could affect Forest Clearance approval if the forest coverage exceeds 40%, which needs to be taken into consideration. Additionally, the access road should be aligned as close as possible to the tower points and follow the shortest feasible distance to minimize impact. The team informed that alternative options was also explored such as using a ropeway for material transportation, in case the proposed route was found to be not feasible.	that the proposed route discussed during the 22nd November consultation was considerably long, measuring approximately 4 km. Therefore, the team, together with the CF Chairperson and the Chiwog Tshogpa, explored an alternative alignment, which was found to be more feasible at only 1.3 km. This revised route was accepted by the CF representatives and BPC Team.
			There have been changes in the CF area. The updated CF now covers a smaller area, and the suggested route primarily falls within the SRFL, with only a small portion of the access route passing through the CF area.	The team will validate the data of updated CF area and make the necessary changes.	

Tashi Wendup
Tandigang Tshogpa

Pema Wangdi
Chairperson
Garabling CF

Namkha Wangdi
BIO. Pay.

s

ATTENDANCE SHEET FOR OFFICIALS PRESENT DURING CONSULTATION MEETING

Venue: Tadingang, Tang

Date: 22/11/2025

Time: 6:30PM

SN	Name	Designation	Department/Office	Signature
1.	Namkha Wangdi	Forest Ranger-II	Department of forest Bumthang Division.	
2.	Yeshi Wangchuk	EO	EGSS, CD, BPC	
3.	Kinga Tenzin	SO (survey)	"	
4.	Kamal Bahun	SO (survey)	"	
5.	Ganga Devi Monger	AEO	"	
6.	Tshewang Choden	AEO	"	
7.	Kishan Dahal	AEO	"	
8.	Tashi Chendup	Tshogpa (Tadingang)	Tang Gewog.	

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ATTENDANCE SHEET FOR OFFICIALS PRESENT DURING CONSULTATION MEETING

Venue: Tandingang

Date: 25/11/2025

Time: 6:00 pm

SN	Name	Designation	Department/Office	Signature
1	Namkha Wangdi	Forest Ranger-II.	DoF (Bumthang)	
2	Yeshi Wangchuk	EO	EGSS, CD, BPC	
3	Kinga Tenzin	SO (survey)	"	
4	Kamal Bahun	SO (survey)	"	
5	Kishan Dhal	AEO	"	
6	Tshewang choden	AEO	"	
7	Ganga Devi Mongar	AEO	"	
8	Tashi Chendup	Tshogpa (Tandingang)	Tang Gewog.	

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Tandingang Chiwog.

Date: 22/11/2025

Time: 6:30 PM

SN	Name & ID Card	Village/Gewog	Signature	Remarks
1.	Dorji - 77430648	Tandingang/ Tang Gewog	1	
2.	Sonam Choejay - 10103002175	Tandiwang/ Tang Gewog	2	
3.	Sangay Chophel - 10103002123	Tandingang/ Tang. Gewog	3	
4.	Dorji —	Tandingang Tang Gewog	4	
5.	Pema Wangda 10103001984	"		
6.	Sangay Dorji - 10103002071	"	5	
7.	Rinchen	"		
	Phone Number - 17428135	"	6	
8.	Sonam Tshering	"	7	
	10103000273	"	8	
9.	Rinchen - 10103001985	"	9	
10.	Yeshi - 10103002067	"	10	
11.	Leki Dorji -	"		
	10103002051	"		
12	Pema Yangmo -	"	11	
	17305922	"	12	
13	Rinzin Dema -	"		
	10103002214	"	13	

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Tandingang Chiwog.

Date: 22/11/2025

Time: 6:30 PM

BPC

SN	Name & ID Card	Village/Gewog	Signature	Remarks
14.	Rinchen Tshering/ 17415673	Tandingang/ Tang Gewog	14	
15.	Rinchen Phuntsho - 77864997	Tandingang/ Tang Gewog	15	
16.	Tashi ~~Lha~~ Lhendup - 10103002004	"	16	
17.	Pema Wangdi - 11507001041	"	17	
18.	Pema Lethro - 101030022024	"	18	
19.	Nidup Dorji - 101030021~~27~~72	"	19	
20.	Dechen Dorji 10103002053	"	20	
21.	Sangay Dema - 10103002110	"	21	

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Tandigang Chiwogs, Tang

Date: 25/11/2025

Time: 6:00 PM

SN	Name & ID Card	Village/Gewog	Signature	Remarks
1	Pema Wangdu	Tandingang, Tang.	1	
2	Yeshi	〃	2	
3	Sanjay Dorji	〃	3	
4	Pema lhatro.	〃		4
5	Sonam Tshering	〃	5	
6	Dorji	〃	6	
7	Sanjay Dema	〃	7	
8	Rinchen Dema	〃	8	
9	Rinchen	〃	9	
10	Dorji Tshering.	〃	10	
11	Sangay chophel			
12	Rinchen Wangmo	〃	11	
13	Sonam Peldon	〃	12	
			13	
14	Dechen	〃	14	
15	Sanjay Dema	〃	15	
16	Dechen Dorji	〃	[illegible]	

PUBLIC CONSULTATION ATTENDANCE SHEET

Venue: Tandingang

Date: 25/11/2024

Time: 6:00PM

BPC

SN.	Name & ID Card	Village/Gewog	Signature	Remarks
17	Sonam Chojey.	Tandingang	17	

Community Forestry Management Group (CFMG) clearance

The Community Forestry Management Group (CFMG) members of ......Gasabling C.F...... (name of CFMG) would like to issue this clearance to **Bhutan Power Corporation Limited (BPC)** for the purpose of .... measuring......................acres/meters with a Right of Way (RoW) measuring......................meters that falls within/runs through our Community Forest.

Both the parties are to abide by the following terms and conditions:

1. The CFMG members will not request for extension of the CF area taken by the BPC for the above purpose.

2. The CFMG will extract the timbers and other forest produces falling inside the area required for the above purpose and utilize as per the CF management plan only after the forest produces are handed over to the members by the concerned forest office.

3. BPC will pay the commercial royalty for trees need to be felled as per the Royalty on Forest Produce 2006 manual on rates prescribed for **standing basis** inside the area required for the above purpose.

4. The forest produce that are not covered in the CF management plan will be disposed off by the concerned forest office as per the provisions of the prevailing forest acts and regulations.

Accorded to the Bhutan Power Corporation Limited on ~~22~~ 25/11/2025 (Insert Date) in presence of the following CFMG members;

No.	Name	Role	CID Number/Phone.	Signature
1.	Pema Wangdi	Thrizin	11507001041	1
2.	Nidup Dorji	Drungchen	10103002172	2
3.	Sonam Gyeltshen	Acc.	10103001022	3
4.	Sonam Chojey	Member	10103002175	4
5.	Pema Wangdi	"	10103001984	5

6	Yeshi	Member	10103002067	6
7	Sanjay Dorji	"	17805863	7
8	Pema Lhaydro	"	10103002124	8
9	Dorji	"		9
10	Sonam Tshering	"	10103000273	10
11	Sangay Dema	"	—	11
12	Rinchen Dema	"	10103002214	12
13	Rinchen	"	—	13
14	Dorji Tshering	"	— (77663064)	14
15	Sangay Chophel	"	17547774	15

16	Rinchen Wangmo	Member	10103002158	16
17	Sonam Pelalon	"	10103002583	17
18	Dechen	"	77351587	18
19	Sangay Dema	"	17350483	19
20	Dechen Dorji	"	10103002053	
21	Tashi Chendup	"	10103002004	

Pema Wangdi
(11507001041)
(17547758)
(Thrizin)

Nidup Dorji
(10103002172)
(77404776)
(Drengchen)

Sonam Gyeltshen
(10103001022)
(17547811)
(Acc.)

Appendix 5-10. Department of Surface Transport (DoST) Clearance

དཔལ་ལྡན་འབྲུག་གཞུང་། ཞི་རྟེན་མཁོ་ཆས་དང་སྐྱེལ་འདྲེན་ལྷན་ཁག།
འགྲོ་འགྲུལ་སྐྱེལ་འདྲེན་ལས་ཁུངས། ཡན་ལག་ཡིག་ཚང་། བྱ་དཀར། བུམ་ཐང་།
MINISTRY OF INFRASTRUCTURE & TRANSPORT
Department of Surface Transport,
Sub-Division Office, Jakar: Bumthang
Construction Industry: "Solutions through innovation and improved technology"

DoST/SDOJ/2025-2026/F-09/119

Date: 28/01/2026

The Manager,
Bhutan Power Corporation,
Thimphu.

Sub: **DoST Clearance.**

Sir,

Please find herewith the provisional DOST clearance for the construction of approach roads at various locations on Nangar – Chamkhar – Tangsibi SNH and on Tang Dzongkhag Road. The clearance shall be valid if and only when the security money for the construction proposed structure at the takeoff points is received.

Therefore, the applicant is required to revalidate the clearance when the actual execution starts.

Thanking You,

Yours Sincerely,

Executive Engineer,
Sub-Division Office,
DoST, Jakar.

Copy to:

1. Chief Engineer,Regional Office, Trongsa for kind information
2. RI, Jakar SDO for information.

དཔལ་ལྡན་འབྲུག་གཞུང་། ཞི་རྟེན་མཐོ་ཆས་དང་སྐྱེལ་འདྲེན་ལྷན་ཁག།

འགྲོ་འགྲུལ་སྐྱེལ་འདྲེན་ལས་ཁུངས། ཡན་ལག་ཡིག་ཚང་། བྱ་དཀར། བུམ་ཐང་།

MINISTRY OF INFRASTRUCTURE & TRANSPORT

Department of Surface Transport,

Sub-Division Office, Jakar: Bumthang

Construction Industry: "Solutions through innovation and improved technology"

DOST, Clearance

This clearance for the construction of approach roads at various locations along the Nangar – Chamkhar – Ura and tang DR is issued based on the joint inspection of sites made on 26th January,2026 in the presence DoST officials and the Engineers from the BPC. This clearance holds the following terms and conditions which shall be followed by the applicant:

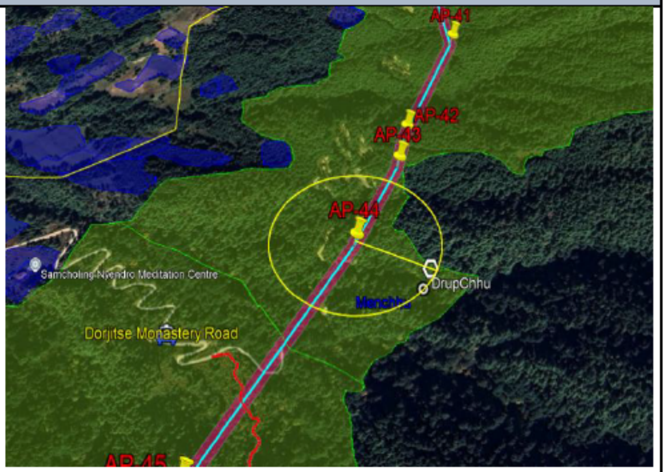
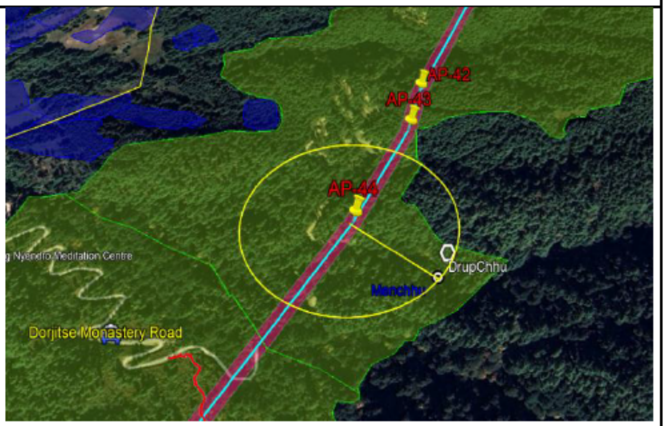
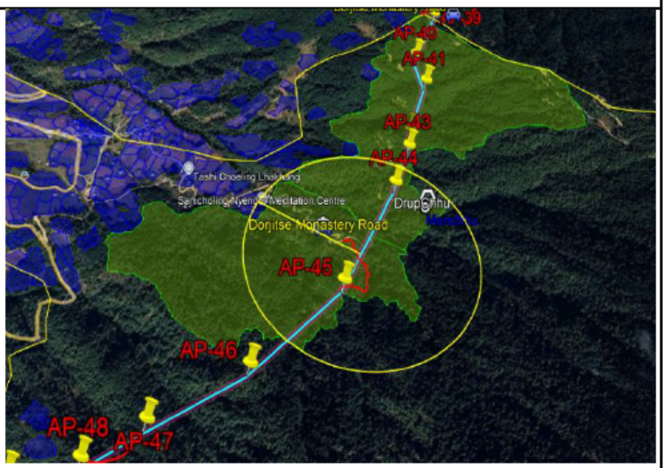
1. The structure proposed at Ch. 7.9km, 19.9km,20.0km, 29.70km and 30.30km on above road shall be constructed when the works are awarded to the contractor.
2. The applicant is responsible for the safety of the road users during the construction of the proposed approach roads.
3. The excavated earth from the construction site shall be disposed to the designated dump yard, not elsewhere within the road right of way.
4. There shall not be any spillage left on the existing road surface during the transportation of excavated earth causing the road surface dusty and dirty.
5. Install all the necessary traffic signs during the construction of roads to avoid accident.
6. The applicant is fully responsible for repair and maintenance of all the road damage occurred during the construction of approach roads.
7. The applicant shall obtain clearance from other agencies if required prior to the construction of wall.

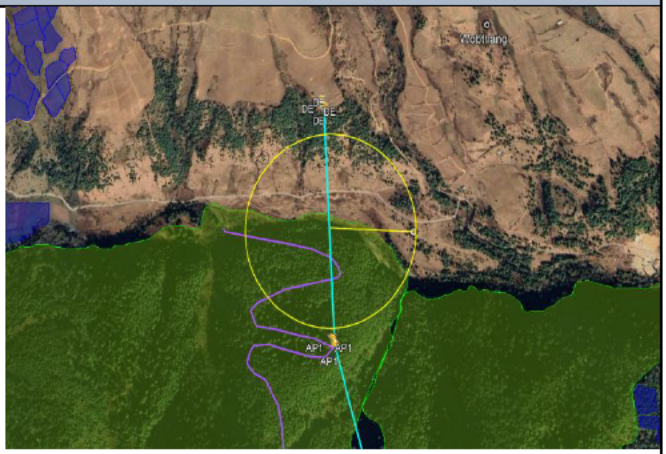
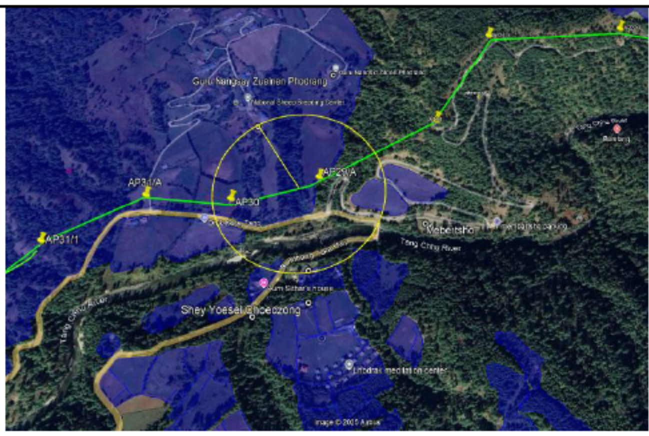
The DoST has reserved right to revoke the clearance if the applicant fails to follow the terms and condition set.

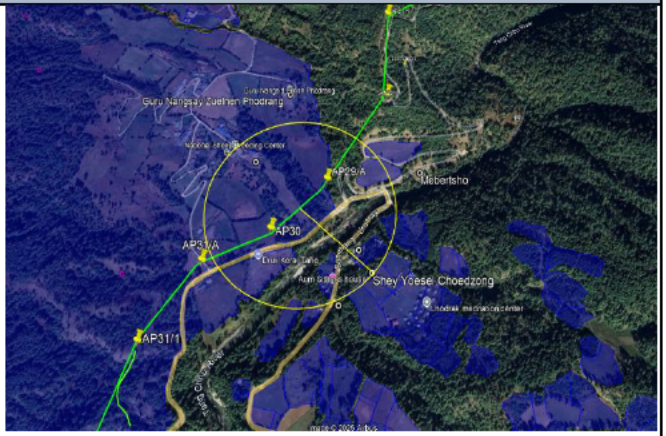
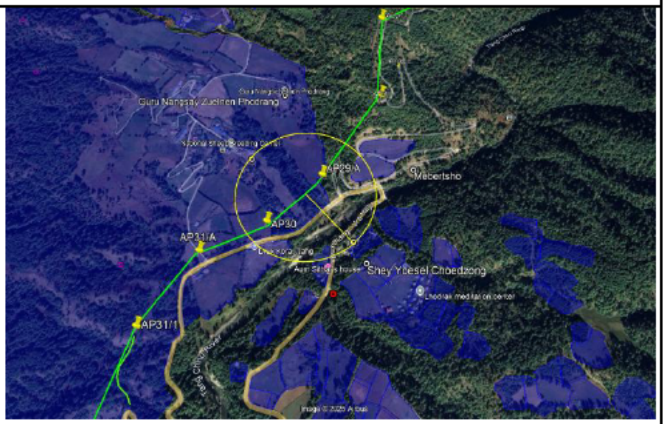
Executive Engineer,
Sub-Division Office,
DoST, Jakar.

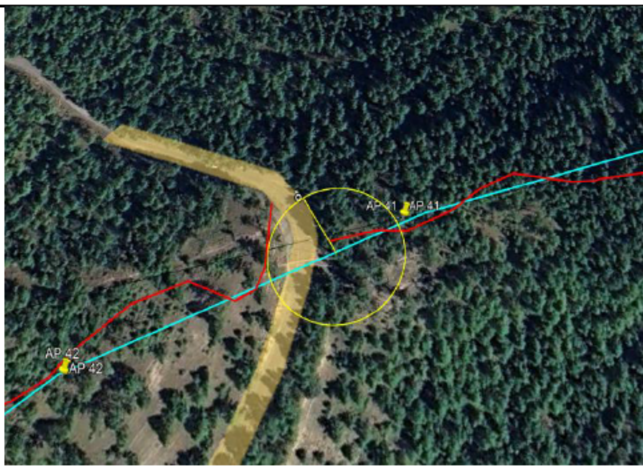
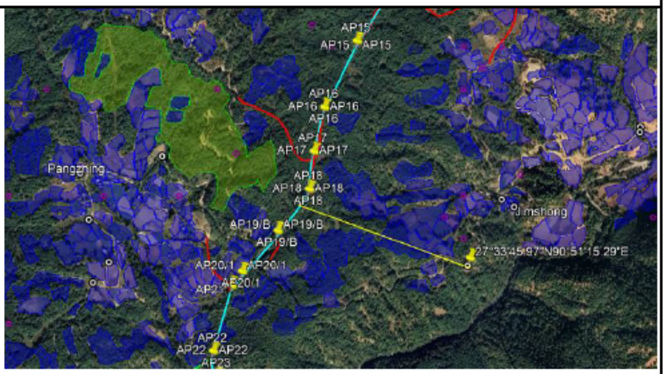
Appendix 5-11. Cultural Sites

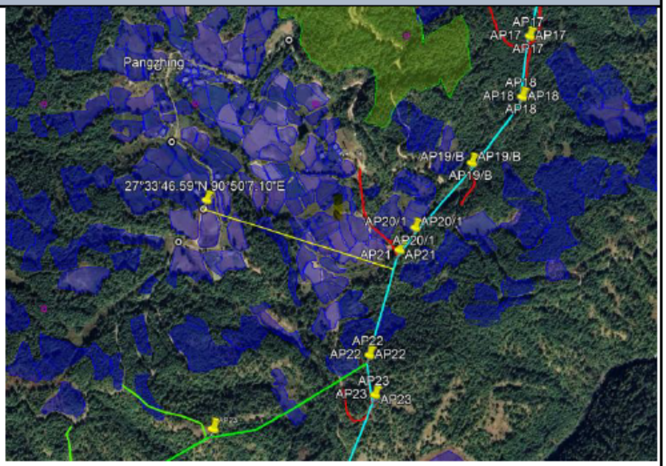
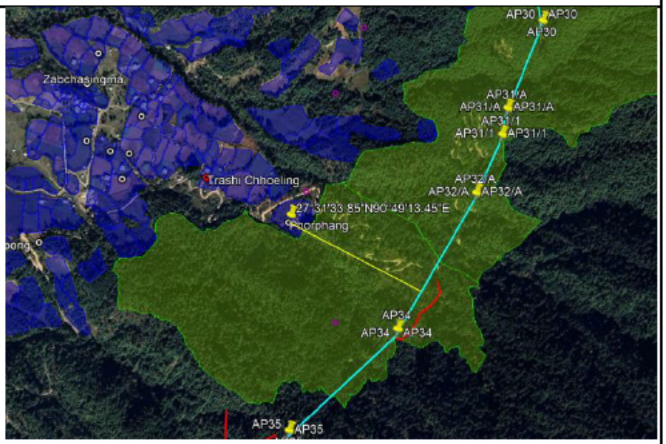
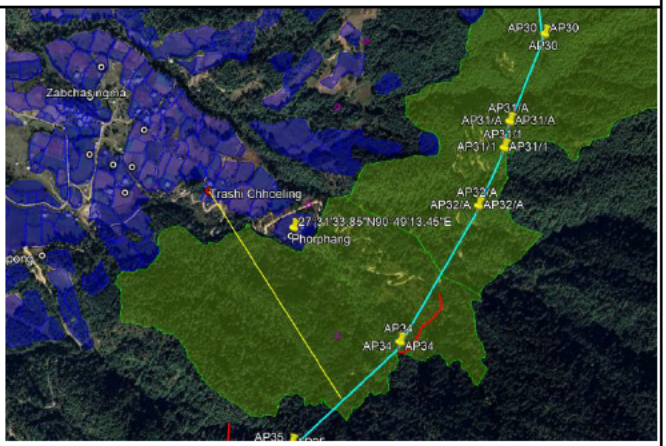
Table 1: Cultural Heritage Sites within 500m-1km to Project Components

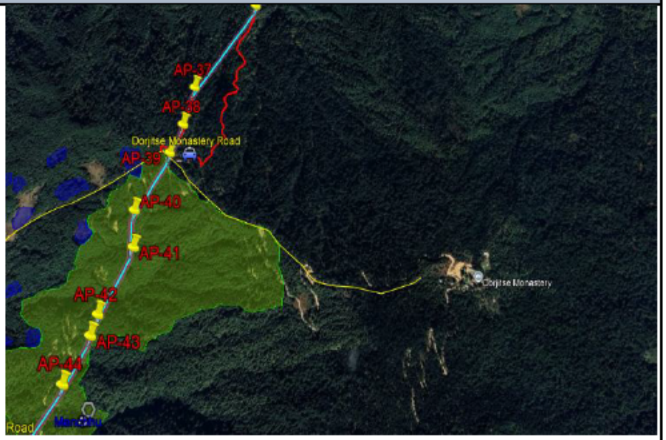
#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
1	Drupchhu (holy water site)	27°31'33.89"N 90°49'41.61"E	163.10 m	
2	Menchhu (medicinal water site)	27°31'32.55"N 90°49'41.05"E	168.95 m 0.17 km	
3	Samcholing Nyendro Mediation Center	27.52624 N 90.82078 E	485.43 m 0.49 km	

#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
4	Dangrim Chorten	27°37'38.02"N 90°52'5.02"E	283.48 m 0.29 km	
5	Namgay Chorten	27°32'20.35"N 90°48'16.38"E	206.81 m 0.20 km	
6	Guru Nangsay Zuelnen Phodrang	27°32'27.95"N 90°48'19.81"E	257.11 m 0.26 kM	

#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
7	Shey Yoesel Choedzong	27°32'9.57"N 90°48'29.01"E	281.61 m 0.28 km	
8	Jangchub Chorten	27°32'11.62"N 90°48'27.66"E	208.79 m 0.21 km	
9	Water Prayer wheel	27°32'6.76"N 90°48'25.58"E	299.98 m 0.31 km	

#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
10	Namgay Chorten	27°32'19.17"N 90°48'34.49"E	226.72 m 0.23 km	
11	Jangchub Chorten	27°31'1.37"N 90°48'4.42"E	35.24 m 0.04 km	
12	Dangrim Chorten	27°33'45.97"N 90°51'15.29"E	0.92 km	

#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
13	Dangrim Chorten	27°33'46.59"N 90°50'7.10"E	0.67 km	
14	Phorbang Lhakhang	27°31'33.85"N 90°49'13.45"E	0.52 km	
15	Trashi chhoeling Lhakhang	27°31'38.79"N 90°49'3.25"E	0.84 km	

#	Name Of the Cultural Heritage Site	Coordinates	Distance from TL	Map
16	Dorjitse Monastery	Dorjitse Monastery is located a few kilometers North of Phromphrong village (about 20 kilometers east of Jakar / Chamkhar town) under Tang Gewog of Bumthang district in central Bhutan. The monastery was first established by Lama Gyalwa Shacha Rabgay the third reincarnation of Gyalsey Darmadodey in the late 12th century.	0.27 km from ACSR Conductor (Rabbit): 50 sq mm.	

Source: Department of Culture and Dzongkha Development