# Initial Environmental Examination

May 2016

# BHU: SASEC Transport, Trade Facilitation and Logistics Project

Prepared by Department of Roads, Royal Government of Bhutan for the Asian Development Bank (ADB)

## CURRENCY EQUIVALENTS

(as of 28 March 2016)

| | | |
|---|---|---|
| Currency unit | – | Ngultrum (Nu) |
| Nu1.00 | = | $0.015 |
| $1.00 | = | 66.73 Nu |

## ABBREVIATIONS

| | | |
|---|---|---|
| AADT | : | Annual Average Daily Traffic |
| ADB | : | Asian Development Bank |
| AIDS | : | Acquired Immune Deficiency Syndrome |
| APs | : | Affected Persons |
| BC | : | Biological Corridor |
| BDBL | : | Bhutan Development Bank Limited |
| BHU | : | Basic Health Unit |
| CA | : | Competent Authority |
| CITES | : | Convention on International Trade in Endangered Species |
| CO | : | Carbon Monoxide |
| CSC | : | Construction Supervision Consultant |
| CWSMP | : | Construction Waste and Spoil Management Plan |
| DGM | : | Department of Geology and Mines |
| DOFPS | : | Department of Forests and Park Services |
| DoR | : | Department of Roads |
| DT | : | Dzongkhag Tshogdu |
| DYT | : | Dzongkhag Yargay Tshogdu |
| EC | : | Environment Clearance |
| EFRC | : | Environment Friendly Road Construction |
| EIA | : | Environmental Impact Assessment |
| EMP | : | Environmental Management Plan |
| EMU | : | Environment Management Unit |
| ES | : | Environmental Specialist |
| EU | : | Environmental Unit |
| FHWA | : | Federal Highway Administration |
| FNCA | : | Forest and Nature Conservation Act |
| FNCR | : | Forest and Nature Conservation Rules |
| GIS | : | Geographic Information System |
| GLOF | : | Glacial Lake Outburst Flood |
| GNHC | : | Gross National Happiness Commission |
| GPS | : | Global Positioning System |
| GRC | : | Greviance Redress Committee |
| GRF | : | Government Reserved Forest |
| GRM | : | Greviance Redress Mechanism |
| GT | : | Geog Tshogchung |
| GYT | : | Geog Yargay Tshogchung |
| HIV | : | Human Immunodeficiency Virus |
| IEE | : | Initial Environmental Examination |
| IPCC | : | Intergovernmental Panel on Climate Change |
| IUCN | : | International Union for Conservation of Nature |
| MOAF | : | Ministry of Agriculture and Forests |
| MoEA | : | Ministry of Economic Affairs |
| MoWHS | : | Ministry of Works and Human Settlement |
| NEC | : | National Environment Commission |

| | | |
|---|---|---|
| NEPA | : | National Environmental Protection Act |
| NFEC | : | Non Formal Education Centre |
| NOC | : | No Objection Certificate |
| NOx | : | Nitrogen Oxides |
| NRDCL | : | Natural Resources Development Corporation Limited |
| NSB | : | National Statistic Bureau |
| OHS | : | Occupational Health and Safety |
| PHCB | : | Population and Housing Census of Bhutan |
| PIA | : | Project Influenced Area |
| PM10 | : | Particulate Matter 10 microgram |
| PM2.5 | : | Particulate Matter 2.5 microgram |
| PMU | : | Project Management Unit |
| PPM | : | Parts per Million |
| PPTA | : | Project Preparatory Technical Assistance |
| RNR | : | Renewable Natural Resources |
| 3Rs | : | Reduce Recycle and Reuse |
| RBP | : | Royal Bhutan Police |
| RECOP | : | Regulation Environmental Clearance of Projects |
| RGoB | : | Royal Government of Bhutan |
| RICBL | : | Royal Insurance Corporation of Bhutan Limited |
| RNP | : | Road Network Project |
| ROW | : | Right of Way |
| RSTA | : | Road Safety and Transport Authority |
| SASEC | : | South Asian Subregional Economic Cooperation |
| SOx | : | Sulphur Dioxide |
| SPS | : | Safeguard Policy Statement |
| USEPA | : | United States Environment Protection Act |
| UNDP | : | United Nation Development Programme |
| WHO | : | World Health Organization |

**WEIGHTS AND MEASURES**

| | | |
|---|---|---|
| AADT | - | Annual Average Daily Traffic |
| dB | - | Decibel |
| Ha | - | Hectare |
| Km | - | Kilometer |
| $km^2$ | - | Square kilometer |
| M | - | Meter |
| Mt | - | Metric ton |
| Vpd | - | Vehicles per day |

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# EXECUTIVE SUMMARY

## A. Background

1. The proposed South Asia Subregional Economic Cooperation Transport, Trade Facilitation and Logistics Project will promote regional connectivity in the Phuentsholing area with a direct road connection between the Samtse and Chukha districts. It has 2 components: (i) construction of 3.3km national highway between Phuentsholing and Chamkuna, and (ii) procurement of equipment for trade facilitation installed in MDP, and LCS. The national highway will have 2-lanes with pedestrian walkways on a 6 meter high embankment along the Amochhu river bed. The procurement of equipment includes a truck x-ray scanner, hand held scanners, heavy machinery for optimized transshipment and off-loading procedures, surveillance and communication systems, and tools for detection of illegal items, which will improve the service delivery and safety in the Phuentsholing MDP and the LCS in Allay

2. The new road section between Phuentsholing and Chamkuna will complete the missing 3.3 km link along the Phuentsholing to Samtse highway and activate the full value of the entire 58 km Southern East-West Highway (SEWH) section. It will provide the vital intra-country linkage of Samtse district with the rest of the country. The trade facilitation and logistics component will improve the infrastructure and services at the border crossing points by providing additional equipment to facilitate cross-border traffic and transit of goods and services, trade and commerce, nationwide.

3. The government has requested ADB's financial assistance for the prioritized construction of the missing 3.3 km Phuentsholing to Chamkuna link. The completed southern east-west highway section between Phuentsholing and Samtse, will provide a direct inland connection which is important to develop the southwestern part of Bhutan. Currently, connecting to the Samtse district involves indirect routes, either south via India or through a long indirect journey using the northern east-west highway to the north. The completed SEWH section from Phuentsholing to Samtse, proceeds parallel to the Indian border and connects several towns in the southwestern part, which are previously not connected by a continuous domestic road. It will also connect indirectly the Haa district, which is to date only connected to the north and requires long detours up north to reach the commercial hub and border crossing point of Phuentsholing. The provision of an alternative domestic road connection for the traffic, coming from the western Samtse district, will reduce the travel distance and decongest the main border crossing in Phuentsholing and its city center.

4. The PCR will have 3 sets of erosion and flood control systems were integrated in the PCR design; first set involves armouring and properly founding the embankment road, second involves river training to maintain safe distance separation of the main Amouchu channel from the embankment road, and the third set manages the surface runoff laden with sediment and boulders from the hill side east of the embankment road and providing adequate conveyance structure across the road to allow safe passage water towards the Amochhu river.

## B. Environmental Categorization

5. The Phuentsoling-Chamkuna Road (PCR) is classified as environment category B project as it is expected have almost no adverse social impacts and less environmental impacts that can be address through readily available mitigation measures. In spite of the presence of the endangered Golden Masheer (*Tor putitora*) along the Amochhu river, a Category B was deemed appropriate because: i) the scale of the project is small, 3.3km, barely touching the

water area, about than 1km of a critical habitat Amochhu/Toorsa whose total length of 358 kilometers, ii) environmental impacts are site specific with no effect on the river hydraulics, sediment transport, and general morphology, iii) the mitigation measures necessary to control silt and avoid disturbing the Golden Masheer's migration are easy to implement requiring the use of geotextile silt curtains and prohibiting any works on the water area during the migration periods of October-November and in the spring between April and May.

6. This initial environmental examination (IEE) studies have been carried out in accordance with the relevant laws and regulations of RGoB and Safeguard Policy Statement 2009 of the ADB. The procurement of trade facilitation logistics component is classified as Category C.

## C. Consultation and GRM

7. Meaningful consultations were carried out during feasibility study, preliminary/ design, and IEE preparations. All the five principles of information dissemination, information solicitation, integration, co-ordination, and engagement into dialogue were incorporated in the consultation process. A framework of mitigating different environmental impacts likely from the project was strengthened and modified based on opinions of all those consulted, especially at the micro level by setting up a dialogue with the village people from whom information on site facts and prevailing conditions were collected. This will be continued during detailed design and implementation of the project by implementing NGOs and through grievance redress mechanism. Most of concerns raised during the consultations pertained to consistency of the project road alignment with the Amochhu Local Area Plan (LAP) and Amochhu Land Reclamation Project (ALRP), need for river bank protection, and sourcing of substantial amount of construction and fill materials. These concerns were adequately considered in the project design. The same grievance and redress mechanism established in South Asia Subregional Economic Cooperation Road Connectivity Project will be utilized by the Project for practical purposes.

## D. Key Environmental Baseline Characteristics

8. The project zone lies in the sub-tropical region with four distinct seasons. Phuentsholing city is located at the base of the Himalayan foothills which falls under sub-tropical climatic zone with hot humid summer months and; with warm and dry winter months. The humid climate helps maintain a fairly even temperature ranging between 15° C and 30°C year-round. In the project area the maximum rainfall occurs in the months of June, July and August, however the rainfall extends from May to September. The minimum rainfall occurs in the post monsoon and winter seasons (November, December, January and February).

9. The geology and topography of Bhutan are shaped by the intense tectonic activity and made up of uplifted sedimentary and metamorphic rocks, which makes the geology among the most fragile in the Sub-Himalayan range. The geology is also highly sensitive to intense rainfall and surface runoff with high erosion rates frequently resulting to substantial landslides. Bhutan is seismically active and the entire country is classified as Zones IV and V, the highest seismic hazard.

10. The drainage pattern of Bhutan is principally segregated into three hydrological regions and are tagged as basins I, II and III. Basin I constitute Amo Chhu and Wang Chhu sub-basins. In Amo Chhu maximum observed discharge was 5,397$m^3$/s recorded I Hasimara Gauging Station, 15.5km downstream of Phuentsholing. The air quality surrounding the project area is relative clean with the exception of the YDF Center one the terminal point of the project road,

and the Phuentsholing main town where ambient TSP and PM10 are exceeded during the pre- and post-monsoons and winter. The primary source of air pollution at the project site are the emissions from automobiles and workshops activities; fugitive sources such as burning of solid wastes and the dust generated particularly at Amochhu/Toorsa area because of the unpaved road condition.

11. The water quality of the Amochhu complies with most physical parameters for drinking water except for turbidity and color which deteriorates during monsoon season.

12. The Project area does not fall in any of the ten protected areas and network of Biological corridors that connects the protected areas. Jigme Khesar Namgyel Wangchuk Strict Nature Reserve is the nearest protected area located approximately about 42km north-west of the proposed Project. However, The Amochhu river supports 91 species of fish including Golden Mahsheer (*Tor putitora*) which protected under schedule I of Forest and Nature Conservation Act of Bhutan, 1995 and listed as endangered by the IUCN supporting the classification of the iver as critical habitat required for the survival of this endangered species.

## E. Climate Risk and GHG Emissions

13. Downscaled climate change models shows a steady increase of temperature, increasing from about $12^0$C (1980) to around $17.0^0$C (2069). The seasonal (monsoonal) trend in mean temperature between 1980 and 2069 show progressive and steady increase by about $3^0$C. Similarly, there will be a progressive and steady increase in precipitation from 1980 to 2069 from, 2000 mm/year (1980) to 2600 mm/year (2069). Using The Transport Emissions Evaluation Model for Projects (TEEMP) developed by Clean Air Asia, improving the road will result to a decrease in GHG emission intensity amounting to about 98 tons CO2e/km and 109 tons CO2e/year. The reduction in GHG emissions is attributed to increase in speed and reduction in fuel consumption.

## F. Environmental Impacts and Mitigation Measures

14. During the pre-construction phase, major potential negative impacts pertains to site mobilization where surface runoff may carry sediment to the Amochu which are detrimental to the Golden Masheer (Tor putitora) spawning behavior. During construction, the river channeling, construction of spur dike, installation of gabions, soil filling, and compaction will also increase sediment flow and increase suspended solids in the water column. To mitigate the significant impacts to the Masheer, no activity in the water environment will be allowed during autumn migration from October-November and in the spring spawning between April and May. The contractor will maintain Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area and take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area. A key mitigation measure is the deployment of geo-textile silt curtains before the start of any work to ensure suspended solids will not settle outside the project area.

15. Another potential significant impact is the on the hydrology and hydraulic characteristics of the Amochhu once the river channelization and spur dikes, aimed at protecting the embankment road. This study relied of the DHI assessment for the ALRP that as long as the river channel maintains a smooth flow and cross-section of 300m, there would be marginal impact on the flow velocity and sedimentation downstream.

16. Only minor environmental impacts were identified during project operation.

17. There is no habitat loss of the Golden Masheer that is attributable to the project. River training will enable the Amochhu river to meander back to its previous course further away from the Phuenstholing river bank and protect the project road with no measureable effect of the river's cross-sectional area. Avoiding all works on the water environment during the critical migration seasons of the Golden Masheer further ensures that reduction of the population is avoided. The scale of the project is small, 3.3km. Of that a maximum of only 1km falls along the edge of the Amochu river which serves as critical habitat for the Golden Mahseer. The total length of Amochhu/Toorsa is about 358 kilometers. No measureable effects on the river hydraulics, sediment transport, and general morphology, and the mitigation measures necessary to control silt and avoid disturbing the Golden Masheer's migration are effective and easy to implement with no significant residual impacts requiring the use of geotextile silt curtains and prohibiting any works on the water area during the migration periods of October-November and in the spring between April and May. Even at fully contracted 300m channel width envisioned under the Amochu Land Reclamation Project corresponding to an increase in average maximum velocity from 3 to 4 m/s" expected during high flood flows, the impacts to the Golden Masheer is negligible as they have already migrated up the Amochhu to avoid peak discharge and flow velocity. Although no specific study on the Masheer's tolerance to flow velocity was gathered, major cold water fishes can thrive at 1.45 m/s during low flow. Comparing this to historical records on the Amochhu river monitoring data by DHI, flood velocity in 2006 reached 2.2 m/s which is much higher than 1.45m/s but still Masheer inhabits the Amochhu river. This amazing survival is attributed to their migration movement where the Masheers take refuge upstream in small channel and avoiding devastating flood flows downstream.

## G. Institutional Arrangement to Implement the Environmental Management Plan

18. The Royal Government of Bhutan (RGoB) through the Department of Roads (DOR) for the road component and the Phuentsholing Thromde for the trade facilitation are the Executing Agencies (EA) and Implementing Agencies of the project. The DOR has Environment Unit with qualified staff in their regular organogram. This unit under the leadership of a Superintending Engineer will assist the PMU on issues related to environmental and social management. The PCR construction implementation will be led by the Project Management Unit (PMU) that will be established within DOR. The PMU, tasked with the day-to-day management of the project will be headed by the Chief Engineer acting as Project Manager (PM), 2 Deputy Managers, and supported by an environmental specialist to supervise the implementation of the EMP, liaise with NEC and other relevant agencies, and prepare annual environmental monitoring reports for disclosure. The Phuenstholing Thromde (PT) has a Project Coordinator implementing the Dry Port Project and the existing environmental institution consisting of PIU and CSC environmental specialist will supervise and implement the EMP.

19. A construction supervision consultant team will be mobilized to ensure works, including the EMP is properly implemented. The CSC will have an environmental specialist primarily to enforce the environmental measures and ensure the contractor stays in compliance.

20. The contractor, tasked with the implementation of all civil works, will have an environmental focal person at the field level to ensure all works are implemented with due regards to the environmental measures stipulated in the EMP and EMOP.

## H. Conclusion and Recommendation

21. The proposed Phuentsholing - Chamkuna road does not pass through any environmentally sensitive area and requires no private land acquisition. All relevant issues raised during focus group discussions and public consultations were also incorporated in the project design and EMP.

22. Mitigation measures were identified to reduce the significant adverse impacts including residual effects. The IEE has shown that environmental impacts anticipated for proposed Project are not significant after the implementing recommended mitigation measures. Most of the impacts are temporary, reversible and all can easily be mitigated using available methods.

# I. INTRODUCTION

## A. Overview and Background

1. The proposed South Asia Subregional Economic Cooperation Transport, Trade Facilitation and Logistics Project will promote regional connectivity in the Phuentsholing area with a direct road connection between the Samtse and Chukha districts. It has 2 components: (i) construction of 3.3km national highway between Phuentsholing and Chamkuna, and (ii) procurement of equipment for trade facilitation installed in MDP, and LCS. The national highway will have 2-lanes with pedestrian walkways on a 6 meter high embankment along the Amochhu river bed. The procurement of equipment includes a truck x-ray scanner, hand held scanners, heavy machinery for optimized transshipment and off-loading procedures, surveillance and communication systems, and tools for detection of illegal items, which will improve the service delivery and safety in the Phuentsholing MDP and the LCS in Allay

2. The new road section between Phuentsholing and Chamkuna will complete the missing 3.3 km link along the Phuentsholing to Samtse highway and activate the full value of the entire 58 km Southern East-West Highway (SEWH) section. It will provide the vital intra-country linkage of Samtse district with the rest of the country. The trade facilitation and logistics component will improve the infrastructure and services at the border crossing points by providing additional equipment to facilitate cross-border traffic and transit of goods and services, trade and commerce, nationwide.

3. The main border crossing point between Bhutan and India is in Phuentsholing and connects Bhutan's main north-south highway with India's national highway network. Phuentsholing is the most important gateway for cross border traffic and accounts for 74% of the total import and export trade in the country. The inadequacy of the border facilities in dealing with this traffic causes long idle times particularly for transporting goods and their clearance, which leads to heavy congestion in the city and is a constraint on trade through the city.

4. The government has requested ADB's financial assistance for the prioritized construction of the missing 3.3 km Phuentsholing to Chamkuna link. The completed southern east-west highway section between Phuentsholing and Samtse, will provide a direct inland connection which is important to develop the southwestern part of Bhutan. Currently, connecting to the Samtse district involves indirect routes, either south via India or through a long indirect journey using the northern east-west highway to the north. The completed SEWH section from Phuentsholing to Samtse, proceeds parallel to the Indian border and connects several towns in the southwestern part, which are previously not connected by a continuous domestic road. It will also connect indirectly the Haa district, which is to date only connected to the north and requires long detours up north to reach the commercial hub and border crossing point of Phuentsholing. The provision of an alternative domestic road connection for the traffic, coming from the western Samtse district, will reduce the travel distance and decongest the main border crossing in Phuentsholing and its city center.

5. The Royal Government of Bhutan (RGOB) through ADB assisted South Asia Subregional Economic Cooperation (SASEC) Transport, Trade Facilitation and Logistic Project plans to improve the existing sections of Southern East West Highway (SEWH) and bridging the missing road links of the SEWH; and also improve the customs' infrastructures and services at the border crossing points and checkpoints for efficient and safe import and export of goods and services. Of the two components, this report will focus on the road component – the

construction of 3.3km Phuentsholing to Chamkuna road (PCR). The road is expected to complete the missing link of Samste-Phuentsholing Highway (SPH).

6. The new construction of the Phuentsoling-Chamkuna Road (PCR) is classified as environment category B project as no significant adverse environmental impacts are anticipated and environmental impacts can address through readily available mitigation measures. In spite of the presence of the endangered Golden Masheer (*Tor putitora*) along the Amochhu river, a Category B was deemed appropriate because: i) the scale of the project is small, 3.3km, barely touching the water area, about than 1km of a critical habitat Amochhu river with a total length of 358 kilometers, ii) environmental impacts are site specific with no effect on the river hydraulics, sediment transport, and general morphology, and iii) the mitigation measures necessary to control silt and avoid disturbing the Golden Masheer's migration are easy to implement requiring the use of geotextile silt curtains and prohibiting any works on the water area during the migration periods of October-November and in the spring between April and May.

7. This initial environmental examination (IEE) studies have been carried out in accordance with the relevant laws and regulations of RGoB and Safeguard Policy Statement 2009 of the ADB. The procurement of trade facilitation logistics is classified as Category C.

## B. Objective of the Project

8. The objective of the project is to support the RGoB thrust of strategic infrastructure development through the improvement of national highways to boost domestic and cross-border trade and allow better delivery and wider coverage of basic social services.

## C. IEE Objectives

9. The project is categorized as category **'B'** in accordance with ADB's Safeguard Policy Statement (SPS), 2009 warranting an initial environmental examination (IEE). IEE identifies the environmental issues to be considered at project planning and design stage. The IEE report covers the general environmental profile of the study area and includes an overview of the potential environmental impacts and their magnitude on physical, ecological, economic, and social and cultural resources within the project's influence area during design, construction, and operation stages. An Environmental Management Plan (EMP) forms part of this report which includes mitigation measures for significant environmental impacts during implementation of the project, environmental monitoring program, and the responsible entities for mitigation and monitoring. IEE has four basic objectives; (i) identify the environmental issues that should be taken into account due to project interventions, (ii) determine the magnitude of potential environmental concerns and to ensure that environmental considerations are given adequate weight at planning/design stage, (iii) identify need for further environmental studies or Environmental Impact Assessment (EIA), and (iv) suggest enhancement measures, if any.

## D. Extent of IEE

10. The IEE considered all likely impacts and risks attributable to the project. It encompasses: (i) the primary project site(s) and related facilities, (ii) associated facilities whose viability and existence depend exclusively on the project, (iii) areas and communities potentially affected by cumulative impacts from further planned development of any existing project or condition, and other project-related developments that are realistically defined at the time of assessment; and (iv) areas and communities potentially affected by impacts from unplanned but predictable developments caused by the project that may occur later or at a different location.

11. During project construction, temporary and permanent impacts will occur both on-and off-site. The most direct physical impact will be on-site within 30 m band along the 3.3 km of PCR construction. The core zone of impact is taken as proposed right of way and its immediate vicinity. The assessment also considers the areas and activities related to associate facilities viz. quarry operation, borrow areas, construction camp, transportation/haulage routes etc. The study area is considered up to 10 km on either side of road alignment for larger analysis of landuse and other environmental features. Assessment is carried out for all components of environment covering terrestrial and aquatic ecology, soil, water, noise and socio economic aspects.

## E. Approach and Methodology

12. This IEE report has been prepared on the basis of feasibility report, field investigations and stakeholder consultations to meet the requirements for environmental assessment process and documentation as per ADB's Safeguard Policy Statement (SPS), 2009 and the Royal Government of Bhutan's (RGoB) Environmental Assessment Act, 2000.

### 1. Reconnaissance Survey and Initial Consultations

13. Reconnaissance survey and initial consultations facilitated in designing the nature of the environmental survey and extent of consultations to be carried out along the road alignment. It allowed the identification of data gaps, valued environment components, key stakeholders and key informants who can further substantiate the collected information. Reconnaissance survey and initial consultations also recognized the need to provide particular attention to the endangered Golden Masheer (Tor putitora) and ensure habitat and species protection.

### 2. Primary Data Collection

14. Environmental resource inventory was prepared for all environmental features viz. terrain, landuse, waterways/water bodies, road side vegetation, sensitive receptors, common property resources, utilities, drainage, flooding/water logging, accident prone areas etc. within the area of interest/core zone. Information about Amochhu river as habitat for the Golden Masheer were gathered through fishe survey conducted by the National Center for Riverine and Lake Fisheries, Ministry of Agriculture and Forest, Royal Government of Bhutan Department of Livestock. Physical baseline data on air, noise and water qualities for this IEE study were collected four seasons which were collected during months of August, November, December 2015; and March 2016. Ecological data were collected using transact survey method which estimates the occurrence of flora and fauna within project area. The vegetation surveys were carried out during for month of August and November 2015.

### 3. Secondary Data Collection

15. Secondary sources included environmental assessment done by feasibility team, published government reports, government websites, recognized institutions and relevant government departments (forests and wildlife, pollution control board, statistics, meteorological). Recent Google images were captured to view environmental features at regional scale. References made to the secondary sources have been mentioned in the text and tables throughout the length of the report.

16. Feasibility study was carried out over period 7 months starting from July 2015 – March 2016. The environmental baseline data which included physical, biological and socioeconomic.

Spatial information with regard to road alignment and other features were collected using Global Position System (GPS) and from the topographical surveys carried out by design engineers. The secondary data from Ministry of Agriculture and Forests (MoAF) and National Land Commission (NLC) on land use, settlement and other topographical information were also collected.

### 4. Public Consultations

17. Meaningful consultations were organized with the government agencies, local people/beneficiary population to know the level of project acceptability, understand their concerns, apprehensions, and overall opinion. Information were gathered about existing baseline environmental condition viz. ambient levels and its effects on health, water resources, water logging/flooding, flora and fauna, wildlife movement, socio-economic standing of local people, impact due to loss of land other assets and common property resources, accident risk during construction and operation stage, perceived benefits and losses, etc. Information thus gathered was used to integrate it in project design and formulate mitigation measures and environmental management plan.

### 5. Other Tools, Additional Surveys and Studies

18. The Transport Emissions Evaluation Model for Projects (TEEMP)[1] developed by Clean Air Asia[2] was utilized to assess the $CO_2$ gross emissions. Required input data-set viz. road length and configuration, traffic, road roughness, and emission factors were collected from different sources.

19. Climate risk screening was used to evaluate the predicted increase in temperature and precipitation and overlayed with existing limitations of the project area like the erosion-prone banks of the Amochhu and the hillslopes on the Phuenstholing banks.

### 6. Assessment of Potential Impacts

20. The assessment of the type, nature, direct, indirect, cumulative or induced impacts and their significance to the physical, biological, and socio-economic components of the environment has been done to ascertain whether the project is environmentally sustainable or not. Nature of impacts has been classified as significant, insignificant, short-term, long-term, reversible, irreversible etc. After identification of nature and extent of impacts, mitigation measures have been suggested.

### 7. Preparation of the Environment Management Plan

21. A general EMP has been formulated with an aim to avoid, reduce, mitigate, or compensate for adverse environmental impacts/risks and propose enhancement measures based on information available during the feasibility study stage. This includes: (i) mitigation of potentially adverse impacts, (ii) monitoring of impacts and mitigation measures during project implementation and operation, (iii) institutional capacity building and training (iii) compliance to

[1] TEEMP is an excel-based, free-of-charge spreadsheet models to evaluate emissions impacts of transport projects.

[2] A network of 250 organizations in 31 countries established by the Asian Development Bank, World Bank, and USAID to promote better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse gas emissions from transport, energy and other sectors.

statutory requirements, and (iv) integration of EMP with project planning, design, construction and operation.

22. During feasibility stage, all engineering designs are typical schematic to be followed by detailed engineering design where more refinements will be made in conjunction with the availability of more accurate information from geodetic, soil bearing capacity, soil founding, bathymetric, and hydrologic surveys. Materials selection, minor geometric alignment, and construction methods will be updated including the definition of other project components like location and extent of the spur dikes, re-channelling alignment, and equipment requirement from which may require further improvements on the environmental management plan. During pre-construction stage, the contractor will propose camp site scale, location, layout, material storage, and deployment of equipment which poses additional environmental risk.

23. The general EMP prepared under this IEE will be subject to updating during the detailed engineering design stage and the contractor will be required to prepare an environmental action plan that further details the EMP based on the contractors appreciation of the site and subject to the Construction Supervision Consultant (CSC) and DOR.

## F. Structure of the report

24. IEE has been structured in accordance with SPS, 2009. An executive summary describing critical facts, significant findings, and recommended actions has been presented in the beginning of the report. The report has been compiled and presented as follows.

- Executive Summary
- Chapter 1 -Introduction
- Chapter 2- Policy, Legal and Administrative Framework
- Chapter 3- Description of Project
- Chapter 4- Description of the Environment
- Chapter 5- Anticipated Impacts and Mitigation Measures
- Chapter 6- Information Disclosure, Consultation, and Participation
- Chapter 7- EMP and Grievance Redress Mechanism
- Chapter 8 -Conclusion and Recommendation

# II. DESCRIPTION OF THE PROJECT

## A. Project Location

25. The project has two components, a road component that will complete the missing link of Samtse-Phuentsholing highway between Chamkuna to Phuentsholing and a trade facilitation component which will provide equipment and capacity building for trade facilitation and logistics in the Phuentsholing Mini Dry Port and the Allay Land Custom Station (LCS).

26. The proposed road alignment of the PCR traverses along the eastern bank of Amochhu River starting from the intersection with Phuentsholing Bypass Road below YDF Hostel and terminates at Cham the kuna. The entire 3.3km embankment road section falls under Phuentsholing Thromde or Municapility and lies less than 1km from the Indo-Bhutan border. Of the total 3.3km road length, about a third or 1.1km is bounded on the west by the aquatic environment of the Amochhu river. The aquatic environment of the Amochhu river is considered a critical habitat for the survival of the endangered Golden Masheer (*Tor putitora*). Project Category.

27. Project categorization has been done using Rapid Environment Assessment (REA) checklist of ADB for roads and highways based on feasibility study findings and initial consultations with key stakeholders. The road component is classified as environmental category B. The scope includes the construction of a 3.3km embankment national highway, river training and erosion control, and material borrowing. The road alignment is within the 21m road corridor bordering the Amochhu Land Reclamation Township Project (ALRTP) of the Druk Holdings, Inc. (DHI) and the Phuentsholing Thromde's Amochhu Local Area Plan (LAP) developments. No land acquisition is required. The project road and the borrow area including the haul roads do not pass through or located nearby any wildlife sanctuary, national park, protected area network, archeological monument/heritage sites or any other similar eco-sensitive areas. As the road alignment is mostly along the dry river bed of the Amochhu and no tree cutting is required. However, a limited number of trees will be cleared in the borrow area. No diversion of water or constriction of flow will be caused by the project and therefore protecting the hydrology of the Amochhu River.

28. The trade facilitation component being limited to procurement of equipment and training of personnel is classified as environmental category C and no EMP is prepared in this environmental examination. However, the mitigation measures prepared in the Alay Land Customs Station and Phuenstholing Mini-Dry Port remain applicable for this project component. Most important of the mitigation measures is the need to for "capacity building for the Alay Land Custom Station to improve identification skills on species, trophies, and parts to customs officials and police force. The project, through its CSC wildlife specialist, will coordinate with entities involve in the controlling the illegal trade of wildlife and poaching like the CITES- South Asia Wildlife Enforcement Network and the RGoB Ministry of Agriculture, Nature and Conservation Division. The coordination will have an end view of harmonizing monitoring and inspection protocols and sharing of intelligence information for interdiction of wildlife trade across the Bhutan."

29. As per Environmental Assessment Act 2000 and Regulation for the Environmental Clearance of Projects 2002 the project needs to secure two environmental clearances for the construction of a new embankment road and for the borrow area operation.

## B. Traffic

30. Currently, the major traffic flows to the Project area is between Phuentsholing- Jaigaon, Samtse-West Bengal, and Phuenstholing - Pasaka. Existing daily traffic between Phuentsholing and Jaigaon is about 10,000 vehicles and 47,000 vehicle passengers and pedestrians. At the Samtse border post there are 1,500 vehicles and more than 3,000 passengers a day traveling between Samtse and the North of West Bengal, mostly to the close town of Chamurchi. Other important flows are Phuentsholing on one side and Pasakha area, Gedu, Thimphu, the north of West Bengal, and the State of Sikkim.

31. Once the project is completed, potential traffic diversion is generated between Samtse and Phuentsholing and between Gomtu and Phuentsholing mainly due to shorter travel time than the existing route through India. Another advantage of moving within Bhutan is that it avoids the frequent strikes and demonstrations occurring in border and dispensing with the need for Escort of Indian Army in remote area, in particular through Assam. Potential diverted traffic largely from NH31 of India at present is estimated at 402 vehicles per day of which 85% will come from Samtse. Through the project road, Gomtu will have direct access to the Penden Cement Factory in Pugli industrial area.[3]

32. Induced traffic due to lower travel costs offered by the new itinerary through Bhutan compared to existing India route is estimated to reduce vehicle operating costs (VOC) by 20% reckoned against Samtse-Chamkuna route. This translates to an increase in daily traffic of 68 vehicles of which 35 are cars/SUVs. No induced traffic is expected to originate from Gomtu to Phuentsholing as this route passes through mountainous terrain.

33. The existing local traffic along the project road is estimated at 1,617 vehicles/day comprised mostly of 577 car/LCV, 369 LCV, and 354 2-axle. Existing traffic along the Chamkuna road comes from the warehousing and scrap yard activities in the form of temporary industrial sheds. Two significant developments will increase local traffic when the local area plans (LAP) of Amochhu and Toorsa Tar, and Amochhu Land Reclamation and Township Project are implemented.

34. With following traffic baseline and using published GDP[4] and population[5] growth rates, and adopted passenger vehicle and freight vehicle growth rates from the RNP II, the succeeding Table 1 presents the projected traffic over the PCR.

**Table 1: Projected Traffic for the Phuenthsoling-Chamkuna Road**

| Year | 2W | Car/SUV | Minibus | Bus | LCV | 2-Axle | 3-Axle | MAV | Total |
|---|---|---|---|---|---|---|---|---|---|
| 2015 | 257 | 557 | 23 | 1 | 369 | 354 | 42 | 16 | 1,617 |
| 2020 | 1,364 | 1,984 | 15 | 1 | 482 | 177 | 21 | 8 | 4,052 |
| 2025 | 3,138 | 5,057 | 64 | 113 | 951 | 143 | 12 | - | 9,477 |
| 2030 | 4,461 | 7,273 | 97 | 173 | 1,335 | 191 | 16 | - | 13,546 |
| 2035 | 4,846 | 8,268 | 132 | 245 | 1,494 | 241 | 20 | - | 15,247 |
| 2040 | 5,231 | 9,275 | 169 | 317 | 1,649 | 288 | 24 | - | 16,953 |
| 2045 | 5,245 | 9,692 | 198 | 378 | 1,699 | 324 | 27 | - | 17,565 |
| 2050 | 5,262 | 10,190 | 233 | 451 | 1,756 | 365 | 31 | - | 18,288 |

[3] However, the diversion of traffic will only take place under the following premises: i) the existing Samtse-Chamkuna road should be maintained and missing asphalted sections should be completed; ii) Through traffic further to the east of Bhutan will be possible if the missing links of the Southern East-west highway missing links are built; iii) Industrial zone of Gomtu/Pugli is still isolated and a link connecting this area to the road from Samtse to Chamkuna, through a connection in Halhalay should be completed by DOR.

[4] 7% from 2010-2014 and 8.4% from 2014-2020 to taper to 2% by 2040

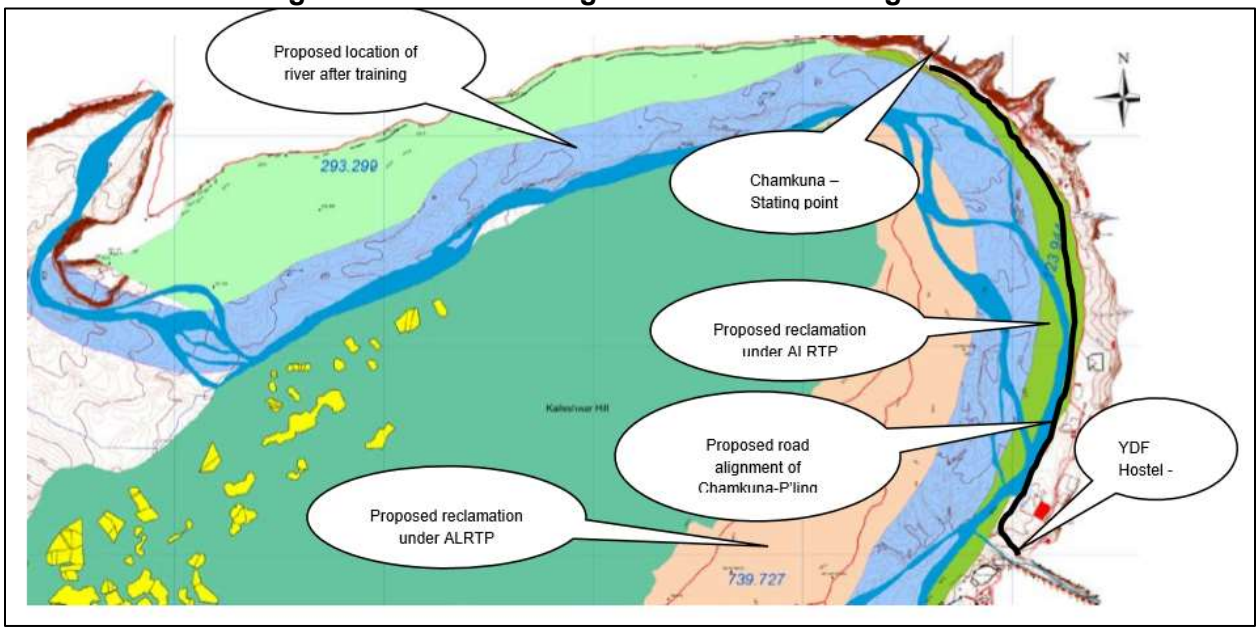
[5] 1.7% from 2010-2014 and 1.6% from 2014-2020

## C. Phuentsholing-Chamkuna Road (PCR) Project Component

35. The road component consist of developing the 3.3 km embankment road section between Phuentsholing-Chamkuna Road (PCR) will be constructed along the right bank of the Amochhu River (see Figure 1) and complies with Bhutan's Primary National Highway Standard with the following specifications:

a) Design speed: 50 kph
b) Road formation: 10.5m
c) Vertical gradient: 0.2-1.8%
d) Carriage width: 7.5m
e) Cross slope of carriageway: 2.5% in both directions
f) Road side covered drains: 1.5m both sides also as footpath

**Figure 1: Phuentsholing-Chamkuna Road Alignment**




36. The pavement structure of the embankment road is 575mm thick consist of 50mm asphalt concrete (AC), 70mm dense bitumen macadam (DBM), 265mm wet mix macadam (WMM), and 190m granular sub-base (GSB), 15 years life for California Bearing Ratio (CBR) value of 7 million standard axle (msa). Drainage structures consist of five PSC bridges with spans ranging from 18- 30 m and eight box culverts of 5 m span each.

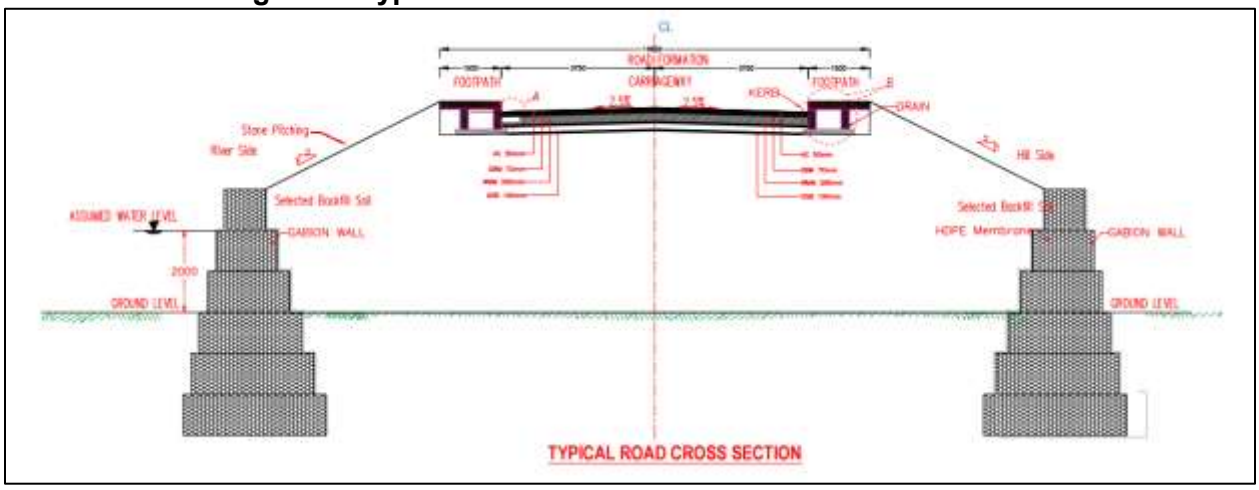
## D. Erosion and Flood Control

37. Three sets of erosion and flood control systems were integrated in the PCR design; first set involves armouring and properly founding the embankment road, second involves river training to maintain safe distance separation of the main Amouchu channel from the embankment road, and the third set manages the surface runoff laden with sediment and boulders from the hill side east of the embankment road and providing adequate conveyance structure across the road to allow safe passage water towards the Amochhu river.

38. Wire meshed baskets filled with small boulders or gabions will be constructed as foundation of the PCR embankment. The gabion bottom will be deeper than the expected

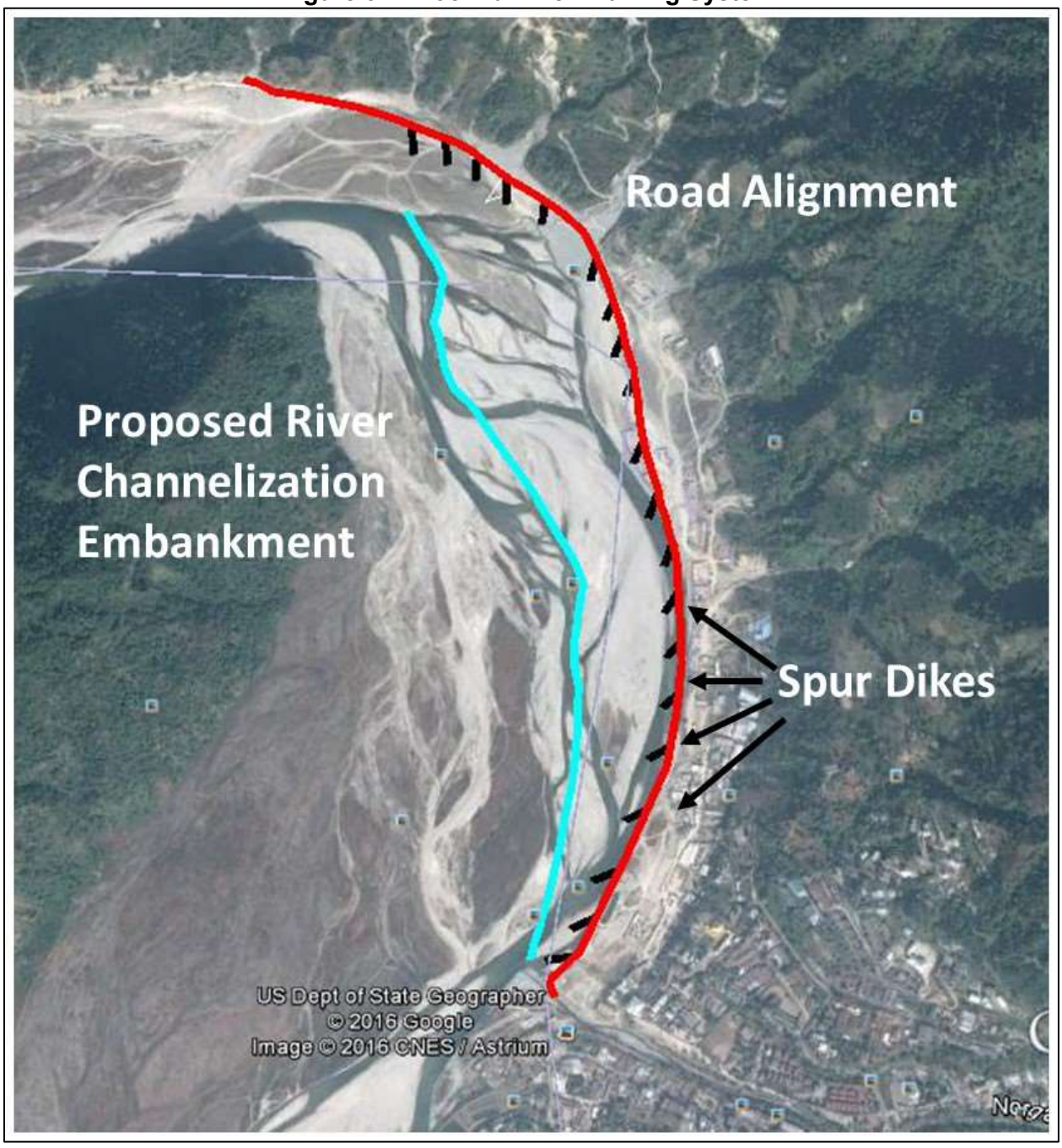
maximum scour depth of the Amochhu River and jutting above the soil surface by at least 2 meters estimated high flow level with freeboard provisions. This arrangement provides adequate toe and flank protection against sustained shear-stress of the Amochhu and foundation stability since the project site has poor load bearing capacity sandy soil. A high-density polyethylene (HDPE) behind and under the gabion baskets to envelop the fill to prevent the movement of soil material through the gabion baskets is part of the embankment road design. The toe and wall gabion is not expected to offer 100% protection from damage against in-stream debris including moving boulders and large woody or sharp objects which tends to harm the wire mesh by impact and scour. In this regard, constant repair is needed and river training to provide distance separation from the Amochhu main channel and avoid or minimize impacts from large woody debris and sharp objects.

**Figure 2: Typical Cross-section of the Embankment Road**




39. The river training has two major components, rechanneling the braided meandering Amochhu into a single channel and away from the PCR embankment, and the construction of spur dikes. During the initial year of construction and Amochhu low flow periods, temporary embankment will be constructed from riverbed dredged materials in order to concentrate minor streams into a single channel. A concentrated river flow will possess higher velocity and promote scouring of river bed into an alignment farther from the road embankment. Elongated gabion walls having one end on the road embankment and the other projecting into the high flood level (HFL) current, called spur dikes, will be constructed along the entire length of the project road. These semi-permanent structures angled downstream will reduce the current along the road embankment, reduce the erosive capability of the Amochhu flood flows, induce sedimentation in between the spurs, and offer protection against woody debris and sharp objection from cutting through the road gabion toe and foundation. Figure 3 illustrates this scheme.

**Figure 3: Amochhu River Training System**




40. The last component of the project's erosion and flood control system deals with the rivers and streams emanating from the hill side on the eastern Amochhu river bank passing through PCR before finally merging with the Amochhu River. A total of 5 bridges and 8 culverts will be installed across the PCR to ensure the surface runoff are collected and diverted towards these structures with reduced sediment load and velocity. A series of gabions, PCC curtain walls, and check dams will be constructed immediately upstream of the bridges and culverts.

## E. Construction Materials

41. Preliminary estimate indicated the embankment road construction will require 307,844 m3 of sand, aggregate, boulders and soil to be sources mostly within the immediate confines of the project area to minimize haulage costs. The final material sources and quantities will be determined in the during detail study stage.

## F. Borrow Area

42. A key component of the embankment road construction is the sourcing and transport of a substantial amount of suitable fill materials. An estimated 307,844 $m^3$ will be required to construct an embankment road by an average of 4m from the current river bed level.

43. A borrow area has been identified for the extraction of fill material located at Bagultar under Khenpagaon village, about 16 kms north of the Chamkuna SEWH project take-off. The area identified is comparatively gentle with side slope ranging between 20-35%. It is covered with regenerated forest of Chilaune (*Schima wallichii*) as predominant tree species. There are 8 large trees in the prospective borrow aite: 2 Angeri (*Lyonia ovalifolia*); 3 Chilaune (*Schima wallichii*); 1 Maylaunney; and 2 Nos of Lakhuri. There are no permanent streams or water bodies in the area except for a small dry creek which flows only during rainy season.

44. In the immediate upslope of the proposed borrow area lies a cardamom plantation belonging to a private individual of Khempagaon village. It was also learnt that the proposed borrow and the adjacent areas at Bagultar has been earmarked by Tading Gewog and Samtse Dzongkhag Administration as resettlement area for the affected persons of the Proposed Amochhu Hydropower Project. The consultation with the Gewog Administration confirmed the area as designated resettlement area for Amochhu Hydropower Project.

45. Haul road passes through settled areas of Khempagaon, Rangteykhey, and Tapa villages. The only known sensitive receptor in the area – Tapa Dramtoe Lower Secondary School located 5km from Amochhu Bridge towards Khempagaon village. The school which is situated at an elevation of 612masl and it is approximately 280m aerial distance from the haul road head (469masl). Given the separation distance, the materials hauling activites on unpaved roads will not deteriorate the air quality surround the school and no adverse impacts pertaining to noise and dust are expected.

## G. Project Cost

46. The cost of civil works including maintenance amounts to about Nu.1,032 million for 3.3 km elevated Road construction based on 2015 prices.

**Figure 4: Location of Proposed Borrow Area and Distance from the Project Road**

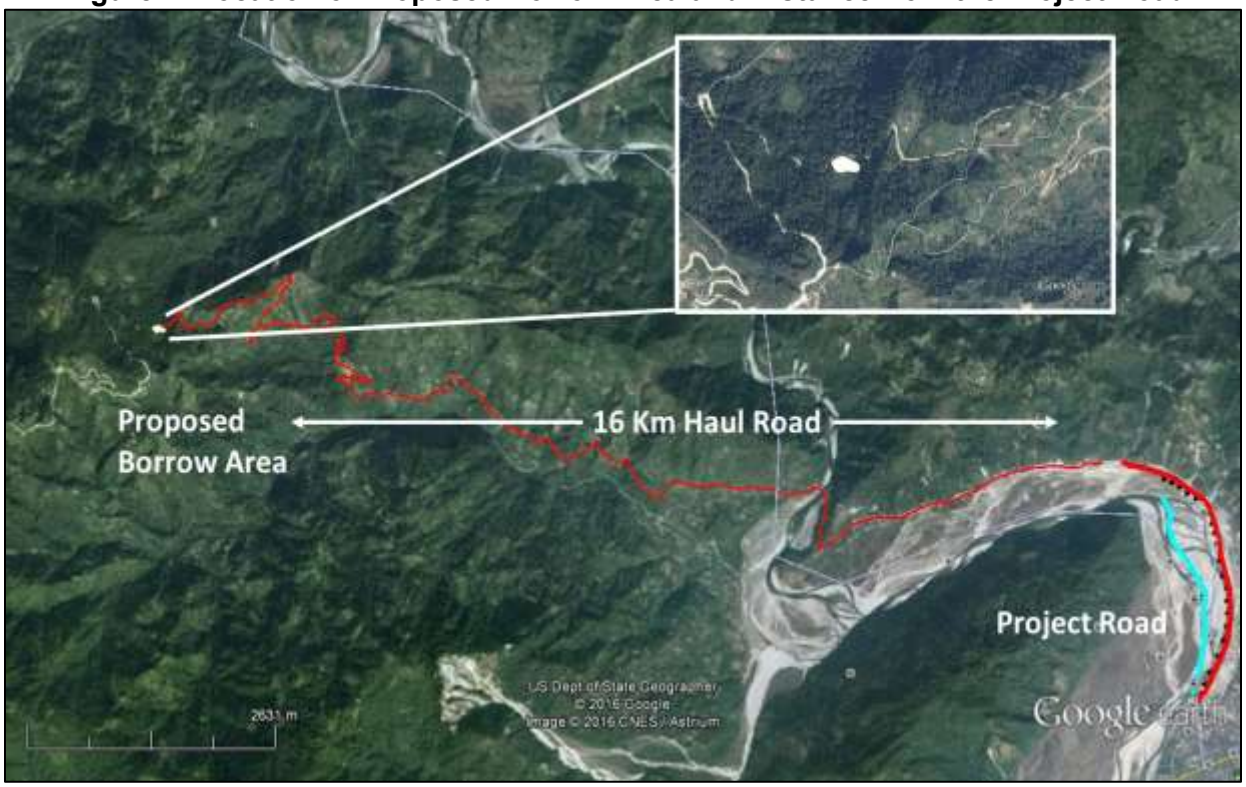
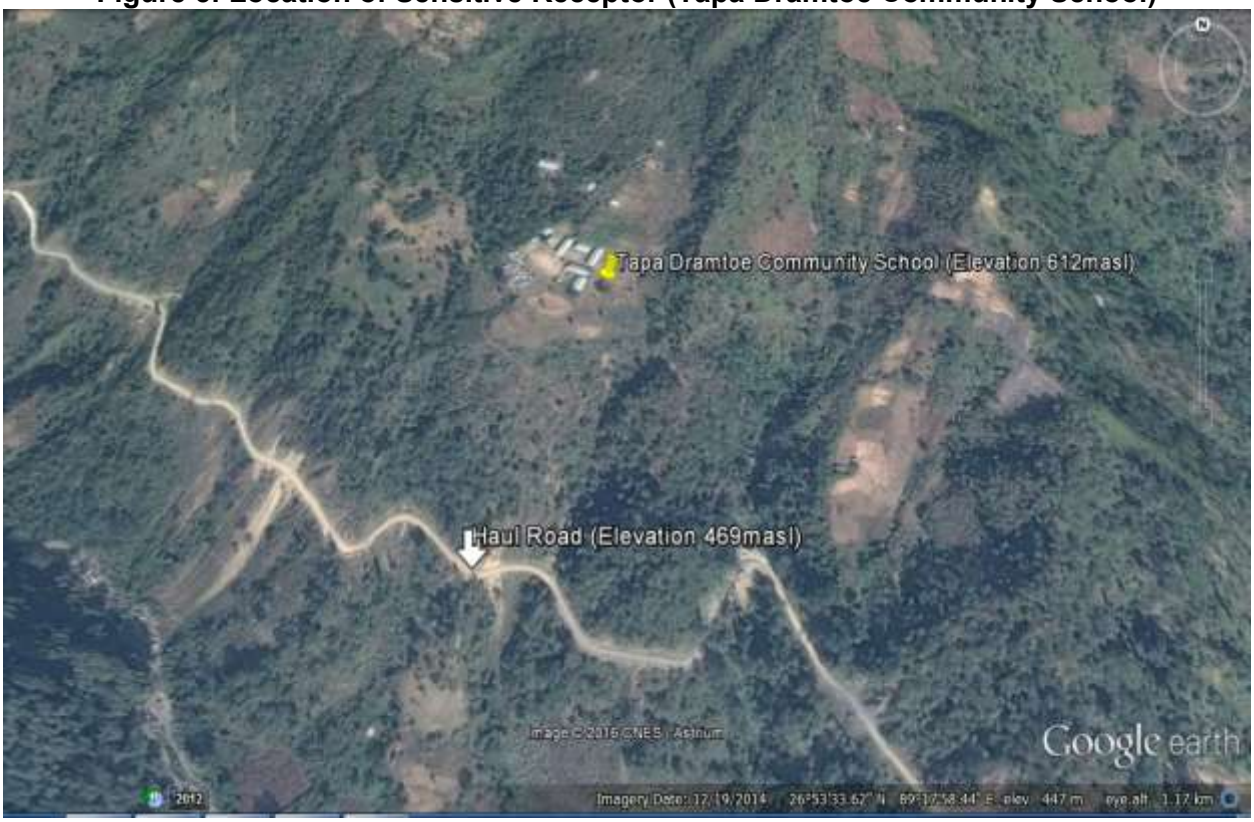



**Figure 5: Location of Sensitive Receptor (Tapa Dramtoe Community School)**



## H. Construction Packaging and Implementation Schedule

47. It is proposed to carry out construction of the elevated road section under one package with a time period of 48 months. The Project is proposed to be undertaken through International Competitive Bidding (ICB). Currently the project is at preparation stage, detailed design and bidding and scheduled to award contract in the last quarter of 2017. The project is expected to complete in last quarter of 2021.

# III. POLICY, LEGAL, AND INSTITUTIONAL FRAMEWORK

## A. Environmental Policy Framework

48. Bhutan is party to twelve multilateral environmental agreements including those on biodiversity, climate change-Kyoto protocol, desertification, endangered species and hazardous wastes. Those with particular relevance to the sub project include: i) UN Framework Convention on Climate Change signed on 11 June 1992 and ratified on 25 August 1995, and ii) Kyoto Protocol to the United Nations Framework Convention on Climate Change. Instrument of accession signed on 26 August 2002, and a member after Kyoto came into force from 2005. Road construction and subsequent operation are not carbon neutral, contributing to a small overall increase in continuous $CO_2$ emissions due to construction vehicular use. However there will be no carbon release due to removal of biomass in road right-of-ways of the road since there is no forest or vegetation.

49. UN Convention on Biological Diversity signed 11 June 1992 and ratified 25 August 1995. Project will have adverse impacts aquatic biodiversity of Amochhu River which is a natural habitat of the Golden Masheer (Tor putiora), an engangered species in the IUCN red list.

## B. ADB's Safeguard Policy Statement (2009)

50. ADB policy requires that an Initial Environmental Examination (IEE) Report be prepared by the borrower in accordance with ADB EA requirements and that loans or grants are classified according to their potential impact on the environment. Since the proposed Project is to construct 3.3km of road within extended municipal area with no sensitive biodiversity area, the sub project is classified as Environmental Category B project. Accordingly, the IEE study was carried out in accordance Safeguard Policy State (2009) which is similar to that of RGOB's EIA guideline for the road and highway project.

51. ADB requires all borrowers to assess the significance of of the project impacts on biodiversity as part of the environmental assessment. The SPS requires that no project activity is allowed inside critical habitats unless:

- there are no measurable adverse impacts, or likelihood of such, on the critical habitat that could impair its high biodiversity value or ability to function;
- the project is not anticipated to lead to a reduction in the population of any recognized endangered or critically endangered species, or a loss in the area of the habitat concerned such that the persistence of a viable and representative host ecosystem will be compromised; and
- any lesser impacts are mitigated to achieve at least no net loss of biodiversity.

## C. RGoB's Environmental Protection Legislation

52. Bhutan has well defined institutional and legislative framework for the protection of environment encompassing air; water; noise; flora and fauna; biodiversity, sensitive habitats and other natural resources. The description of relevant legislations and regulations are provided in the following sections while the table 5 summarizes the applicable ones.

53. **National Environmental Protection Act:** This act came into force on 31st July 2007 and provided the establishment of an effective system to conserve and protect environment through the National Environment Commission (NEC), designation of competent authorities and

constitution of other advisory committees, to independently regulate and promote sustainable development in an equitable manner. The act empowers NEC as an independent authority and the highest decision making body on all matters relating to the environment and its management in the country. The commission shall exercise the jurisdiction and powers and discharge the functions and duties conferred or imposed by or under this Act.

54. **Environmental Assessment Act 2000:** The Royal Government of Bhutan has in place detailed policies regarding environmental assessment that are founded in the Environmental Assessment Act (2000). The National Environmental Commission (NEC) through its Secretariat is empowered to implement the EA Act, which sets out the guidelines for obtaining an environmental clearance (EC) for a project. Article 9 states that if the activity is going to be implemented by a Competent Authority (CA), the application for Environmental Clearance (EC) is to be forwarded to the NEC for approval. The application for an EC must include a description of potential environmental effects. The Secretariat of the NEC determines if the information provided is sufficient to identify effects, and if not the Secretariat can request that environmental assessment documents be prepared, following approved terms of reference. Additional information may be required by the NEC Secretariat if the EIA is considered incomplete. The EC is issued when the Secretariat is satisfied that: a) effects are foreseeable and acceptable, b) the applicant is capable of carrying out the terms of the EC, c) the Project is seen to contribute to sustainable development of the country, d) the interests of concerned people have been taken into account, and e) the project is consistent with the Nation's environmental commitments. Once a decision is made, the environmental terms, description of mitigation measures and non-technical summary of the EC are made available to the public. The Secretariat also controls and monitors compliance with the terms of the EC (Art. 34.2). The EA Act provides right of access to work sites for monitoring and penalty provisions in cases of offense under the Act, including providing false information, denying access and other infractions.(Art. 49). The EA Act contains rules for appeals, dispute resolution, and other provisions.

55. **Regulation for the Environmental Clearance of Projects 2001:** The Regulation for the Environmental Clearance of Projects (February 2001) provides further information to supplement the EA Act. Upon receipt of the application for the EC a total period of 1 -3 months will be taken by NEC for issuing the EC. Official clearance from other concerned agencies is required for Projects within sensitive areas (Art. 17). Only upon receipt of all other clearances and No Objection Statements will the EC be issued. The EC is valid for a period of five years or less, but may be renewed in cases where the Project is in compliance with the EC. Minimum requirements for public consultation are set forth in Section 31 of the Regulation. These include written notice to local communities, newspaper notices, facilitation of consultation, and provision of a minimum period of time for the public to comment on the EIA. The Regulation specifies that the EC will contain binding mitigation and compliance measures and appropriate means for monitoring, recordkeeping and reporting. The EC Regulation sets out requirements and formats that are similar to those of ADB.

56. The Regulation requires that environmental units be established in agencies and projects, and while there is an Environment Unit within the Department of Roads [5], it is not fully empowered. Staff who received training is no longer with the unit. Current staffing of the EU includes one active personnel and the unit has difficulty in contributing to field activities.

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required for Projects within sensitive areas (Art. 17). Only upon receipt of all other clearances and No Objection Certificates as given in table 4 will the EC be issued. The EC is valid for a period of five years or less, but may be renewed in cases where the Project is in compliance with the EC. Minimum requirements for public consultation are set forth in Section 31 of the Regulation. These include written notice to local communities, newspaper notices, facilitation of consultation, and provision of a minimum period of time for the public to comment on the EIA. The Regulation specifies that the EC will contain binding mitigation and compliance measures and appropriate means for monitoring, recordkeeping and reporting. The EC Regulation sets out requirements and formats that are similar to those of ADB.

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59. **Waste Prevention and Management Regulation 2012** is adopted under section 53 of the Waste Prevention and Management Act, 2009. The Act defied the roles and areas of implementation of the implementing agencies for the purpose of establishing a sound waste management system including monitoring procedures at every organization level, through efficient collection, segregation, treatment, storage, transportation, reduction, reuse, recycling and safe disposal of solid, liquid and gaseous wastes. It also provides control and prohibit illegal dumping or releasing of waste into the environment. The act also provided the requirements for the management of hazardous wastes to include: labeling, pre-treatment process, storage, record keeping, transportation, and disposal of hazardous waste by the generator. Sanctions and penalties are provided for non-compliance.

60. **Forest and Nature Conservation Act (FNCA), 1995:** The Forest and Nature Conservation Act (FNCA), 1995 includes policies for activities that are prohibited in forested areas and stipulates activities that need special permits from the Department of Forests and Park Services. It describes the types of activities such as forest clearing, tree felling, hunting and polluting that are not allowed in Government Reserved Forests. All wild animals whether enlisted under Schedule I (totally protected species) or not, cannot be killed, injured, captured or collected unless under special conditions of self-protection and other genuine reasons.

61. **Forest and Nature Conservation Rules 2006:** Further to the FNCA, the Forest and Nature Conservation Rules of Bhutan updated in 2006 provides rules for many of the activities that will be undertaken in the project, such as clearing and felling of trees, blasting and others. The Act describes activities that are prohibited and restricted in forested areas and outlines procedures for sourcing stone, sand, gravel, rock, peat and surface soil from forested areas. Biodiversity protection provides an additional framework within which the Project must develop due to the presence of national parks and wildlife sanctuaries within range of the project area. Management areas were also established under the act to enable protection of the rich biodiversity resource of the region.

62. **Biological Corridor Rules 2007:** Biological corridor (BC) rules have been promulgated in July 2007 as an addendum to Forest and Nature Conservation Rules 2006. “Biological Corridor” means an area set aside to connect one or more protected areas, which shall be conserved and managed for the safe movement of wildlife. BC is managed centrally by the

[6] The Unit was established in 2007 during implementation of the Rural Access Project funded by World Bank.

Department of Forest and Park Services (DOFPS). Any form of construction activities are prohibited inside the BC except with a written permit or authorization from the Department based on technical regulation. Any person who, within a Biological Corridor conducts any activity undertaken in contravention of prohibitions listed shall be guilty of an offense punishable under these Rules.

63. **The Local Government Act of Bhutan, 2007:** On enactment of this Act, the Dzongkhag Yargay Tshogdu Chathrim, 2002, the Geogs Yargay Tshogchhung Chathrim, 2002, and the Bhutan Municipal Act, 1999, shall be amended as per the articles of the Local Governments' Act of Bhutan 2007. Till the amendment of Dzongkhag and Geog Yargay chathrims, the environmental provisions of chathrims will remain valid and these are explained in following section.

64. **Dzongkhag Yargay Tshogchung Chatrims and Geog Yargay Tshogchung 2002:** The Chathrims were enacted to support the decentralization policy and empower locally elected community bodies (DYTs and GYTs) with the authority and responsibility to decide, plan and implement development programmes and activities, including those concerning environmental management. Powers and functions vested in the DYTs and GYTs in relation to environmental management are specified below. The DYT has the power and function to: promote awareness and dissemination of national objectives; adopt procedures and rules to implement national laws, wherever relevant; and make recommendations on activities with major environmental impacts such as construction of roads, extraction and conservation of forests, mining and quarrying. They also have jurisdiction among others, over i) designation and protection of areas of special scenic beauty or biodiversity, such as dzongkhag parks and sanctuaries; control of noise pollution; establishment of quarries and mines; and protection of public health as per prevailing national guidelines or Acts (section 14).

65. **Rules and Regulation on Explosives:** As the project will require huge quantity of explosives this rules and regulations is very important particularly pertaining to import, transportation and handling of explosives. The Department of Law and Order under the Ministry of Home and Cultural Affairs is the custodian of this Rule and Regulation.

66. General Rules and Regulations on Occupational Health and Safety (OHS) in Construction, Manufacturing, Mining and Service Industries 2006: The purpose of the OHS Rules and Regulations is to assure safe and healthful working conditions for working men and women as well as other persons present at workplaces from work related risks to their health, safety, and well-being. The Rules shall apply to all employers and workers (both Bhutanese and non-Bhutanese) of licensed manufacturing, mining and service enterprise, constructions, body corporate incorporated under the Companies Act 2000 of the Kingdom of Bhutan, and any other agency employing large number of workers at the work site(s). Annexure II describes Minimum Safety Standards for the Construction Industry. This includes personal protective and life-saving equipment, fire protection hand and power tools, signs, signals & barricades, Material handling, storage, use and disposal, Scaffolds, Excavations, Electrical works, Sanitation and Hygiene.

67. **Mines and Minerals Act 1995:** The Mines and Minerals Management Act 1995, provides framework for exploring mineral resources in the country. This also complements the EA Act 2000 as it has provisions for environmental requirements. This Act requires the project to seek site clearance for sand and stone quarrying needed for the road construction.

68. **Golden Masheer (Tor putitora) Conservation Program.** The RGoB, through its National Center for Aquaculture is establishing its Golden Masheer Conservatin program in

recognition to the dwindling population due to overfishing and habitat loss. In Bhutan, Golden Masheer are mostly found in n Punatshang-chhu in Punakha-Wangduephodrang-Dagana region, Mangde-chhu in Trongsa-Zhemgang region, and Sarpang-chhu, Mou-chhu, Bhur-chhu, Phibsoo-chhu, Taklai-chhu and Kanimakara-chhu in Sarpang region. The Center collects masher fingerlings and breeding them on ponds and as of March 2016 more than 20,000 fingerlings have been released to the said rivers. Last year, the Fisheries Conservation Foundation has partnered with the World Wild Life Fund (WWF), Bhutan and the Ministry of Agriculture and Forestry to trace the spawning migration movement of the Golden Masheer through radio telemetry. Information gathered about the Masheer's life history will be important towards effective conservation and formulation of management plans.

**Table 2: Summary of Environment and other applicable legislation and guidelines**

| Legislation | Key Requirement | Applicability | | Reasons for Applicability |
|---|---|---|---|---|
| | | Construction | Operation | |
| National Environment Protection Act (NEPA) 2007 | NEPA in its preamble states that Bhutan shall adhere to the principles of sustainable development and respect international environmental laws such as UFCC & UNCBD | Applicable | Applicable | There will be greenhouse gas emission as a result of one time removal of biomass for road construction and by operation of construction equipment; and also due to subsequent vehicular operation |
| Environment Assessment Act, 2000 | Act requires the competent authority (CA) (DOR/MoWHS) to prepare EIA report as per the approved terms of reference | Applicable | Applicable | The project road require environmental Clarence as it entails construction of new road (primary national highway) of 3.3km within extended municipality boundary Phuentsholing City. |
| Regulation for Environment Clearance of Projects (RECOP) 2002 and Guideline for Application for Environmental Clearance for Highways and Roads, 2004 | Minimum public consultation requirement set.<br><br>Affected communities or stakeholders have to be informed through written notice or newspaper. | Applicable | Not-Applicable | PCR passes close Amochhu settlement. |
| Strategy for air quality assessment and management in Bhutan, 2010 | Baseline ambient quality of the all sensitive areas such as settlements and critical habitat areas has to be determined for future air quality monitoring. Baseline air quality will be assessed prior to the start of construction works. | Applicable | Applicable | Road construction is expected to cause air pollution mainly due to construction generated dust and emissions from operation of construction equipment.<br><br>Although minimal, some air pollution is also expected to occur during operation of road. |
| Waste Prevention and Management | To protect human health through protection of | Applicable | Applicable | Road construction will generate huge amount of spoil |

| Legislation | Key Requirement | Applicability | | Reasons for Applicability |
|---|---|---|---|---|
| | | Construction | Operation | |
| Act of Bhutan, 2009 | environment with proper handling, storage and disposal of hazardous and non-hazardous wastes | | | which will need to be disposed of safely to prevent downstream water pollution and siltation. Construction works also expected to generate other solid (municipal waste) and hazardous liquid waste. Hazardous waste such spent oils will have to stored and recycled wherever feasible.<br><br>During operation, there are chances of spilling both hazardous and non-hazardous waste during transportation. |
| Waste Prevention and Management Regulation of Bhutan, 2012 | Regulation prohibits illegal dumping or releasing of waste into the environment.<br><br>Any organization or persons will be prohibited from disposing waste in manners other than as prescribed by this regulation. | Applicable | Applicable | Road construction will generate minmal amount of spoil as most of the dredged materials will be used as fill material for the embankment of river re-channeling. Construction works also expected to generate other solid (municipal waste) and hazardous liquid waste. Hazardous waste such spent oils will have to stored and recycled wherever feasible.<br><br>During operation, there are chances of spilling both hazardous and non-hazardous waste during transportation. |
| Forest and Nature Conservation Act (FNCA) 1995<br>Forest and Nature Conservation Rules (FNCR) 2006 Rules on Biological Corridor 2007 | FNCA and its regulations require the proponent to process and seek the forestry clearance prior to the start construction.<br>FNCR rule 9 (2.9) sets out the procedure for tree felling. Only the marked trees within the prescribed construction corridor can be felled.<br>FNCR strictly prohibits killing, injuring, destroying, capturing or collecting of wildlife.<br><br>Schedule I provides the totally protected wildlife of Bhutan. | Applicable | Not Applicable | Proponent will have to process for the forestry clearance or permit for the construction of road through biological and government reserved forest.<br>Project will require tree felling which needs to be carried out as per FNCR rules.<br><br>PCR passes along the bank of Amochhu River which has harbours golden masher *(Tor putitora)* protected under Schedule I of FNCA, and listed as endangered under IUCN red list. |

| Legislation | Key Requirement | Applicability | | Reasons for Applicability |
|---|---|---|---|---|
| | | Construction | Operation | |
| Land Act 1979 (amended 2007) Land Compensation Rate 2009 | Act requires any land acquisition whether public or private to be done as per the established procedure.<br><br>For private land acquisition, the number of affected families' needs to be identified. Resettlement plan and compensation have to be worked out.<br><br>Act also requires Government to provide land substitution instead of cash compensation while acquiring land. Allotment of all substitute land shall be from the same Dzongkhag.<br><br>For structural acquisition, compensation has to be carried out by qualified engineer.<br><br>Land compensation Rate 2009 will govern the compensation of land and structures. | Not Applicable | Not-Applicable | No land acquisition is required for this Project. |
| The Local Government Act of Bhutan, 2007, Dzongkhag Yargay Tshogchung Chatrims Geog Yargay Tshogchung 2002 | Local government Act and the chathrims provide local governments with following power:<br>To provide No-objection Certificate or clearance for projects<br>Monitor developmental activities such as road construction and their impacts on the communities and environment<br><br>Enforce regulation of protection of monuments and sites of cultural and historical | Applicable | Applicable | Project falls within Phuentsholing Thromde/ Municipality, which has power to provide administrative clearance for the projects that fall within their administrative boundary.<br><br>Road construction activities will be monitored by Thromde authorities.<br><br>The construction activities will generate waste particularly excavated material.<br><br>Thromde will be involved in identifying and approval of identified disposal sites prior to construction. |

| Legislation | Key Requirement | Applicability | | Reasons for Applicability |
|---|---|---|---|---|
| | | Construction | Operation | |
| | interest<br><br>Enforce 50feet ROW[7] regulations which prohibits the construction any unauthorized structures within ROW<br><br>Enforce waste management regulations<br>Protection of water sources and other water bodies within their jurisdiction | | | Thromde will be granted the clearance for the use of construction water from Amochhu and drinking supply for the labourers from its ground water sources. |
| General Rules and Regulations on Occupational Health And Safety (OHS) in Construction, Manufacturing, Mining and Service Industries 2006 | OHS Rule prescribes the minimum safety standards to be followed for the construction works. This includes personal protective and lifesaving equipments, fire protection hand and power tools, signs, signals & barricades, Material handling, storage, use and disposal, Scaffolds, Excavations, Electrical works, Sanitation and Hygiene. | Applicable | Applicable | During construction, project will employ large number of workers who will be working in hazardous condition. The OHS rules will have to be strictly implemented to minimize health and life risk associated while constructing road through hazardous condition.<br>During operational period, safety of road maintenance workers will have to be ensured through provision of OHS rule. |

[7] ROW – Right of Way is 50 feet either side from the road center line.

# IV. PUBLIC CONSULTATION AND INFORMATION DISCLOSURE

## A. Meaningful consultation

69. Meaningful consultations were carried out during feasibility study, preliminary/design, and IEE preparations. All the five principles of information dissemination, information solicitation, integration, co-ordination, and engagement into dialogue were incorporated in the consultation process. A framework of mitigating different environmental impacts likely from the project was strengthened and modified based on opinions of all those consulted, especially at the micro level by setting up a dialogue with the village people from whom information on site facts and prevailing conditions were collected. This will be continued during detailed design and implementation of the project by implementing NGOs and through grievance redress mechanism.

## B. Objectives of the Public Consultations

70. Public consultations were held to allow the incorporation of relevant views of the stakeholders in the feasibility study, mitigation measures, implementation issues, and improve coordination of plans particularly between the DHI, Phuentsholing Thromde, and DOR which are planning and implementing sectoral and land use projects. Stakeholder's consultations were held with intent to understand their concerns, apprehensions, overall opinion and solicit recommendations to improve project design and implementation. Informal meetings, interviews were organized covering the entire project design stage. Consultations provide affected public a platform to ensure incorporation of their concerns in the decision making process and foster co-operation among DOR, the community and the stakeholders to achieve a cordial working relationship for smooth implementation of the project. It inculcates the sense of belongingness in the public about the project.

71. The discussions were designed to receive maximum inputs from the participants regarding their acceptability and environmental concerns arising out of the sub-project. They were given brief outline of the project to which their opinions was sought particularly in identifying and mitigating any potential adverse impact. People affected by the project are those living and working along the corridor and included businessmen, residents, farmers, agricultural workers, squatters and encroachers. Throughout the process of consultation, the focus was on understanding community impacts and to obtain their feedback to effectively establish appropriate road design and implementation.

## C. Methodology Adopted for Public Consultations

### 1. Levels of Public Consultations and Stakeholder Profiles

72. Public consultations were conducted both at screening and project preparation stages. Consultations conducted at screening stage played an important role in scoping the level and extent of consultation to be taken in the project preparation stage. Public consultations have been held at two levels as follows:

73. Local Level: Public consultations in the project area were held at local level. The following steps have been adopted for carrying out public consultations in this project: i) disseminating information and requesting communities to attend the public consultation meeting; ii) sharing the opinions and identify the local environmental issues; and iii) involving the potentially affected persons to avoid/mitigate the impacts.

- **Institutional Level:** Institutional level consultations at Phuentsholing were held with Forest Range Office, Natural Resource Development Corporation Limited (NRDCL), Phuentsholing Thromde, Royal Bhutan Police (RBP), DOR Field Division, Food Corporation of Bhutan, Bhutan Power Corporation Limited (BPCL), Health Information Service Center (HISC).

### 2. Tools for Consultations

74. Public consultation was done using various tools including interviews with government officials, questionnaire based information with stakeholders, discussions with the stakeholders and project affected people:

- **Structured Interviews**: Individual household level surveys were carried out using structured formats as part of census and socio-economic surveys.
- **Individual Stakeholder Meetings (or Informal discussion**): A reconnaissance survey was carried out at the initiation of the project, informally drawing project affected people (AP) into dialogue to obtain an overview of likely impacts and concerns of the community. The key informants during the project preparation phase included both individuals and groups namely: i) Head and members of the households likely to be affected, ii) Community of Chamkuna Baidungtar village, iii) Residential and Commercial stakeholders of Phuentsholing Thromde, iv) Phuetsholing Thromde Officials, v) NRDCL officials, vi) BPCL, vii) FCB official, viii) HISC official ix) RBP, x) Range Office, Department of Forest and Park Services, and xi) Other project stakeholders with special focus on women and people belonging to the vulnerable group.
- **Focus Group Discussion**: Focus Group Discussions (FGD) were held at Chamkuna Baidungtar village on September 1, 2015 and at Phuentsholing Thromde with on March 22, 2016. During the FGD, interaction/discussions were held with the Thromde Communities and Chamkuna villagers. FGDs were jointly carried out environmental and Social safeguard specialist.

## D. Public Consultation and Involvements

75. The public consultation process has commenced in the initial feasibility stages (prior to construction) in order to disclose the project information to the stakeholders and record feedback regarding the proposed Project and preferences. The following processes were employed to gather public opinions, feedbacks and recommendations:

### 1. Phuentsholing Municipal/Thromde Official Meeting

76. Several rounds of meetings were held with Phuentsholing Thromde officials regarding the proposed Phuentsholing – Chamkuna road to be constructed through the Phuentsholing Thromde/Municipality. First meeting was held on 10.08.2015 between Social Safeguard and Environmental Specialists and the Thromde officials (which included the Executive Secretary, Principal Engineer, and Chief Planning Officer) at the office of Executive Secretary. The main purpose of the meeting of was to inform the Thromde of the IEE study of the proposed project. The study team (Social & Environmental Specialist) requested for Thromde's permission to carry out the IEE, and Social/Resettlement studies within Phuentsholing City. Consequently, the team was authorized to conduct the study.

77. Second meeting was held on 19.08.2015 with the Chief Planning Officer, Deputy Chief Planning Officers and Urban Planner of the Thromde regarding the road alignment options. It was learnt that since the hill alignment (the earliest alignment proposed by Thromde and the DOR) had high social and environmental impacts, the DOR, the Thromde, and the DHI agreed for the lower river bank alignment. Thromde officials explained the importance of River Bank alignment as it is in line with their Amochhu Local Area Plan and the Proposed Road will takeoff from the ongoing Phuentsholing By-pass Road intersection below YDF Center. The By-pass road is also being funded by the ADB. To aid IEE/Social studies, Thromde provided the team with relevant documents, Amochhu Local Area Plan and the cadastral map of the project area.

78. Third meeting held on 12.02.2016 with the Chief Planning Officer and Survey Officer of Thromde regarding the final boundary demarcation between Thromde's Amochhu Local Area Plan (LAP) and the DHI's ALRTP. As the follow up of the Thromde meeting, the joint site visit was carried out on 18.02.2016 by the officials from National Land Commission, Phuentsholing Thromde, DHI along with the Study team. During the site visit, some discrepancies in boundary demarcation were observed. The road ROW which is supposed to be 17m or more was less in some areas. The representative of Thromde and DHI agreed to resolve the boundary and Road ROW issues during the permanent boundary pillar construction with the help of National Land Commission.

**Figure 6: Chamkuna Community Consultation**

**Figure 7: Thromde Community Consultation**

### 2. Focus Group Discussion with People of Chamkuna Byadungtar

79. FGD was conducted at Chamkuna Baidungtar village on 01.09.2015 at Tshogpa's (village head) house. The Chamkuna Baidungtar has 12 households and is located 300m north of Proposed CPR alignment. Of the total households, the representative of 7 households attended the FGD, of which more than half were women attendees. FGD was jointly organized by Social Safeguard and Environmental Specialist to present and explain the proposed Project to the community. The views, opinions and feedbacks expressed by the attendees were recorded. These are summarized and provided in following Section E.

### 3. Stakeholder Workshop

80. Stakeholder workshop for the presentation of Interim Report of SASEC: Trade Facilitation, Logistic and Transport Project (ADB TA-8708) to the key stakeholders was

conducted on 09.10.2015 at the Conference Hall of Hotel Park Avenue in Phuentsholing. The key stakeholders invited were officials from Phuentsholing Thromde, Department of Trade, Regional Revenue and Customs Office, DHI and the ADB Mission members. The presentations were made on objective, scope, various options, engineering aspects, and the environmental and social consequences of the Project. The key feedbacks or recommendations from the stakeholder workshop are summarized and presented in the following Section E.

### 4. Individual Stakeholder Meeting

81. Meetings between specific stakeholder groups have been carried out throughout the Project Feasibility Study and will continue even during detailed study and implementation period. The meetings were held to provide opportunity for each stakeholder group to express their concerns and issues directly with the Project proponent. The key stakeholder groups were NRDCL; Forest Range Office; Regional Office DOR; BPCL; FCB; RBP; HISC; ABI; BEA and other individuals.

82. Additional individual stakeholder meeting was recently held on 23.04.2016 with the owner (Mr.Mahindra Ghalley) of a land adjacent to the proposed borrow area at Bagultar of Khempagaon village under Tading Gewog. The discussion with the person in-charge of the land revealed that the land under cardamom plantation was once in his family name. However, during the re-cadastral survey carried out recently, the land in question has been dropped from his landholding list. The land now belongs to the government. However, according to Mr.Ghalley, the land at Bagultar (in and around the proposed Borrow area) was designated as resettlement area for the affected persons of the proposed Amochhu Hydropower Project. The consultation with Tading Gewog Administration revealed that the land still belongs to government since no formal resettlement activities are planned so far.

83. The key feedbacks or recommendations from the individual stakeholder meeting are summarized and presented in the following Section E.

### 5. Stakeholder Workshop with Phuentsholing Thromde Communities

84. The Social Safeguard and Environmental Specialists with the help of Phuentsholing Thromde carried out Phuentsholing community workshop on 22.03.2016 at the Conference Hall of the Thromde. The total of 55 persons attended the consultative meeting. Of the total almost 30% of the attendees were female. The attendees represented the individuals from the direct Project influenced area (Amochhu Local Area Plan) and the non-affected parties as far as from Pekarzhing area. Since the Thromde upon several consultations have come up the Phuentsholing-Chamkuna Road alignment along the Amochhu River bank (which is in line with their local area plan), the discussion was confined to the technological options of the Proposed Road. The people were presented with two alternative options – i) highway rise or elevated road all the way from Phuentsholing – Chamkuna; and ii) the embankment road. The pros and cons of both the options were also described to the attendees. In general, although less durable, the people preferred the embankment road to a high rise or elevated road. The concern with the people of the Thromde particularly the ones from LAP area is that elevated road may not of help to them from the raging flood water of Amochhu. The key feedbacks or opinions from the community stakeholder meeting are summarized and presented in the following Section E.

## E. Summary of Key Issues and Perspectives Heard to Date

85. The main purpose of the consultation was to present the proposed project, illicit issues and concerns that the people in the impact area may have relevant to the proposed development and discuss the environmental requirement for projects of this type. In general, the people living within the Project influenced area welcomed the prospect of building last section of Samtse-Phuentsholing Highway as this will bring about economic development opportunities for Phuentsholing Thromde and nearby areas. *List of attendees of FGDs are attached as* Appendix 2 and List of individual officials consulted is provided in Appendix 1. Table 3 provides summary of keys issues raised by the people and proposed measures that will be taken up the Project.

**Table 3: Issues raised and measure proposed**

| S.No. | Issues Raised | Proposed Measure | Action Taken/Proposed |
|---|---|---|---|
| 1. | Phuentsholing-Chamkuna road (PCR) need to be in line with the Amochhu Local Area Plan (LAP) and Amochhu Land Reclamation Project (ALRP). | PCR will be designed and developed in accordance with LAP and ALRP | Feasibility PCR designs take into account of LAP and ALRP. |
| 2. | Alignment following the Amochhu River bank is preferred because it will be the permanent boundary between ALRP and LAP. It will facilitate the development of Thromde's LAP. | PCR alignment along the river bank is final. | There will be no change of alignment |
| 3. | Of the two design options (Elevated and embankment roads), the embankment road is preferred both by the Thromde and the public because it can dual purposes – river bank protection and road connectivity. | Both embankment and elevated road designs will be studied in detail and come up with suitable design. | The Project will carry out the detail studies of both the design options and recommend the best one. |
| 4. | Amochhu flood plain is the source of construction materials such as stone and sand. The proposed PCR may completely disrupt the collection of sand and boulder from the river basin. | Provision of access road for resource extraction. | The Project will keep the provision for access road to the river banks for sand extraction of construction material from Amochhu River banks. |
| 5. | The construction of PCR and subsequent LAP development may permanently displace seasonal orange export business from Amochhu. | **Temporary measure:** Thromde will have to allow the orange exporters to continue to Amochhu area till such time that LAP is ready.<br>**Permanent Measure:** Thromde proposes the relocation of orange export business to Pasakha/Alay area by allotting permanent site. There is an advantage in relocation to new area as it will have dry port, customs checkpost and direct linkage to India and Bangladesh through SASEC road in an immediate future. | Thromde will allow the use of Amochhu area temporarily till the permanent solution is found.<br>Permanent relocation of orange export business will take only after the completion of dry port and direct road connectivity to Pasakha from India. |
| 6. | Cumulative impact of PCR development and ALRP through permanent Amochhu river channelization may have trans- | PCR will not cause change the hydrologic regime as it will constrict | DHI Study shows graduall flow direction and maintaining 300m channel width will not |

| S.No. | Issues Raised | Proposed Measure | Action Taken/Proposed |
|---|---|---|---|
| | boundary impact of downstream erosion through increased flow velocity. | the Amochhu. Rive channelization and spur dikes are measures to protect the embankment road only. | result to increase in velocity or sediment load downstream the project area. The Amochhu Project will provide permanent measures to address erosion along the river bank of Phuenstholing. |
| 7. | PCR and subsequent LAP development may bring about positive development of affordable housing for low income people. Currently about 2000 families live across the border in India due to acute shortage of housing within Bhutan. | PCR embankment road will complement the LAP as it immediately provides protection against erosion. | Road alignment is consistent with the LAP. |
| 8. | Borrow area proposed at Bagultar under Khempagaon of Tading Gewog for the extraction of construction material is designated as resettlement area for the affected families by the proposed Amochhu Hydropower Project. The land on uphill slope (right adjacent) to the borrow area once belong to the family of Mahindra Ghalley. However, in the recent resurvey it is not included in his name although he has his Cardamom plantation on that land. | Discussion with the Gewog Authority of Tading is required to be determined the exact status of the land at Bagultar.<br><br>Detailed study needs to be carried out for the use of borrow area. | Discussion with the Gewog will be carried out.<br><br>Detailed investigation of Borrow area will be carried out during detailed design phase. |

## F. Information Disclosure

86. During the public consultation, the description of the project attributes in the local context provided to members of the public that attended consultation. It was noted that the project will be funded by the ADB. The meetings were held in conjunction with field surveys. Specific aspects were described of the RGoB policy on resettlement and compensations for lost land and assets. The draft IEE report will was be presented by the DOR to the Phuentsholing Thromde and Dungkhag and their comments and suggestions will be incorporated during the detailed engineering design stage. Furthermore, ADB's Safeguard Policy Statement 2009 and the Public Communications Policy Review 2011 require the EIA report prepared be reviewed by the ADB and disclose that same on its website for wider public dissemination.

## G. Grievance Redress Mechanism

87. The same grievance and redress mechanism established in South Asia Subregional Economic Cooperation Road Connectivity Project will be utilized by the Project for practical purposes.

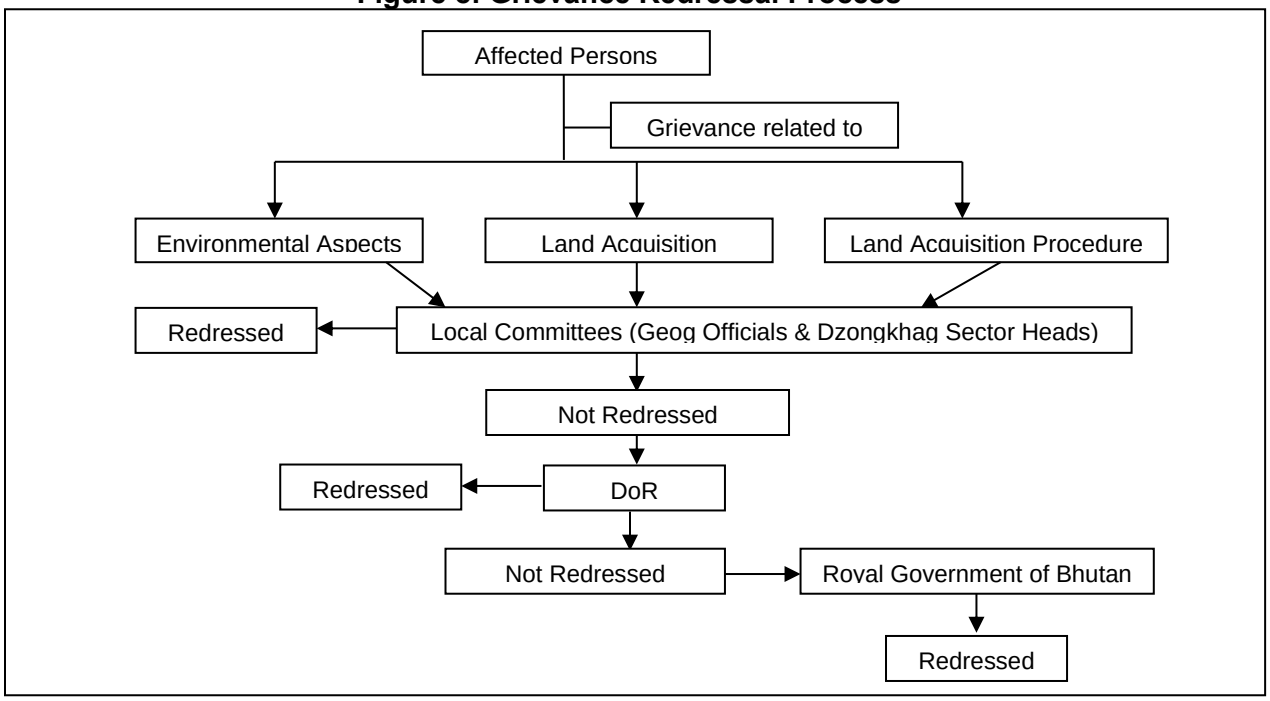
88. A grievance redress mechanism is already established to receive and facilitate the resolution of concerns, complaints and grievances of affected people and relevant agencies on the social and environmental performance of the project in a time bound and transparent manner.

89. The project specific GRM is not intended to bypass the government's own redress process, rather it is intended to address project affected people's concerns and complaints promptly, making it readily accessible to all segments of affected persons and is scaled to the

risks and impacts of the project. While the affected person or party may submit their complaints concerning the project to any relevant agency, the steps recommended for the GRM are:

- **Step 1:** If any affected person or party faces grievances related to environment, land acquisition or resettlements, he/she can approach the contractor, construction supervision consultants or site staff of DOR and PT directly at the site level.
- **Step 2:** If grievances are not addressed at the site level, the affected person or party can lodge a written grievance to the grievance redress committee (GRC) comprising of Sector Heads of the Dzongkhag Administration as well as Geog Officials. The affected person or party may also skip step 1 and directly file written grievance to the GRC. All grievances which cannot be address at the site level should be forwarded to the grievance redress committee within 15 days from the receipt of complaint. The committee must respond within 15 days. Further, the GRC will treat grievances of both male and female affected persons equally and address them fairly.
- **Step 3:** If the affected person or party is not satisfied with the decision or he/she receives no response within 15 days of registering the grievance, he/she can approach the DOR and finally, can appeal to the Royal Government of Bhutan or His Majesty the King.

**Figure 8: Grievance Redressal Process**



# V. BASELINE ENVIRONMENTAL STATUS

## A. General

90. As a precursor for the prediction of various types of environmental impacts likely to arise due to implementation of this Project, it is essential to establish the base line environmental status of the physical, natural and socio-cultural environmental parameters along the project roads and within the project influence area. Details of the baseline environmental parameters are required for decision making for the Project design, implementation and operation from the environmental point of views. The data has been collected from the primary surveys and secondary sources.

## B. Physical Environment

### 1. Meteorology

#### a. Climatic Condition

91. The project zone lies in the sub-tropical region with four distinct seasons. Winter starts from December and ends in February. Summer is between March to May. Monsoon is between June to September while Autumn/Post Monsoon is from October to November.

#### b. Temperature

92. Phuentsholing city is located at the base of the Himalayan foothills which falls under sub-tropical climatic zone with hot humid summer months and; with warm and dry winter months. The humid climate helps maintain a fairly even temperature ranging between 15° C and 30°C year-round. The temperature remains in high 30s from the month of May until October, while the night time temperature below 20°C degrees are recorded from November to February. Succeeding Figure illustrates the average monthly rainfall and the average minimum and maximum temperature of Phuentsholing area.

#### c. Rainfall

93. The details of monthly total rainfall of the Phuentsholing Meteorological Station located near to the Project road. In the project area the maximum rainfall occurs in the months of June, July and August, however the rainfall extends from May to September. The minimum rainfall occurs in the post monsoon and winter seasons (November, December, January and February).

#### d. Humidity

94. The details of the relative humidity (RH) of monthly variations recorded at Department of Hydro-Met Services (DHMS) Class A meteorological observatory station in Phuentsholing is provided in Figure 10. It can be noted that high humidity occurs in the month of June, July, August and September and low humidity occurs in the month of February, March, April, November and December.

**Figure 9: Total Average Monthly Rainfall in mm**

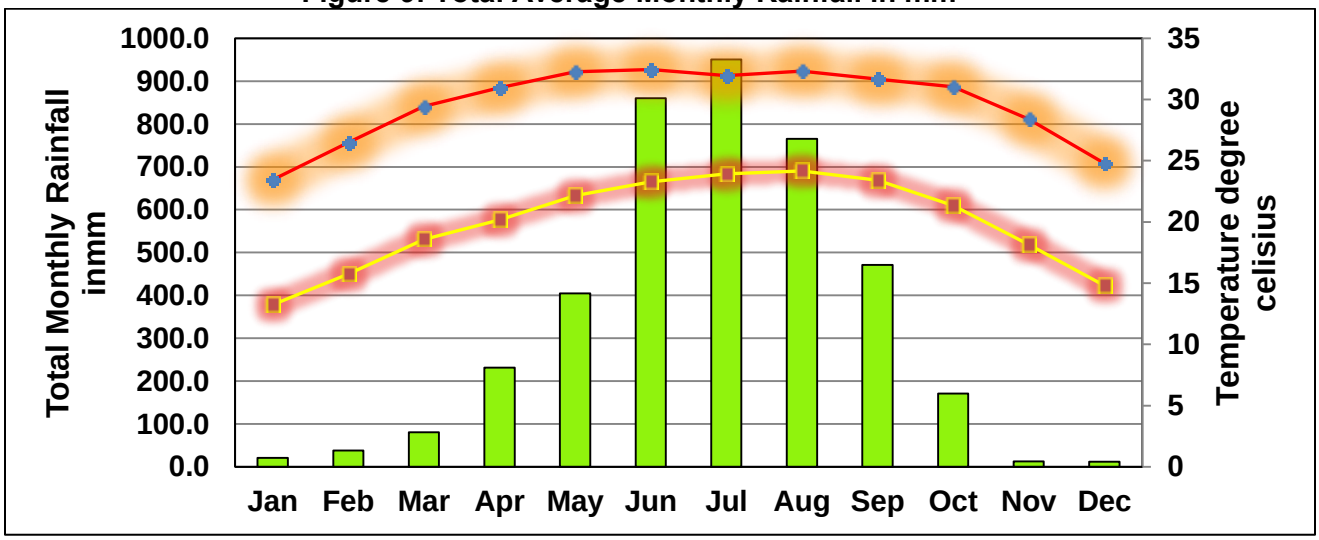



**Figure 10: Monthly Average Range of Humidity**

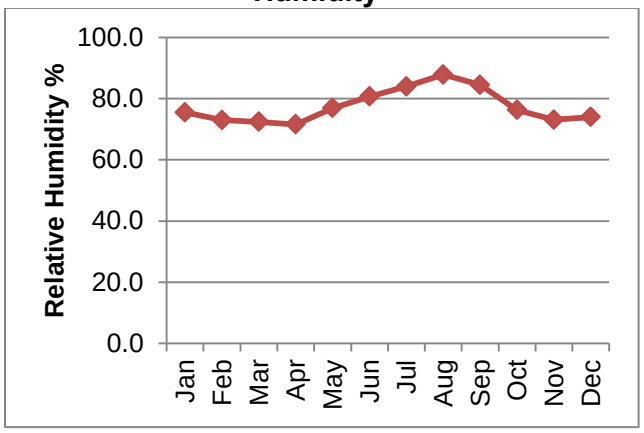
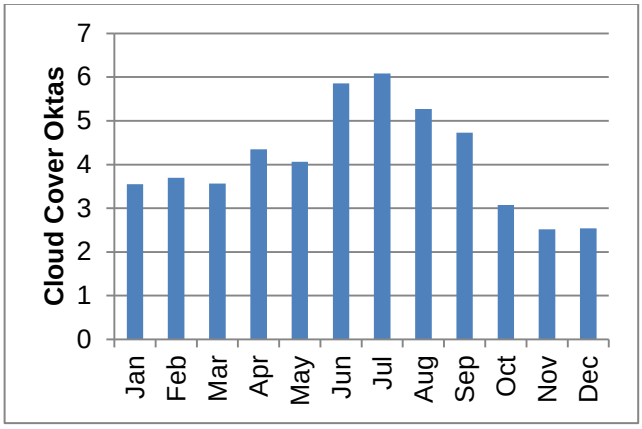



**Figure 11: Monthly Average Range of Cloud Cover in Oktas**




### e. Wind Speed and Direction

95. Mean wind speeds are observed to be highest in the months of February, March and April (1.2-1.4 kmph) at Phuentsholing and lowest in the month of June, July, August and September (0.4 -0.6 kmph). Monthly mean wind speeds are presented in Figure 12. Most predominant wind direction is "South – South West" and the corresponding months are from January, February, June, September, November to December. The least predominant wind direction is "South" and the corresponding month is October. Refer Table 4 for monthly wind direction observed at Phuentsholing meteorological station.

**Figure 12:Monthly Average Wind Speed in km/h**

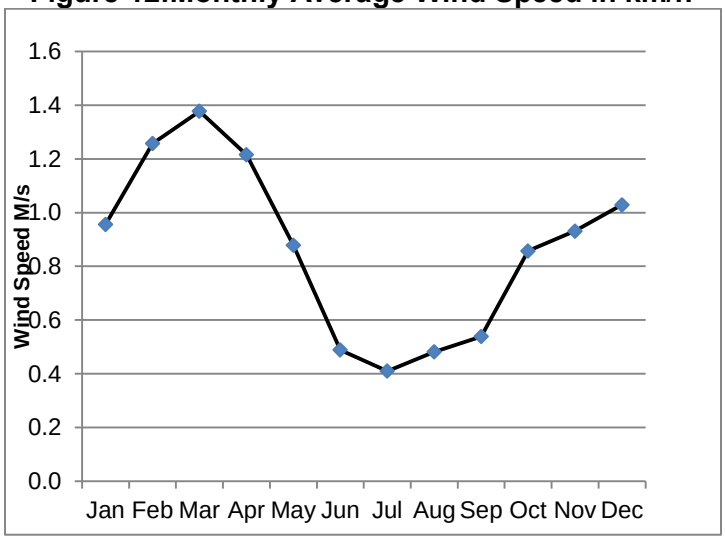



**Table 4: Monthly Wind Direction**

| Month | Degrees | Compass Rose |
|---|---|---|
| Jan | 187.53 | SSW |
| Feb | 202.66 | SSW |
| Mar | 234.74 | SW |
| Apr | 171.3 | SSE |
| May | 262.16 | W |
| Jun | 194.53 | SSW |
| Jul | 255.03 | W |
| Aug | 229.66 | WSW |
| Sep | 204.33 | SSW |
| Oct | 182.94 | S |
| Nov | 199.47 | SSW |
| Dec | 197.84 | SSW |

## 2. Geology, Soil and Seismicity

96. The Department of Geology and Mines (DGM) under the National Adaptation Programme of Action (NAPA) carried out extensive study on Geology and landslides of Phuentsholing's Thromde extended municipal areas particularly for the areas between Pekarzhong and Phuentsholing main town. The report which was published in 2013 clearly describes type geology at country, regional and local level (i.e., for Phuentsholing Thromde).

97. The geotechnical investigation and assessment study that was carried out by DHI Infra Ltd through the DHI Water, Environment and Health (2007) of Amochhu left bank towards the preparation of Amochhu Land Reclamation and Township Project (ALRTP) is directly relevant to SASEC's Chamkuna-Phuentsholing road project. Chamkuna-Phuentsholing road falls completely within the ALRP study area.

98. In addition to the above studies, SASEC's PPTA team also conducted independent geotechnical investigation for CPR project. The relevant findings from all three studies from are presented in the following sections:

a) **Bhutan Geology**. Bhutan is geo-tectonically classified in to three zones namely; i) the Frontal Belt representing foothills and parts of lower Himalaya; ii) the Central Crystalline Belt occupying portion of lesser and higher Hiamalaya; and iii) the Tethyan Belt covering the higher Himalaya and isolated but large portions of the lesser Himalaya (Figure 13). The frontal belt is mainly composed of Manas, Duiri, Shetikhola and I-III formations. Manas formation comprised of dolomite, limestone, quarts and conglomerates. The Duiri formation is mainly characterized by hard phyllite with quartzite, Siltstone and Diamicitte. The Shetikhola formation is composed of feldspathic sandstone, sandstone, siltstone, shale, carbonaceous shale and coal. And the I-III formation which is dominant in the lower latitude is comprised of sandstone, siltstone, shale and clay. The Thimphu Gneissic Complex and the Paro Formation makes the Central Crystalline Belt. The Thimphu Gneissic Complex is characterized by migmatites and biotite-granite-gneisses with thin beds of quartzite, quartz mica schist, calc-silicate, and marble, and is the major rock type covering the country. The Paro Formation is

characterized by quartz mica schist, quartzite, calc-silicate, marble, and a thin bed of graphitic schist, and this is exposed in and around Paro. The Tibetan-Tethyan Himalayas generally begins from the top of the Higher Himalayan Zone and extends to the north in Tibet. This zone is composed of fossiliferous sedimentary rocks such as shale, sandstone and limestone etc. The geology and topography of Bhutan are thus shaped by the intense tectonic activity and made up of uplifted sedimentary and metamorphic rocks, which makes the geology among the most fragile in the Sub-Himalayan range. The geology is also highly sensitive to intense rainfall and surface runoff and erosion rates are high, frequently resulting in substantial landslides and other climate-induced disasters such as landslides and flash floods.

b) **Project Area Geology.** DHI Infra Ltd. through DHI Water, Environment and Health in 2007 carried out detailed geotechnical investigation towards the preparation of ALRTP. The proposed CPR lies completely within ALRP study area. Therefore, the geological investigation carried out by DHI Infra is totally valid even for CPR project. Although the CPR alignment follows the flood plain of Amochhu, the overall project influenced area is characterized by the abrupt rise of topography from flat area of 190m at Omchhu and Amochhu confluence to almost 1000m on the hilltop of the upper catchment of Bangay stream just within a span of 2.5km. There are number of parallel streams flowing north to south indicating the ruggedness of the topography. There are three major streams sections on the left bank of Amochhu reveals that Damdara/Neda hill range is made up of layers of metamorphic rocks. It was observed that Chamkuna and Bangay streams banks near to Amochhu are covered with huge amount of transported metamorphic rocks and other debris. The left bank hill range is mainly made up of two types of metamorphic rock – quartzites and phyllites. Quartzite layers occupy the major portion of the hill range, while phyllite layers occur at intervals at different heights with an apparent dip of 50º to the horizontal. The hill slope has soil cover of about 2m thickness which is mainly silty sand with low plasticity. Its shear strength is mainly due to friction, with an angle of friction of 30º, with negligible cohesion under effective stress. During dry season, in addition to the soil cohesion due to roots of trees and bushes, cohesion is also developed due to suction in the pores of the soil. However, this condition changes during the rainy season, the soil is saturated and the cohesion due to suction in the pore is lost; and under the prolonged and intense rainfall as a result of climate change, the immense pore pressure develops in the slope, with flow lines parallel to the slope. This immense pore pressure coupled with other forces such as seismic activities, blasting, slope excavation works etc. in turn leads to the slope failures and eventually landslides. Landslides triggered due to toe erosions and slope excavation works are common on the left bank of Amochhu.

**Figure 13: Geology of Bhutan**

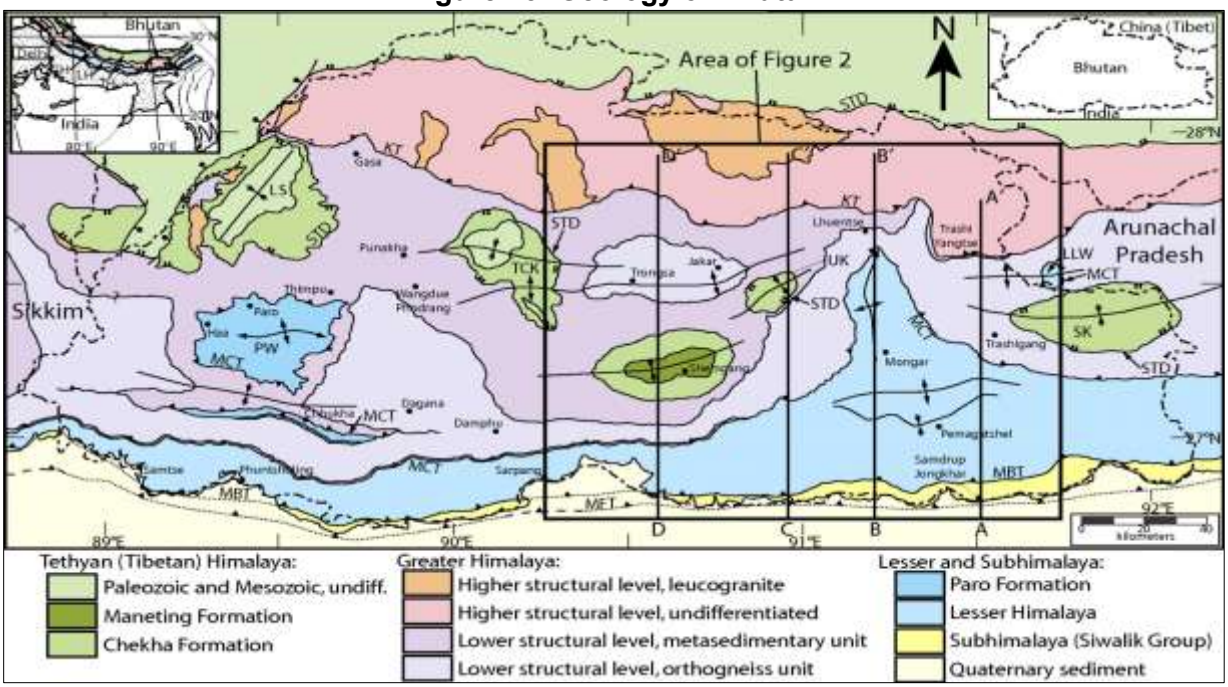
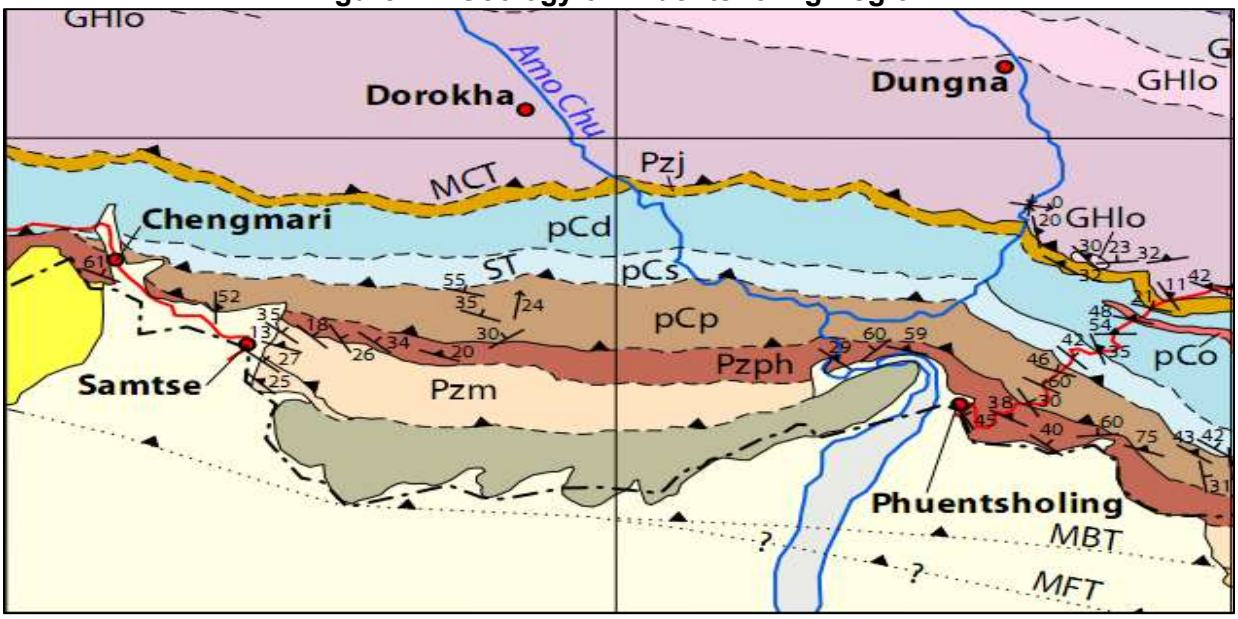


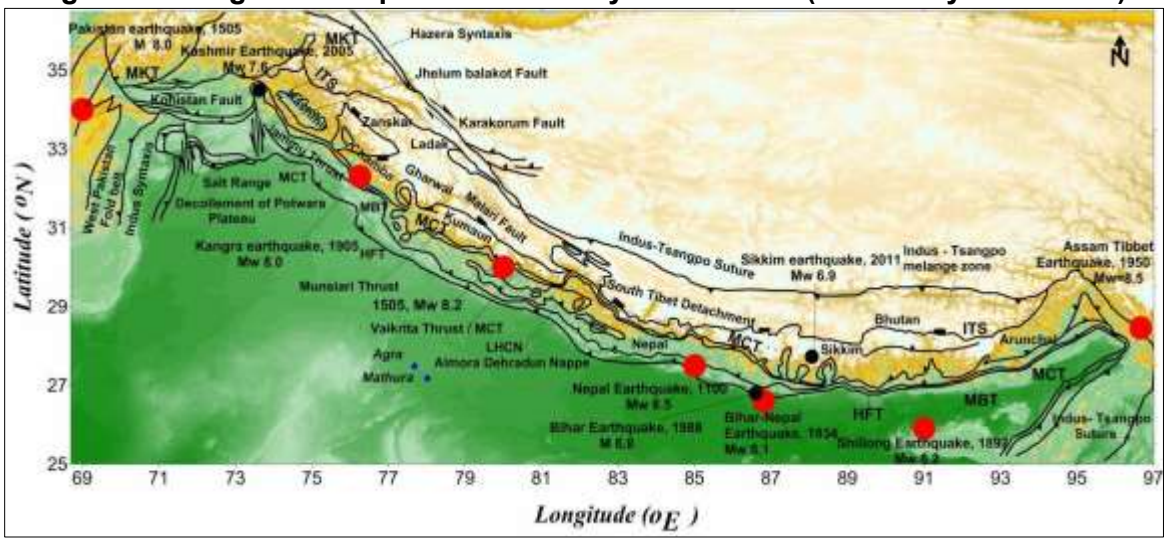

**Figure 14: Geology of Phuentsholing Region**




Source: (Department of Geology and Mines (DGM), 2013)

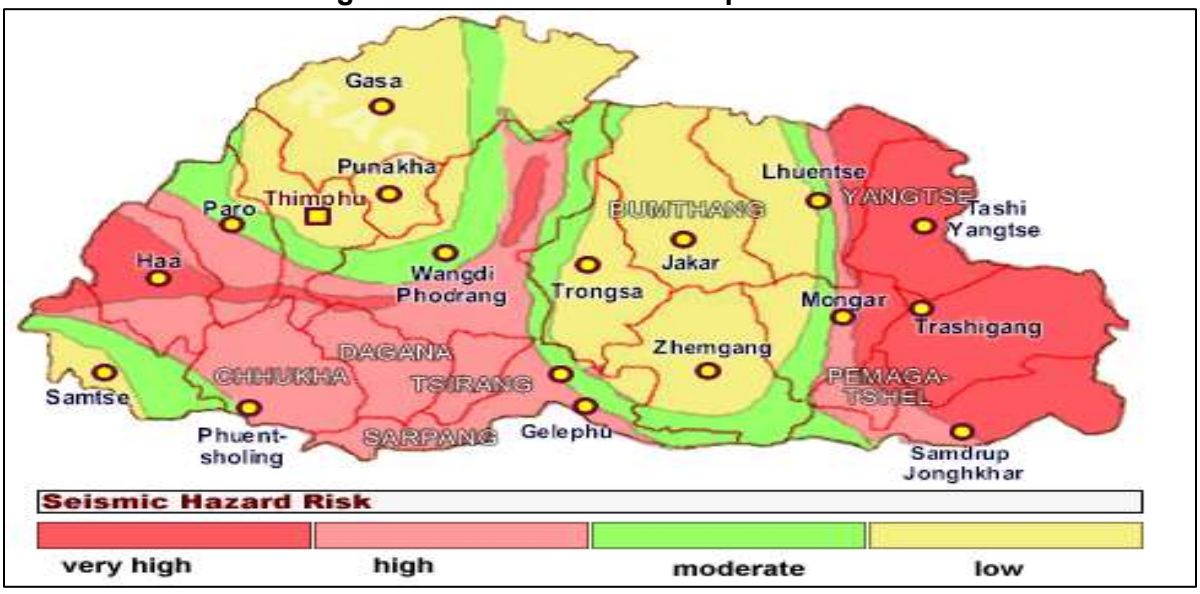
99. Seismicity. Bhutan supposedly falls under highest seismic hazard zones of IV and V. Historically, earthquakes in the magnitude 5.0-6.0 range have been experienced and at least one magnitude 7.0 event is thought to have occurred in the 1700's in eastern Bhutan and adjoining parts of India (ASC 2009). There is absence of larger magnitude seismic event in Bhutan (Refer Figure 15). Nonetheless, Bhutan of being in high risk zone developed the Bhutan Building Code which is similar to Indian Seismic Code IS: 1893: “Criteria for Earthquake Resistant Design Structures”, as applicable to Zone V. According to the code, the design ground acceleration for the Maximum Credible Earthquake for Zone V is 0.36g.

**Figure 15: Largest earthquakes in Himalaya since 1900 (marked by red circles).**




Source: Srivastava et al. 2013

**Figure 16: Seismic Hazard Map of Bhutan**




Source: IIT, Rourkee, 2009

## 3. Water Resources

### a. Surface Water Resources/ Hydrology

100. Bhutan has four major river systems: the Drangme Chhu or Manas; the Punatsang Chhu or Sunkosh; the Wang Chhu or Raidak and the Amo Chhu or Toorsa River. Fed by the Himalayan glaciers, these rivers flows swiftly out of the Himalayas, southerly through the Duars to join the Brahmaputra River in India. The project area is drained by Amo Chhu and its last tributary, the Om Chhu /Doti Khola. Amo Chhu originates from Mount Pauhunri (7,128m) in Tibet on China-India border. It flows from Chumbi valley of Tibet and enters through western Bhutan before broadening near Phuentsholing and flowing on into India. The total catchment

area of Amo Chhu is 4,011Km$^2$ as reported in the Detailed Feasibility and Engineering Study of Toorsa Flood Mitigation Project, (DHI Water, Environment and Health, 2007).

### b. Flood Frequency Analysis

101. The drainage pattern of Bhutan is principally segregated into three hydrological regions and are tagged as basins I, II and III. Basin I constitute Amo Chhu and Wang Chhu sub-basins. Amo Chhu gauged on daily basis at Doyagang since 2006. Observed maximum discharge of available daily series is 1,552 m$^3$/s. The highest observed discharge in the Amo Chhu is at Hasimara Gauging Station, 15.5km downstream of Phuentsholing in India, in the year 1996 (5,397m$^3$/s) (DHI Water, Environment and Health, 2007).

**Figure 17: Hydrology of Bhutan**

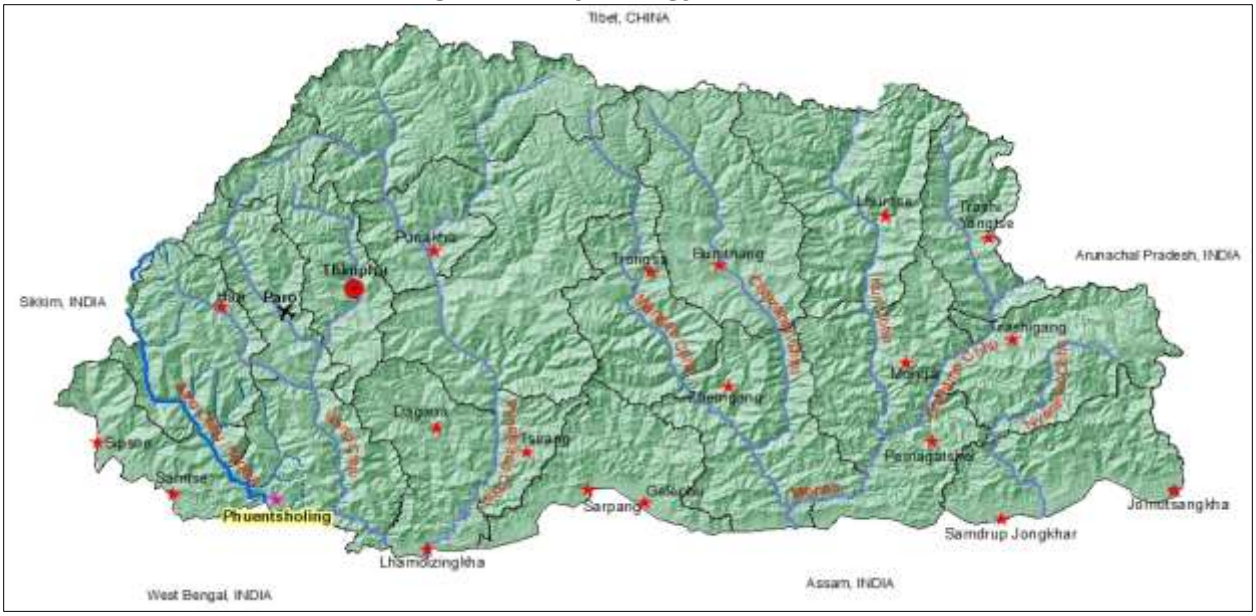
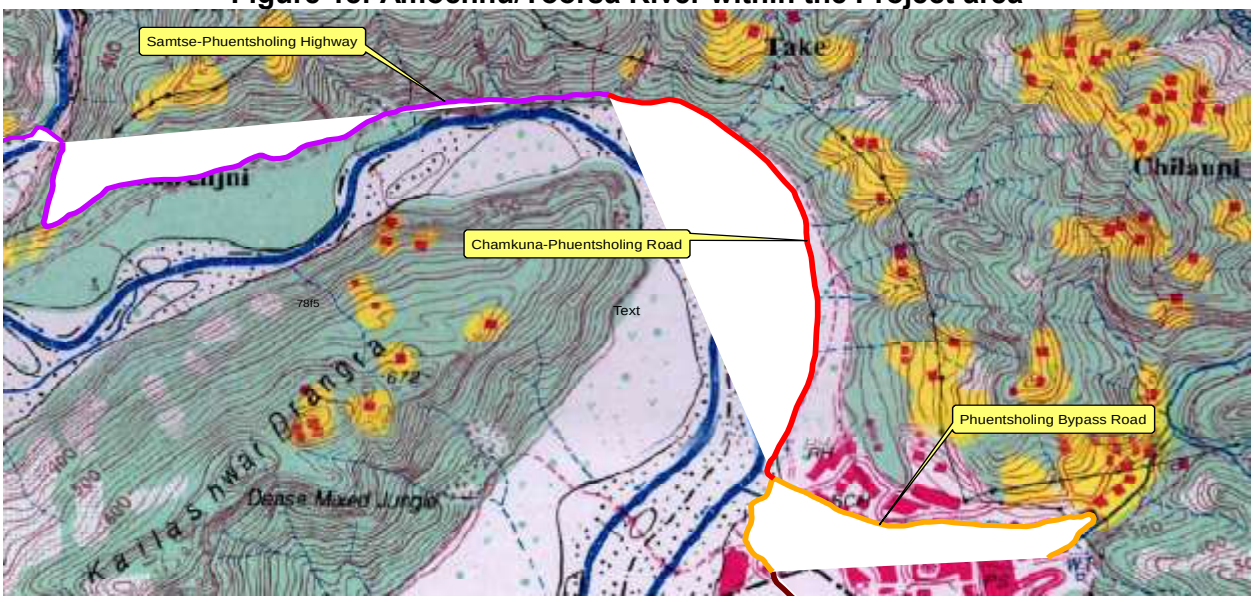



**Figure 18: Amochhu/Toorsa River within the Project area**



### c. Ground Water

102. The major source of the groundwater in the area is deep borehole ground water pumping station operated by Phuentsholing Thromde. There are at 6 boreholes for pumping ground water in Phuentsholing Thromde. The ground water pumping station is located about 190m away from the proposed road. This ground water is supplied by Thromde to Phuentsholing resident for drinking and other industrial usage. There are no wells, tube wells and hand pumps in the area.

## 4. Ambient Air, Water and Noise Pollution Scenario of the Project Area

### a. The Ambient Air and Bhutan Ambient Air Quality Standard

103. The purpose of the ambient air quality monitoring is to establish the ambient air quality baseline data for the project area prior to the implementation of the project and allow assessment of future air quality variation. The air quality monitoring was done in line with the Strategy for Air Quality Assessment and Management in Bhutan 2010 by the NEC. For the measurement of particulate matters both the total suspended particulate matter (TSPM) and Respirable Particulate Matter (RPM) or Particulate Matter (PM10), a high volume sampler was used for 24 hours particulate monitoring for 3 consecutive days for each location for three seasons (Winter, Pre-Monsoon and Post-monsoon). While for Nitrous oxides (NOx), Sulphur dioxide (SO2), and carbon monoxide (CO), the handheld multigas detectors were used to record the gas concentration on hourly basis for 8 hours for four seasons (Winter, Pre-Monsoon, Monsoon and Post-Monsoon).

104. The monitoring were carried out at three locations; i) Phuentsholing town; ii) near YDF Youth Hostel (close to road termination point); and iii) Bangay Bazar (800m from Chamkuna).

105. The primary source of air pollution at the project site are the emissions from automobiles and workshops activities; fugitive sources such as burning of solid wastes and the dust generated particularly at Amochhu/Toorsa area because of the unpaved road condition. It has been observed that dust levels from vehicles on existing roads may occasionally even be high enough to obscure vision temporarily. The key pollutants likely to be found at project proposed location are carbon monoxide (CO), oxides of nitrogen ($NO_X$), sulfur dioxide ($SO_2$), and particulate matter (PM).

106. The sources of air pollution in Amochhu area is from the activities such as auto workshops, small factories, stockyards and depots for Mega Hydropower Projects in Bhutan. Further every winter for almost 3 months, Amochhu area sees brisk orange/mandarin export business. During peak and a good orange season, almost 100 trucks ply every day along the dust road of Amochhu area. All these activities and the corresponding vehicular movements contribute to the air pollution in the project area.

107. In addition to the above, Phuentsholing city including the project area being adjacent to densely populated Indian border town of Jaigaon is susceptible to trans-boundary pollution. Two locations were chosen within Amochhu LAP (Direct Influence Area) – i) Bangay/Chamkuna; and ii) Adjacent to YDF Hostel. The area has been classified by Thromde light industrial zone with the established workshops, depots, warehouse, and factories. Therefore air qualities monitored in these two locations are within the permissible limits of Industrial emission standards (see succeeding Table). The main sources of pollutants are fugitive dust from the unpaved road and industrial activities carried out in the area. Third sampling location is in the core of

Phuentsholing city which is classified as mixed area with both residential and commercial activities taking place in the same area. In general, the air quality of Phuentsholing town is poor during the dry seasons (winter and pre-monsoon) due to presence of high total suspended particulate matter which exceeds the permissible limit of the mixed area). However, PM10 level for the past three seasons are found to be within the national limit. The sources of suspended particulate matters could be from the Amochhu area or from across the border (Jaigaon, West Bengal). Table 5 provides results of air quality monitoring for four seasons. Baseline monitoring locations are provided in Figure 19.

**Table 5: Air Quality Monitoring Results for four seasons**

| Station No | Location | Season | IN MICROGRAM PER CUBIC METER | | | | |
|---|---|---|---|---|---|---|---|
| | | | TSPM | PM 10 | $SO_2$ | NOx | CO |
| 1 | Bangay/ Chamkuna | Pre-Monsoon | 184.8 | 98.2 | BDL | BDL | BDL |
| | | Monsoon | - | - | BDL | BDL | BDL |
| | | Post-Monsoon | 111.4 | 40.5 | BDL | BDL | BDL |
| | | Winter | 122.6 | 115 | BDL | BDL | BDL |
| 2 | YDF Center | Pre-Monsoon | 551 | 191.5 | BDL | BDL | BDL |
| | | Monsoon | - | - | BDL | BDL | BDL |
| | | Post-Monsoon | 283.25 | 39.5 | BDL | BDL | BDL |
| | | Winter | 536 | 167 | BDL | BDL | BDL |
| 3 | Phuentsholing main town | Pre-Monsoon | 312.9 | 85.8 | BDL | BDL | BDL |
| | | Monsoon | - | - | BDL | BDL | BDL |
| | | Post-Monsoon | 163.6 | 77 | BDL | BDL | BDL |
| | | Winter | 354.9 | 89.1 | BDL | BDL | BDL |

*NOTE BDL – Below Detectable Limit*

**Table 6: NEC's Ambient Air Quality Standards (Maximum Permissible Limits in µg/m3)**

| Parameter | Industrial Area | Mixed Area* | Sensitive Area** |
|---|---|---|---|
| ***Total Suspended Particulate Matter*** | | | |
| 24 Hour Average | 500 | 200 | 100 |
| Yearly Average | 360 | 140 | 70 |
| ***Respirable Particulate Matter (PM 10)*** | | | |
| 24 Hour Average | 200 | 100 | 75 |
| Yearly Average | 120 | 60 | 50 |
| ***Sulfur Dioxide*** | | | |
| 24 Hour Average | 120 | 80 | 30 |
| Yearly Average | 80 | 60 | 15 |
| ***Nitrogen Oxides*** | | | |
| 24 Hour Average | 120 | 80 | 30 |
| Yearly Average | 80 | 60 | 15 |
| ***Carbon Monoxide*** | | | |
| 8 Hour Average | 5000 | 2000 | 1000 |
| 1 hour Average | 10000 | 4000 | 2000 |

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

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

**Figure 19: Baseline Sampling Locations**


### b. Noise Level of the Project and the Standard

108. The permissible noise levels for the Mixed Area of Phuentsholing City are for 65dBA day time and night time of up to 55dBA and for Industrial area of Amochhu/Toorsa areas are 75dBA and 65dBA, respectively. Ambient noise measurements were carried out at three locations; Phuentsholing town, YDF Hostel, and Bangay area (Figure 19 for Sampling Location). Noise levels were measures on hourly basis for a continuous period of one day for all four seasons and it is presented in the Table 7. The analyses showed that noise levels for Phuentsholing town for all four seasons within the national limits of mixed areas. Similarly, for Bangay and YDF centers under Amochhu area are also within the national limits of industrial areas.

**Table 7: Noise Level Monitoring (dBA) for Four Seasons**

| S.No | Location | Seasons | Day (Leq) | Night (Leq) |
|---|---|---|---|---|
| 1 | Phuentsholing Town | Winter | 60.2 | 54.4 |
| | | Pre-Monsoon | 58.2 | 52.3 |
| | | Monsoon | 61.2 | 53.4 |
| | | Post Monsoon | 60.3 | 54.5 |
| 2 | Near YDF Building (Takeoff Point) | Winter | 57.3 | 51.2 |
| | | Pre-Monsoon | 5 | 56.9 |
| | | Monsoon | 56.7 | 50.3 |
| | | Post Monsoon | 58.0 | 56.9 |
| 3 | Bangay/Chamkuna | Winter | 51.2 | 48 |
| | | Pre-Monsoon | 48.2 | 47.3 |
| | | Monsoon | 49.9 | 49.5 |
| | | Post Monsoon | 50 | 49 |

Source: Ambient Noise monitoring in August and November 2015; and February and March 2016.

**Table 8: Noise Level Limits, Environmental Standard 2010, NEC**

| Location | Day | Night |
|---|---|---|
| Industrial Area | 75 dBA | 65 dBA |
| Mixed Area | 65 dBA | 55 dBA |
| Sensitive Area | 55 dBA | 45 dBA |

### c. Surface and Ground Water Quality

109. For ambient water quality monitoring, the water samples from Amochhu/River (WS1), Omchhu (WS2) and downstream of Confluence of Amochhu and Omchhu (WS3) were and analyzed for four seasons. The analytical results of the water samples collected during four seasons (winter, Pre-monsoon, monsoon and post monsoon) for each location are presented in tables 9, 10, 11, and 12. The water analysis results were compared with criteria for drinking water under Environmental Standards, 2010 NEC, Bhutan.

### d. Ground Water

110. For baseline establishment, the sample of Ground Water was collected from Borehole closest (Near YDF Hostel) to the proposed road and tested to assess the groundwater quality. The analytical results of the water samples collected during four seasons (winter, summer, monsoon and post monsoon) for each location are presented in Table 9 - 12.

**Table 9: Ambient Water Quality Monitoring for Monsoon Season**

| Sl.No | Parameters | Units | Standard | WS1[1] | WS2[2] | WS3[3] | WS4[4] |
|---|---|---|---|---|---|---|---|
| 1 | Temperature | °C | NA[5] | 23 | 25 | 23.5 | 27 |
| 2 | Conductivity | µmhos/cm | 800 | 116.5 | 149.7 | 142.3 | 153.2 |
| 3 | Color | CU | NA | 223 | 242 | 137 | 12 |
| 4 | Odour | NA | UO6 | UO | UO | UO | UO |
| 5 | Turbidity | FAU | NA | 215 | 325 | 293 | 1 |
| 6 | pH | pH | 6.5-8.5 | 8.32 | 8.32 | 8.2 | 8.15 |
| 7 | Ammonia Nitrogen | mg/L | 0.05 | 0 | 0.06 | 0.19 | 0 |
| 8 | Chlorine | mg/L | 50 | 0.01 | 0 | 0 | 0 |
| 9 | Copper | mg/L | 0.05 | 0 | 0 | 0 | 0 |
| 10 | Chromium | mg/L | 0.05 | 0 | 0 | 0 | 0 |
| 11 | Sulphate | mg/L | 25 | 2.00 | 6.99 | 1.00 | 4.00 |
| 12 | Fe(Iron) | mg/L | 0.2 | 0.50 | 0.24 | 0.39 | 0.06 |
| 13 | Phosphate | mg/L | 0.5 | 0.03 | 0.05 | 0.05 | 0.02 |
| 14 | Nitrate | mg/L | 10 | 0.02 | 0.18 | 0 | 0.46 |
| 15 | Si (Silica) | mg/L | NA | 8.73 | 9.05 | 7.85 | 7.94 |
| 16 | Do (Dissolved Oxygen) | mg/L | 6 | 6.992 | 6.256 | 6.992 | 5.88 |
| 17 | Fluoride | mg/L | 1 | 0 | 0 | 0 | 0 |
| 18 | Total Hardness | mg/L | NA | 56 | 72 | 60 | 64 |
| 19 | Total Alkalinity | mg/L | NA | 80 | 80 | 80 | 64 |

Water samples collected in the month of August 2015

**Table 10: Ambient Water Quality Monitoring for Post-Monsoon Season**

| Sl.No | Parameters | Units | Standard | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|---|
| 1 | Temperature | °C | NA | 16 | 20 | 18 | 23 |
| 2 | Conductivity | µmhos/cm | 800 | 120 | 239 | 113 | 156 |

[1] WS1 – Amo Chhu River Water before the Om Chhu confluence
[2] WS2 – Om Chhu River Water before the Confluence with Amo Chhu confluence
[3] WS3 – Amo Chhu River Water after the confluence with Om chhu
[4] WS4 – Ground Water from Phuentsholing Thromde's Bore well Pump station
[5] NA – Not Available
[6] UO – Unobjectionable for describing odour of water samples

| Sl.No | Parameters | Units | Standard | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|---|
| 3 | Color | CU | NA | 3 | 7 | 3 | 0 |
| 4 | Odour | NA | UO | UO | UO | UO | UO |
| 5 | Turbidity | FAU | NA | 1 | 0 | 0 | 1 |
| 6 | pH | pH | 6.5-8.5 | 8.32 | 8.32 | 8.2 | 8.15 |
| 7 | Ammonia Nitrogen | mg/L | 0.05 | 0.01 | 0.17 | 50.0 | 0.01 |
| 8 | Chlorine | mg/L | 50 | 0.04 | 0.01 | 0.01 | 0 |
| 9 | Copper | mg/L | 0.05 | 0 | 0 | 0 | 0 |
| 10 | Chromium | mg/L | 0.05 | 0.01 | 0.05 | 0.13 | 0.01 |
| 11 | Sulphate | mg/L | 25 | 2.00 | 6.99 | 1.00 | 4.00 |
| 12 | Fe(Iron) | mg/L | 0.2 | 0.04 | 0.02 | 0.04 | 0.02 |
| 13 | Phosphate | mg/L | 0.5 | 0.01 | 0.06 | 0.03 | 0.03 |
| 14 | Nitrate | mg/L | 10 | 0.18 | 0.48 | OR | OR |
| 15 | Si (Silica) | mg/L | NA | 8.73 | 9.05 | 7.85 | 7.94 |
| 16 | Do (Dissolved Oxygen) | mg/L | 6 | 9.8 | 7 | 7 | 7.1 |
| 17 | Fluoride | mg/L | 1 | 0 | 0.4 | 0.2 | 0 |
| 18 | Total Hardness | mg/L | NA | 40 | 62 | 50 | 60 |
| 19 | Total Alkalinity | mg/L | NA | 20 | 40 | 20 | 40 |

Water samples collected in the month of November 2015

**Table 11: Ambient Water Quality Monitoring for Winter Season**

| Parameters | Units | Standard | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|
| Temperature | °C | NA | 19 | 19 | 19 | 22 |
| Conductivity | µmhos/cm | 800 | 800 | 120 | 239 | 113 |
| Color | CU | NA | 23 | 225 | 17 | o |
| Odour | NA | UO | UO | UO | UO | UO |
| Turbidity | FAU | NA | 2 | 22 | 0 | 0 |
| pH | pH | 6.5-8.5 | 8.1 | 8.3 | 8.0 | 8.2 |
| Ammonia Nitrogen | mg/L | 0.05 | 0.03 | O.64 | 0.07 | 0.26 |
| Chlorine | mg/L | 50 | 0.01 | 0.00 | 0.00 | 0.01 |
| Copper | mg/L | 0.05 | 0.01 | 0.19 | 0.01 | 0.03 |
| Chromium | mg/L | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 |
| Sulphate | mg/L | 25 | 20 | 37 | 18 | 22 |
| Fe(Iron) | mg/L | 0.2 | 0.05 | 0.31 | 0.03 | 0.08 |
| Phosphate | mg/L | 0.5 | 0.03 | 0.08 | 0.05 | 0.03 |
| Nitrate | mg/L | 10 | 0.16 | 0.17 | 0.18 | 0.15 |
| Si (Silica) | mg/L | NA | 8.8 | 9.25 | 8.85 | 7.3 |
| Do (Dissolved Oxygen) | mg/L | 6 | 9.5 | 8 | 8 | 8.2 |
| Fluoride | mg/L | 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Hardness | mg/L | NA | 50 | 120 | 50 | 61 |
| Total Alkalinity | mg/L | NA | 61 | 150 | 60 | 50 |

Water samples collected in the month of December 2015

**Table 12: Ambient Water Quality Monitoring for Pre-Monsoon Season**

| Parameters | Units | Standard | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|
| Temperature | °C | NA | 19 | 19 | 19 | 22 |
| Conductivity | µmhos/cm | 800 | 800 | 120 | 239 | 113 |
| Color | CU | NA | 23 | 225 | 17 | o |
| Odour | NA | UO | UO | UO | UO | UO |

| Parameters | Units | Standard | WS1 | WS2 | WS3 | WS4 |
|---|---|---|---|---|---|---|
| Turbidity | FAU | NA | 2 | 22 | 0 | 0 |
| pH | pH | 6.5-8.5 | 8.1 | 8.3 | 8.0 | 8.2 |
| Ammonia Nitrogen | mg/L | 0.05 | 0.05 | O.67 | 0.08 | 0.26 |
| Chlorine | mg/L | 50 | 0.01 | 0.00 | 0.00 | 0.01 |
| Copper | mg/L | 0.05 | 0.01 | 0.19 | 0.01 | 0.03 |
| Chromium | mg/L | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 |
| Sulphate | mg/L | 25 | 20 | 37 | 18 | 22 |
| Fe(Iron) | mg/L | 0.2 | 0.05 | 0.31 | 0.03 | 0.08 |
| Phosphate | mg/L | 0.5 | 0.04 | 0.1 | 0.05 | 0.03 |
| Nitrate | mg/L | 10 | 0.16 | 0.17 | 0.18 | 0.15 |
| Si (Silica) | mg/L | NA | 8.5 | 9.5 | 8.5 | 7.5 |
| Do (Dissolved Oxygen) | mg/L | 6 | 9.5 | 8 | 8 | 8.2 |
| Fluoride | mg/L | 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| Total Hardness | mg/L | NA | 53 | 125 | 52 | 64 |
| Total Alkalinity | mg/L | NA | 65 | 145 | 62 | 51 |

Note: Water samples collected in the month of March 2016

### e. Result and Interpretation of Water Quality Monitoring

111. Amochhu river water quality is in general good for all four seasons comparable to the drinking standard of Bhutan, NEC 2010. Similarly, ground water quality also found to be good meeting the drinking water standard. Omchhu/Doti khola river water was found to be of poor quality owing presence of high phosphate and ammonia content which are well above the national drinking water standards (0.05mg/l for Phosphate and 0.05mg/l for ammonia). The presence of phosphate and ammonia in the natural water body indicates the pollution from wastewater and untreated sewage. The levels of phosphate and ammonia in Omchhu found to be more in dry winter and pre-monsoon seasons. This could due to low volume of water flow during dry season with same amount of pollution load.

## C. Biological Environment

### 1. Protected Areas

112. The Project area does not fall in any of the ten protected areas and network of Biological corridors that connects the protected areas. Jigme Khesar Namgyel Wangchuk Strict Nature Reserve is the nearest protected area located approximately about 42km north-west of the proposed Project.

### 2. Critical Habitat

113. Amochhu is originates from the hills of Tibet in the north and joins with Brahmaputra river, India in the south. These river swell up extremely in the rainy season and almost dry up in winter. The Amochu river is a modified habitat where several terrestrial species of otter, birds, and fish are found co-existing with the industrial and residential activities along its flood banks. A survey conducted by the Royal Government of Bhutan Department of Livestock, National Center for Riverine and Lake Fisheries along the water environment of the project area using cast net, rod and line, and electro fisher yielded 22 fish species mostly Barilius, Gara, Badis and Katle. The endangered Golden Masheer (*Tor putitora*) was also caught during the sampling

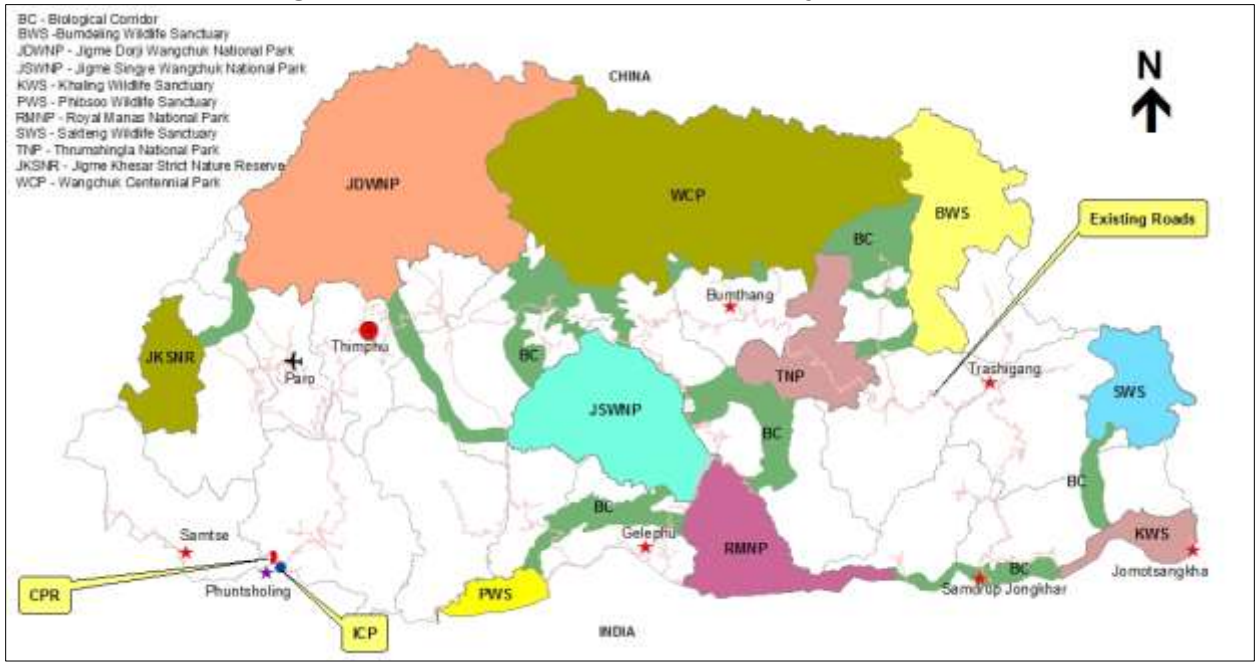
period supporting the classification of the Amochhu river as critical habitat required for the survival of this endangered species.

### 3. Vegetation

114. There are no natural trees or not even a single one within the 100 feet (30.48m) road right of way (ROW). The PCR road alignment follows the left bank of Amochhu River with virtually no vegetation cover.

115. Forest covers are found on hill slopes on both sides of Amochhu river banks. The common tree species found in the project area are *Ficus elastic, Michelia champaca, Phoebe golparaensis, Dillenia pentagyna, Sapium baccatum, Putrangiba assamica, Cannarium sikkimensis, Mangifera sylvesteris, Careya arborea, Diplocknema butyraceae, Vitex heterphylla, Phoenix humilis, Trachycarpus martianus* and *Caryota urens*. Common shrubs found are *Piper mulesua, Crotolaria sp. Flemingia sp., Todalia asiatica, Citrus lemon, Cipadessa baccifera* and *Tithonia diversifolia.*

**Figure 20: Protected Areas and the Project Location**




### 4. Avifauna and Aquatic Fauna

#### a. Avifauna

116. Since the Project area is devoid of natural vegetation cover, there is no wildlife except for avifauna. The birds those which reside in close proximity to human settlement and the aquatic birds are common in the Project area. The common birds found in the Project area are Common Myna (*Acridotheres tristis*)[1], Hill Myna (*Gracula religiosa)*[2], Red vented bulbul

[1] One of the most invasive species according to IUCN
[2] Classified as least concern

(*Pycnonotus cafer)*[1], Crested Serpent Eagle (*Spilomis cheela)*[2], Spotted Dove (*Streptopelia chinensis)*[3], Slaty-Backed Forktail (*Enicurus schistaceus)*[4], Asian Pied Starling (*Sturnus contra)*[5], Little Egret (*Egretta garzetta)*[6], Indian Pond Heron (*Ardeola grayii)*[7], Little Cormorant (*Phalacrocorax pygmeus)*[8], Great Cormorant (*Phalacrocorax carbo)*[9], and Red-Wattled Lapwing(*Vanellus indicus)*[10].

117. The entire project corridor from Phuentsholing to Chamkuna follows the river bank that is highly disturbed area due to its proximity to human settlement. There are no bird nesting and breeding area in the Project site observed during the four seasons of 2015. However, birds especially cormorants, egrets, and geese in large group flock in the morning hours for feeding in the Amochhu River from October – May when the fishes are sluggish due to cold water temperature. During the rainy season from June to September, water birds tend to spread out to other rivers and rivulets as there are plenty of food available.

### b. Aquatic fauna

118. About 91 species of fishes are confirmed to occur in Bhutan (Gurung et al. 2013)[11]. Only the Golden Mahsheer (*Tor putitora*) is a totally protected species under schedule I of Forest and Nature Conservation Act of Bhutan, 1995 and listed as endangered by the IUCN. A Baseline Fish survey for Amochhu basin was conducted by Fishery Ecology and Environment Unit, National Center for Riverine and Lake Fisheries in November 2015. Total of 22 species were found to exist in Amochhu River during the sampling period in November 2015 belonging to three orders and seven families. During sampling period the most fish caught was Barilius, Gara, Badis and Katle in Amochhu River and its tributaries – Omchhu/Doti khola and Loari khola. Of the total fish species, the Golden Masheer (*Tor putitora)* an endangered (IUCN red list) or FNCA Schedule I species was also recorded in the Amochhu basin. The lists of the collected fish species, order, family and their scientific names are presented in Table 13. Complete baseline fish survey report is provided as Appendix 5.

**Table 13: Fish species found during the baseline study period from Amochhu and its tributaries**

| Order | Family | Species Recorded | IUCN Status |
|---|---|---|---|
| Cypriniformes | Cyprinidae | *Tor putitora* | EN |
| | | *Neolissochilus hexagonolepis* | NA |
| | | *Semiplotus semiplotus* | LC |
| | | *Barilius varga* | LC |
| | | *Barilius bendelisis* | LC |
| | | *Barilius barna* | LC |
| | | *Devario aequipinnatus* | LC |

[1] Least concern
[2] Least concern
[3] Least concern
[4] Least concern
[5] Least concern
[6] Least concern
[7] Least concern
[8] Least concern
[9] Least concern
[10] Least concern
[11] An annotated checklist of fishes from Bhutan (http://threatenedtaxa.org/ZooPrintJournal/2013/October/o316026x134880-4886.pdf)

| Order | Family | Species Recorded | IUCN Status |
|---|---|---|---|
| | | *Danio rerio* | LC |
| | | *Chagunius chagunio* | LC |
| | | *Punitus sophere* | LC |
| | | *Schizothorax richadsonni* | LC |
| | | *Gara gotyla* | LC |
| | | *Gara annandalei* | LC |
| | | *Acanthocobitis* spp. | LC |
| | | *Oreichtys crenuchiodes* | LC |
| | Psilorhynchidae | *Psilorhynchus balitora* | LC |
| | Balitoridae | *Schistura* spp. | LC |
| Siluriformes | Amblycipitidae | *Amblyceps apangi* | LC |
| Siluriformes | Claridae | *Clarias gariepinus* | LC |
| Perciformes | Channidae | *Channa* spp. | LC |
| | | *Channa gachuua* | LC |
| | Nandidae | *Badis badis* | LC |

*Source: A Baseline Fish Survey – Amochhu basin Phuentsholing, November 2015*

### c. Golden Masheer[1]

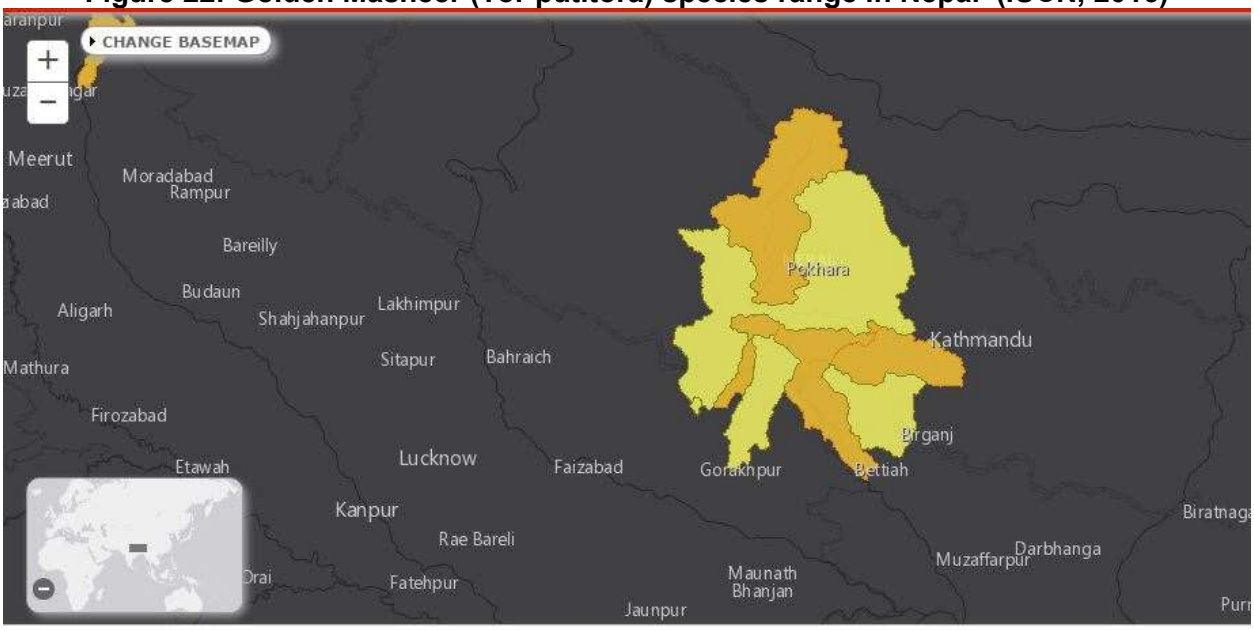
119. Golden Masheer (Tor putitora) inhabits the montane and submontane regions in mid hills stretches of Himalayan region. It inhabits rapid streams with rocky bottom, riverine pools and lakes. It is a benthopelagic column feeder in freshwater found in pH ranges 7.4 - 7.9 and in subtropical condition 13°C-30°C. The usual depth of range is within 1m. It is omnivorous in nature during their adult stage and feed on periphytic algae and diatoms in juvenile stage.[2] Range of occurrence includes Afghanistan, Pakistan, India, Nepal, Bangladesh, Bhutan, and Mynmar.

**Figure 21: Golden Masheer (Tor putitora) species range in India (IUCN, 2016)**


[1] This section draws heavily from K.L. Sehgal (undated). "Coldwater Fish And Fisheries In The Indian Himalayas: Rivers And Streams." Food and Agriculture Organization of the United Nations. ISBN: 9251043094. ISSN: 0429-9345

[2] IUCN and www.fishbase.org

**Figure 22: Golden Masheer (Tor putitora) species range in Nepal (IUCN, 2016)**




120. The geographical distribution, life cycle, and mating behavior of the Masheer is intrinsically tied to the cold flowing rivers of the trans-Himalayas like the Amochu and dependent on the following important factors: i) current velocity, ii) fluctuation in water discharge, iii) water temperature, iv) water temperature and dissolved oxygen, iv) substratum, v) shelter from the current, and vi) food availability represented mostly by organisms clinging to and growing on rock and stone surfaces in fast current . The Golden Masheer migrate to the Brahmaputra river in autumn and come back to Bhutan in the spring between April and spawn during low phase of flood. Fry are found among stones in marginal areas of the stream. Natural spawning grounds are usually marginal lakes where streams are draining the nearby hills. Matured female Masheers with nearly matured eggs are attracted by the sound of the cascading and highly oxygenated waters. In addition to the high dissolved oxygen level, these marginal lakes have water temperatures ranging from 21°C to 26°C which are suitable for the eggs to properly mature. The fertilised eggs are demersal, lemon yellow or brownish golden in colour measuring 2.8 to 3.2 mm in diameter. The eggs of the mahseer are laid on sand and gravel and perish if there is the presence of mud. The early hatchlings of mahseer are golden yellow and pass through a semi-quiescent stage during which they remain huddled in corners and crevices with their heads tucked away from light. In this condition, they are exposed to heavy predation by other predatory animals. This condition continues for about six days and forms the most critical period of its early life cycle.

121. Preliminary findings from the radio telemetry survey of the Fisheries Conservation Foundation (FCF), WWF-Bhutan, and Ministry of Agriculture and Forestry in the two major arms of the Manas River, the Mangde Chhu and Dangme Chhu, indicated “Golden Mahaseer exhibit a wide range of different movement patterns. Some fish move upstream from the lowest reaches near the Manas National Park Ranger Station, traveling up the Mangde Chhu and the Dangme Chhu from April through at least July, with large distances often being covered within a just few days. Some fish also moved rapidly downstream at different periods of the year, entering India below Manas. Some of these tagged fish have returned to Bhutan, while other fish have not.”

122. Masheer spend the major part of their life facing the current to maintain their upright position, and make respiration easier. They have to open their mouths to take in water and boost the respiratory current. The need for shelter from the current has led to territoriality. Mahseers chase intruders to defend the limited food resource and available shelter. Such a behaviour develops after the young fish emerges from the eggs laid in gravel. During winter months all size groups of mahseers are present in pools when the water level is at its lowest and water is highly transparent mainly to confuse predators.

123. Water temperature is an important limiting factor affecting geographical distribution of sub-himalayan fish however Mahseers have a wide tolerance and even survive water temperatures over 25°C. Fluctuating discharge of water and drying out of streams, leaving only isolated pools or no water at all, is another important factor for Masheer survival. Reduction of torrential streams to stagnant pools exposes the fish to terrestrial predators and to depletion in dissolved oxygen concentrations, especially when autumn leaf fall takes place. However, due to low temperature, the level of dissolved oxygen may not fall below the optimum required by coldwater fish (7.0-8.0 mg l-1). As soon as the flow is restored with spring rains and snow-melt water a rapid recolonisation of the stream takes place. Change in pH in conjuction with change and temperature corresponds to a decrease in dissolved oxygen, decline in the density of nymphs of mayflies and stoneflies, but in an increase in larval and adult aquatic beetles. Seghal (1988, 1989) provided key water quality information based on studies made on eleven rivers, i.e. Indus, Jhelum, Chenab, Ravi, Beas, Sutlej, Jamuna, Bhagirathi, Alaknanda, Mandakini and Pindar provides the following: current velocity (cm/sec): 0.6-1.2; transparency (cm): 4.2-33.7; pH: 7.1-7.8; water temperature (oC): 9.0-19.0. For the following chemical components the values are given as mg l-1: dissolved oxygen: 7.6-11.2; total alkalinity: 50.3-202.2; chlorides: 4.0-12.5 (the highest value measured in the Indus, representing twice the value of the next highest); silicates: 0.5-1.25; calcium: 1.2-1.9.

124. Golden Masheer's population is fast depleting due to overfishing and dam construction which fragmented their natural habitat. Masheers have been heavily poached, and further damage has been inflicted by dams and weirs which have stopped fish migrations. Increased soil erosion, resulting from the deforestation of mountains, has led to heavy siltation of rivers and streams and destruction of spawning areas. Attempts to culture and conserve Tor putitora are being implemented in most trans-Himalayan countries.

## D. Socio-economic Environment

### 1. Demographic Features

125. Phuentsholing is the second largest city in Bhutan. In 2005 the total population of 20,537 has been projected to exceed 24,000 by 2013. The unprecedented growth of the city in 1986-1991 converted the surrounding forests and available agricultural land into residential, commercial, and other uses to accommodate the increasing population. The population is projected to reach 67,000 by the year 2027.

### 2. Educational and Health Facilities

126. **Education.** Phuentsholing Thromde has 1 College of Science and Technology; 1 Primary School (PS); 1 Lower Secondary School (LSS); 1 Middle Secondary School (MSS), 1 Higher Secondary School (HSS), 1 Non-Formal Education (NFE), 1 Monastic School and 4 Private Schools. None of these institutions are within the Project Area.

127. **Health Facilities.** There is 1 hospital located at Dhamdara about 0.5 km from Phuentsholing town. There several private clinics in Indian border town of Jaigaon which occasional Bhutanese national avail their services.

### 3. Transport Infrastructures

128. Phuentsholing Thromde is the main commercial hub of Bhutan with majority of trade with India and third countries take place through this city. The Thimphu-Phuentsholing national highway (now designated as Asian Highway in Bhutan), which connects Bhutan with the Indian border town of Jaigaon, also runs through core area of the city. Currently, this highway is also the only entry and exit point for the core city area which results in heavy traffic congestion from local traffic and trucks transporting goods to and from Thimphu and containers carrying raw materials and finished goods to and from the Pasakha industrial area.

129. Phuentsholing Thromde with financial assistance from the ADB in the process of constructing second entry and exit gate, by-pass road and bridges to divert traffic and reduce congestion, provide an alternative crossing over the OmChhu River to connect the eastern and western parts of the city, and accommodate the expected traffic arising from the AmoChhu Land Reclamation project area (approximately +870 acres), Amochhu LAP and Samtse Dzongkhag. The proposed PCR would connect to the intersection to the Phuentsholing by-pass road to Samtse-Phuentsholing Highway thus completing the transportation link of the Samtse region.

### 4. Religious, Cultural, Historical and Archeological Resources

130. There are no religious, cultural, historical and archeological resources within road ROW (30.48m). The nearest religious structure are – i) Crematorium near Bangay (100m away from the PRC corridor); and Palden Tashi Choling Shedra (monastic school) is about 250m away from the proposed road. Other important religious structures are Zangto Pelri (in the heart of Phuentsholing town) and Kharbandi Goenpa (3km from the town center).

### 5. Potential Development Area

131. There are two potential development areas adjacent to the PCR – 1) Amochhu Land Reclamation and Township Project (ALRTP) of DHI, and ii) Amochhu Local Area Plan (LAP) of Phuentsholing Thromde.

132. ALRTP is expected to give access to about 1,000 plus acres of land on either side of the riverbanks which will help address numerous challenges faced by Phuentsholing town including space crunch for expansion of the fast growing commercial town. The township, which will be available to interested investors, will be leased out after all the common urban infrastructure such as roads, sewer lines, water supply, power lines, and car parking facilities, are in place.

133. Similarly to the east of ALRP is the planned Amochhu Local Area Plan (LAP) by Phuentsholing Thromde which is designated as residential and light commercial zone. LAP development will help ease the acute shortage of an affordable housing for the Bhutanese citizen particularly the low income groups who currently residing mostly in Jaigaon, India.

# VI. CLIMATE CHANGE IMPACTS AND RISKS

## A. Climate Change Scenarios and Trends

135. This section deals with the trends in mean annual and seasonal (monsoon/wet and winter/dry) temperature ($^0$C) and mean annual and seasonal (monsoon/wet and winter/dry) precipitation/rainfall (mm) for Bhutan from 1980-2069, using simulations from the downscaled HadCM3 and ECHAM5 climate models. The monsoon/wet season is assumed to last between June to September and the winter/dry season to last between December to March. The simulations consisting of dynamically down-scaled temperature and precipitation using the PRECIS regional model was performed by NEC/START-SEA, Bangkok, Thailand. Both the HadCM3 and ECHAM5 climate models were downscaled using the SRES A1B forcing scenario. The downscaling using Precis provided climate variables diagnostics on a 22 x 22 km grid network covering Bhutan and surrounding areas.

### 1. Temperature Trends

136. The annual trends in annual mean temperature between 1980 and 2069, based on down-scaled simulations of both the HadCM3 and ECHAM5 climate models are shown in Figure (reproduced below as Figure 13) as yearly data and polynomially smoothed data. Both the downscaled HadCM3 and ECHAM5 climate model outputs of air temperature show a progressive and steady increase in air temperature from 1980 to 2069. However, there is a difference of ~ 1.5$^0$C, between the downscaled HadCM3 and ECHAM5 simulations, the HadCM3 simulations being higher. This difference was attributed to the way the two models vary certain parameters such as corrections for elevation, Bhutan being largely a mountainous country. The HadCM3 simulations therefore shows a steady increase of temperature, increasing from ~ 13.5$^0$C (1980) to ~ 17.0$^0$C (2069), a temperature increase of ~ 3.5$^0$C. On the other hand, the ECHAM5 simulations shows a steady increase of temperature, increasing from ~ 12.00 C (1980) to ~ 15.5$^0$C (2069), a similar temperature increase of ~ 3.5$^0$C. The seasonal (monsoonal) trend in mean temperature between 1980 and 2069 show progressive and steady increase, by ~ 3$^0$C by HadCM3 simulation (~19.5$^0$C to ~22.5$^0$C) and about the same by ECHAM5 simulation (~17.5$^0$C to ~20.5$^0$C).

### 2. Precipitation Trends

137. The annual trends in annual mean total precipitation between 1980 and 2069, based on down-scaled simulations of both HadCM3 and ECHAM5 climate models are shown in the figure reproduced below (Figure 14). Both the downscaled HadCM3 and ECHAM5 climate model outputs of precipitation/rainfall show a progressive and steady increase in precipitation from 1980 to 2069. However, there is difference of ~ 100 mm/year between the downscaled HadCM3 and ECHAM5 simulations, the ECHAM5 simulations showing higher, especially towards 2069. The ECHAM5 simulations show a steady increase of precipitation/rainfall increasing from ~ 2000 mm/year (1980) to ~ 2600 mm/year (2069). The HadCM3 simulations also show increasing trend from ~1900 mm/year (1980) to ~ 2400 mm/year (2069).

138. The seasonal (monsoonal) trend in monsoonal mean total precipitation between 1980 and 2069 show progressive and steady increase, by ~ 350 mm/year by HadCM3 simulation (~1150 mm/year to ~1500 mm/year) and ~450 mm/year by ECHAM5 simulation (~1300 mm/year to ~1750 mm/year).

**Figure 23: Annual Mean Temperature according to HADCM3 and ECHAM5**

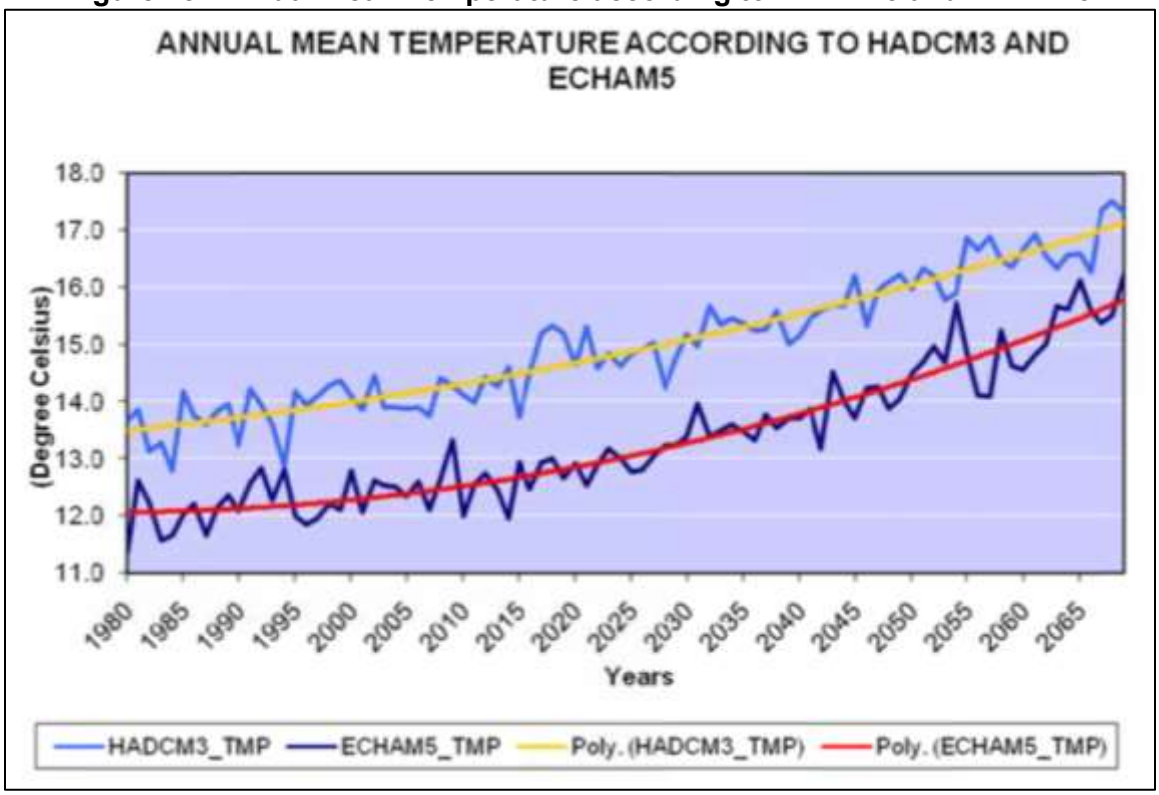
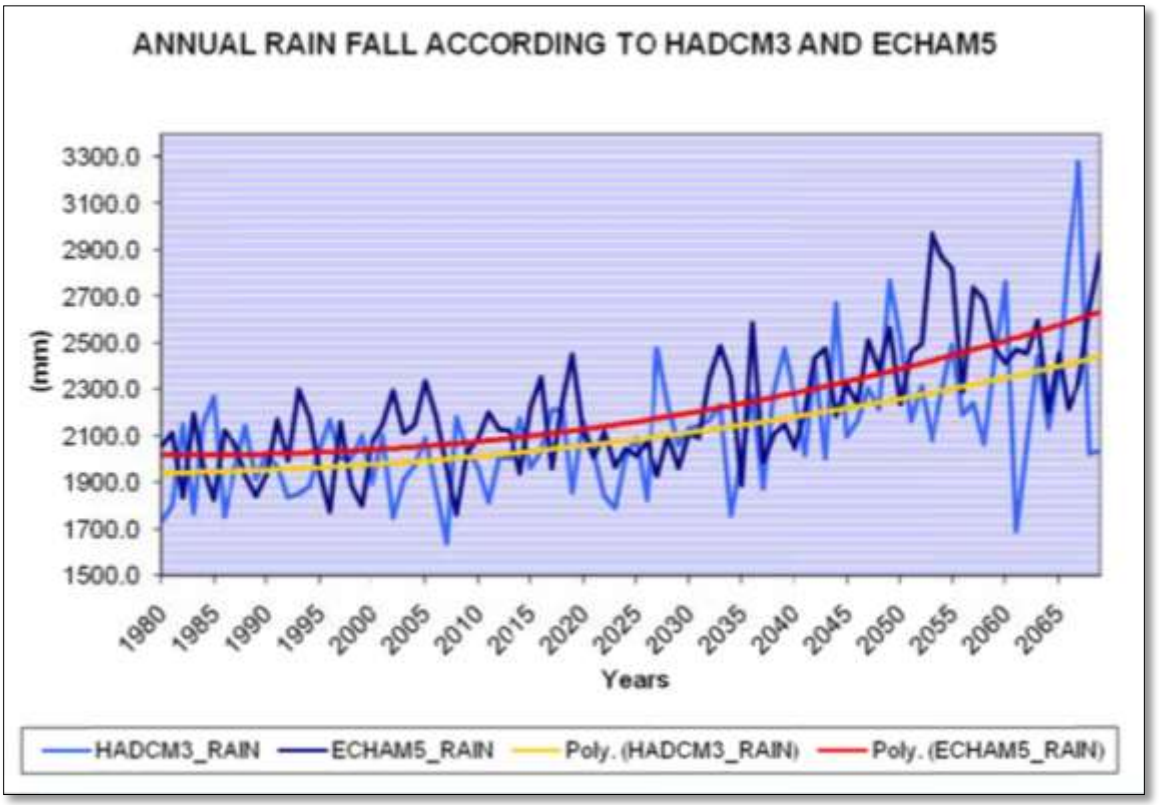



**Figure 24: Annual Rainfall According to HADCM3 and ECHAM5**



## B. Estimated Greenhouse Gas Emissions

139. With a vast forested area, limited population and low level industrial activity, Bhutan is a net sink fof greenhouse gases[1]. The estimated sequestration capacity of our forest is 6.3 million tons of CO2 while the emissions for year 2000 is only 1.6 million tons of CO2 equivalent. Bhutan generates all its electricity from hydropower.Agriculture sector is the highest contributor but has remained constant from 1994-2000. However, emissions industrial and transport sectors showed rapidly increase. From 2000-2013, emissions from the energy sector increased by 191.6% from 0.270 million tons of CO2e in 2000 to 0.79million tons of $CO_2e$ in 2013. Emissions from industrial processes increased by 154.3% from 0.24 million tons of CO2e to 0.6 million tons of CO2e. Emission from waste management also increased by 247.54% from 0.047 million tons of CO2e to 0.16 million tons CO2e[2]. Transportation sector in Bhutan, according to the UNFCC Climate Change Secretariat[3] increased its GHG emissions by 173% from 1994 to 2000.

140. The Transport Emissions Evaluation Model for Projects (TEEMP)[4] developed by Clean Air Asia[5] was used to assess the marginal chage CO2e emissions "with" the project embankment road against "without" project road. The without project road consideres the GHG emissions from the projected traffic using the same unpaved river bank road. The with project road, benefits from improve road roughness which translates to faster travel speed. No benefit was assumed from road widening since the existing alignment is not fully defined and vehicles can generally carve its own path limited only by the presence of natural impediments like depressions, boulders, and the Amochhu river. The following options and assumptions were using in the TEEMP:

- Period of analysis, 36 years starting 2015
- Induced elasticity from the feasibility study traffic analysis is 1.2 to occur after 3 years upon project completion
- Volume capacity saturation, 2
- Road section details: 3.75, lane width, 3.3km homogenous section, 2 lanes
- Road roughness improvement from 12 to 2.5 m/km
- Traffic is provided in the project description chapter and linear interpolation in-between years of projection.
- Vehicle fleet characteristics: in 2015; 40%, 40% , and 20% of gasoline and diesel cars are Euro 1,2, and 3 compliant, respectively. By Year 2050, no Euro-1 and 40% and 60% Euro-2 and 3 compliant vehicles for both gasoline and diesel fed.
- CO2 emission during construction of the embankment road was assumed at 739 CO2e ton/km[6]

[1] 2nd National GHG Inventory, September 2015

[2] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Bhutan/1/Bhutan-INDC-20150930.pdf

[3] https://unfccc.int/files/ghg_data/ghg_data_unfccc/ghg_profiles/application/pdf/btn_ghg_profile.pdf

[4] TEEMP is an excel-based, free-of-charge spreadsheet models to evaluate emissions impacts of transport projects.

[5] A network of 250 organizations in 31 countries established by the Asian Development Bank, World Bank, and USAID to promote better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse gas emissions from transport, energy and other sectors.

[6] World Bank (2010): Table 12, Greenhouse Gas Emissions Mitigation in Road Construction and Rehabilitation A Toolkit for Developing Countries Introduction to Greenhouse Gas Emissions in Road Construction and Rehabilitation Executive Summary

- Fuel consumption efficiencies provided in succeeding Table

**Table 14: Fuel efficiency in km/l**

| Scenario | BAU | | WPS | |
|---|---|---|---|---|
| | Petrol | Diesel | Petrol | Diesel |
| 2 Wheeler | 40.00 | | 50.00 | |
| 3 Wheeler | | 15.00 | | 20.00 |
| Car | 12.00 | 15.00 | 15.00 | 20.00 |
| LCV | | 5.00 | | 8.00 |
| Bus | | 5.00 | | 8.00 |
| HCV | | 5.00 | | |

Source: DPR Consultant

141. The following Table and Figures presents the results of TEEMP on the proposed construction of a 3.3 km embankment road. Improving the road roughness alone will result to a decrease in GHG emission intensity amounting to about 98 tonsCO2e/km and 109 tons CO2e/year. The reduction in GHG emissions is attributed to increase in speed and reduction in fuel consumption.

**Table 15: GHG Emission Intensities**

| Details | CO2 | | |
|---|---|---|---|
| | Business-As-Usual | Project (without Induced Traffic) | Project (with Induced Traffic) |
| tons/km | 2,519.59 | 2,421.66 | 2,421.66 |
| tons/year | 2,806.55 | 2,697.46 | 2,697.46 |
| tons/km/year | 69.99 | 67.27 | 67.27 |
| g/pkm | 45.93 | 44.15 | 44.15 |
| g/tkm | 505.54 | 485.89 | 485.89 |

**Figure 25: GHG Emissions Intensities**

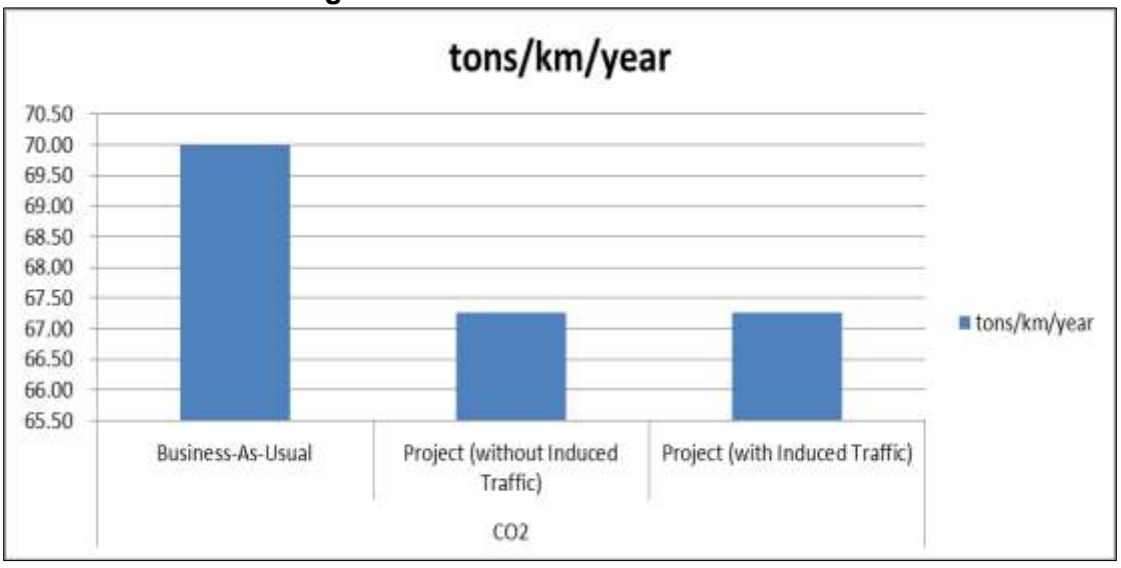
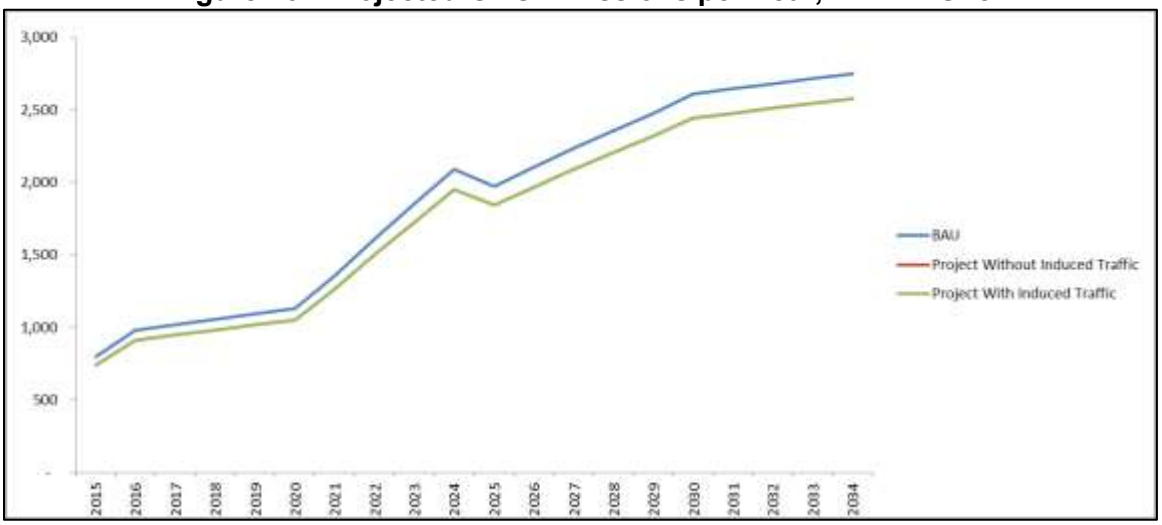


**Figure 26: Projected GHG Emissions per Year, in MT CO2e**



# VII. ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

142. This Chapter presents the environmental assessment process and planning undertaken by the Department of Roads (DoR) in addressing the environmental impacts and risk associated with the construction of the new 3.3km embankment road along the Amochhu river Connecting Phuentsholing to Chamkuna. This chapter starts with the identification and screening of potential impacts. The identification of impacts was conducted by identifying the general project components e.g. site mobilization, establishment of camps, road construction, and road operation and corresponding interaction with specific environmental aspects e.g. physical, biological, and human.

## A. Project components interacting with environment

143. The critical project components that will have substantial interaction with the environment are as follow:

### 1. Preconstruction stage:

a) Road alignment and design – involves the screening and selection roads to avoid environment sensitive areas particularly during the feasibility stage, finalization of road alignment to avoid land acquisition and ensure consistency ALRP and the Amochhu LAP plans, minimize erosion, minimize/avoid tree cutting, and provide appropriate cross-drainages.
b) Construction and camp site location
c) Construction mobilization - land clearing, installation of electricity and other utility connections; perimeter fencing; establishment of storage areas for rocks, gabion wires, fill materials, geotextile, aggregates, and cement; waste disposal; and installation of production equipment (hot mix, concrete batching, rock crusher, casting) in the labor and camp sites.

### 2. Construction Phase

a) River channeling and spur dike construction- temporary embankment will be constructed from riverbed dredged materials to concentrate minor streams into a single channel, promote river bed scouring into an alignment farther from the road embankment. Spur dikes will be constructed along the entire length of the project road to reduce the erosive capability of the Amochhu flood flows, induce sedimentation in between the spurs, and offer protection against woody debris and sharp objection from cutting through the road gabion toe and foundation
b) Installation of silt curtains – deployment of silt curtains during low flow parallel to the Amochhu river to trap silt within the immediate water area and avoid downstream contamination
c) Soil filling and compaction - hauled borrow earth used to fill the geotextile and compacted to form the embankment
d) Road construction – includes earthworks for sub-grade, sub-base, gravelling of base; preparation of wearing course, and construction of shoulders. A total of 5 bridges and 8 culverts will be installed across the PCR to ensure the surface runoff are collected and diverted towards these structures with reduced sediment load and velocity.
e) Construction plants operation for hot mix and cement batching

f) Borrow area operation and hauling – quarrying of soil and hauling to project site 16 kms away through sparsely populated area. Contractor will not excavate sand from Amochhu by itself. The sand will be bought from Natural Resource Development Corporation Limited (NRDCL) which is the authorized supplier of sand and boulders from Amochhu River basin. Hence no separate sand excavation management plan for this project is required. NRDCL extract sand and boulder as per the environmental conditions put forward by the National Environment Commission (NEC) of Bhutan. Any additional sand required will be procured from Indian supplier from across the border. NRDCL is allowed to quarry sand in the winter or dry season starting from late November to April

g) Site-Restoration involves the clean-up and restoration of construction zones to near its original condition prior to Contractor demobilization to include: river beds used for sand mining; camps; hot mix plant, crushers, batching plant sites; and borrow areas rehabilitated.

**3. Post-Construction Phase**

a) Road maintenance- routine maintenance of sealed road pavement, foot paths, kerbs and channels, storm drainage, and pavement markings.

## B. Identification and Assessment of Environmental Impacts

144. The identification of potential effect requires identifying the components of the physical, biological, and human environments that are at risk of being impacted in the construction of a new embankment road. Similar to the classical Leopold matrix, it involved an integration grid between the valued environmental components and project activities. The valued environmental components for this project were drawn from the environmental baseline and are as follow:

a) **Physical environment** – soil and sediment quality, surface water quality, hydrology and hydraulics, and air quality and greenhouse gas emissions
b) **Biological environment** – special status species (Tor putitora), avifaunal habitats, and mammals, terrestrial vegetation, mammals, avifauna, and special status species
c) **Human environment** – private land and buildings, public infrastructures, sound environment, aesthetic and visual, and community and occupational health and safety.

145. The assessment of potential environmental impacts requires the definition of the effects associated with the state highway upgrading in terms of intensity, duration, and scope as follow:

a) **Intensity of the effect**: The intensity of the effect refers to the level of disruption to the component. Three levels have been defined: i) Low: Little change in the characteristics of the component. Difficult to quantify; ii) Average: Change in certain characteristics of the component. The change may be quantifiable; iii) High: Change in all or in the main characteristics of the component. The change is quantifiable
b) **Duration of the effect**: Duration means the time dimension of the effect. The terms permanent, temporary and short are used to describe the period of time: i) Short-lived: the effect disappears promptly; ii) Temporary: the effect is felt during

one project activity or, at most, throughout implementation of the project; iii) Permanent: the effect has repercussions for the life of the infrastructure.

c) **Scope of the effect**: The scope describes the spatial dimension of the effect caused by an action in the environment. It refers to the distance or area covered by the disruption. The terms regional, local and limited are used to describe the scope: i) Limited: the scope is limited when the action affects only one environmental element located near the project; ii) Local: the scope is local when the action affects the study area; iii) Regional: the scope is regional when the action affects areas beyond the study area

146. **Assessment of the potential effect**. These three parameters are incorporated into a multicriteria matrix, making it possible to place the potential effect into one of three categories: i) Major (MAJ): signifies an effect that is permanent and that affects the integrity, diversity and sustainability of the element. Such an effect substantially or irremediably alters the quality of the environment; ii) Medium (MED): signifies a perceptible, temporary and/or low-return effect that has little impact on the environmental component and is not irreversible. Such an effect is short-lived and/or limited in scope; iii)Minor (MIN): signifies that the effect is non-existent or virtually non-existent, that it does not affect the environmental component in any observable or quantifiable way and that it is related to a randomly occurring natural effect. As a rule, this would be a short-lived effect, limited in scope.

| **Intensity** | **Duration** / **Scope** | **Short-lived** | **Temporary** | **Permanent** |
|---|---|---|---|---|
| Low | Limited | MIN | MIN | MED |
| | Local | MIN | MIN | MED |
| | Regional | MIN | MED | MAJ |
| Average | Limited | MIN | MED | MED |
| | Local | MED | MED | MAJ |
| | Regional | MED | MAJ | MAJ |
| High | Limited | MED | MAJ | MAJ |
| | Local | MED | MAJ | MAJ |
| | Regional | MAJ | MAJ | MAj |

147. The relationship between these project phases and its components, and the environment were established to identify anticipated environmental impact is provided in the succeeding Figure.

**Figure 27: Grid Displaying the Interaction Between Environmental Components and Bhutan SASEC TTLFP Embankment Road Component**

| Environmental Component | Pre-Construction | | Construction | | | | | | Operation |
|---|---|---|---|---|---|---|---|---|---|
| | Road Alignment and Design | Construction Mobilization | River rechanelling and spur dike construction | Installation of Gabion foundation, soil filling and compaction | Road construction | Construction plants and camp site operations | Borrow area operation/hauling | Site Restoration | Road Maintenance and erosion control |
| **Physical Environment** | | | | | | | | | |
| Soil and sediment quality | | X | X | X | | X | X | X | |
| Surface Water Quality | | X | X | X | X | | X | X | X |
| Hydrology and hydraulics | | | X | X | | | | | |
| Air Quality and GHG | | X | | | X | X | X | X | |
| **Biological Environment** | | | | | | | | | |
| Special Status Species | | | X | X | | | | | |
| Avifauna habitats | | X | | | | | | | |
| **Human Environment** | | | | | | | | | |
| Private Land and Buildings | X | X | | | | | | | |
| Public Infrastructures | X | X | | | X | X | X | X | |
| Sound Environment | | X | | X | | X | X | | |
| Community and OH Safety | | X | | | X | | X | | X |

148. Mitigation measures were identified to reduce the significant adverse impacts including residual effects. As the project is currently in the feasibility study stage a number design and construction methods alternatives like method of river channeling, location and scale of the spur dikes, road side protection, location of camp and plat sites, borrow area, and quarries remains to be decided and from which a host of impacts will be assessed. However, the analysis of impacts shown in the succeeding Table revealed the following:

149. During the pre-construction phase, major potential negative impacts pertains to site mobilization where surface runoff may carry sediment to the Amochu which are detrimental to the Golden Masheer (Tor putitora) spawning behavior. During construction, the river channeling, construction of spur dike, installation of gabions, soil filling, and compaction will also increase sediment flow and increase suspended solids in the water column. To mitigate the significant impacts to the Masheer, no activity in the water environment will be allowed during autumn migration from October-November and in the spring spawning between April and May. The contractor will maintain Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area and take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area. A key mitigation measure is the deployment of geo-textile silt curtains before the start of any work to ensure suspended solids will not settle outside the project area.

150. Another potential significant impact is the on the hydrology and hydraulic characteristics of the Amochhu once the river channelization and spur dikes, aimed at protecting the embankment road. This study relied of the DHI assessment for the ALRP that as long as the river channel maintains a smooth flow and cross-section of 300m, there would be marginal impact on the flow velocity and sedimentation downstream.

151. Only minor environmental impacts were identified during project operation.

### C. Loss of Habitat and Survival of the Golden Masheer

152. There is no habitat loss of the Golden Masheer that is attributable to the project. River training will enable to Amochhu to meander back to its previous course further away from the Phuenstholing river bank and protect the project road with no measureable effect of the river's cross-sectional area. Avoiding all works on the water environment during the critical migration seasons of the Golden Masheer further ensures that reduction of the population is avoided

153. The scale of the project is small, 3.3km, barely touching the water area, about than 1km of a critical habitat Amochhu/Toorsa whose total length of 358 kilometers. No measureable effect on the river hydraulics, sediment transport, and general morphology, and the mitigation measures necessary to control silt and avoid disturbing the Golden Masheer's migration are effective and easy to implement with no significant residual impacts requiring the use of geotextile silt curtains and prohibiting any works on the water area during the migration periods of October-November and in the spring between April and May.

154. Even at fully contracted 300m channel width envisioned under the Amochu Land Reclamation Project corresponding to an increase in average maximum velocity from 3 to 4 m/s"[35] expected during high flood flows, the impacts to the Golden Masheer is negligible as they have already migrated up the Amochhu to avoid peak discharge and flow velocity. Although no specific study on the Masheer's tolerance to flow velocity was gathered, major cold water fishes can thrive at 1.45 m/s during low flow. Comparing this to historical records on the Amochhu river monitoring data by DHI, flood velocity in 2006 reached 2.2 m/s which is much higher than 1.45m/s but still Masheer inhabits the Amochhu river. This amazing survival is attributed to their migration movement where the Masheers take refuge upstream in small channel and avoiding devastating flood flows downstream.

### D. Trans-Boundary Impact

155. The construction of the embankment road and the associated river channelization and spur dikes were assessed against the likelihood concentrating the several stream into channel which may force river to flow rapidly and cause inundation, flooding and erosion across the border in West Bengal, India; and increased silt and debris deposition across border and particularly in the Jaldapara National Park located 25km downstream of the Proposed Project.

156. DHI is planning a large scale rechannelization of the Amochhu to reclaim land on both banks of the existing channel as future expansion area of Phuenthsoling. Comprehensive studies showed that there will be minimal change in velocity and water levels as result of ALRTP. Over the reach of the river from the international boundary to Hashimara Road Bridge, the impact in terms of water levels, discharge, velocities and sediment transport shown to be negligible. The minor impact anticipated immediately across the border on water levels where the recession of the flood wave will be slightly faster, and maximum flow velocities which will be slightly higher (2.5m/s compared with 2.4m/s – figure 27), but it is expected that it will rapidly disappears further downstream.

### E. Induced Development and Impacts

[35] The executive summary of the report is available at:
http://pcc.bt/Downloads/Amochu_Executive_Summary.pdf

157. Phuentsholing-Chamkuna road construction will be the precursor to the development of Amochhu Local Area Plan. Phuentsholing Thromde is crowded with little or no space for further expansion. It is estimated that Thromde will need 54 hectare of buildable land (Urban Development Plan 2002-2017, Phuentsholing Thromde) for its growing population. With implementation of Amochhu LAP, Thromde will be able to get more than half of its land need. This will help ease the chronic housing shortage of buildable land it is facing currently. This will ultimately help bring back about 1500 people living across in India due to the shortage of housing within Bhutan. Refer Figure 28 for Amochhu Local Plan.

158. The planned urban development by the Thromde and DHI during construction stage will have similar impacts as the PCR but on a larger scale considering the need to elevate the existing ground level by 4-7 meters. The unmitigated sediment increase and the deterioration of the water quality from increase turbidity will require more rigorous impact assessment of the Masheer. During its operation stage, untreated effluents from the domestic source with high biochemical oxygen demand may reduce the dissolve oxygen to a level that will not support the Masheer.

**Figure 28: Google map illustrating the Amochhu flow and Jaldapara National Park**

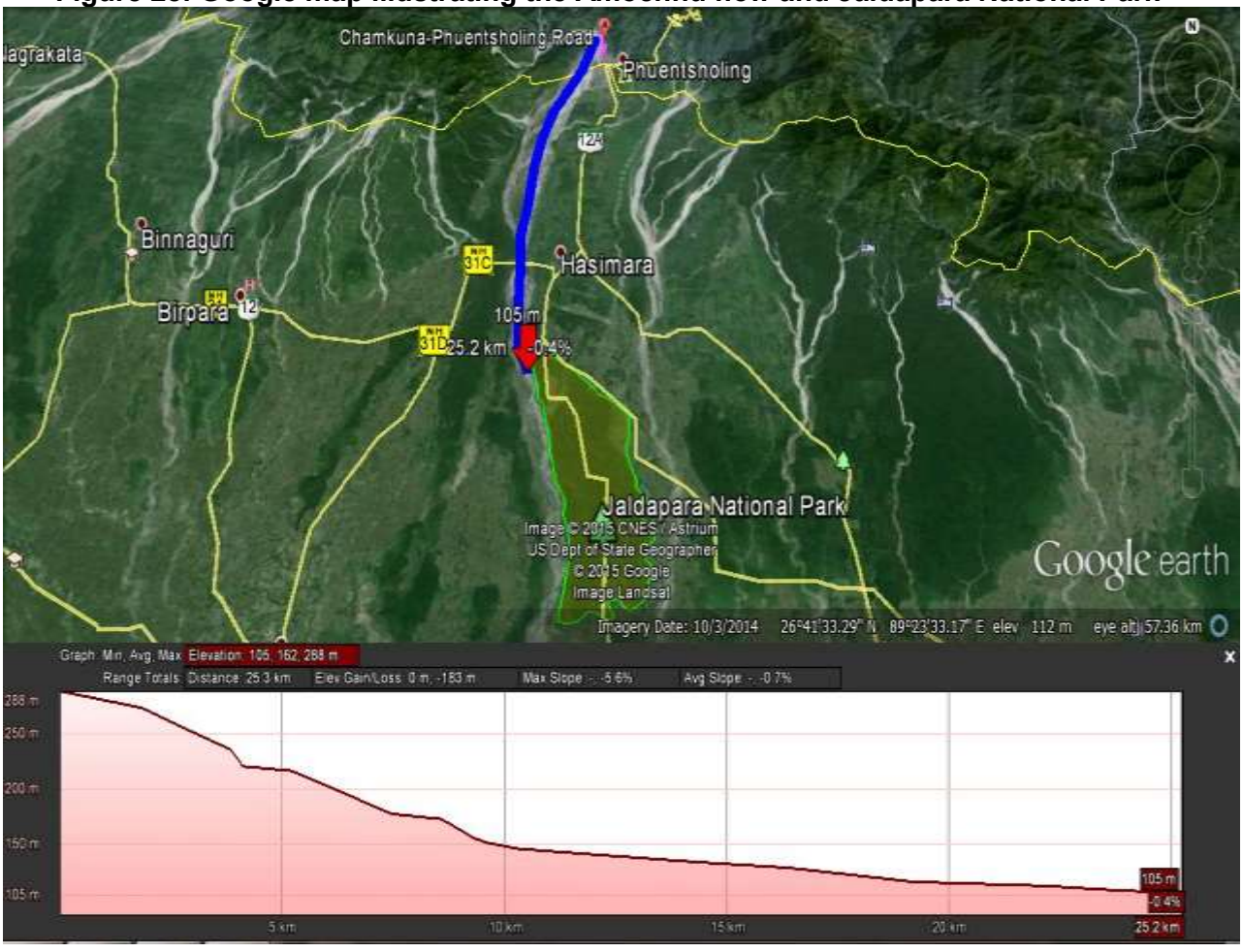


**Figure 29: River flow velocity before and after channelization**

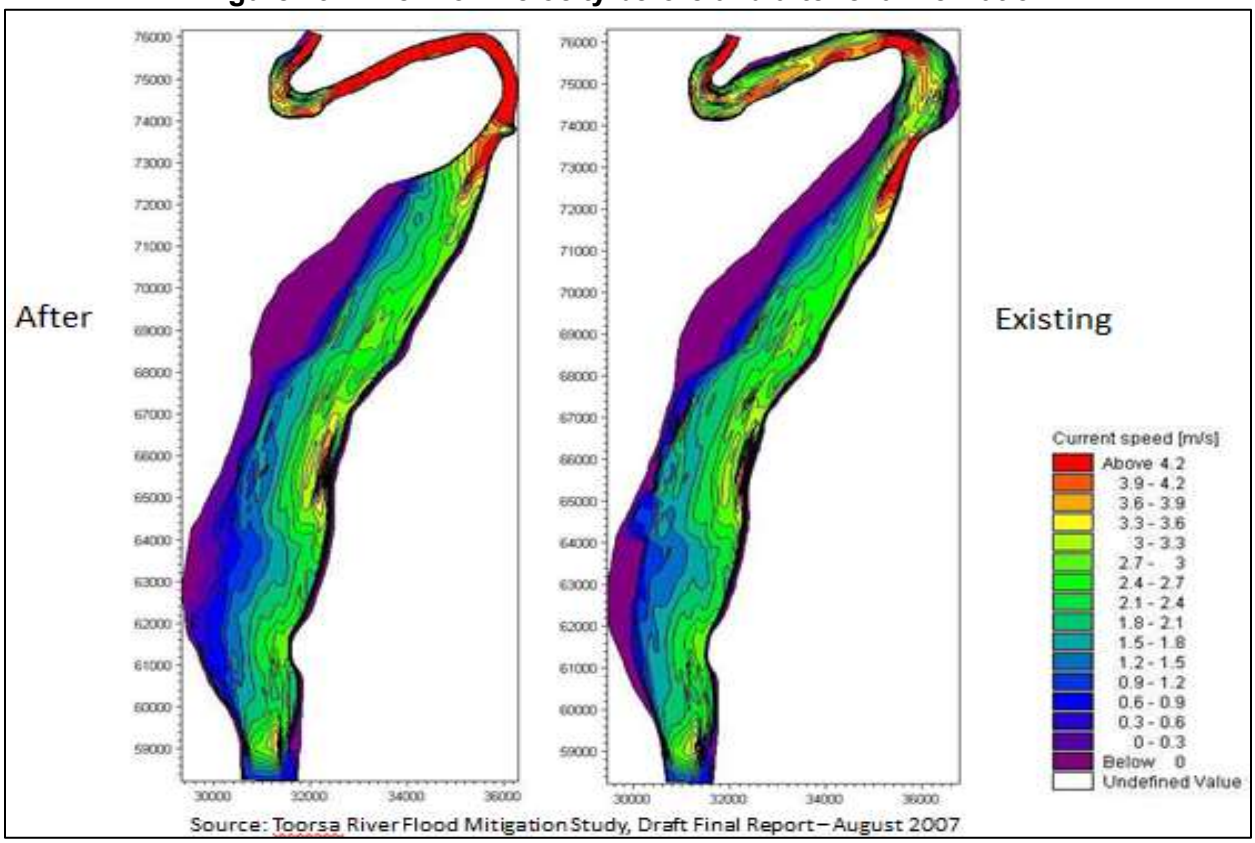



**Figure 30: Amochhu Local Area Plan**

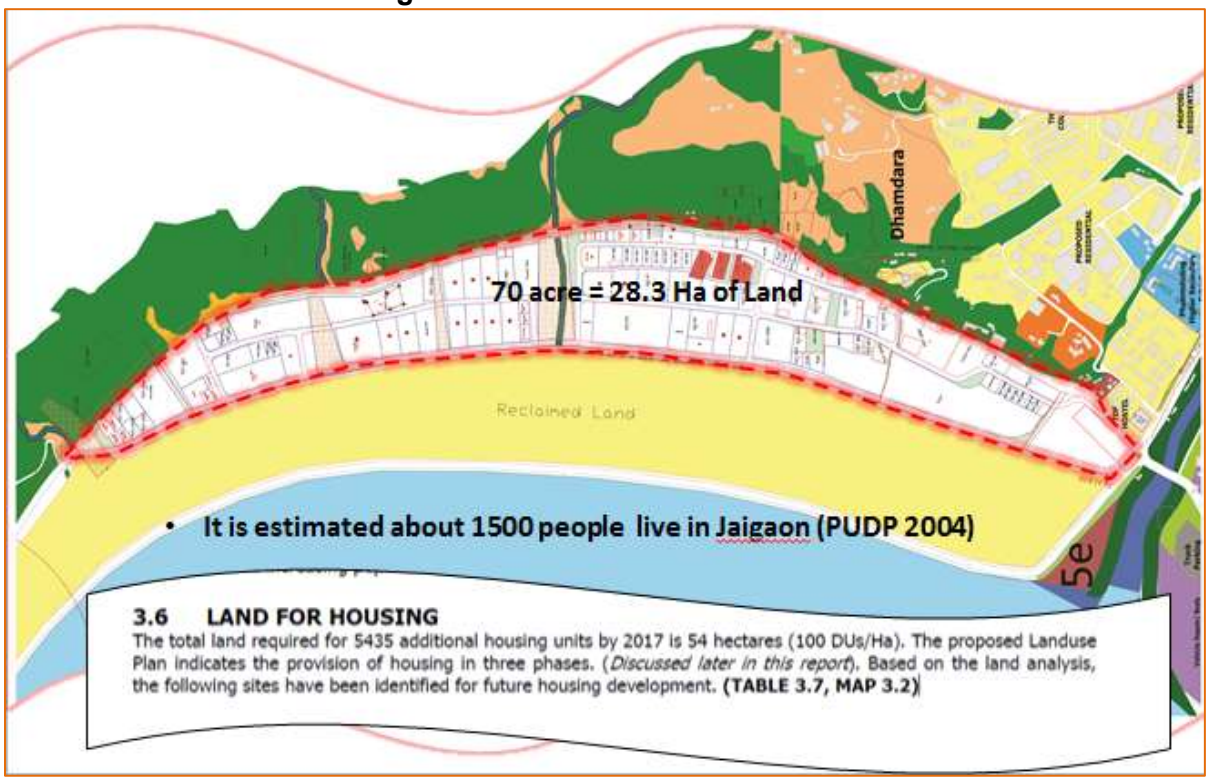


**Table 16: Analysis of Environmental Impacts: Bhutan SASEC TTFP Road Component**

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Pre-Construction | Road alignment and design | Land and Buildings | Loss of private land and building for RoW | Low | Short-lived | Limited | MIN | Coordinate with the DHI and the Phuestholing Thromde to ensure proposed road alignment are consistent to the respective Amochhu Land Reclamation Township Project (ALRTP) and Local area plan.<br><br>Ensure the same flood return period of 100 year for the Amochhu flood level corresponds to the final road surface elevation plus free board and 150 year return period in the design of the cross drains and minor bridges.<br><br>For climate resilience, during the detailed engineering design the following should be considered:<br><br>The proposed bridges and culverts along the PCR will be designed to accommodate | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | discharge of 2.5 to 12m3/s (recommended climate change adaptation).<br><br>Road and bridges will be designed to withstand extreme temperatures using Emerson and Kuppa methods. | |
| 2 | Pre-Construction | Road alignment and design | Public infrastructures | Demolition and reconstruction of road section, kerb at the the Chamkuna start point and YDF Hotel end point for horizontal and vertical alignment correction | Low | Short-lived | Limited | MIN | Prior information to the public on the schedule of demolition, reconstruction, and proposed alternate routes particularly at the YDF end point.<br><br>Contractor will coordinate with the Phuenstholing Thromde on the traffic management no later than 45 days before the start of the construction in the affected section. | Non-significant |
| 3 | Pre-Construction | Site Mobilization and construction of temporary facilities | Soil and sediment quality | Oil or fuel spills during site mobilization could affect soil and sediment quality. | Low | Temporary | Limited | MIN | Maintain transportation vehicles and construction equipment in good working order to prevent leaks of oil, fuel or other pollutants | Non-signifcant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Prohibit access to the site to any mobile equipment that leaks oil.<br><br>Keep a vehicle maintenance log. | |
| 4 | Pre-Construction | Site Mobilization and construction of temporary facilities | Soil and sediment quality | Excavation, fill and grading activities carried out in aquatic environments during site mobilization could result in dispersion of contaminated sediments which can affect Tor putitora habitat. | Low | Limited | Regional | MED | No excavation, fill or grading activites will be allowed in the Amochhu water area during site mobilization | Non-significant |
| 5 | Pre-Construction | Site mobilization and construction of temporary facilities | Surface water quality | Potential increase in the suspended solid (SS) concentration of the Amochhu which could degrade the habitat of fish | Low | Shortlived | Limited | MIN | The work must not produce concentrations of SS in the river in excess of 8 NTUs for short term exposure (24-hour) and 2 NTUs long term exposure (30 days)[36]. If these concentrations are | Non-significant |

[36] Since RGoB does not have standard for turbidity to protect biodiversity, these values were adopted from the Canadian Water Quality Guidelines for the Protection of Aquatic Life

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | like Tor Putitora | | | | | exceeded, additional mitigation measures must be implemented, such as:<br>- Install a turbidity curtain;<br>- Adjust working methods;<br>- Identify and control sources of suspended solids discharge<br><br>Take all necessary precautions to prevent deposition of fine suspended solids into the aquatic environment beyond the immediate work area. | |
| 6 | Pre-Construction | Site mobilization and construction of temporary facilities | Air quality and GHG | Construction of temporary facilities may produce a short-term degradation of air quality due to fugitive dust | Low | Shortlived | Limited | MIN | Do not exceed a threshold of 150 µg/m3 for fine airborne particulate matter less than 10 microns in diameter over a 24-hour average (PM 10 24 hr. average) and 50 µg/m3 long term (annual) at 50 metres from the source. Where these thresholds cannot be met, mitigation measures must be implemented, for | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | example:<br>- Use equipment fitted with dust collection systems.<br>- Install tarpaulins around work that generates dust.<br>- Cover piled materials with geotextile.<br><br>Workers camps will be established away from water bodies and community areas near Bangay area on government land;<br><br>Stockyard also will not be placed on the flood plain and on the river bank. It will be located on the Thromde's vacant land also close by Bangay area. | |
| 7 | Pre-Construction | Site mobilization and construction of temporary facilities | Avifaunal habitat | Disturbance of avifauna habitat during construction of temporary facilities particularly in Chamkuna area | Low | Short-lived | Limited | MIN | Avoid carrying out potentially destructive or disruptive activities during sensitive periods to reduce the risk of affecting cormorants, egrets, geese feeding from 6am-8:30am from October - May every year. | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Pre-Construction | Site mobilization and construction of temporary facilities | Private Land and Buildings | Possible encroachment on private land for construction of materials storage areas, borrow area, and bypass roads | Low | Short-lived | Limited | MIN | Minimize encroachment of detours on private land. The contractor must secure an agreement with the land owner(s) on any encroachment.<br><br>When the work is completed, the Contractor must: remove its own equipment and material and all unused materials, scrap, waste, gravel, whole or crushed stone, wood, stumps and roots; clean-up equipment and materials locations; restore obstructed ditches and watercourses; repair or rebuild demolished or damaged fences and other necessary structures; and dispose of all materials without disfiguring the area in the vicinity of the work or related structures.<br><br>The Contractor must | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | repair any damage to the work site, to private property affected by the work, to bodies of water, to camp sites, equipment storage sites, materials storage and supply sites, to the environment and to forest or agricultural land.<br><br>The Contractor compensate trees cleared in the borrow area.<br><br>Minimize encroachment of detours on private land. | |
| 9 | Pre-Construction | Site mobilization and construction of temporary facilities | Public Infrastructures | Chamkuna road section pavement elevation correction | Low | Short-lived | Limited | MIN | The Contractor must repair any damage to any public property affected by the work | Non-significant |
| 10 | Pre-Construction | Site mobilization and construction of temporary facilities | Sound Environment | Site mobilization activities may increase noise levels along the borrow area haul road | Low | Short-lived | Limited | MIN | The camp site and location of construction plants should be located in near the Chamkuna section where very little inhabitants and activities are located. | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Along the haul road only the Tapa Dramtoe Lower Secondary School was identified as noise sensitive located 5km from Amochhu Bridge towards Khempagaon village. The school is approximately 280m aerial distance from the haul road.<br><br>Noise levels must not exceed L10% = 75 dbA during daytime (NEC Standard for Industrial Area); ambient noise +5 dbA during evening and night (measured at 5 m from residential areas). If exceeded, the following must be implemented:<br>- prohibit work at night;<br>- plan the noisiest work during daytime;<br>- use equipment with good quality mufflers in working order;<br>- ensure that equipment used on the site is in proper working order; | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | - install temporary stationary noise barriers around the site, or mobile barriers around certain equipment;<br>- arrange construction site trailers or heavy vehicles as noise barriers; and increase the distance between noisy equipment and noise-sensitive areas | |
| 11 | Pre-Construction | Site mobilization and construction of temporary facilities | Community and OH Safety | Movement if heavy equipment and hazardous construction activities may cause injury to nearby communities and workers | Low | Short-lived | Limited | MIN | The location, layout and basic facility provision of each labor camp will be submitted to CSC and PIU prior to their construction. The construction shall commence only after approval of CSC.<br>The contractor will maintain necessary living accommodation and ancillary facilities in functional and hygienic manner as approved by the CSC.<br><br>Adequate water and sanitary latrines with septic tanks attached to soak pits shall be provided. | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Preventive medical care to be provided to workers including a First-Aid kit that must be available in the camp.<br><br>Waste disposal facilities such as dust bins must be provided in the camps and regular disposal of waste must be carried out.<br><br>The Contractor will take all precautions to protect the workers from insect and pest to reduce the risk to health. This includes the use of insecticides which should comply with local regulations.<br><br>No alcoholic liquor or prohibited drugs will be imported to, sell, give, barter to the workers of host community.<br><br>Awareness raising to immigrant workers/ local community on communicable and | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | sexually transmitted diseases.<br><br>Contractors to adopt and maintain safe working practices.<br><br>Usage of fluorescent and retroflectory signage, in local language at the construction sites<br><br>Training to workers on safety procedures and precautions.<br><br>Mandatory appointment of safety officer.<br><br>All regulations regarding safe scaffolding, ladders, working platforms, gangway, stairwells, excavations, trenches and safe means of entry and egress shall be complied with.<br><br>Provision of a readily available first aid unit including an adequate supply of dressing | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | materials.<br><br>The contractor will not employ any person below the age of 18 years for any work<br><br>Use of hazardous material should be minimized and/or restricted.<br><br>Emergency plan (to be approved by CSC) shall be prepared to respond to any accidents or emergencies.<br><br>Temporary access and diversion, with proper drainage facilities.<br><br>Access to the schools, temples and other public places must be maintained when construction takes place near them.<br><br>Restrict access to construction sites to authorized personnel.<br><br>Physical separation | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | must be provided for movement of vehicular and human traffic.<br><br>Adequate signage must be provided for safe traffic movement | |
| 12 | Construction | River rechanneling and spur dike construction | Soil and sediment quality | Dredging the Amochhu river to increase depth, increase embankment and rechanneling will re-suspend sediments which can lead to led to heavy siltation and destruction of Tor putitora spawning areas | Average | Short-lived | Regional | MED | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>During detailed design, establish a working method where most of the dredging and excavation will occur on the dry section of the river bed.<br><br>No work will be allowed in the water area without installing geotextile silt curtains. | Non-significant |
| 13 | Construction | River rechanneling and spur dike construction | Surface Water Quality | Increase turbidity and decrease in dissolved oxygen from | Average | Short-lived | Regional | MED | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | silt will decline the density of nymphs of mayflies and stoneflies that supports juvenile Tor putitora | | | | | from October-November and in the spring between April and May<br><br>During detailed design, establish a working method where most of the dredging and excavation will occur on the dry section of the river bed.<br><br>No work will be allowed in the water area without installing geotextile silt curtains. | |
| 14 | Construction | River rechanneling and spur dike construction | Hydrology and hydraulics | Rechanneling may constrict the flow of Amochhu during monsoon increasing velocity increase the risk of river bank erosion and change sedimentation pattern downstream | High | Permanent | Regional | MED | The rechanneling is not expected to cause changes in the river velocity and flow. A DHI study on the Amochhu established that maintaining a 300m width channel will have minimum impact on flow and velocity including to downstream India. By ensuring smooth transition "the impact in terms of water levels, discharge, velocities and | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | sediment transport shown to be negligible. The minor impact anticipated immediately across the border on water levels where the recession of the flood wave will be slightly faster, and maximum flow velocities which will be slightly higher (2.5m/s compared with 2.4m/s – figure 27), but it is expected that it will rapidly disappears further downstream." | |
| 15 | Construction | River rechanneling and spur dike construction | Special Status Species | Restrict the migration movement of Tor putitora due to disturbance of the river | Average | Short-lived | Regional | MED | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area. | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area.<br><br>No work will be allowed in the water area without installing geotextile silt curtains.<br><br>Dredging of the dry river bed for rechanneling will implemented in such a way that excavated ponds will allow settling of silt | |
| 16 | Construction | Installation of Gabion foundation, soil filling and compaction | Soil and sediment quality | Disturbance of river bed can resuspend sediment, soil spills from filling and compaction will increase sediment to the Amochhu | Average | Short-lived | Local | MED | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>Install geotextile turbidity curtains around the worksite and parallel to the river | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | flow prior to the start of work.<br><br>Do not carry out earthwork or excavation work close to water during flood periods or periods of heavy rain.<br><br>Take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area.<br><br>Properly install the geotextile lining around the gabion foundation before filling.<br><br>To prevent/minimize erosion cleared land during stripping should be confined within the RoW and limited to the segment of the route under construction.<br><br>Works on the dry river bed should be provided with a | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | berm/interceptor drains, to collect silt-laden runoff and collected through a settling basin with geotextile membrane to remove suspended solids prior to disposal. | |
| 17 | Construction | Installation of Gabion foundation, soil filling and compaction | Surface Water Quality | Potential contamination of surface water due soil spills will increase suspended solids.<br><br>Accidental oil spills from equipment operating in the near or in the aquatic environment. | Average | Short-lived | Local | MED | The work must not produce concentrations of SS in the river in excess of 8 NTUs for short term exposure (24-hour) and 2 NTUs long term exposure (30 days)[37]. If these concentrations are exceeded, additional mitigation measures must be implemented, such as:<br>- Install a turbidity curtain;<br>- Adjust working methods;<br>- Identify and control sources of suspended solids discharge<br><br>Take all necessary precautions to prevent deposition of fine | Non-significant |

[37] Since RGoB does not have standard for turbidity to protect biodiversity, these values were adopted from the Canadian Water Quality Guidelines for the Protection of Aquatic Life

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | suspended solids into the aquatic environment beyond the immediate work area.<br><br>Properly maintain all equipment and vehicles to ensure they are fuel and lubricant leak free.<br><br>The operations site must be free of waste at all times including empty containers of any kind unless they are properly stored and sealed.<br><br>Release into a body of water of waste, oil, chemicals or other contaminants of a similar nature originating from the construction site is prohibited.<br><br>Parking and storage areas and other temporary facilities must be located at least 60 metres from a water environment. | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Refuelling and mechanical inspection of automotive equipment must not be performed within 15 metres of a body of water. | |
| 18 | Construction | Installation of Gabion foundation, soil filling and compaction | Hydrology and hydraulics | Installed facilities may cause changed in the river morphology, increase velocity, erosion, and sedimentation downstream | High | Permanent | Regional | MED | The rechanneling is not expected to cause changes in the river velocity and flow. A DHI study on the Amochhu established that maintaining a 300m width channel will have minimum impact on flow and velocity including to downstream India. By ensuring smooth transition "the impact in terms of water levels, discharge, velocities and sediment transport shown to be negligible. The minor impact anticipated immediately across the border on water levels where the recession of the flood wave will be slightly faster, and maximum flow velocities which will be slightly higher | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (2.5m/s compared with 2.4m/s – figure 27), but it is expected that it will rapidly disappears further downstream." | |
| 19 | Construction | Installation of Gabion foundation, soil filling and compaction | Special Status Species | Potential increase in the suspended solid (SS) concentration of the Amochhu which could degrade the habitat of fish like Tor Putitora | High | Permanent | Regional | MED | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May | Non-significant |
| 20 | Construction | Installation of Gabion foundation, soil filling and compaction | Sound environment | Noise from construction vehicle, equipment and machinery can elevate ambient noise | Low | Short-lived | Limited | MIN | Noise standards will be strictly enforced for all site vehicles, plants, equipment, and construction machinery.<br><br>Machinery and vehicles will be maintained regularly, with particular attention to silencers and mufflers, to keep construction noise levels to minimum. Workers in the vicinity of high noise levels shall wear earplugs/ | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | earmuffs and be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB(A) per 8-hour shift.<br><br>Ambient noise will be monitored during construction to compare with baseline with noise quality and to check compliance with noise emission standard, EDS 2010, NEC.<br><br>Traffic bottlenecks particularly near YDF Hotel will be avoided<br><br>Construction equipment and machinery to be fitted with silencers and maintained properly.<br><br>Only IS approved equipment shall be used for construction activities.<br><br>PPEs to workers | |
| 21 | Construction | Road construction | Surface Water Quality | Oil and bitumen spills | Low | Short-lived | Limited | MIN | Take all necessary precautions to prevent | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | will contaminate the Amochhu river | | | | | deposition of fine suspended solids into the aquatic environment beyond the immediate work area.<br><br>Properly maintain all equipment and vehicles to ensure they are fuel and lubricant leak free.<br><br>The operations site must be free of waste at all times including empty containers of any kind unless they are properly stored and sealed.<br><br>Release into a body of water of waste, oil, chemicals or other contaminants of a similar nature originating from the construction site is prohibited.<br><br>Parking and storage areas and other temporary facilities must be located at least 60 metres from a water environment | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| 22 | Construction | Road construction | Air Quality and GHG Public Infrastructures | Fugitive dust emission and fumes from construction vehicles | Low | Short-lived | Local | MIN | Transport, loading and unloading of loose and fine materials through covered vehicles.<br><br>Paved approach roads.<br><br>Storage areas to be located downwind of the habitation area.<br><br>Water spraying on earthworks, unpaved haulage roads and other dust prone areas such as unpaved roads<br><br>provision of PPEs to workers.<br><br>Regular maintenance of machinery and equipment. | Non-significant |
| 23 | Construction | Road construction | Sound environment | Noise from construction vehicle, equipment and machinery can elevate ambient noise | Low | Short-lived | Limited | MIN | Noise standards will be strictly enforced for all site vehicles, plants, equipment, and construction machinery.<br><br>Machinery and vehicles will be maintained regularly, with particular | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | attention to silencers and mufflers, to keep construction noise levels to minimum. Workers in the vicinity of high noise levels shall wear earplugs/ earmuffs and be engaged in diversified activities to prevent prolonged exposure to noise levels of more than 90dB(A) per 8-hour shift.<br><br>Ambient noise will be monitored during construction to compare with baseline with noise quality and to check compliance with noise emission standard, EDS 2010, NEC.<br><br>Traffic bottlenecks particularly near YDF Hotel will be avoided<br><br>2323Construction equipment and machinery to be fitted with silencers and maintained properly.<br><br>Only IS approved | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | equipment shall be used for construction activities.<br><br>PPEs to workers | |
| 24 | Construction | Road construction | Community and OH Safety | Movement of heavy equipment will create hazardous road condition | Low | Short-lived | Limited | MIN | The public will be informed of the work and the detours provided. Alternate routes will be proposed<br><br>Minimize encroachment of detours on private land. The private partner must come to an agreement with property owners with respect to encroachment on private land<br><br>Installation of signs and barriers to separate community from active construction site | Non-significant |
| 25 | Construction | Construction plants and camp site operations | Soil and sediment quality | | | | | MED | | |
| 26 | Construction | Construction plants and camp site operations | Surface water quality | Deterioration of receiving water quality from batching, | Low | Short-lived | Limited | MIN | Collection of all surface runoff and facility washing to a sedimentation basin | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | hot mix plants effluents, and sewage from camp. | | | | | prior to disposal.<br><br>All sewage will be collected and treated in a 3-chamber septic tank.<br><br>No untreated wastewater will be allowed to be disposed to natural environment. | |
| 27 | Construction | Construction plants and camp site operations | Air Quality and GHG | Air quality deterioration from plant combustion and fugitive emissions | Low | Short-lived | Limited | MIN | Batching, asphalt mixing plants and crushers at downwind (1km) direction from the nearest settlement.<br><br>Used only crushers licensed by the NEC/Geogs<br><br>DG sets with stacks of adequate height and use of low sulphur diesel as fuel. | Non-significant |
| 28 | Construction | Construction plants and camp site operations | Sound Environment | Increase in noise level due to batching plant and hot mix plant operations | Low | Short-lived | Limited | MIN | Observe regular and proper maintenance of plant equipment<br><br>Install silencers on all tail/emission pipes<br><br>Establish multi-layer vegetation in-between | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | the plant and nearest sensitive receptor for attenuation when necessary.<br><br>To the extent possible, enclose noise generating equipment with noise barriers | |
| 29 | Construction | Borrow area operation/hauling | Soil and sediment quality | Trigger slope failure and soil erosion | Average | Temporary | Limited | MED | The Project will require approximately 92,000 cum of binding material for embankment construction. It is planned to be extracted from the tentatively designated Borrow area at Bagultar under Khenpagaon village which is located some 16km south-west of the Project location.<br><br>For establishment of borrow area at Khenpagaon, the Project will prepare separate IEE and Environmental Management Plan as required by the NEC. Borrow area closure plan will also be prepared as part of the | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | IEE.<br><br>Quarrying at the borrow area will be carried out in scientifically approved manner – i.e., through series of benches to avoid catastrophic slope failure and soil erosion. All critical area in the borrow area will be supported by retaining walls to prevent slope failure. Drainages will also be constructed to prevent further soil erosion.<br>After completion of borrowing activities, the area will be rehabilitated through compensatory plantation. The planted area will be fenced with barbed wire. The area will be under supervision for at least two monsoons so that regeneration of trees and vegetation takes place firmly<br><br>Topsoil to be stockpiled and protected for use at | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | the rehabilitation stage. | |
| 30 | Construction | Borrow area operation/hauling | Surface water quality | Deterioration of receiving water quality from surface runoff | Low | Temporary | Limited | MIN | Installation of bunds around exposed area<br><br>Collection of surface runoff in sedimentation pond prior to disposal | Non-significant |
| 31 | Construction | Borrow area operation/hauling | Air Quality and GHG | Deterioration of air quality along haul road due to increase in dust | Low | Short-lived | Limited | MIN | Transport of materials in covered trucks.<br><br>During quarrying and haulage, the water will be sprinkled at twice daily to dampen the dust. The critical haulage route that passes through settlement will be totally watered on top of the borrow area. At least two water tankers with self-pumping equipment will ferry water from Amochhu. The usage of water will have to be approved by Phuentsholing Thromde since the water extraction area falls under Phuentsholing City. | Non-significant |
| 32 | Construction | Borrow area operation/hauling | Public Infrastructures | Damage to haul roads | Low | Short-lived | Limited | MIN | Use the access roads as identified by the Thromde corridor to | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | the construction sites nd limite the the movement of machinery to the work areas located within this corridor.<br><br>When working in Phuentsholing built up area, remove loose material and other debris on a daily basis from streets used by vehicles and machinery.<br><br>When the work is completed, the Contractor must: remove its own equipment and material, unused materials, scrap, waste, gravel, whole or crushed stone, wood, clean-up equipment and materials locations; repair or rebuild demolished or damaged fences and other necessary structures; and dispose of all materials without disfiguring the area in the vicinity of | |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | the work or related structures. | |
| 33 | Construction | Borrow area operation/hauling | Sound Environment | Increase noise level in quarries from blasting, rock crushing, and hauling | Average | Short-lived | Limited | MIN | Comply with the location separation distance from nearest inhabited area<br><br>Use materials storage piles to attenuate noise | Non-significant |
| 34 | Construction | Borrow area operation/hauling | Community and occupational health and safety | Increase risk of accident from open borrow areas | Low | Permanent | Limited | MED | To the extent borrow areas shall be sited away from habitated areas. Rehabilitation of the borrow areas as per NEC EC requirements. | Non-significant |
| 35 | Construction | Site Restoration | Soil and sediment quality | Clean-up Operations, Restoration and Rehabilitation | Average | Short-lived | Limited | MIN | Contractor will prepare site restoration plans, which will be approved by the CSC<br><br>The clean-up and restoration operations are to be implemented by the contractor prior to demobilization.<br><br>All construction zones including river-beds, culverts, road-side areas, camps, hot mix plant sites, crushers, batching plant sites and any other area | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | used/affected by the project will be left clean and tidy, at the contractor's expense, to the satisfaction of the Environmental officer.<br><br>All the opened borrow areas will be rehabilitated and CSC will certify in this regard. | |
| 36 | Construction | Road Maintenance and erosion control | | Emissions from hot patch work, fumes from pavement marking works, dust from concrete grinding, and dust demolition debris may deteriorate local air quality | Average | Short-lived | Limited | MIN | Provision of PPEs to workers<br><br>Water sprinkling to control dust<br><br>Covered haul trucks | Non-significant |
| 37 | Operation | Road Maintenance and erosion control | Community and occupational health and safety | Risk of injury to pedestrian and road users | Low | Short-lived | Limited | MIN | Implement road safety | Non-significant |
| 38 | Operation | Road Maintenance and | Air Quality an d GHG | Deterioration of ambient air from vehicular | Low | Permanent | Limited | MED | Maintain road quality to ensure vehicular speed is maintained at | Non-significant |

| No | Project Phase | Project Component | Environmental Components | Description of the Environmental Effects | Intensity | Duration | Scope | Assessment of Potential Effect | Required Mitigation Measures | Significance of Residual Effect |
|---|---|---|---|---|---|---|---|---|---|---|
| | | erosion control | | emissions | | | | | optimum level and congestion is avoided | |

# VIII. ENVIRONMENTAL MANAGEMENT AND MONITORING PLAN

## A. Environmental Management Plan

159. Environmental Management Plan (EMP) is intended to set out clearly and unambiguously the likely negative impacts of construction and/or operation of the project, the action that is required to avoid or mitigate each impact and the responsibility for taking action. Responsibility is made legally binding since actions are subsequently specified in contracts.

160. The EMP has been prepared based on all foreseen impacts during feasibility study stage when this IEE is prepared. Mitigation measures were identified to reduce the significant adverse impacts including residual effects. During detailed engineering design, a number of construction alternatives like scale of river channelization and spur dike that needs to be constructed for river effective river training location of camp and plant sites, borrow area, source quarries, and even minor geometric realignments to minimize exposure against the erosive force of the Amochhu remains to be decided and from which a host of impacts may be generated and warrants updating of the EMP under the supervision of the CSC and ADB.

## B. Acquisition of Prior Clearances and No-objection Certificates

161. Table below summarizes the administrative clearances and no-objection certificates that are necessary for implementation of the construction works.

**Table 17: Administrative Clearance and No Objection Certificates Required by the Project**

| Agency or Group | Purpose and Status | Responsible Party | Timeframe |
|---|---|---|---|
| National Environment Commission | Environmental clearance required for implementation PCR<br>Status: To be processed | DOR | Prior to construction |
| Phuentsholing Thromde | Administrative approval from Phuentsholing Thromde<br>Status: To be applied | DOR | Prior to construction |
| Samtse Dzongkhag Administration | Administrative approval from Phuentsholing Thromde<br>Status: To be applied | DOR | Prior to construction |
| BPCL | Requirement of additional power supply<br>Status: To be processed | DOR | Prior to construction |
| Phuentsholoing Thromde | Usage of water resources for construction and domestic use<br>Status: To be applied | DOR | Prior to construction |
| Tading Gewog | Usage of water resources for construction and domestic use<br>Status: To be applied | DOR | Prior to construction |
| Department of Forest and Park Services | Forestry Clearance for the construction of PCR and for Borrow area operations<br>Status: To be applied | DOR | Prior to construction |

## C. Environmental Monitoring Plan

162. The monitoring and evaluation are critical activities in implementation of the project. Monitoring involves periodic checking to ascertain whether activities are going according to plan or not. It provides the necessary feedback for project management to ensure project objectives are met and on schedule. The reporting system is based on accountability to ensure that the environmental mitigation measures are implemented. Environmental monitoring program has the underlying objective to ensure that the intended environmental mitigations are realized and these results in desired benefits to the target population causing minimal deterioration to the environmental parameters. Such program targets proper implementation of the EMP. The broad objectives are:

a) To evaluate the performance of mitigation measures proposed in the EMP.
b) To evaluate the adequacy of environmental assessment.
c) To suggest ongoing improvements in management plan based on the monitoring and to devise fresh monitoring on the basis of the improved EMP.
d) To enhance environmental quality through proper implementation of suggested mitigation measures.
e) To meet the requirements of the existing environmental regulatory framework and community obligations.

## D. Institutional/Organizational Set-up to Implement the EMP

### 1. Construction Phase

163. The Royal Government of Bhutan (RGoB) through the Department of Roads (DOR) for the road component and the Phuentsholing Thromde for the trade facilitation are the Executing Agencies (EA) and Implementing Agencies of the project. The DOR has Environment Unit with qualified staff in their regular organogram. This unit under the leadership of a Superintending Engineer will assist the PMU on issues related to environmental and social management. The PCR construction implementation will be led by the Project Management Unit (PMU) that will be established within DOR. The PMU, tasked with the day-to-day management of the project will be headed by the Chief Engineer acting as Project Manager (PM), 2 Deputy Managers, and supported by an environmental specialist to supervise the implementation of the EMP, liaise with NEC and other relevant agencies, and prepare annual environmental monitoring reports for disclosure. The Phuenstholing Thromde (PT) has a Project Coordinator implementing the Dry Port Project[38] and the existing environmental institution consisting of PIU and CSC environmental specialist will supervise and implement the EMP.

164. A construction supervision consultant team will be mobilized to ensure works, including the EMP is properly implemented. The CSC will have an environmental specialist primarily to enforce the environmental measures and ensure the contractor stays in compliance.

165. The contractor, tasked with the implementation of all civil works, will have an environmental focal person at the field level to ensure all works are implemented with due regards to the environmental measures stipulated in the EMP and EMOP. The roles and responsibilities of Environmental Unit, CSC, and contractors are presented below.

[38] BHU(39225-034): SASEC Road Connectivity Mini Dry Port.

**Table 18: Roles and Responsibilities to Implement the Environmental Management Plan**

| Organizations | Responsibilities |
|---|---|
| DOR and PT[39] | • Ensure that the project complies with the ADB's SPS, 2009 and Royal Government of Bhutan environmental laws and regulations applicable for the project.<br>• Ensure that contract documents include all relevant parts of the IEE, EMP and project agreements.<br>• Ensure that sufficient funds are available to properly implement all agreed environmental safeguards measures for the project. |
| PMU | • Obtain all statutory clearances, permissions and NOCs applicable for the Project.<br>• Review and approve the Contractor's implementation Plan with recommendation of Supervision Consultant for the environmental measures, as suggested in the EMP.<br>• Review and approve all monitoring reports with assistance of the CSC<br>• Review overall environmental performance of the project through an assessment of the annual environmental monitoring reports submitted by CSC and Contractor<br>• Submit annual environmental monitoring reports to ADB and its closure<br>• Ensure updating of the EMP if any new or unanticipated environmental impacts occur during project implementation due to change in design.<br>• Interact with the Environmental Expert of the Supervision Consultant on the state of the environment and mitigation and enhancement measures adopted;<br>• Timely endorsement and signing of key documents and forwarding to the respective agency required for processing of clearances, permits, and permissions,<br>• Ensure all contractors obtain permits, licenses etc. for activities such as operation of asphalt plants, quarries, borrow areas etc. before the implementation of the respective construction activity. |
| Contract | • Ensuring inclusion of EMP in bidding documents<br>• Supervising CSC for the implementation of EMP<br>• Ensure that all the project activities are carried out in environmentally sound manner.<br>• Closely coordinate with other concerned agencies, local governments and communities to support implementation of EMP<br>• Preparation of progress reports on implementation of EMP.<br>• Ensure effective implementation of EMP components not directly tasked to the contractor including components dealing with indirect, induced and cumulative effects, as well as operations and maintenance stage plans and measures.<br>• Commissioning and review of consultant reports for EIAs/EMPs to be developed for subsequent phases of PCR implementation. |
| CSC | • Review, monitor, and advise the Contractor on needed revisions on the EMP and EMoP as part of the engineering design<br>• Conduct environmental site induction training[40] to all contractors and PMU to ensure understanding of the EMP and domestic environmental |

[39] If applicable to Phuenstholing Thromde

| Organizations | Responsibilities |
|---|---|
| | laws and regulations requirements particularly on the required clearances and permits, training on occupational and community health and safety, timely mobilization of the Contractor's EFP, and review of sub-plans required in the EMP and advise the PIU on adequacy<br>• Guide the Contractor on the preparation of the Contractor's Environmental Management Implementation Plan<br>• Ensure contractors secure necessary permits and clearances<br>• Conduct at least monthly site inspections<br>• Prepare environmental monitoring report template for contractor's monthly self-monitoring reports<br>• Design quarterly and semi-annual compliance assessment checklist and report formats for PMU and ADB review<br>• Prepare annual environmental monitoring reports required by the ADB for public disclosure<br>• Preparing summary monthly, quarterly, and semi-annual monitoring reports based on the monthly environmental self-monitoring reports prepared by the Contractor's Environment Focal Person (EFP) for the review and guidance of the PMU<br>• Advise the Contractor through the PMU on how to comply with requirements to address non-compliances<br>• Report apparent unanticipated impacts, recommend mitigation measures to be implemented by the PMU and update the IEE report |
| Contractor | • Appoint the Contractor's environment focal person (EFP) and attend the site induction workshop to be organized by the PMC<br>• Obtain necessary environmental license(s), permits etc. from relevant agencies as specified Table 21 for associated facilities for project road works, quarries, hot-mix plant etc. prior to commencement of civil works contracts<br>• Prepare an Environmental Implementation Plan based on the EMP and EMoP, as advised by the PMU and CSC<br>• Implement all mitigation measures in the EMP and activities in the EMoP<br>• Submit monthly, quarterly, and annual self-monitoring reports to the PMU and CSC<br>• Ensure that all workers, site agents, including site supervisors and management participate in training sessions delivered by CSC.<br>• Ensure compliance with environmental statutory requirements and contractual obligations<br>• Collect the baseline data on environmental quality before the start of physical works and continue collection of environmental quality data as given in the Environmental Monitoring Plan during construction and operation |

[40] Site induction training includes but not limited to: i) discussion and review of EMP and EMoP detailing how specific environmental risks associated with their Scope of Work will be managed legal compliance, inspection and audits, and progress tracking and reporting; ii) environmental training and awareness needs shall be determined and documented via a training needs analysis prior to commencement; iii) Health and Safety Awareness Course, which details general environmental awareness and specific performance requirements expected on site; and iv) GRM.

| Organizations | Responsibilities |
|---|---|
| | • Participate in resolving issues as a member of the GRC<br>• Respond promptly to grievances raised by the local community or any stakeholder and implement environmental corrective actions or additional environmental mitigation measures as necessary.<br>• Based on the results of EMP monitoring, cooperate with the PMU and CSC to implement environmental corrective actions and corrective action plans, as necessary. |

## E. Institutional Arrangement for EMP Implementation

166. The succeeding Figure illustrates the institutional arrangement to implement the EMP. The project has two executing and implementing agencies (EA/IA), the Department of Road for the PCR component and the Phuentsholing Thromde for the trade facilitation component. Each EA/IA will have its own implementation, supervision, and monitoring system to ensure efficient and effective implementation of the EMP. For reporting purposes and considering the relative significance of the potential environmental impacts anticipated in the road component as compared to the trade facilitation component, the environmental monitoring reports will be shared between the two agencies first at the level of the PMU and then at the EA/IA level with the objective of producing an integrated annual report with the DOR as the lead.

**Figure 31: Institutional Arrangement for EMP Implementation**

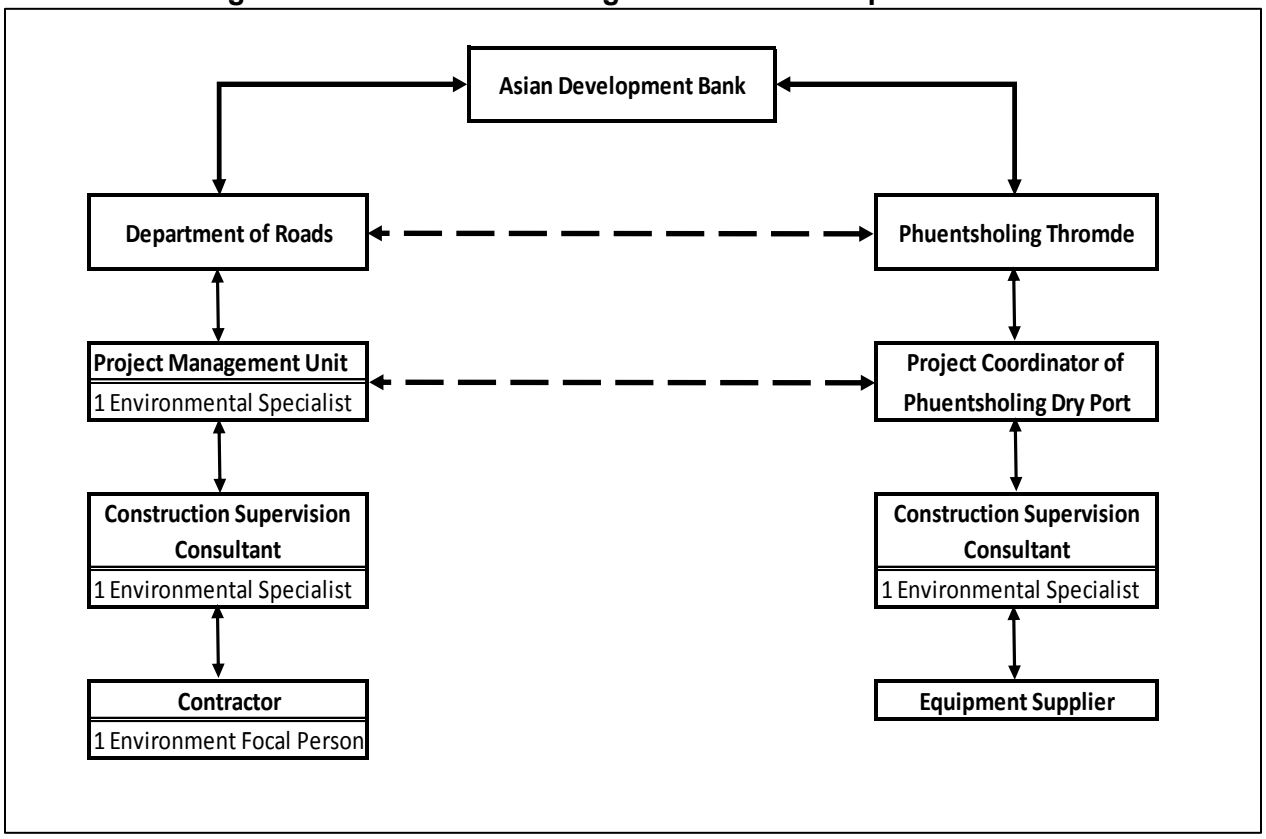


**Table 19: Environmental Management Plan**

| Environmental Impact/Issue | Mitigation Measures | Location | Responsibility | | Key Performance Indicator | Timing/ Schedule | Cost Allocation |
|---|---|---|---|---|---|---|---|
| | | | Execution | Monitoring | | | |
| **1. Activity: Design Phase** | | | | | | | |
| 1.1 Seismicity: Bhutan falls under high seismic risk zone IV & V. | Earthquake risk will be incorporated into the detailed design of bridges<br><br>For bridge structural design in Bhutan, IRC Standard (Standard Specifications and Code of Practice for Roads Bridges; Section II Loads and Stress; The Indian Road Congress) will be applied | Design Office | Design Consultant | Project Management Unit (PMU) | IRC Standard (Standard Specifications and Code of Practice for Roads Bridges; Section II Loads and Stress; The Indian Road Congress) is applied for bridge design | During Detailed Design | Included in design costing |
| 1.2 Detailed design: Climate Change hazard on bridges and embankment due to extreme temperature and flooding | The proposed road embankment bridges and culverts along the PCR will be designed to accommodate discharge of 2.5 to 12m3/s (recommended climate change adaptation).<br><br>Road embankment will be designed to pass 100 years ARI flood as part of the critical adaptation to climate change.<br><br>Bridges will be designed to withstand extreme temperatures using Emerson and Kuppa methods. | Design Office | Design Consultant | Project Management Unit (PMU) | Documentary evidence of climate change adaptation in bridge design | During Detailed Design | Included in design costing |
| 1.3 Erosion, landslides and flood damages of bridges due to surface runoff from the hills | River training works and bridge protection | East bank of the Amochhu river between the emabnkemt road and hills | Detailed design engineers | Project Management Unit (PMU) | River training of the 5 rivers on the east bank coming from the hills and protection such as wing walls as bridge protection | Finalized during detailed design and incorporated in the bid documents | Nu. 52.632M (Feasibility study estimate) |
| 1.4 Flooding and Erosion of Amochhu River bank since almost 3km road passes through the river bank | Channelization of the Amochhu River to provide a safe distance separation of the main channel from the road embankement<br><br>Construction of spur dikes to reduce erosive capability of the Amochhu and induce sedimentation between spurs, | Amochhu River Bed during dry flow | Detailed design engineers | Project Management Unit (PMU) | Amochhu Channelization<br><br>Spur dikes | Finalized during detailed design and incorporated in the bid documents | Nu. 30M for dredging and NU9.914 for spur dike (Feasibility study estimate) |
| 1.5 Borrow Area for extraction of | Identified borrow area site is Khempagoan near Setibhir about 16 | Doyagang area | Design Consultant | Project Management Unit | Separate IEE for NEC will be prepared | Before borrow area operation | Nu. 2.751M |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
|---|---|---|---|---|---|---|---|
| construction material | kilometers by road north east of the project from the Chumkuna end<br><br>Separate IEE study will be conducted to obtain the Environmental Clearance from the NEC and comply with the requirements of the Environmental Assessment Act 2000 | | | (PMU) | for Borrow area<br><br>Environmental Clearance for Borrow area is approved by NEC | | |
| 1.5 Changes in Land use | Contractor will rehabilitate the lease the land for construction facilities on temporary basis. Proper documentation will be carried out in consultation with the community and Phuentsholing Thromde officials; approval from NEC will also be required for the selected sites is meant for establishment of Crusher/Hotmix/ batching plant. | Amochhu area | Contractor | CSC | Documentary evidence of land leasing for temporary facilities<br><br>NEC clearance for the selected sites for establishment of crusher/hot mix/ batching plant etc.<br><br>Absence of grievances regarding temporary | Before contractor mobilization | Included in contractor's costs |
| 1.7 Impact on air quality due to establishment of construction camps, material stocking and vehicular emissions | No objection letter from Phuentsholing Thromde for extraction of water from Amochhu River. Haulage route and stockyards willbe sprayed with water at least twice a day to minimize dust related air pollution;<br><br>Water can be sourced from Amochhu using self-pumping three numbers of Water Tankers with 5000 liters capacity each.<br><br>Regular maintenance of transport vehicles will be carried out by the contractors. | Amochhu area | Contractor | CSC | No objection letter from Phuentsholing Thromde for Amochhu River water usage for construction purpose Spraying of water twice daily for dust suppression<br><br>No public complaints on dust pollution | During pre-construction | Included in contractor's costs |
| 1.8 Impact on Amochhu River water quality due to establishment of construction camps, material stocking and | Workers camps will be established away from water bodies, near Bangay area on government land;<br><br>Stockyard also will not be placed on the flood plain and on the river bank. It will | Amochhu area | Contractor | CSC | Workers camp and Stockyard established away from water body<br><br>Solid waste dumped | During pre-construction | Contractor cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| vehicular emissions | be located on the Thromde's vacant land also close by Bangay area.<br><br>Solid waste from camps will be dumped in the municipal landfill to avoid illegal dumping into the river. | | | | in the municipal landfill site | | |
| **2. Activity: Contractor Mobilization** | | | | | | | |
| 2.1 Preparatory activities | Submit appointment letter and resume of the Contractor‟s Environmental Focal Person (EFP) to DOR Project Directorate<br><br>EFP will engage CSC-Environment Specialist and PMU to a meeting to discuss in detail the EMP, seek clarification and recommend corresponding revisions if necessary. EFC will prepare Contractors Environmental Implementation Plan based on the approved EMP, EMOP, and agreements reach during the meeting with CSC-ES and PMU<br><br>Request CSC-ES copy of monthly monitoring formats and establish deadlines for submission.<br><br>EFC will submit for CSC-ES approval action plans and layout plans to secure all permits and approvals needed to be secured during construction stage which include but not limited to: i) operation of crushers and hot mix plants, ii) transport and storage of hazardous materials (e.g. fuel, lubricants), iii) waste disposal sites, iv) temporary storage location, iv) water use, and v) emission compliance of all vehicles. Arrangements to link with government health programs on hygiene, sanitation, and prevention of communicable diseases will also be included in the action plan. | Project site | Contractor | CSC | Approvals, attendance | The Contractor will complete the activities no later than 30 days upon issuance of Notice to Proceed | Contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | EFC will submit for approval of CSC-ES the construction camp layout before its establishment. | | | | | | |
| 2.2 Site induction | No works will be initiated by the contractor until the site induction training is carried out by the CSC<br>Site induction training includes but not limited to: i) discussion and review of EMP and EMoP detailing how specific environmental risks associated with their Scope of Work will be managed legal compliance, inspection and audits, and progress tracking and reporting; ii) environmental training and awareness needs shall be determined and documented via a training needs analysis prior to commencement; iii) Health and Safety Awareness Course, which details general environmental awareness and specific performance requirements expected on site; and iv) GRM. | Construction Site | CSC | PMU | Attendance to the training | No less than 15 days after issuance of notice to proceed | Part of construction cost |
| 2.3 Soil Erosion and contamination | No excavation, fill or grading activites will be allowed in the Amochhu water area during site mobilization<br><br>The work must not produce concentrations of SS in the river in excess of 8 NTUs for short term exposure (24-hour) and 2 NTUs long term exposure (30 days) . If these concentrations are exceeded, additional mitigation measures must be implemented, such as:<br>- Install a turbidity curtain;<br>- Adjust working methods;<br>Identify and control sources of suspended solids discharge<br><br>Take all necessary precautions to prevent deposition of fine suspended | Construction zone | Contractor | CSC | Number of any non-compliance report | Throughout contractor mobilization and demobilization | Included in Contractor costs |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | solids into the aquatic environment beyond the immediate work area.<br><br>Vehicular traffic on unpaved roads will be avoided as far as possible. Operation of vehicles and machinery close to the stream banks will be minimized<br><br>Vehicles and equipment will not be repaired in the field. If unavoidable, impervious sheathing will be used to avoid soil and water contamination.<br><br>Waste management plan developed will be implemented. | | | | | | |
| 2.3 Air quality | Construction machinery and vehicles will be kept good working conditions and properly tuned, in order to minimize the exhaust emissions, and in compliance with vehicular emission standard (Environmental Discharge Standard/EDS, 2010, NEC)<br><br>Fugitive dust emission will be minimized by spraying water at least twice daily on bare soil all long the unpaved road<br><br>Speed limit of 15km/hr will be applied for the Project vehicles that passes through settled area<br><br>Air quality will be properly monitored, especially near the population centers and sensitive receptors. Appropriate actions will be undertaken in case ambient air quality at the population centers deteriorates beyond EDS 2010 limits | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Number of community complaints<br><br>Ambient air quality found beyond the national standard (EDS, 2010) | Throughout contractor mobilization and demobilization | Included in contractor's cost |
| 2.4 Noise level | Vehicles' mufflers (silencers) will be maintained to reduce noise generation;<br><br>Night time traffic will be avoided near the | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Noise measurement | Throughout contractor mobilization and | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | communities. Communities will be informed if the night work is unavoidable Ambient noise monitoring and compliance with EDS 2010 will be ensured | | | | data<br><br>Number of community complaints | demobilization | |
| 2.5 Public safety | Public will be barred from entering into the zone by providing an alternative passage<br><br>Special attention will be focused on safety training for workers to prevent and restrict accidents and on the knowledge how to deal with emergencies<br><br>Road signage will be fixed at appropriate locations to reduce safety hazard associated with project-related vehicular traffic<br>Liaison with traffic police will be maintained<br><br>Project drivers will be trained on defensive driving<br><br>Vehicle speed near / within the communities will be kept low, to avoid safety hazards | Construction zone | Contractor | CSC | Number of any non-compliance reports<br><br>Number of any related public complaints<br><br>Number of accidents, incidents and near-misses | Throughout contractor mobilization and demobilization | Included in contractor's cost |
| 2.6 Damage to infrastructure | All damaged infrastructure will be restored to original or better condition | Construction zone, borrow area, haulage route | Contractor | CSC | Number of any non-compliance report<br><br>Number of any public complaints | Throughout contractor mobilization and demobilization | Included in contractor's cost |
| **3. Activity: Construction workers camp establishment and operation** | | | | | | | |
| 3.1 Soil erosion, soil and water contamination | Camp site will be located away from water bodies in appropriate locations and distances (100m – 500m) away from the Amochu river in consultation with Phuentsholing Thromde<br><br>Photographs will be taken to record the site conditions prior to the establishment of the camp | Campsites | Contractor | CSC | Compliance to waste management plan<br><br>Number of non-compliance reports<br><br>Results of soil and water analysis and their compliance to national standard | Throughout contractor mobilization and demobilization | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Land clearing, leveling and grading will be minimized, and carried out in manner to minimize soil erosion<br><br>Camp will have storm water drainage arrangement<br><br>Contractor will implement waste management plan<br><br>For the domestic sewage treatment, the contractor will construct septic tank and soak pit to avoid ground contamination<br><br>Waste oils will be collected in drums and recycled<br><br>The inorganic waste such cardboard, papers, metal scrap will be sold to recycling dealers<br><br>Domestic waste will be sent to Thromde landfill for dumping<br><br>The camp site area will be completely restored after completion of construction works. All temporary structures will be demolished.<br><br>Over all contract will comply with waste management plan | | | | (EDS, 2010)<br><br>Number of related complaints | | |
| 3.2 Air quality | Construction machinery and vehicles will be kept good working conditions and properly tuned, in order to minimize the exhaust emissions, and in compliance with vehicular emission standard (Environmental Discharge Standard/EDS, 2010, NEC)<br><br>Fugitive dust emission will be minimized by spraying water at least twice daily on bare soil all long the unpaved road<br><br>Speed limit of 15km/hr will be applied for | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Number of community complaints<br><br>Compliance to ambient air quality standards (EDS, 2010) | Throughout construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | the Project vehicles that passes through settled area<br><br>Air quality will be properly monitored, especially near the population centers and sensitive receptors. Appropriate actions will be undertaken in case ambient air quality at the population centers deteriorates beyond EDS 2010 limits | | | | | | |
| 3.3 Noise level | Vehicles' mufflers (silencers) will be maintained to reduce noise generation;<br><br>Night time traffic will be avoided near the communities. Communities will be informed if the night work is unavoidable<br>- | Campsite | Contractor | CSC | Number of non-compliance reports<br><br>Noise measurement data<br><br>Number of community complaints<br><br>Compliance to Ambient noise standard (EDS 2010) | Throughout construction phase | Included in contractor's cost |
| 3.4 Health and safety | The construction workers will be provided with adequate and appropriate shelters which are wind and rainproof. The camps will be constructed at safe distance (200m) from the habitation of the local communities to minimize the disturbances or undue interference by the foreign workers.<br><br>Access to healthcare will be ensured with provision of first aid at the work sites. And in the event of major accidents, emergency services of the Phuentsholing hospital will be availed.<br><br>Adequate and clean drinking water supply, pit toilets and solid waste disposal sites will be provided Firefighting equipment will made available at the camps | Campsite | Contractor | CSC | Number of non-compliance reports<br><br>Number training conducted<br><br>Number of accidents, incidents, and near misses | Throughout construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Fuel and hazardous material storage will be away from the camp establishment.<br><br>For wellbeing of labourers, the regional labour officer from the Ministry of Labour and Human Resources (MOLHR) will make frequent and surprise check on the compliance of occupational health and safety. | | | | | | |
| **4. Activity: Transportation of Equipment and Construction Material** | | | | | | | |
| 4.1 Traffic Management | Traffic Management Plan will be developed by the contractor<br><br>Traffic facilities, such as speed limits, load weight limits and signal lights, are to be put in place<br><br>Coordinate and assistance of Traffic Police of Phuentsholing at busy junctions | Construction zone and haulage route | Contractor with CSC | CSC | Number of any non-compliance report;<br><br>Number of complaints/ grievances<br><br>Number of traffic accidents/ incidents involving project vehicles and trucks bringing materials and supply to Project | During mobilization and demobilization | Included in Contractor costs |
| 4.2 Soil Erosion and Contamination | Vehicular traffic on unpaved roads will be avoided as far as possible. Operation of vehicles and machinery close to the stream banks will be minimized<br><br>Vehicles and equipment will not be repaired in the field. If unavoidable, impervious sheathing will be used to avoid soil and water contamination.<br><br>Waste management plan developed will be implemented. | Construction zone and haulage route | Contractor | CSC | Number of any non-compliance report | Before and during construction zone | Included in Contractor costs |
| 4.3 Air Quality | Construction machinery and vehicles will be kept good working conditions and properly tuned, in order to minimize the exhaust emissions, and in compliance with vehicular emission standard (Environmental Discharge | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Number of community complaints | Throughout contractor mobilization and demobilization | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Standard/EDS, 2010, NEC)<br><br>Fugitive dust emission will be minimized by spraying water at least twice daily on bare soil all long the unpaved road<br><br>Speed limit of 15km/hr will be applied for the Project vehicles that passes through settled area<br><br>Air quality will be properly monitored, especially near the population centers and sensitive receptors. Appropriate actions will be undertaken in case ambient air quality at the population centers deteriorates beyond EDS 2010 limits | | | | Ambient air quality found beyond the national standard (EDS, 2010) | | |
| 4.4 Noise | Vehicles' mufflers (silencers) will be maintained to reduce noise generation;<br><br>Night time traffic will be avoided near the communities. Communities will be informed if the night work is unavoidable | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Noise monitoring data<br><br>Number of community complaints<br>Compliance to ambient noise standards (EDS 2010) | Before and during construction | Included in contractor's cost |
| 4.5 Public Safety | Road signage will be fixed at appropriate locations to reduce safety hazard associated with project-related vehicular traffic<br><br>Liaison with traffic police will be maintained<br><br>Project drivers will be trained on defensive driving<br><br>Vehicle speed near / within the communities will be kept low, to avoid | Construction zone | Contractor | CSC | Number of any non-compliance reports<br>Number of any related public complaints<br>Number of accidents, incidents and near-misses<br>Number of training provided | Before and during construction | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | safety hazards | | | | | | |
| 4.6 Damages to Infrastructure | All damaged infrastructure will be restored to original or better condition | Construction zone and haulage route | Contractor | CSC | Number of any non-compliance reports | Before and during construction | Included in contractor's cost |
| 4.7 Block routes | Community consultation to be carried out to properly schedule vehicular movement to minimize blockages of access<br>Road signages<br>Community awareness | Construction zone and haulage route | Contractor | CSC | - Number of any non-compliance reports | Before and during construction | Included in contractor's cost |
| **5. Activity: Construction of River Revetment (Spurs at Critical Locations such near Chamkuna)** | | | | | | | |
| 5.1 Amochhu River Bank and Soil Erosion | Works will be carried out in a manner not to cause river bank erosion<br><br>Vehicular traffic near the bank line will be minimized<br>Temporary protective measures such boulder stacking will be done construction to prevent bank erosion<br><br>Construction works will be suspended during rainy or monsoon season. | Construction zone | Contractor | CSC | - Monitoring of extent of erosion or accretion by chaiage by month of the Amochhu River | Throughout construction phase | Included in contractor's cost |
| 5.2 Soil and water contamination | Construction materials will be stored, used and handled appropriately<br><br>Reduce risk of a pollution through implementation of Waste management plan<br><br>Hazardous and toxic materials to be stored separately<br><br>Used oil or fuel will be stored in drum and recycled.<br><br>Inorganic waste such as cardboard, pet bottles, metal scraps etc. will sold to recycling agent<br><br>Organic and other non-hazardous waste will be sent to Phuentsholing Thromde landfill for disposal. | Construction zone | Contractor | CSC | Compliance to Environmental Discharge Standard, 2010, NEC | Throughout construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Impervious concrete base and sump will be constructed at the fuel, waste oil and chemical storage yard. A brem will also be constructed along the periphery of the concrete platforms. An oil interceptor will be constructed for providing for treating the oil waste collected in the sumps.<br><br>Construct a designated, signposted concrete | | | | | | |
| 5.3 Air Quality | Construction materials will be stored in designated areas away from sensitive receptors.<br><br>Construction machinery and vehicles will be kept good working conditions and properly tuned, in order to minimize the exhaust emissions, and in compliance with vehicular emission standard (Environmental Discharge Standard/EDS, 2010, NEC)<br><br>Fugitive dust emission will be minimized by spraying water at least twice daily on bare soil all long the unpaved road<br><br>Speed limit of 15km/hr will be applied for the Project vehicles that passes through settled area<br><br>Batching plants, asphalt plants and crushers will have appropriate dust and emission abatement system (e.g., wet scrubber) as appropriate.<br>- Air quality will be properly monitored, especially near the population centers and sensitive receptors. Appropriate actions will be undertaken in case ambient air quality at the population centers deteriorates beyond EDS 2010 limits | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Number of community complaints<br><br>Compliance to ambient air quality national standard (EDS, 2010) | Throughout construction phase | Included in contractor's cost |
| 5.4 Health and Safety | Construction site will be cordoned off to | Construction | Contractor | CSC | Number of non- | Throughout | Included in |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | stop unauthorized access<br><br>Develop controls and standard operating procedures for the use of fuels and other hazardous substance to prevent spills, accidents, and pilferage<br><br>Train and designate personnel for various OHS aspects such as spill control procedures, firefighting<br><br>Establish firefighting system and fire safety (fire extinguishers) at the construction sites where fire is an hazard<br><br>Impervious concrete base and sump will be constructed at the fuel, waste oil and chemical storage yard. A brem will also be constructed along the periphery of the concrete platforms. An oil interceptor will be constructed for providing for treating the oil waste collected in the sumps.<br><br>Construction workers in hazardous zone will be provided with gas mask<br><br>Provision of life insurance compensation for major injury or loss of life in line with national life insurance standard<br>Construction sites will have first aid boxes | zone | | | compliance observed and reported<br><br>Number of respiratory protective devices and other personal protective equipment (PPE) issues to workers<br><br>Monitoring of compliance with Health and Safety standards (including monthly reporting of accidents)<br><br>Number of accidents, incidents, and near misses<br><br>Number of trainings provided | construction phase | contractor's cost |
| 5.5 Noise and vibration | Vehicles' mufflers (silencers) will be maintained to reduce noise generation;<br><br>Night time traffic will be avoided near the communities. Communities will be informed if the night work is unavoidable<br><br>Ambient noise monitoring and compliance with EDS 2010 will be ensured | Construction zone | Contractor | CSC | Number of non-compliance reports<br><br>Noise monitoring data<br><br>Number of noise related grievance/ complaints | Throughout construction phase | Included in contractor's cost |
| 5.6 aquatic habitat | Perform work outside sensitive periods when Tor putitora is migrating in | Construction zone | Contractor | CSC | Number of instances of spoil being | Throughout construction | Included in contractor's |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | watercourse in autumn from October-November and in the spring between April and May<br><br>Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area.<br><br>Take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area.<br><br>No work will be allowed in the water area without installing geotextile silt curtains.<br><br>Dredging of the dry river bed for rechanneling will implemented in such a way that excavated ponds will allow settling of silt | | | | deposited in non-designated areas<br><br>Number of reported incidences of hunting or poaching on the project area<br><br>Number of reports of sighting of key wild species<br><br>Evidence of monitoring<br><br>Availability of monitoring reports | phase | cost |
| 5.7 Mortality of Fish | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>Install geotextile turbidity curtains around the worksite and parallel to the river flow prior to the start of work.<br><br>Do not carry out earthwork or excavation work close to water during flood periods or periods of heavy rain.<br><br>Take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area.<br><br>Properly install the geotextile lining around the gabion foundation before | Construction Zone | Contractor | CSC | - Number of any non-compliance report<br>- Any evidence of fish mortality | Construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | filling.<br>To prevent/minimize erosion cleared land during stripping should be confined within the RoW and limited to the segment of the route under construction.<br><br>Works on the dry river bed should be provided with a berm/interceptor drains, to collect silt-laden runoff and collected through a settling basin with geotextile membrane to remove suspended solids prior to disposal. | | | | | | |
| **6. Activity: Construction of Embankment and Road** | | | | | | | |
| 6.1 Changes in Land Use | Road corridor with 20m ROW will be provided by Phuentsholing Thromde.<br><br>Phuentsholing-Chamkuna Road is in line with Amochhu Local Area Plan and there will be no alteration of land use | Road ROW | Design consultant | PMU | - Documentary evidence of Amochhu LAP<br>- Evidence of Road design and the ROW | Before construction | Included in overall project cost |
| 6.2 Changes to land form and topography (Embankment and road will higher than existing ground level to maintained future back fill height ALRP) | Provision for access to Amochhu LAP will kept at all designated future LAP road and highway connections<br><br>Provision for access will also be kept Amochhu flood plain for sand and stone mining by NRDCL and<br><br>Access will be also provided to the seasonal orange depot setup and export businesses | Construction zone | Contractor | CSC | Provision for access to LAP and ALRP<br><br>Evidence of unhindered quarrying by NRDCL<br><br>No complaints from community and orange exporters | Construction phase | Included in contractor's cost |
| 6.3 Soil erosion during earthwork for embankment foundation construction.<br>(Foundation will be 3m ground level) | Excavated material will be temporarily stored away from river bed.<br><br>Excavated material will be reused for backfilling<br><br>6m gabion wall (3m below surface and 3m above the ground level) will be constructed to stop bank erosion. | Construction zone | Contractor | CSC | Monitoring of spoil storage and reuse<br><br>Observation of construction of gabion walls | Construction phase | Included in contractor's cost |
| 6.4 Soil and water contamination | Construction materials will be stored, used and handled appropriately | Construction zone | Contractor | CSC | Monthly auditing of management of | Throughout construction | Included in contractor's |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Reduce risk of a pollution through implementation of Waste management plan<br>Hazardous and toxic materials to be stored separately<br><br>Used oil or fuel will be stored in drum and recycled.<br><br>Inorganic waste such as cardboard, pet bottles, metal scraps etc. will sold to recycling agent<br><br>Organic and other non-hazardous waste will be sent to Phuentsholing Thromde landfill for disposal.<br><br>Impervious concrete base and sump will be constructed at the fuel, waste oil and chemical storage yard. A brem will also be constructed along the periphery of the concrete platforms. An oil interceptor will be constructed for providing for treating the oil waste collected in the sumps.<br><br>Construct a designated, signposted concrete | | | | hazardous material against safety data sheet<br><br>Soil and water quality monitoring data<br><br>Number of reports if any non-compliance<br><br>Number of related complaints | phase | cost |
| 6.5 Air Quality | Construction materials will be stored in designated areas away from sensitive receptors<br><br>Construction vehicles will be sprayed with water when entering and leaving the site, covered if transporting materials;<br><br>Speed limit of 15km/hr will be applied in sensitive areas;<br><br>Engine will be turned off when idling<br><br>Water spraying will be carried out in the construction zone and haulage route at twice daily using water tankers | Construction zone | Contractor | CSC | Number of dust related complaints<br><br>Number of air quality related complaints<br><br>Air quality monitoring data<br><br>Distance of batching plants and asphalt plants from nearest residential area. | Throughout construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | Batching plants, asphalt plants and crusher plant will be located 1-2km upstream of Chamkuna away from settlement and will have appropriate dust and emission abatement systems (e.g. wet scrubber)<br><br>Monitoring of ambient air quality insensitive areas | | | | | | |
| 6.6 Health and Safety | Construction site will be cordoned off to stop unauthorized access<br><br>Develop controls and standard operating procedures for the use of fuels and other hazardous substance to prevent spills, accidents, and pilferage<br><br>Train and designate personnel for various OHS aspects such as spill control procedures, firefighting<br><br>Establish firefighting system and fire safety (fire extinguishers) at the construction sites where fire is an hazard<br><br>Impervious concrete base and sump will be constructed at the fuel, waste oil and chemical storage yard. A berm will also be constructed along the periphery of the concrete platforms. An oil interceptor will be constructed for providing for treating the oil waste collected in the sumps.<br><br>Construction workers in hazardous zone will be provided with gas mask<br><br>Provision of life insurance compensation for major injury or loss of life in line with national life insurance standard<br><br>Construction sites will have first aid boxes | Construction zone | Contractor | CSC | Number of non-compliance observed and reported<br><br>Number of respiratory protective devices and other personal protective equipment (PPE) issues to workers<br><br>Monitoring of compliance with Health and Safety standards (including monthly reporting of accidents)<br><br>Number of accidents, incidents, and near misses<br><br>Number of trainings provided | Throughout construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| 6.7 Noise and vibration | Construction activities will be limited to daylight hours (8am -5.00pm);<br><br>Night time traffic will be avoided near the communities. Communities will be informed if the night work is unavoidable<br><br>Ambient noise monitoring and compliance with EDS 2010 will be ensured | Construction zone | Contractor | CSC | Construction work timing<br><br>Noise monitoring data<br><br>Number of noise related grievance/ complaints | Throughout construction phase | Included in contractor's cost |
| 6.8 Avifauna and aquatic habitat | Awareness raising of construction workers illegal fishing and poaching;<br><br>Construction workers will be strictly prohibited from carrying out illegal fishing and poaching<br><br>Disturbance and harassment of birdlife will be prohibited<br><br>Forest Range office of Phuentsholing will carry out surprise check<br><br>Avoid dumping of spoil into river and stream beds,<br><br>Dumping of waste water and effluents and solid waste in water bodies will be prohibited | Construction zone | Contractor | CSC | Number of reported incidences of hunting or poaching in the project area<br><br>Monitoring birdlife | Throughout construction phase | Included in contractor's cost |
| 6.9 Mortality of Fish | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area.<br><br>Take all necessary precautions to prevent deposition of fine particulate | Construction zone | Contractor | CSC | Number of non-compliance report<br><br>Number of related grievances | construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
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| | matter into the aquatic environment beyond the immediate work area.<br><br>No work will be allowed in the water area without installing geotextile silt curtains.<br><br>Dredging of the dry river bed for rechanneling will implemented in such a way that excavated ponds will allow settling of silt | | | | | | |
| 6.10 Disturbance of visual landscape | Perform work outside sensitive periods when Tor putitora is migrating in watercourse in autumn from October-November and in the spring between April and May<br><br>Install geotextile turbidity curtains around the worksite and parallel to the river flow prior to the start of work.<br><br>Do not carry out earthwork or excavation work close to water during flood periods or periods of heavy rain.<br><br>Take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area.<br><br>Properly install the geotextile lining around the gabion foundation before filling.<br><br>To prevent/minimize erosion cleared land during stripping should be confined within the RoW and limited to the segment of the route under construction.<br><br>Works on the dry river bed should be provided with a berm/interceptor drains, to collect silt-laden runoff and collected through a settling basin with geotextile membrane to remove suspended solids prior to disposal. | Construction zone | Contractor | CSC | Number of non-compliance report | construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
|---|---|---|---|---|---|---|---|
| 6.11 Social conflict due to the Influx of workers and in-migrants | Liaison will be maintained with the communities and local authorities to minimize the social conflict<br><br>Construction workers will be brief and made aware of local norms and values<br><br>Contractor and work force will follow local rules and code of conduct<br><br>Complaints from the local community will be addressed by the Grievance Mechanism that has been developed | Construction Zone | PMU | Environmental Uni/DOR | Number of public grievances relating to in-migrants | construction phase | Included in contractor's cost |
| 6.12 Adverse Effects on Health or HIV/AIDS | Construction site will be cordoned off to stop unauthorized access<br><br>Develop controls and standard operating procedures for the use of fuels and other hazardous substance to prevent spills, accidents, and pilferage<br><br>Train and designate personnel for various OHS aspects such as spill control procedures, firefighting<br><br>Establish firefighting system and fire safety (fire extinguishers) at the construction sites where fire is an hazard<br><br>Impervious concrete base and sump will be constructed at the fuel, waste oil and chemical storage yard. A brem will also be constructed along the periphery of the concrete platforms. An oil interceptor will be constructed for providing for treating the oil waste collected in the sumps.<br><br>Construction workers in hazardous zone will be provided with gas mask<br><br>Provision of life insurance compensation for major injury or loss of life in line with national life insurance standard | Construction zone | Contractor | CSC | Number of patients being treated in the local hospital | construction phase | Included in contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
|---|---|---|---|---|---|---|---|
| | Construction sites will have first aid boxes<br><br>To minimize the risk of spread of the communicable diseases, the construction will be made aware of the danger of diseases through educational campaigns. For example, Health Information and Service Center (HISC) or Phuentsholing Hospital will be invited to provide awareness education on sexually transmitted and other communicable diseases. | | | | | | |
| 6.13 Blockage of local access route | Local access routes will not be blocked to the extent possible<br><br>If blockage of route or road is unavoidable , consultation will be carried out with the affected community or stakeholder and alternates will be identified<br><br>Work schedule will be prepared in consultation with the communities to minimize impact of blocked access or routes<br><br>Embankment to have stairs/ramps to facilitate people and their livestock crossing embankment<br><br>Provision for access road towards Amochhu LAP and ALRP side will be maintained | Construction zone | Contractor | CSC | Number of related community or affected party complaints | Construction phase | Included contractor's cost |
| **7. Activity: Material Borrowing (Borrow Area Management)** | | | | | | | |
| 7.1 Land use and topographical change | Material extracted through benching to minimize scarring and erosion<br><br>Storm water drainage will be constructed<br><br>Retaining walls will be constructed in all critical areas | Borrow area at Bagultar under Khempagaon | Contractor | CSC | Construction of storm water drainage and retaining wall<br><br>Evidence of compensatory plantation and restoration of borrow | End of Construction phase | BTN: 2,751,200 |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
|---|---|---|---|---|---|---|---|
| | After completion of use of borrow area, the area will be revegated through compensatory plantation program | | | | area | | |
| 7.2 Soil erosion | Borrow pits/areas to be restored after completion of use of the area through compensatory plantation<br><br>Compensatory plantation will be carried out after completing the quarrying , using native plant species such as albizia, erythrina species etc. | Borrow area at Bagultar under Khempagaon | Contractor | CSC | Evidence of compensatory plantation and restoration of borrow area | Construction phase | Included contractor's cost |
| 7.3 Soil and Water contamination | Borrowing activities will be prohibited during rainy season<br><br>Borrowing will be done in benches to minimize soil erosion and thereby water contamination<br><br>After completion of use of borrow area, the area will be revegated through compensatory plantation program | Borrow area at Bagultar under Khempagaon | Contractor | CSC | Number of non-compliance report<br><br>Evidence of compensatory plantation and restoration of borrow area | Construction phase | Included contractor's cost |
| 7.4 Air Quality | Dust generation borrow area will be minimized by spraying water at least twice daily.<br><br>Similarly, haulage route will also be sprayed twice daily to dampen the dust<br><br>Trucks carrying borrow material will be properly covered<br><br>Construction equipment and vehicles will be regularly maintained to minimize the exhaust pollution | Borrow area at Bagultar under Khempagaon and haulage route | Contractor | CSC | Number of non-compliance report<br><br>Number of public grievances relating to in-migrants | Construction phase | Included contractor's cost |
| 7.5 Health and Safety | Construction workers in hazardous zone will be provided with gas mask<br><br>Provision of life insurance compensation for major injury or loss of life in line with national life insurance standard<br><br>Construction sites will have first aid | Borrow area (Khempagaon) | Contractor | CSC | Number of non-compliance report<br><br>Evidence of gas mask | Construction phase | Included contractor's cost |

| Environmental | Mitigation Measures | Location | Responsibility | | Key Performance | Timing/ | Cost |
|---|---|---|---|---|---|---|---|
| | boxes<br>Borrow area will be cordoned off so that the unauthorized person cannot enter | | | | | | |
| **8. Activity: Site Restoration** | | | | | | | |
| 8.1 Site restoration | Demolition of temporary structures<br><br>Removal of all debris, excess construction material, scraps, spoils, other wastes<br><br>Landscaping will be carried out<br><br>Restoration of sites for camps, offices, hot mix, crusher and batching plant areas will be carried out. | Campsites<br>Construction zone,<br>Hot mix, Crushing, Batching plant areas | Contractor | CSC | Photographic record<br><br>Clearance from CSC | Construction phase | Included contractor's cost |
| **9. OPERATION AND MAINTENANCE PHASE** | | | | | | | |
| 9.1 Air pollution | The road surface will be maintained for smooth traffic flow and reduction of vehicular emission | Project Road | DOR Field[41] Division, Phuenthsoling | DOR | Ambient air monitoring | During construction and O&M phases | Included in overall O&M cost |
| 9.2 Noise | Noise barrier will be installed if needed in future | Project Road | DOR Field Division, Phuenthsoling | DOR | Noise monitoring against standards (see footnote 40)<br><br>Public complaint | During O&M phases | Included in overall O&M cost |
| 9.3 Water pollution | Storm water drainage to be maintained in good working condition | Project Road | DOR Field Division, Phuenthsoling | DOR | Effluent monitoring against standrds | During O&M phases | Included in overall O&M cost |
| 9.4 Embankment breaches | Regular inspection of embankment | Project Road | DOR Field Division, Phuenthsoling | DOR | Erosion/accretion records | During O&M phases | Included in overall O&M cost |
| 9.5 Community safety | Zebra crossing is to be maintained<br>Pedestrian footpath will be maintained | Project Road | DOR Field Division, Phuenthsoling | DOR | Crash data<br><br>Number of complaints associate with safety | During O&M phases | Included in overall O&M cost |

[41] The ongoing SASEC Road Connectivity Project (Project #39225-034) includes a component on building the capacity of Phuentsholing DOR on air and noise monitoring. It is expected that they will be able to start monitoring air and noise levels by the time the Chamkuna – Phuentsholing road section becomes operational.

**Table 20: ENVIRONMENTAL MONITORING PLAN**

| Env. Indicators | Project Stage | Parameters | Method/ Guidelines | Location | Frequency and Duration | Standards | Approximate cost (Rs) | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|---|
| Air Quality | Construction stage | PM 10 PM2.5 SO2, NOX, CO | High volume sampler to be located 50 m from the road edge and 150m towards the selected locations in the downwind direction. Use method specified by NEC | Every one kilometer road length within 50 meters from the road edge and 150m towards the populated area. | Monthly | Air quality standard by NEC | 6stationsxNu10,000/sample*36months =2,160,000 Nu | Contractor | DOR/CSC |
| | Operation stage | | | Every one kilometer road length within 50 meters from the road edge and 150m towards the populated area. | Semi-annual | Air quality standard by NEC | 6X10000x2 =NU120,000 /yr | DOR through approved monitoring agency | DOR |
| Surface water quality | Construction | current velocity transparency, pH, water temperature, dissolved oxygen, total alkalinity, chlorides, silicates, calcium | Composite | Upstream and downstream of the project area | Monthy | Compared to upstream baseline | 2*Nu15,000 x36=Nu1,080,000 | Contractor | DOR/CSC |
| | Operation | | | | Semi-annual | | 2*15,000*2= Nu60,000/year | DOR | DOR |
| Ground Water Quality | Construction stage | WHO Drinking Water Quality Standard | Grab samples from water taps | Groundwater at Construction Camps | Monthly for 3 years, 2 camps with 2 borewells each | Water quality standard by NEC | 36x Nu6000x2 =Nu 432,000 | Contractor | DOR /SC |
| | Operation stage | | | None | None | None | None | None | None |
| Noise levels | Construction stage | Equivalent Noise levels on dB (A) | World Bank EHS Guideline Values fore | Same as air quality | Monthly | World Bank EHS Guide Values | 6x3000x36 =Nu648,000 | Contractor | DOR/CSC |

| Env. Indicators | Project Stage | Parameters | Method/ Guidelines | Location | Frequency and Duration | Standards | Approximate cost (Rs) | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|---|
| | Operation stage | scale for day and night | Nois | 1 | Semi-annual | | 2x3000x2 =Nu12,000 | DOR | DOR |
| Soil Erosion | Construction Stage | Visual check for Soil erosion and siltation | As specified by the site engineer DOR /supervision consultant | Throughout the Project Corridor especially at River banks, bridge locations and river training structures | Weekly during monsoon | Visual Checks | Included in Engineering Cost | Contractor | DOR/CSC |
| | Operation Stage | | | | Weekly during monsoon | Visual Checks | Routine Engineering Work | Engineering Team of DOR | |
| Drainage Congestion | Construction stage | Visual Checks | | Throughout the Project Corridor especially Probable drainage congestion areas | Once in a year before rainy season | None Specific | Included in Engineering Cost | DOR | DOR/CSC |
| | Operation Stage | | | | Once in a year before rainy season | None Specific | Routine Engineering Work | DOR | |
| Borrow Areas | Construction Stage | Visual Checks | NEC guidelines | Borrow areas to be operated | Once in a month | Environment clearance conditions | Contractor | Contractor | DOR/CSC |
| | Operation Stage | Visual Checks | Rehabilitation as per IRC guidelines | Closed Borrow Areas | Quarterly for 1 year | | | DOR | |
| Construction Sites and Labor Camp | Construction stage | Hygiene, drainage Medical Facilities Etc. | Rapid audit as per reporting format | Construction Sites and Camp | Quarterly during construction period | National labor guidelines | Part of the regular monitoring | Contractor | DOR/CSC |
| Record of Accident | Construction Stage | Type, nature and cause of accidents. Methodology as suggested by CSC and approved by DOR | | Throughout the stretch including construction sites, crusher, diversions, HMP, earthwork, demolition site etc. | occurrence of accidents | As suggested by CSC | Part of the regular monitoring | Contractor | DOR/CSC |
| | Operation stage | | | Throughout the stretch | occurrence of accidents | - | - | Road Safety unit of DOR with support from local police | |

| Env. Indicators | Project Stage | Parameters | Method/ Guidelines | Location | Frequency and Duration | Standards | Approximate cost (Rs) | Implementation | Supervision |
|---|---|---|---|---|---|---|---|---|---|
| Fish Survey | Construction Stage | The sampling method includes such as cast net, rod and line and electro fisher. Catch and release method. | | Amochhu Dortikhola Loarikhola | Semi-annual during Masheer migration season | Species distribution and number | NU300,000/ yr | Contractor | DOR/CSC |
| | Operation stage | | | | | | NU300,000/ yr | DOR | |
| **Monitoring Costs Construction Phase: Nu4,527,000** | | | | | | | | | |

# IX. CONCLUSION AND RECOMMENDATION

## A. Conclusion

167. The proposed Phuentsholing - Chamkuna road does not pass through any environmentally sensitive area and requires no private land acquisition. No environmental clearance will required however, forest clearance will be required for the operation of borrow area at Bagultar under Khempagaon. All relevant issues raised during focus group discussions and public consultations were also incorporated in the IEE and EMP.

168. Mitigation measures were identified to reduce the significant adverse impacts including residual effects. As the project is currently in the feasibility study stage a number design and construction methods alternatives like method of river channeling, location and scale of the spur dikes, road side protection, location of camp and plat sites, borrow area, and quarries remains to be decided and from which a host of impacts will be assessed.

169. During the pre-construction phase, major potential negative impacts pertains to site mobilization where surface runoff may carry sediment to the Amochu which are detrimental to the Golden Masheer (Tor putitora) spawning behavior. During construction, the river channeling, construction of spur dike, installation of gabions, soil filling, and compaction will also increase sediment flow and increase suspended solids in the water column. To mitigate the significant impacts to the Masheer, no activity in the water environment will be allowed during autumn migration from October-November and in the spring spawning between April and May. The contractor will maintain Maintain constant free flow of water at any given time to preserve the functions of the fish habitat (feeding, nursery, spawning) downstream from the work area and take all necessary precautions to prevent deposition of fine particulate matter into the aquatic environment beyond the immediate work area. A key mitigation measure is the deployment of geo-textile silt curtains before the start of any work to ensure suspended solids will not settle outside the project area.

170. Another potential significant impact is the on the hydrology and hydraulic characteristics of the Amochhu once the river channelization and spur dikes, aimed at protecting the embankment road. This study relied of the DHI assessment for the ALRP that as long as the river channel maintains a smooth flow and cross-section of 300m, there would be marginal impact on the flow velocity and sedimentation downstream.

171. Only minor environmental impacts were identified during project operation.

172. The IEE has shown that none of the anticipated environmental impacts of constructing the proposed road is significant enough to need a detailed follow-up EIA or special environmental study. Therefore, this IEE is sufficient for approval of the sub-project.

## B. Recommendations

173. The environmental impacts anticipated for proposed Project are not significant after the implementing recommended mitigation measures. Most of the impacts are temporary, reversible and all can easily be mitigated using available methods. Nonetheless, since the environmental examination was conducted during the feasibility study stage, there is a need to update the assessment and mitigation measures during detailed engineering design stage. To ensure the effective implementation of the EMP, the following recommendations are emphasized:

- Separate IEE studies for Borrow area and the establishment of Hot Mix/WMM Plant will need to be carried out during detailed study phase to secure required environmental clearances
- Environmental conditions shall be incorporated into standard bidding document and EMP shall be attached with Bid document.
- Project Coordinator for Project shall act as Environmental Focal Person and report to the Overall Environmental Monitoring In-Charge.
- DOR (or Environmental Monitoring In-Charge) shall submit a semi-annual environmental monitoring report on EMP implementation to ADB and the relevant government agencies.
- At the implementation stage, other relevant agencies such as Phuentsholing Thromde, Department of Forests and Park Services, National Environment Commission shall monitor the implementation of mitigation measures as specified under the EMP.

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**Appendix 1: List of Official Consulted**

| | | |
|---|---|---|
| **Thimphu** | | |
| Mr. Tenzin | Director | DES, MoWHS, Thimphu |
| Mr. Phub Rinzin | Chief Engineer | DES, MoWHS, Thimphu |
| Mr. Sonam Tobgye | PC, SASEC | MoWHS, Thimphu |
| Mr. Karma Gheley | General Manager | DHI/INFRA, Thimphu |
| | | |
| **Phuentsholing** | | |
| Mr. Tharchen Lhendup | Executive Secretary | Phuentsholing Municipal |
| Mr. D.C. Dhimal | Principal Engineer | Phuentsholing Municipal |
| Mr. Tshering Phuentsho | Chief Urban Planner | Phuentsholing Municipal |
| Mr. Karma Dorji | Planner | Phuentsholing Municipal |
| Ms, Anu Pradhan | Project Manager, ADB | Phuentsholing Municipal |
| Mr. Dorji Wandi | Chief Engineer | DoR, Phuentsholing |
| Mr. Praveen Gurung | AE | DoR, Phuentsholing |
| Mr. NL Rai | Dy. Team Leader | ADB, Phuentsholing |
| Dasho Rabgyel Tobden | Sub-district Administrator | Phuentsholing Dungkhag |
| Dasho Nima Tshering | Superintendent of Police | RBP, Phuentsholing |
| Ms. Deki | AWE | RBP, Phuentsholing |
| Dasho Pelden | OIC, WCP | RBP, Phuentsholing |
| Mr. Bhim Gurung | Marketing Advisor | FCB, Phuentsholing |
| Mr.Tshering Yeshey | General Secretary | Bhutan Exporter Association |
| Mr. Jigme | Principal | THS School |
| Mr. KB Tiwari | Chief Manager | BPC, Phuentsholing |
| Mr.BB Subba | Chief Engineer | BPC, Phuentsholing |
| Mr.Jigme Gayleg | Executive Engineer | BPC, Phuentsholing |
| Mr. Sam Tshewang | Offtg. Div. Manager | BPC, Phuentsholing |
| Mr. Sherab Tenzin | Electrical Engineer | BPC, Phuentsholing |
| Mr.Tashi Wangdi | Health Councilor | HISC, Phuentsholing |
| Mr.Sonam Gyeltshen | Assistant to GM | Industries Association of Bhutan |
| Mr. Sangay Dorji | Regional Secretary | BCCI, Phuentsholing |
| Mr. Phuentsho Wangdi | LAP representative | Phuentsholing |
| Mr. NL Rai, | Council Representative | Chamkuna, Phuentsholing |
| Mr. Karma Chen | Town Secretary | Phuentsholing Municipal |
| Mr. Tshering Wangdi | Town Secretary | Phuentsholing Municipal |
| Mr. Chimmi Dorji | Orange Exporter | Chamkuna depot |
| Ms. Rinchen Bidha | Orange Exporter | Chamkuna depot |
| Mr. Sangay Penjore | Orange Exporter | Chamkuna depot |
| Mr. Arjun Pradhan | Orange Exporter | Chamkuna depot |
| Mr. Gyembo Tshering | Orange Exporter | Chamkuna depot |

## Appendix 2: List of Attendees of Focus Group Discussions

### *Focus Group Discussion at Chamkuna Baidungtar*

FOCUS GROUP DISCUSSION at Chamkuna, P/Ling Date 12.1.2016

ADB TA-8708 BHU, SASEC TRANSPORT, TRADE FACILITATION AND LOGISTICS PROJECT

| Sl No. | Name | Age | Sex | Hailing from | Signature |
|---|---|---|---|---|---|
| 1. | Mr. Chimi Dorji | 57 | Male | Jabana, Paro | |
| 2. | Ms. Rinchen Bidha | 49 | Female | Dopsari, Paro | |
| 3. | Mr. Sanjay Rai | 48 | Male | Jabana, Paro. | |
| 4. | Mr. Ramesh Sharma | 28 | Male | P/Ling. | |
| 5. | Mr. Gyembo Dorji | 40 | Male | Jabana, Paro | |
| 6. | | | | | |
| 7. | | | | | |
| 8. | | | | | |
| 9. | | | | | |

Page 1 of 3

***Focus Group Discussions Attendees of Phuentsholing Municipality***

FOCUS GROUP DISCUSSION at Pling Date 22/3/2016

| Sl No. | Name | Age | Sex | Signature |
|---|---|---|---|---|
| 1 | Lok Nath Sub (Ward.) | 62 | M | |
| 2 | Shasmita Limbu | 32 | F | |
| 3 | Singye Dema | 30 | F | |
| 4 | Bhakta Bdr Tamang | 60 | M | |
| 5. | Amar Gurung. | 23 | M. | |
| 6. | Sushil Rai. | 22 | M | |
| 7. | Harka Man Rai | 40 | M | |
| 8. | Gajendra Chhetri | 30 | M | |
| 9 | Prem Bdr Monger | 30 | M | |
| 10 | Beoman Monger | 27 | M | |

FOCUS GROUP DISCUSSION at D/HQ Date 23/3/2016

| Sl No. | Name | Age | Sex | Signature |
|---|---|---|---|---|
| 11 | Chitra Bdr Monger | 39 | m | |
| 12 | Anil Pradhan | 42 | m | |
| 13 | Kiran Bhakta Khemraj | 36 | m. | |
| 14 | Dhan Bdr. Rai | 47 | M | |
| 15. | Sam. Bdr Rai | 57 | M | |
| 16 | Robindra Rai | 26 | M | |
| 17. | Indra kumari | 21 | F | |
| 18 | Bir Bal Rai | 58 | M | |
| 19. | Mangburg Rai | SD | F | |
| 20. | Uger Sing Rai | SD | M | |

FOCUS GROUP DISCUSSION at D/Ling Date 22/3/2016

| Sl No. | Name | Age | Sex | Signature |
|---|---|---|---|---|
| 21. | Man Rani Rai | 60 | F | |
| 22 | Pioth Sing Rai | 48 | M | |
| 23. | Mani Dhan Rai | 29. | M | |
| 24. | Khari maya G. | 39 | F | |
| 25 | Sujata Tamang | 28 | F | |
| 26. | Karna Bdr Rai | 52 | M | |
| 27. | Maile Tamang | 60 | F | |
| 28. | Mena Kumari Rai | 28 | F | |
| 29. | Mongali Tamang | 38 | F | |
| 30 | Santa Maya Rai | 45 | F | |

FOCUS GROUP DISCUSSION at P/liy Date 22/3/2016

| Sl No. | Name | Age | Sex | Signature |
|---|---|---|---|---|
| 40 | Tshing Choden | 40 | F | |
| 41 | Sadhar Ghalley | 46 | M | |
| 42 | Tek Nath | 28 | M | |
| 43 | Gangay Pamang | 25 | F | |
| 44 | Hem Kr Ghalley | 44 | M | |
| 45 | | 46 | M | |
| 46 | Tenzin Dorji | 65 | M | |
| 47. | Dilmaya sharma | 48 | F | |
| 48 | SB Tamang | 50 | M | |
| 49 | R Chhetri | 69 | M | |

FOCUS GROUP DISCUSSION at Pilibhit Date 22/3/2016

| Sl No. | Name | Age | Sex | Signature |
|---|---|---|---|---|
| 50 | Nan Kalawi | 32 | F | |
| 51 | Phurtsho Wangdi | 54 | M | |
| 52 | Tshering Yeshi | 37 | M | |
| 53 | Pem Gyelsh | 52 | M | |
| 54 | Dolma Dema | 40 | F | |
| 55 | Dambar Kr Chhetry | 27 | M | |
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# Appendix 3: Climate Change Study Report

## A: Synopsis of Literature Review

### A1. Amo-chu Land Reclamation Project (ALRP), DPR 1

1. The River Toorsa, known as the Amo-chu upstream in Bhutan, flows out of Tibet into the Chumbi Valley and swiftly through western Bhutan before broadening near Phuntsholing and flowing on into India. The river has its source on Mount Pauhunri (7,128 m amsl) on the Indo-Sino border. The catchment area down to Hasimara gauging station in India, 15 km downstream of the Indo-Bhutan border, is 4,006 km2.

2. The city of Phuntsholing in Bhutan is located at a geographically and commercially strategic position on the Indo-Bhutan border. Phuntsholing lies on the left bank of the Amo-chu and with every monsoon onslaught, the land along the north-western city limits have been eroded over time exposing the town to the danger of flooding from the river.

3. With support from DANIDA, the Ministry of Works and Human Settlements and the Phuntsholing City Corporation (PCC) initiated a study entailing feasibility leading to detailed design of flood and bank protection and related works. In line with the desired objectives, the report "***Toorsa River Flood Mitigation Project - Detailed Feasibility Study and Engineering Design***" was produced in August 2007.

4. The primary outputs of the above study were:

- Primary and secondary data for the analysis of the hydrologic and geotechnical site conditions.
- Advanced mathematical model analyses of the hydrology and morphology of the river, as it is at present and as it would be with the proposed flood and bank protection works.
- Designs, drawings, quantities and costs for the works, including a road bridge and hill slope protection measures, and an implementation plan.
- A conceptual land use plan for the reclaimed area.
- Financial evaluation of the proposed works.

5. The design flood is defined as the flood for which the structures planned to protect Phuntsholing from flood and bank erosion are designed. In line with general standards in Bhutan, the statistical once in 50 year return period was adopted as the design standard. Two approaches were taken to estimate the design flood: flood frequency analysis, and synthetic unit hydrograph. The former statistical approach gave a peak discharge of 5,200 $m^3/s$, slightly less than the observed maximum.
(*The maximum discharge in the Toorsa river was recorded at Hasimara in India, 5,400 $m^3/s$ in July 1996 where recordings had commenced in 1978. Compared to Doyagang river gauging station, about 10 km upstream of Phuntsholing, where discharge measurements started only in 2006, the Hasimara gauge had the longest and most reliable data on the Toorsa River*.)

6. The synthetic unit hydrograph approach was based on long term observations in catchments to railway bridges in India. The analysis yielded a hydrograph with a peak discharge of 5,900 $m^3/s$, with flood wave duration of 53 hours. As being the more conservative result, this was adopted for the design of the flood and bank protection works at Phuntsholing.

## A2: Amo-chu Land Reclamation Project (ALRP), DPR 2

7. DHI INFRA Bhutan initiated a revision of the previous 2007 study, as the earlier study had not taken into account the proposed Amo-chu Hydro-electric Project, just some tens of kilometers upstream of Phuntsholing. It was therefore necessary to revisit the earlier hydrological and morphological studies and revalidate the designs of various components studied in 2007. The revised study "***Revision of Amo-chhu Flood Management and Land Reclamation Project Study-2007***" approved by December 2013, included impact of Amo-chu HEP on design discharge of structure proposed for bank protection, reservoir sedimentation, morphological impact, dam break, flood hazard map for discharge with different return period, study leading to detailed design of flood and bank protection, dam break, revised financial analysis, and revised construction schedule.

8. The peak discharge of 5,900 $m^3/s$ remains as that of 2007 study. Mathematical models have been applied to analyze the impact from the Design Flood in terms of water levels and discharges, the pattern of flow velocities, sediment transport along the river, and erosion and deposition of sediment along the river bed and banks.

9. The design comprises a smoothly aligned main river channel over a reach of 9 km excavated to a width of 300 m and a depth of 2 m below the general existing bed level. The alignment and dimensions have been formulated and refined to give the minimum impact. The impact is to reduce maximum water levels along the protected reach by 0.3 m, with an increase in average maximum velocity from 3 to 4 m/s.

10. Key hydraulic parameters for flood and bank protection have been derived through mathematical model studies of the complex morphological processes of the Amo-chu. The parameters are water levels, flow velocities and bed levels resulting from potential scour through the protected reach from Phuntsholing upstream.

11. Conclusions on Design Discharge by Revised DPR, 2013

12. Studying all hydrological reports, revisiting catchment hydrology, studying reservoir operation policy and modeling moderation of flood due to Amochhu Hydro Electric Project (AHEP), and the old design in Detailed Project Report, (DPR) 2007, the following conclusions were arrived at:

- The design discharge values and their return periods of AHEP are much higher than ALRP. Therefore, there appears no reason to re-asses and re-design the ALRP.
- The discharge observations are made only once a day at 8:00am and may miss the actual peak discharge, which could occur during night or later in the day.
- Some of the major flood peaks are calculated from the rating curves developed for the sites with unstable controls. The discharge may be in error up to 30%. For example, the peak at Hasimara in 1996 is actually observed at 5,397$m^3/s$, and corresponds to a lower stage compared to the next highest discharge of 3,800$m^3/s$ in 2000, which is derived from a rating curve.
- It is seen due to AHEP, maximum flood moderation of 11% will occur. To achieve that 2 m rise in water level above FRL need to be allowed. This decision can be taken after discussion with Dam monitoring authority. A close monitoring between dam monitoring authority and ALRP committee is also necessary.

- The waterway of 300 m was decided and tested in the mathematical model and was finalized. This waterway was evolved during the field observations. The observations indicated the narrowest waterway found in the vicinity of the study reach. No erosion was observed on both the banks in that reach. It is known that the highest observed flood at Hashimara gauging site was 5,400$m^3$/s in the year 1996. No signs of erosion were observed during the inspections of site. Therefore, the waterway of 300 m was taken as a stable waterway for the river in that reach. It may be noted that the process of evolving the stable waterway was fully based on the field observations, and subsequently confirmed by the mathematical model studies. Therefore, the changes in the design discharges, if any, cannot be co-related to the waterway provided in the design.
- The protection works of both banks were designed using the highest velocities and intensities of discharge observed in the mathematical model. These were the maximum values observed in the model within the specific reaches. It was also observed during mathematical model runs that the changes in the river discharge did not show any significant changes in the velocities and intensity of discharges. The protection works are evolved on the basis of the overall maximum values observed in a specific reach, and not on the parameters from section-to-section. Therefore, the design of protection works will not go any significant change due to small changes in the river discharges.
- Changes in the design values over different reaches of the proposed protection works were decided on the overall analysis of hydraulics and morphology of the river in the study reach, and not just on the results of mathematical model studies. Therefore, changes in division of the reaches due to changes in the design discharge would not be expected.
- In view of aforesaid points, revision of the design discharge for ALRP cannot be recommended.

**A3: Second National Communication from Bhutan to the UNFCCC, Vulnerability and Adaptation Assessment, Volume I, Technical Paper, September 2011 (National Environment Commission, Bhutan)**

**1. Climate Baseline and Scenarios Data**

13. The National Environment Commission (NEC) notes that in order to conduct vulnerability assessments in regards to the impacts of climate change, one need to have baseline climate data on two of the key climate variables, namely air temperature and precipitation at the local/regional level. Bhutan however has observed data at the Dzongkhag level that generally covers the period 1985 to 2010. But amongst the 23 Class A and Class C stations for which data are available for maximum and minimum temperature and rainfall, almost all coverage periods span from 1996-2008 (13 years) and some cover the period 1994-2008 (15 years). Besides in a number of cases there are gaps in data (missing data).

14. For climate change impacts studies, the normal convention is to use 30-year time slices. For the current or control climate scenario, and on account of data availability, the study used the 1980-2009 period from the PRECIS simulations. Moreover, these data sets were cross-checked for consistency and accuracy against observed stations data that generally cover the period 1994/96-2008 (NEC/START-SEA, 2011). As for the future scenarios the study has used two time slices, namely a short term time period (2010-2039) centered around the twenties decade and a long term time period (2040-2069) centered around the fifties decade.

15. These future short term (2010-2039) and long term scenarios (2040-2069) of daily maximum and minimum air temperature, daily precipitation and daily solar radiation, at minimum, were supplied by NEC/START-SEA for the climate change scenarios using the PRECIS regional climate model**.** The downscaled Climate Change Scenarios (22km resolution) prepared in PRECIS was piloted by two GCMs, namely the German ECHAM5 A1B and the British HADCM3 A1B covering the period 1979-2069. Finally mapping techniques (GIS) were used to provide monthly and seasonal maps of air mean annual and seasonal air temperature and total annual and seasonal precipitation (rainfall only) for the current (1980-2009) climate and the two future (2010-2039 and 2040-2069) climate scenarios.

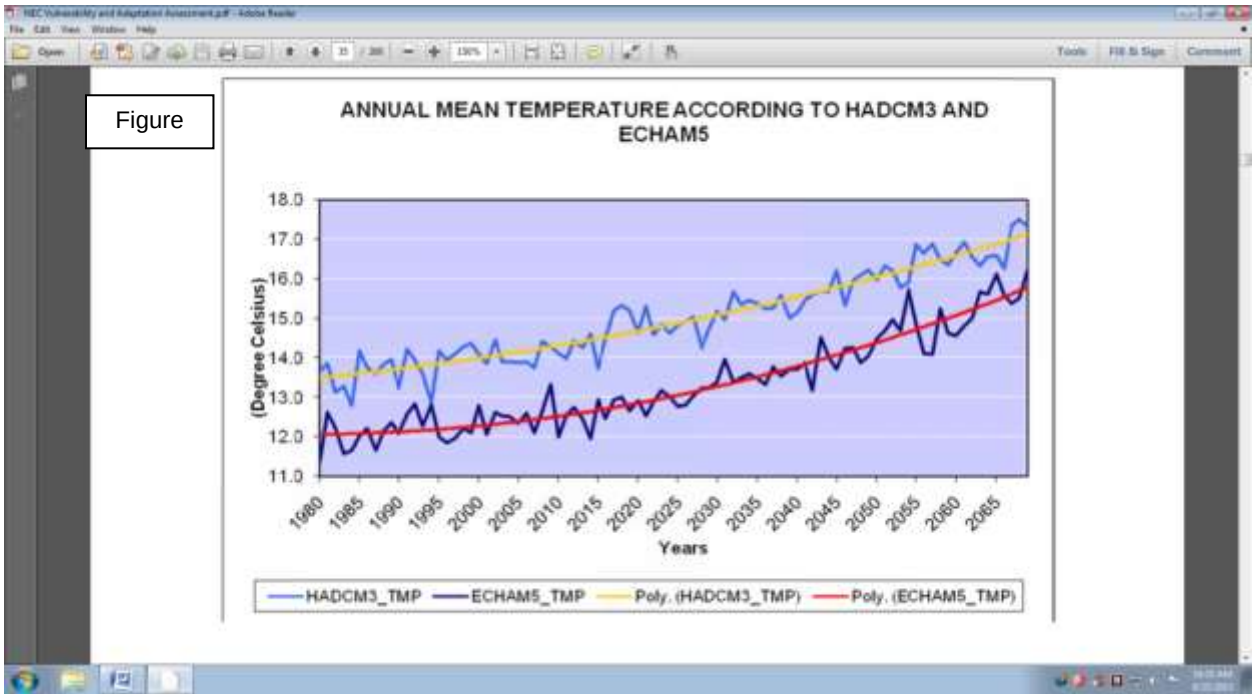
## 2. Climate Change Scenarios and Trends

16. A section of the technical report deals with the trends in mean annual and seasonal (monsoon/wet and winter/dry) temperature ($^0$C) and mean annual and seasonal (monsoon/wet and winter/dry) precipitation/rainfall (mm) for the entire surface area of Bhutan for the period 1980-2069, using simulations from the downscaled HadCM3 and ECHAM5 climate models. The monsoon/wet season is assumed to last between June to September and the winter/dry season to last between December to March. The simulations consisting of dynamically down-scaled temperature and precipitation using the PRECIS regional model was performed by NEC/START-SEA, Bangkok, Thailand. Both the HadCM3 and ECHAM5 climate models were downscaled using the SRES A1B forcing scenario. The downscaling using Precis provided climate variables diagnostics on a 22 x 22 km grid network covering Bhutan and surrounding areas.

### 2.1 Temperature Trend

17. The annual trends in **annual mean temperature** between 1980 and 2069, based on down-scaled simulations of both the HadCM3 and ECHAM5 climate models are shown in Figure (reproduced below as Figure 1) as yearly data and polynomially smoothed data. Both the downscaled HadCM3 and ECHAM5 climate model outputs of air temperature **show a progressive and steady increase in air temperature from 1980 to 2069.** However, there is a difference of ~ 1.5$^0$C, between the downscaled HadCM3 and ECHAM5 simulations, the HadCM3 simulations being higher. This difference was attributed to the way the two models vary certain parameters such as corrections for elevation, Bhutan being largely a mountainous country. The HadCM3 simulations therefore shows a steady increase of temperature, increasing from ~ 13.5$^0$C (1980) to ~ 17.0$^0$C (2069), a temperature increase of ~ 3.5$^0$C. On the other hand, the ECHAM5 simulations shows a steady increase of temperature, increasing from ~ 12.00 C (1980) to ~ 15.5$^0$C (2069), a similar temperature increase of ~ 3.5$^0$C.

Figure



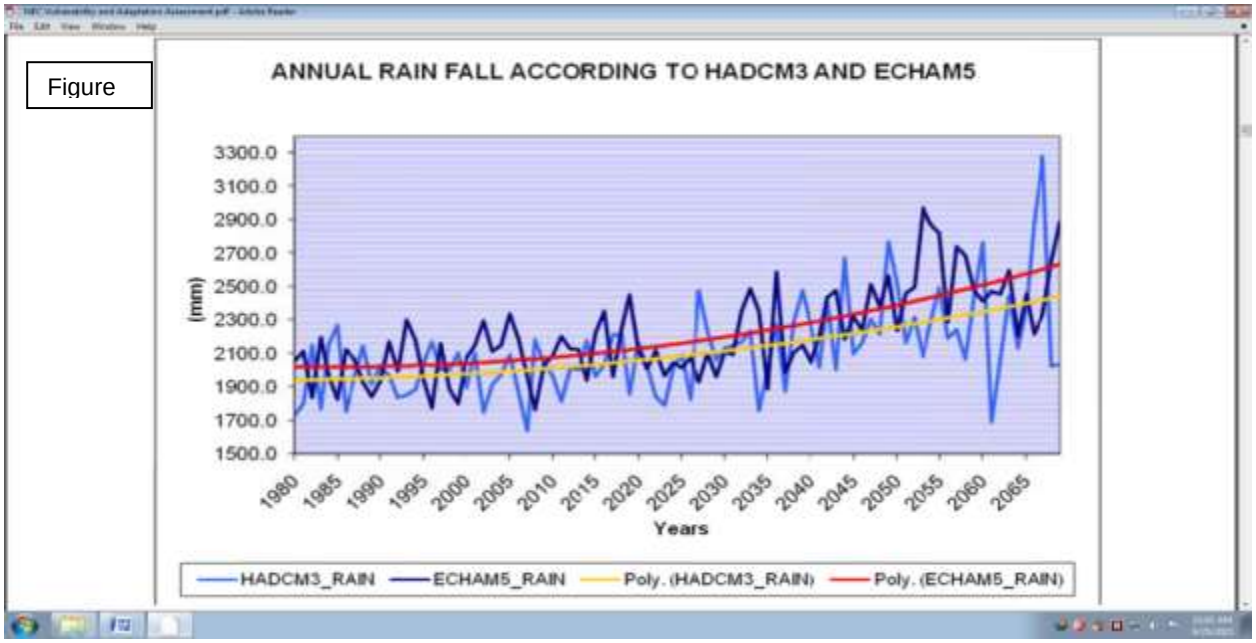

The **seasonal (monsoonal) trend in mean temperature between 1980 and 2069 show progressive and steady increase**, by ~ $3^0$C by HadCM3 simulation (~$19.5^0$C to ~$22.5^0$C) and about the same by ECHAM5 simulation (~$17.5^0$C to ~$20.5^0$C).

### 2.2 Precipitation Trend

18. The annual trends in **annual mean total precipitation** between 1980 and 2069, based on down-scaled simulations of both HadCM3 and ECHAM5 climate models are shown in the figure reproduced below (Figure 2). Both the downscaled HadCM3 and ECHAM5 climate model outputs of precipitation/rainfall **show a progressive and steady increase in precipitation from 1980 to 2069**. However, there is difference of ~ 100 mm/year between the downscaled HadCM3 and ECHAM5 simulations, the ECHAM5 simulations showing higher, especially towards 2069. The ECHAM5 simulations show a steady increase of precipitation/rainfall increasing from ~ 2000 mm/year (1980) to ~ 2600 mm/year (2069). The HadCM3 simulations also show increasing trend from ~1900 mm/year (1980) to ~ 2400 mm/year (2069).

19. **The seasonal (monsoonal) trend in monsoonal mean total precipitation between 1980 and 2069 show progressive and steady increase**, by ~ 350 mm/year by HadCM3 simulation (~1150 mm/year to ~1500 mm/year) and ~450 mm/year by ECHAM5 simulation (~1300 mm/year to ~1750 mm/year).

Figure




## B: Climate Change Resilient Approach

### B1: The Amo-chu Design Flood Discharge

20. Today, there is serious concern throughout the world that large flood events may be occurring at greater than expected rates and that existing flood frequency estimates may not be sufficient to address anomalies due to climate trends. The DPRs of the ALRP cited earlier make no mention of any approaches to formulating and implementing the project for climate change adaptation. It is widely recognized that changes in climate will threaten the efficacy, adequacy, and durability of flood control structures and their continued services. Increases in the intensity and frequency of floods could overwhelm these structures, causing them to fail and any failure of flood control structures can result in dire consequences on human lives and destruction to the services and investments made.

21. The design flood, which is the flood for which the structures planned to protect ALRP from flood and bank erosion are designed, is said to be in line with general standards in Bhutan; the statistical once in 50 year return period has been adopted as the design standard. Two approaches used in the DPR to estimate the design flood are the flood frequency analysis and synthetic unit hydrograph. The former statistical approach gave a peak discharge of 5,355$m^3$/s, almost same as observed maximum at Hasimara just 20 km south in India. The synthetic unit hydrograph approach was based on long term observations in catchments to railway bridges in India. The analysis yielded a hydrograph with a peak discharge of 5,900$m^3$/s, with a flood wave duration of 53 hours.

22. Assessment of climate change impacts on flood frequency due to projected changes in extreme precipitation are very complex comprising of a series of linked models and analyses. The basis for all methodologies is climate change projections from large-scale Global Climate Models (GCMs), which model coupled atmospheric-oceanic processes for historical and future periods. The GCM model runs are based on climate forcing scenarios representing various alternatives as to how society and technology will develop through the 21st century (and in some cases beyond) and the impacts this will have on greenhouse gas emissions and

concentrations. Examples of climate forcing scenarios include the IPCC SRES scenarios and the newer RCP (Representative Concentration Pathways) scenarios. Output from GCMs, typically having grid cell sizes of 100 – 250 km, is generally too coarse for direct analyses of flood generating processes, and further processing is required before likely changes can be assessed. This further processing takes the form of a dynamical downscaling using a regional climate model (RCM) and/or some form of statistical processing (including statistical downscaling and bias correction) to obtain suitable data for use in further analyses and modeling.

23. Climate projections at a local level are highly uncertain. Given that uncertainty, the alternative is to look at several plausible future scenarios of flood risk based loosely on findings in the literature to provide some bounds on how potential changes in flood risk could translate into economic damages. These scenarios are not meant to represent any particular future reality, but instead are used to generate order-of-magnitude estimates of climate resilience.

24. A few countries around the world have adopted policy design guidelines on climate change adjustment factors to be applied to current design estimates, owing to actual paucity of published guidelines on the incorporation of climate change effects in flood frequency estimation. A review of applied methods in Europe for flood frequency analysis[42] in a changing environment indicate a gap between the need for considering climate change impacts in design and actual published guidelines that incorporate climate change in extreme precipitation and flood frequency.

25. A few examples of policy design guidelines that prescribe a “climate change factor” in the stationary design estimates adopted in Europe are:

- In the UK like elsewhere, statistical procedures for flood frequency analysis are currently based on assumptions of stationarity. However, a number of procedures exist to adjust design flow estimates for the perceived influence of climate change and land-use. Considering the effect of climate change on design flood estimates a safety margin of 20% is applied, as recommended by Defra (2006), to compensate for climate change with a time horizon until 2085.
- In Germany, the two federal states of Bavaria and Baden-Württemberg have both introduced climate change allowances to be applied for design flood estimates. In Bavaria a factor of +15% is added to the 100-year estimate, whereas Baden-Württemberg have adopted climate factors varying between 0% and +75%, depending on the region and the return period (Hennegriff *et al.*, 2006).
- In Norway, regional factors of 0%, 20% and 40% increase of design flood estimates derived assuming stationary conditions are recommended based on consideration of region, location (inland or coastal catchment), and prevailing flood season. For all catchments with a catchment area less than 100km$^2$, a default increase of 20% is recommended, reflecting evidence that short-term extreme precipitation will increase throughout the country under a future climate, and that smaller catchments are most vulnerable to this increase (Lawrence and Hisdal, 2011).
- In Denmark, Arnbjerg-Nielsen (2008) published climate factors for use with existing IDF curves in Denmark. The guidelines prescribe climate factors of 1.2, 1.3 and 1.4 (20%, 30% and 40%) when estimating design rainfall of 2, 10, and 100-year, respectively. While recognising that the effects might vary for different

[42] FLOODFREQ Cost Action ESO901; European Cooperation in Science and Technology, Center for Ecology and Hydrology, 2013; http://www.cost-floodfreq.eu

durations and geographical locations, these effects were considered secondary in relation to return periods, and thus, not considered.

- The Swedish Water & Wastewater Association (SWWA, 2011) published guidelines for a regional climate factor, multiplying design rainfall totals with between 1.05 – 1.3 depending on the region

26. In a paper on the effect of climate change on flood risk[43], the states of Baden-Wuerttemberg and Bavaria as well as the German weather service initiated the joint project KLIWA (climatic change and consequences for water management) in 1999, which was to examine the influence of climatic scenarios. In this joint project, so-called climatic factors were determined with which regionally dependent peak discharge quantities for different occurrence probabilities needed to be increased, in order to be able to consider the climatic changes. The introduction of a climate-change factor *f* was recommended as under:

| Return Period (year) | 2 | 5 | 10 | 20 | 50 | 100 | 200 | 500 | >1000 |
|---|---|---|---|---|---|---|---|---|---|
| Climate Change Factor, *f* | 1.5 | 1.45 | 1.4 | 1.33 | 1.23 | 1.15 | 1.08 | 1.03 | 1.0 |

27. The current peak discharge determined is multiplied by the climate change factor *f* to arrive at the design discharge under climate change.

28. For instance, the design "1 in 50 year return period" flood of Amo-chu determined by the DPR 1 and 2 is 5,900 $m^3$/s. Using the recommendation from above, the climate change factor is 1.23 which gives an estimated climate change discharge of 5,900 x 1.23 = 7,257 $m^3$/s. DPR 2, page 22 on design Flood projects a 100-year flood estimate of 7,100$m^3$/s, which is to say that a 100 –year flood nearly equates to a 50-year flood under a stressed climate.

29. It is recommended to seriously reconsider the design parameters of the ALRP flood protection works to take into account the uncertainties associated with climate change by **adopting a 1 in 100-year flood** rather than the adopted standard 1 in 50 as given in the DPR.

30. To reduce climate change impacts on flood control structures and the resulting damage and destruction to communities and infrastructure in the reclaimed land, the project authority must adapt flood control structures to future climate stressors. The resilience of flood control structures can be increased in many ways as experts see fit. Different options exist to mitigate the impacts of these climate stressors, including structural changes (e.g., changes to embankment heights and slopes) and policy changes (e.g., changes to zoning codes, relocation, designing redundancy plans).

### B2: The Small Side Drainages

31. There are numerous small side drainages, mainly ephemeral, flowing from the slopes of the ALRP, where landslides, debris flow and flashfloods are more pronounced particularly during the monsoon season. Most devastating events are flashfloods that develop within short periods after intense precipitation and or cloudbursts turning a minute drainage into a thundering wall of water that sweeps away everything in its path.

[43] The Effect of Climate Change on the Flood Risk – example of a section of River Neckar; Andreas Kron, Institute for Water and Water Resources Management, University of Karlsruhe; (*Forum DKKV/CEDIM:* ***Disaster Reduction in Climate Change*** *15./16.10.2007, Karlsruhe University); e-mail: kron@iwg.uka.de, phone: +49/721-608-8421*

32. The ALRP DPR seems not to have given much recognition of the higher risk that flash floods pose to human life and livelihoods in comparison with the more regular riverine floods that build up over days when there is heavy rainfall upstream. The tendency for flash floods to carry with them much higher debris flows with consequent higher damage to roads, power lines, bridges, buildings, and other expensive infrastructure needs to be appreciated in the design of check dams, catch-water drains, cross-drainages and collector drains.

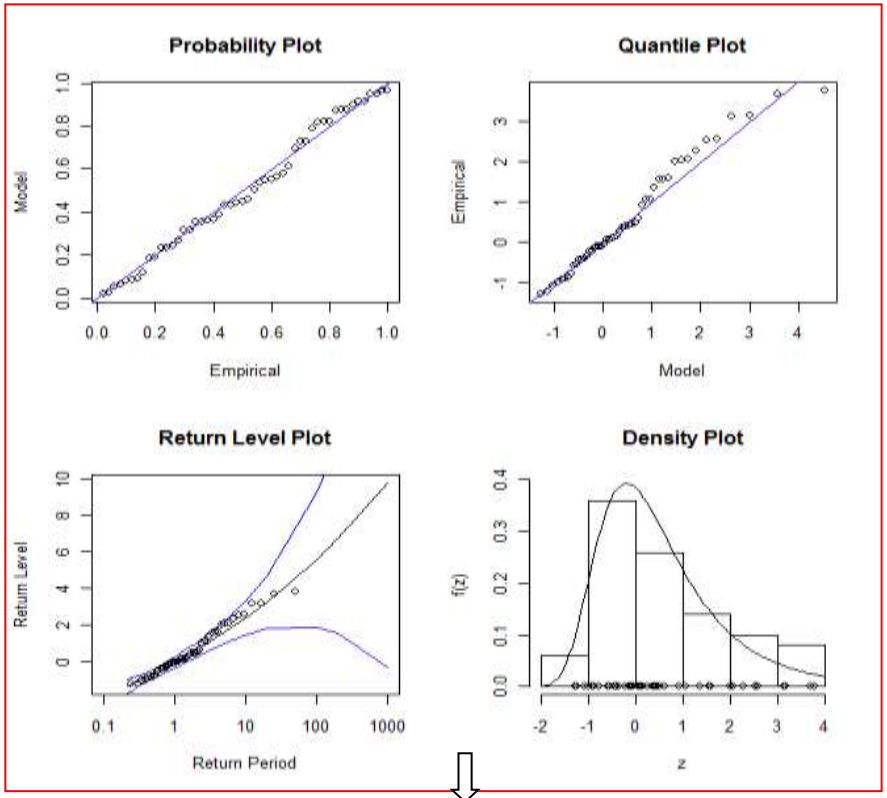
*33.* The catchment areas of the small drainages along the hillslopes are reported to range from 0.35 and 1.35km$^2$, with corresponding discharges stated as ranging from 2.5 to 12 m$^3$/s. Cross drains discharging between 5 and 10m$^3$/s of flow have been considered in the design. However, a revisit of rainfall-runoff processes may be necessary in view of changing climate. In this assessment, an extreme value (EV) assessment of the precipitation recorded at Phuntsholing Class A met station showing Intensity-Depth-Frequency (IDF) curves and a Depth-Duration (DD) table are developed under a changed climate as approximated by a positive shift in the location parameter of the frequency distribution through use of "*Extremes Toolkit Ver. 1.60*". *(See Box 1).*

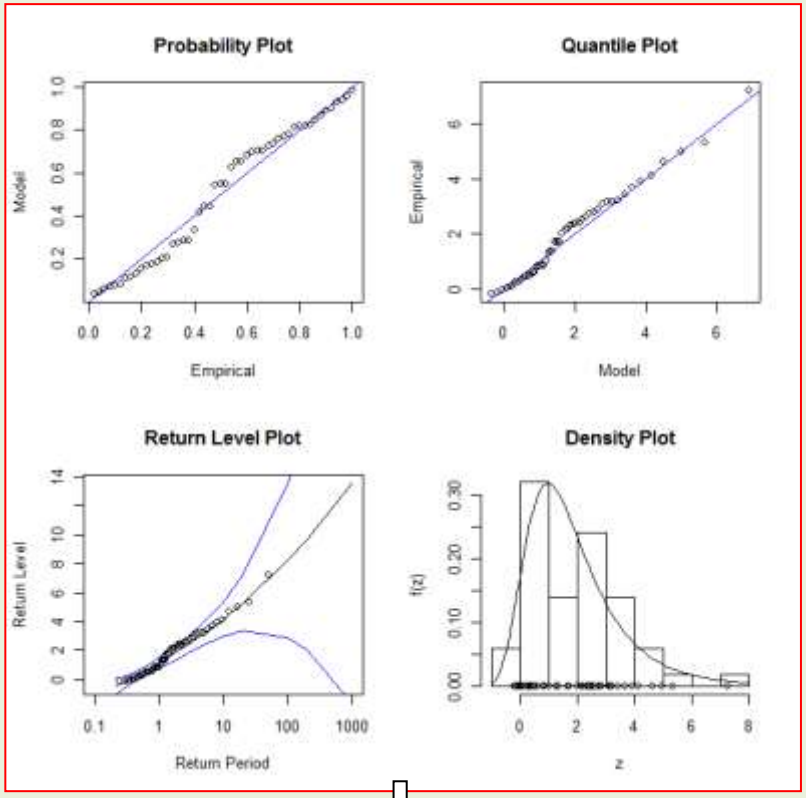
**Box 1 Annual Maximum (AM) Rainfall Frequency Analysis**

1. Annual Maximum Series of 24-hour Rainfall, mm, (1996-2013) – Phuntsholing Class-A Met Station

| 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | Mean | Stdev | N | Q1 | Q2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 195.3 | 194.5 | 227.7 | 185 | 495.3 | 132.6 | 197.2 | 200 | 174.8 | 191 | 97 | 212 | 125 | 120.8 | 155 | 130.1 | 170 | 162.5 | 187.0 | 84.8 | 18 | 138.2 | 196.7 |

2. Data Simulated from a GEV Distribution in Extremes Toolkit Ver. 1.60



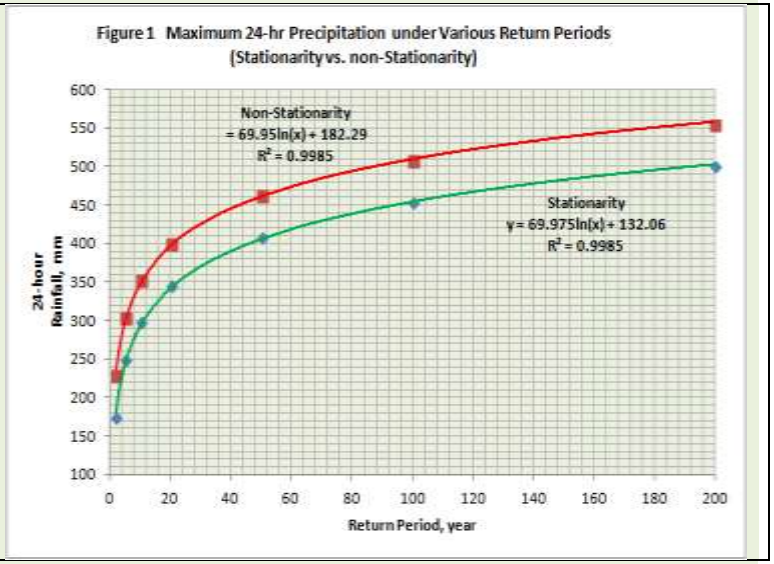




*GEV simulated data generated, Stationarity*
*Parameters: μ: 0 Trend: 0 σ: 1 ξ: 0.2*
*GEV Fit*
*L-moments (stationary case) estimates (used to initialize MLE optimization routine):*
*Location (μ): -0.07868346 Scale (σ): 1.001435 Shape (ξ): 0.0624423*
*Likelihood ratio test (5% level) for ξ=0 does not reject EV Type I, Gumbel hypothesis.*
*Likelihood ratio statistic is 0.677147 < 3.841459 1 df chi-square critical value.*
*p-value for likelihood-ratio test is 0.4105709*

*GEV Simulated Data Generated, Non Stationarity*
*Parameters: μ: 0 Trend: 0.045 σ: 1 ξ: 0.2*
*GEV Fit*
*L-moments (stationary case) estimates (used to initialize MLE optimization routine):*
*Location (μ): 1.159830 Scale (σ): 1.296229 Shape (ξ): 0.009626862*
*Likelihood ratio test (5% level) for ξ=0 does not reject Gumbel hypothesis.*
*Likelihood ratio statistic is 0.5488624 < 3.841459, 1 df chi-square critical value.*
*p-value for likelihood-ratio test is 0.4587829*

3. Estimates of 24-hr Maximum Precipitation (mm) for Various Return Periods (Stationarity vs. Non-Stationarity)

| Sample mean, $\bar{x}$ | | 187.0 | |
|---|---|---|---|
| Sample StDev, $s$ | | 84.8 | |
| Return Period, T (year) | Frequency Factor $K_T = -\frac{\sqrt{6}}{\pi}\left(0.5772 + \ln\left[\ln\left(\frac{T}{T-1}\right)\right]\right)$ | Rainfall (mm) under Stationarity $X_T = \bar{x} + K_T s$ | Rainfall (mm) under Non-Stationarity; Trend in location parameter $X_T = \bar{x} + K_T s$ |
| 2 | -0.1643 | 173.1 | 228.5 |
| 5 | 0.7195 | 248.0 | 303.4 |
| 10 | 1.3046 | 297.7 | 353.0 |
| 20 | 1.8658 | 345.3 | 400.6 |
| 50 | 2.5923 | 406.9 | 462.2 |
| 100 | 3.1367 | 453.1 | 508.4 |
| 200 | 3.6791 | 499.1 | 554.4 |

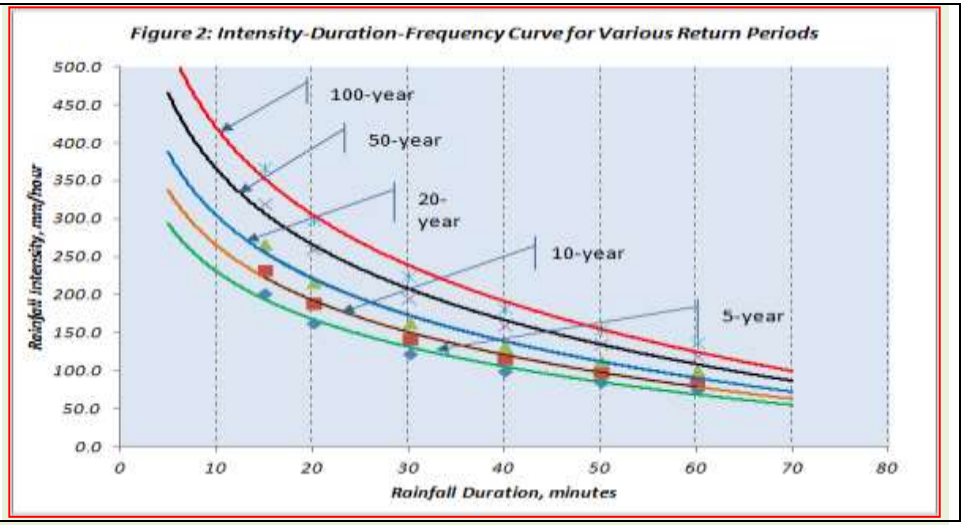



3. Intensity-Duration-Frequency (IDF), i.e., expected average rainfall depth that falls per specific time duration, under Non-Stationarity

| *IDF Method* | | $P_t^T = C\frac{T^{0.2}}{D^{0.71}}(P_{24}^2)^{0.33}$ | *Ref: Kouthyari and Garde (1992), Indian Met Divison(IMD)* |
|---|---|---|---|
| $P_t^T$ | = | *Rainfall intensity in mm/hour for T-year return period, and t-hours duration* | |
| $C$ | = | *constant having value 9.1 for North East India (Assam & W. Bengal)* | |
| $P_{24}^2$ | = | *2-year return period, 24 hour maximum rainfall, mm* | |

| Return Period, year | IDF Estimator Eqs. for Rainfall Intensity, mm/hour |
|---|---|
| 100 | $y = -151.9\ln(x) + 736.82$ |
| 50 | $y = -132.3\ln(x) + 641.44$ |
| 20 | $y = -110.1\ln(x) + 534.03$ |
| 10 | $y = -95.87\ln(x) + 464.9$ |
| 5 | $y = -83.46\ln(x) + 404.72$ |

| Rainfall Duration D, min | 5-year | 10-year | 20-year | 50-year | 100-year |
|---|---|---|---|---|---|
| | Rainfall Intensity, mm/hr | | | | |
| 15 | 201.7 | 231.7 | 266.1 | 319.7 | 367.2 |
| 20 | 164.4 | 188.9 | 217.0 | 260.6 | 299.4 |
| 30 | 123.3 | 141.6 | 162.7 | 195.4 | 224.5 |
| 40 | 100.5 | 115.5 | 132.6 | 159.3 | 183.0 |
| 50 | 85.8 | 98.6 | 113.2 | 136.0 | 156.2 |
| 60 | 75.4 | 86.6 | 99.5 | 119.5 | 137.2 |




## 4. Depth-Duration- (DD) Estimates of Rainfall

| DDF Method | $P_t = P_{24}^T \left(\frac{T}{24}\right)^{0.33}$ | Ref: Rathnam et.el, IMD, 2000 |
|---|---|---|
| where | $P_{24}^T$ | = 24 hour precipitation for T-year return period |
| | $P_t$ | = required rainfall depth for the duration t hour, mm |

| Return Period | 5 | 10 | 20 | 50 | 100 |
|---|---|---|---|---|---|
| Rainfall Duration D, hours | Rainfall Depth, mm | | | | |
| 0.25 | 66.4 | 77.2 | 87.6 | 101.1 | 111.2 |
| 0.33 | 73.0 | 85.0 | 96.4 | 111.3 | 122.4 |
| 0.50 | 83.6 | 97.3 | 110.4 | 127.3 | 140.1 |
| 0.67 | 92.0 | 107.0 | 121.5 | 140.1 | 154.1 |
| 0.83 | 99.1 | 115.3 | 130.8 | 151.0 | 166.0 |
| 1 | 105.3 | 122.5 | 139.0 | 160.4 | 176.4 |
| 2.00 | 132.6 | 154.3 | 175.1 | 202.1 | 222.2 |
| 24 | 303.4 | 353.0 | 400.6 | 462.2 | 508.4 |

*Note: As is the case with all types of modeling, either statistically-derived or based on numerical simulation models, estimates obtained using flood frequency analysis are associated with uncertainty. For the analysis of historical time series, the observed data can have significant error or bias and the lack of a perfect hydrological model fit to peak flows can also introduce error in the analysis. Flood frequency analysis is also based on the assumptions that the events analyzed are independent of each other, that they represent the same flood generating mechanism, and that there are no trends in the sequence of events. These assumptions are rarely fully satisfied in practice, and thus, deviations from these assumptions also introduce error. In addition, the choice of the extreme value distribution used for the analysis, the methods used to estimate the model parameters, and the techniques for plotting events introduce uncertainty. As is true for all statistical analyses, uncertainty in the statistical model parameters increases as the number of observations available for analysis decreases. In flood frequency analysis, uncertainty increases with increasing return period, due to the larger discrepancy between the length of the record used for the analysis and the return period.*

**Appendix 4: A Baseline Fish Survey of Amochhu Basin, Phuentsholing**

Royal Government of Bhutan Department of Livestock

Ministry of Agriculture and Forest

National Center for Riverine and Lake Fisheries

# A Baseline Fish Survey - Amochhu Basin in Puntsholing, Chukka Dzongkhag

Prepared by:

Fishery Ecology and Environment Unit
National Center for Riverine and Lake Fisheries

November 2015

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## 1. Background

Amochhu is originates from the hills of Tibet in the north and joins with Brahmaputra river, India in the south. These river swell up extremely in the rainy season and almost dry up in winter. The river is rich in aquatic biodiversity and other inhabitant living nearby includes terrestrial animal like Otter and birds.

The economic development activities such as hydro power, sand mining, river diversion and road development all this will likely to affect the aquatic biodiversity. The construction of these project may invention of immense threat to the aquatic biodiversity, mainly due to modification of water flow and hindering of spawning route for migratory fish species that are dwelling in river. Therefore, there is need of plan for development of management plan and mitigation measures without proper database on aquatic resources, it will be difficult to plan any management plan. This study is mainly aimed at developing a basic database on fisheries in Amochhu and to minimize the threat to aquatic biodiversity that need to be come all the time before the developmental activities transform the habitats such as migratory route and loss of spawning grounds.

## 2. Objectives

The objectives of this particular fish survey was as follows:

- To assess the fish species diversity along the Amochhu basin.
- To generate data for further reference in order to study the impact by the project activities on aquatic life.

## 2. Materials and Methods

### 2.1 Sampling Areas

Sampling sites were randomly selected as per the zone and station developed. Sampling were also done in two tributaries of Amochhu that is Loarikhola and Dortikhola as shown in (Fig.1). The GPS coordinates were recorded in all sampling sites to provide distribution of species present as given in (Table 1).

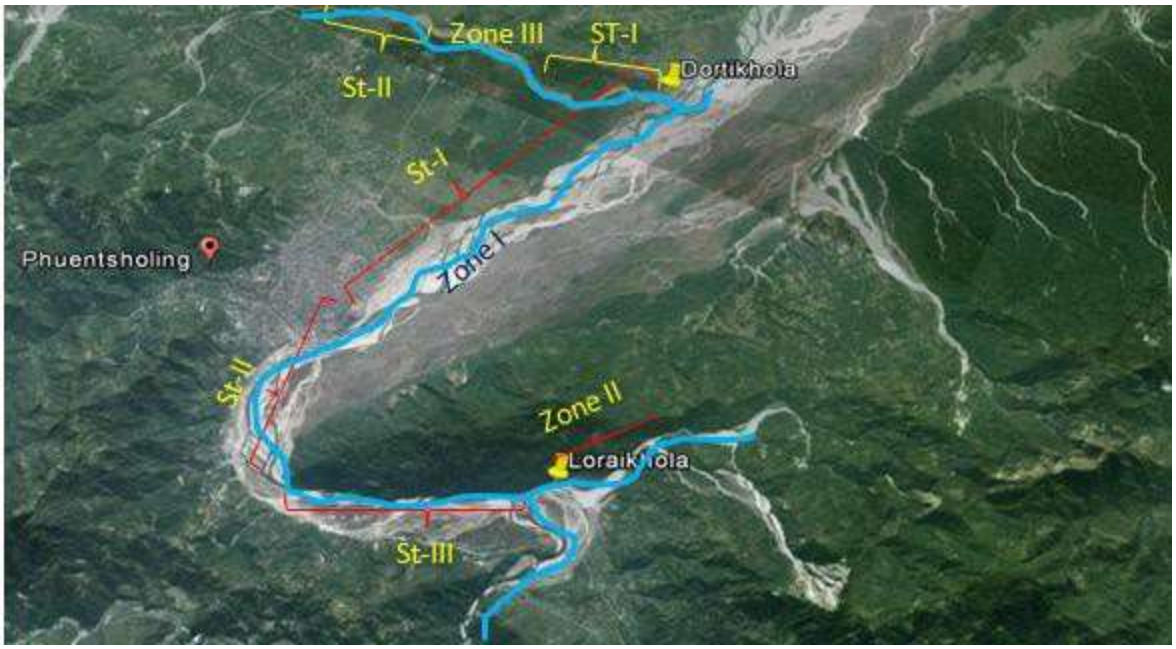


**Figure 1. Location of study area with zone and stations**

**Table 1 GPS co-ordinate of the sample areas**

| Zones | Stations | Location | North | East | Altitude (m) |
|---|---|---|---|---|---|
| 1 | I | Confluence of Dortikhola to Bange Bazaar | 26.8704 | 86.3734 | 187 |
| | II | Bange Bazaar to Jenchu | 26.87247 | 89.33648 | 195 |
| | III | Jenchu to loarikhola confluence | 26.88181 | 89.35346 | 197 |
| 2 | I | Loarikhola to Purbay | 26.87122 | 89.33267 | 233 |
| 3 | I | Dortickhola to Bridge | 26.8704 | 86.3734 | 187 |
| | II | Crocodile Farm to Hathidungga | 26.86450 | 89.393310 | 252 |

## 3.2 Sampling Methods

### *3.2.1 Different Kind of Sampling Method*

Different kind of fish sampling method were applied to obtain true representative samples. The sampling method includes such as cast net, rod and line and electro fisher as shown in (Fig. 2). Catch and release method was applied and only those samples required for specimens was collected.

**Figure 2. Fishing gears used during fishing in Amochhu**

### *3.2.2 Water Quality*

Water samples were collected for water quality test. Two water parameter were tested and recorded as given in (Table 2).

**Table 2. Showing the temperature of Amochhu basin**

| Sample site | Temperature ($^{o}$C) | Dissolved Oxygen (DO) |
|---|---|---|
| Amochhu | 16 | 9.60 |
| Dortikhola | 20 | 9.00 |
| Loarikhola | 19 | 9.80 |

### 3.3 Specimen Collection and Preparation

For each sampled species, a specimen was collected and fixed using standard stock solution of 10% formalin. After two weeks specimens will be transferred to 70% ethyl alcohol for permanent preservation in specimen jar with proper labels. The specimens will be important resources for future reference and educational/research purposes. The specimens was preserved in national Center for Riverine and Lake Fisheries, Haa.

## 4. Observation/ Result

### 4.1 Fish Species Diversity in Amochhu Basin

During the sampling period a total of 22 species were studied. And this, belong to three orders and seven families. During sampling period the most fish caught was Barilius, Gara, Badis and Katle in Amochhu river and its tributaries - Dortikhola and Loarikhola. The lists of the collected fish species, order, family and their scientific names are presented in (Table 3)

**Table 3. Fish species found during the baseline study period from Amochhu and its tributaries**

| Order | Family | Species Recorded | ICUN Status |
|---|---|---|---|
| Cypriniformes | Cyprinidae | *Tor putitora* | EN |
| | | *Neolissochilus hexagonolepis* | NA |
| | | *Semiplotus semiplotus* | LC |
| | | *Barilius varga* | LC |
| | | *Barilius bendelisis* | LC |
| | | *Barilius barna* | LC |
| | | *Devario aequipinnatus* | LC |
| | | *Danio rerio* | LC |
| | | *Chagunius chagunio* | LC |
| | | *Punitus sophere* | LC |
| | | *Schizothorax richadsonni* | LC |
| | | *Gara gotyla* | LC |
| | | *Gara annandalei* | LC |
| | | *Acanthocobitis* spp. | LC |
| | | *Oreichtys crenuchiodes* | LC |
| | Psilorhynchidae | *Psilorhynchus balitora* | LC |
| | Balitoridae | *Schistura* spp. | LC |
| Siluriformes | Amblycipitidae | *Amblyceps apangi* | LC |
| Siluriformes | Claridae | *Clarias gariepinus* | LC |
| Perciformes | Channidae | *Channa* spp. | LC |
| | | *Channa gachuua* | LC |
| | Nandidae | *Badis badis* | LC |

## 5. Conclusion

The 22 species of fish was found in Amochhu basin with one endangered fish species, beside aquatic biodiversity it was also found good feeding ground for terrestrial animal like migratory birds. Under such a situation the concerned authority as well as other stakeholder should take adequate steps to plan the aquatic resources by adopting scientific practice, which would not only boost up the economy of the nation but also save fish genetic resources from verge of extinction.

## 6. Recommendations

The few recommendation is made after studies are follows:

- The study was carried out in lean season and require to study in peak season to ensure true representative database of fish species in Amochhu basin.
- The study will act as baseline data for one season and need to disseminate to other researcher/educational purpose.

**Annexure 1: List of Fish Species found in Amochhu Basin**

1.Barilius varga

2. Channa gachuua

3. Oreichthys crenuchides

4. Punitus sophore

5. Psilorhynchus balitora

6. Danio rerio

7. Badis Badis

8. Clarias gariephinus

9. Tor putitora

10. Channa spp

11. Davario aequipinnatus

12. Chagunius chagunio

13. Neolissochilus hexagonolepis

14. Barlius barna

15. Semipltus semiplotus

16. Amblyceps apangi

17. Acanthocobitis spp

18. Schistura spp

19. Barlius Bendelisis

20. Gara gotyla

21. Schizothorax richardsonni

22. Gara annandalei

**Annexure 2. Materials used during study period**

- Cast Net
- Rod and line (Angling)
- Scope net
- Weighing balance
- Fish Measuring scale
- DO meter
- Bucket
- Digital Camera
- Electro Fisher
- Specimen jar
- Formalin
- Cool box
- GPS
- Fish measuring Scale
- Sampling bottle