Strategic Environmental Assessment

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BHU: Master Plan for National Highways Connectivity

Prepared by the Department of Surface Transport for the Asian Development Bank

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

ABBREVIATIONS

ADB	Asian Development Bank
BAP	Biodiversity Action Plan
BCTA	Bhutan Construction and Transportation Authority
BMP	Biodiversity Management Plan
CCKP	Climate Change Knowledge Portal
CMIP6	Coupled Model Intercomparison Project Phase 6
CNDP	Comprehensive National Development Plan for Bhutan 2030
CO_2	Carbon dioxide
COP	Conference of Parties
DOCDD	Department of Culture and Dzongkha Development
DOST	Department of Surface Transport
DOFPS	Department of Forests and Park Services
EFRC	Environmentally Friendly Road Construction
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMP	Environmental Management Plan
ESSU	Environmental and Social Safeguards Unit
GHG	Greenhouse Gas
GNH	Gross National Happiness
GNHI	Gross National Happiness Index
HMP	Highways Master Plan
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
JICA	Japan International Cooperation Agency
KBA	Key Biodiversity Area
MDB	Multilateral Development Bank
MMPI	Modified Multidimensional Poverty Index
MOIT	Ministry of Infrastructure and Transport
NTFP	Non-Timber Forest Product
PAA	Paris Agreement Alignment
PBL	Policy-Based Lending
PNH	Primary National Highway
PPP	Policies, Plans and Programs
PS6	IFC Performance Standard 6
PWS	Phibsoo Wildlife Sanctuary
RAM	Road Asset Management
RGOB	Royal Government of Bhutan
RMNP	Royal Manas National Park
RoW	Right-of-Way
SEA	Strategic Environmental Assessment
SESMP	Strategic Environmental and Social Management Plan
SESMPOC	SESMP Oversight Committee
SNH	Secondary National Highway

SPS	Safeguard Policy Statement, 2009
TA	Technical Assistance
ToR	Terms of Reference
UNFCCC	United Nations Framework Convention on Climate Change

WEIGHTS AND MEASURES

ha	hectares
km	kilometers
m	meters
masl	meters above sea level
MT	metric tons

CURRENCY EQUIVALENTS

(as of 10 January 2025)

Currency unit	–	Ngultrum (BTN)
BTN 1.00	=	USD 0.012
USD 1.00	=	BTN 86.092

NOTE

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EXECUTIVE SUMMARY

This Strategic Environmental Assessment (SEA) report has been prepared to inform evaluation and decision-making with respect to the proposed Bhutan Master Plan for National Highway Connectivity. The highway master plan (HMP) and SEA have been developed concurrently under the auspices of Asian Development Bank TA-6916 BHU: Master Plan for National Highway Connectivity. David Lupton and Associates, Ltd. (New Zealand), in association with APECS Consultancy (Bhutan) and Maxwell Stamp (Bangladesh), was engaged to provide consulting services for the TA, including preparation of the HMP and SEA, with the supervision and support of the Department of Surface Transport (DOST).

Bhutan Master Plan for National Highway Connectivity

The HMP is a 15-year strategic plan to help realize the long-term vision articulated for the road sector through prior planning efforts including the Comprehensive National Development Plan for Bhutan 2030; the Road Sector Master Plan 2007–2027; the Road Act of Bhutan 2013; the Bhutan Transport 2040 Integrated Strategic Vision; the Road Classification and Network Information 2020; the Twelfth Five-Year Plan 2018–2023; and the Thirteenth Five-Year Plan 2024–2029. Core elements of the long-term vision include optimizing the national road network through consolidation, enhancement and building new roads to fill missing links; reducing travel time by means of bypass roads and tunnels; and improving the condition of the national highways using environmentally friendly road construction and climate-ready technology.

The central objectives of the HMP are to identify feasible highway network improvements that support the aims of the long-term vision, and to provide a sound basis for prioritizing and planning investments to deliver them. The HMP comprises a Development Plan to drive the capital investment dimension of the mission, and a Maintenance Plan to define the necessary investments in highway maintenance. The HMP as proposed comprises 127 projects spanning several project classes, as well as safety improvements and a 15-year highway maintenance program.

Rationale for Strategic Environmental Assessment

The purpose of SEA is to enable critical foresight that can inform the design or updating of higher-order, broadly-scaled governmental initiatives, including policies, plans, and programs (PPPs). PPPs provide the institutional context and funding frameworks for concrete investment and change implemented through on-the-ground projects or other actions. Conducting SEA on a PPP facilitates early and proactive identification of environmental and social consequences well upstream of the formulation of projects, sub-projects and other vehicles of PPP rollout and delivery. An SEA study is a high-level analysis chiefly concerned with broadly-scaled, systemic and cumulative effects, which are difficult to conceptualize and remedy during project-level assessment.

In Bhutan, SEA is required for all new and revised governmental PPPs that can reasonably be expected to have significant environmental effects, under the Regulation on Strategic Environmental Assessment (2002), which is pursuant to the Environmental Assessment Act (2000). The SEA study for the HMP has been conducted in accordance with the requirements indicated in the Regulation, with additional guidance from the Draft National Guidelines for Strategic Environmental Assessment in Bhutan (2016) and international SEA guidance materials.

SEA Study Process

The SEA study described in this report was conducted in tandem with formulation of the HMP, which is an SEA best practice that enables environmental and social considerations to inform and shape the subject PPP from the earliest stages, proactively avoiding many potential negative impacts. The SEA specialists were an integral part of the master planning team, and this facilitated close interaction and interchange throughout the HMP formulation process.

Stakeholder Engagement

Consultation with representative entities whose mandates or constituencies may be affected by the implementation of a PPP is an essential element of the SEA process. The SEA study was supported and enriched by consultation with a wide range of institutional stakeholders in the governmental, non-governmental, inter-governmental and private sectors. Stakeholder engagement conducted during the SEA study was enabled by close collaboration between DOST and the SEA study team.

A half-day SEA Scoping Workshop was held on 14 February 2024, at Hotel Migmar in Thimphu. The workshop was hosted by DOST, and featured presentations by the TA Consultants. Workshop participants learned about the highways master planning process and the parallel SEA process, and subsequently engaged in an extended discussion of the key themes that could animate the SEA study. Overall, 59 people representing 37 different stakeholder entities joined in the workshop (28 attended in person, and 31 via video link). Follow-up meetings were held with selected key stakeholders to further discuss specific concerns.

A second half-day SEA Consultation Workshop was organized on 14 October 2024, at the Thimphu Deluxe Hotel. The event was an opportunity to seek further perspective on the major themes identified during scoping, to share updated information on the highways master planning, and engage stakeholders in discussion of preliminary assessment findings and mitigation possibilities. Forty-nine participants representing 33 stakeholder entities attended the workshop, with 28 joining in person, and 21 taking part remotely. Participants represented a broad range of entities, including government agencies, *dzongkhag* administrations, NGOs, and international partner organizations.

SEA Scope

In keeping with the purpose of SEA, the assessment has focused on potential for broadly-scaled, systemic and cumulative impacts. The analysis was been guided by nine broad themes identified and ranked through the Scoping Workshop and focused meetings with key stakeholders, and presented in a Scoping Report prepared following the Scoping Workshop and shared with stakeholders. The nine ranked themes (in declining order of priority to stakeholders) are:

(1) Wildlife and Biodiversity
(2) Climate Change Mitigation and Adaptation
(3) Water Resources
(4) Public Safety
(5) Equitable Development
(6) National Economic Vitality
(7) Cultural Heritage
(8) Natural Resource Use
(9) Pollution and Waste

Information sources

The master planning team produced extensive primary data on the existing road network, existing traffic flows on the highway network. Primary data flowing from preliminary alignment identification, cost estimation, traffic modelling and economic analysis were also essential inputs to the environmental analysis. Secondary information, used particularly to understand the baseline context, was obtained from a wide range of sources, both domestic and international. Key sources included statistical databases, plans, policy documents and websites, as well as mapping resources obtained from various agencies, websites and ADB. Online mapping tools were used extensively. Climate change projection data were obtained from the World Bank.

Summary of Findings

The main findings and conclusions of the study are summarized below, according to the nine themes identified through the scoping process.

Wildlife and Biodiversity

The SEA study has identified potentially significant threats to the integrity of the national protected area system, to transboundary ecological connectivity, and to the country's biodiversity values in general, due principally to new highways. Mitigation of biodiversity impacts for all proposed new highways will hinge on enhancing the permeability of road corridors to wildlife and ecological processes. A variety of permeability-enhancing mitigation options have been proposed for feasibility analysis in project-level EIA studies.

Heightened biodiversity risks are foreseen for two new highway links that would cross highly-valued protected areas in the southern foothills. The Lhamoizhingkha–Sarpang project is proposed to traverse the Phibsoo Wildlife Sanctuary, and impingement on the sanctuary's core and transition zones is anticipated. Similarly, the Tareythang–Panbang project would see the construction of a new highway through the Royal Manas National Park, where it is also thought likely that traversing the core zone would be unavoidable. These impingements would contravene national conservation policy, and are likely to degrade biodiversity values even with aggressive mitigation, possibly to an extent unacceptable to key stakeholders. The significance of potential impacts on habitat and species, as well as tradeoffs against possible management co-benefits from the new highways, will have to be further investigated through detailed ecological studies and deeper economic evaluation at the feasibility study stage for each of these projects. Rigorous evaluation of alternatives will be a critical element of the project-level feasibility studies.

Cumulative biodiversity impacts may be significant for all network expansion projects proposed in the south of the country, as the effects of new highways may combine with historical, ongoing and future effects from completion of other highway links in the Southern East-West Highway, as well as clusters of industrial projects and the eventual development of the Gelephu Mindfulness City. Further and more detailed analysis will be required at the project level to determine the significance of the potential cumulative biodiversity impacts.

Climate Change Mitigation and Adaptation

The SEA study assessed the HMP's implications for Bhutan's efforts to meet its goals and international commitments with regard to emissions reduction and climate change adaptation. This included a Paris Agreement Alignment assessment. The HMP was found likely to make a positive contribution towards national carbon emissions reduction goals, as the projected emissions savings from improved network efficiency and condition outweigh the expected works emissions, yielding a modest net emissions savings. Numerous projects proposed in the HMP can be considered adaptation-supportive investments, including slope stabilization projects,

bridge upgrades and replacements, and tunnels. These project classes collectively account for over half of the total capital investment proposed under the HMP, and will unambiguously contribute to Bhutan's stated goal of strengthening the climate resilience of its infrastructure. The HMP was deemed to meet the requirements for Paris Agreement Alignment with respect to both mitigation and adaptation.

Water Resources

The principal concern identified with respect to the country's surface waters is the potential for cumulative effects arising from simultaneous bridge replacement and upgrading works, riverbed mining operations, and hydropower project works in certain river basins. Degradation of water quality and habitat quality, as well as disturbance of sensitive populations of the highly endangered White-bellied heron, are considered possibly significant risks. The timing and spatial clustering of such works will be important factors in determining the significance of cumulative effects, and this will have to be assessed in context during feasibility and design studies for the proposed bridge works.

Public Safety

The HMP proposes substantial investments in slope stabilization (44 projects), bridge upgrading and replacement (40 projects), guardrails (over 800 km), pavement markings, and pavement condition. All of these investments will contribute to enhancing the safety of road users. The HMP is expected to be broadly beneficial to public safety. It is recommended that the HMP's investments in enhanced safety be complemented by parallel collaborative efforts to improve collection and management of road accident data and expand road safety education, amongst other things.

Equitable Development

The highway network improvements proposed in the HMP can be considered likely to improve prospects for development in marginalized areas of Bhutan, principally by reducing travel time and travel cost for long-distance trips made in whole or in part on the highway network. Reduced east-west travel time in particular should increase potential for people and enterprises in the eastern half of the country to benefit from increased tourist flows and better access to urban markets. New highways, and some improvements to existing ones, are expected to require some compensation and resettlement, but provided established procedures are competently followed during project-level assessment, this should not be expected to create significant potential for marginalization of project-affected people in rural areas.

National Economic Vitality

The proposed investments collected under the HMP umbrella are likely to improve general economic prospects by enhancing the reliability of the network and helping to break down the travel time and travel cost barriers to market access and economic activity. High-level economic analysis of network expansion projects in the HMP suggests that most of these projects are likely to produce moderate to strong economic benefit per unit of investment. Three of the expansion projects were found to have questionable economic viability, and as such may be detrimental to the public purse. The high-level analysis conducted to date is not sufficient to rule these potentially problematic projects out at this stage. Detailed and rigorous economic analysis at the project level may suggest modifications to the HMP, such as possible subtraction of projects that are unlikely to deliver positive economic benefits.

Cultural Heritage

Building new highways and road widening projects often have some potential to threaten the integrity of cultural heritage sites, but the desktop alignments used in master planning are too uncertain to identify and aggregate specific risks at this stage; these risks are appropriately addressed through more detailed project-level EIA studies. In a broader sense, the proposed improvements to national highway network should enable appreciation and visitation of cultural heritage, by increasing accessibility to a greater number of sites, particularly in the eastern part of the country, where visitation has historically been lower than in the west. There may be some potential in the case of new highway projects to enhance visitation at priority cultural sites through selection of favorable alignments, and it will be important for the Department of Culture and Dzongkha Development to be involved early in project-level feasibility studies for that reason.

Natural Resource Use

New highway links, road widening projects and maintenance improvements should all enhance the potential for rural natural resource-based development, as transport costs and low accessibility are constraints presently experienced in natural resource sectors. Some capital projects (new highway links and widening projects), are proposed in areas where forest management units already exist, and will likely bring benefits, including by improving access for heavy trucks. Provision of new or upgraded roads to connect industrial sites to planned dry ports, rail heads and industrial areas to the national highways network is likely to benefit the minerals, agriculture and forestry sectors. The proposed highway network improvements are not considered likely to trigger unsustainable extraction of natural resources in any sector, although potential for this should be assessed in project-level EIA studies.

Pollution and Waste

Road-associated forms of pollution were considered to have limited significance in the context of the HMP, which concerns rural inter-urban highways rather than urban roads. Indirect impacts of highway improvement, such as increased development in areas lacking proper solid waste and sewage management facilities, is acknowledged but considered part of a nearly ubiquitous problem more appropriately addressed by existing waste management policy than through a transport sector plan. Wastes and pollution associated with construction works are appropriately mitigated at the project level.

Analysis of Alternatives

Taken together, the findings outlined above comprise a generally favorable assessment of the HMP as currently proposed, with some notable caveats that will await more detailed, in-context study to definitively evaluate. Chapter VI of the SEA study report compares this picture to the alternative of not implementing any new master plan for improving the highway network (the 'No Master Plan' alternative), and finds that the risks associated with the 'No Master Plan' alternative on balance probably substantially outweigh the risks identified for the HMP as proposed. This assumes that project-level assessment and mitigation are thorough, especially in relation to the projects flagged as being potentially problematic.

The Strategic Environmental and Social Management Plan

Impact assessment findings ultimately mean little without a plan to act on them. Numerous proposals for mitigation were formulated through the impact assessment, and the Strategic Environmental and Social Management Plan (SESMP) brings these together into a cohesive framework. Many negative impacts have already been headed off during the intertwined master

planning/SEA study process by removal of projects with unacceptable environmental impacts, often jointly supported by other feasibility concerns. And many positive impacts have been baked into the HMP, by inclusion of projects with significant potential to strengthen climate change resilience and enhance public safety, for example. The remaining impact potentials identified in the impact assessment are to be addressed through implementation of the SESMP.

Mitigation

Most of the prescribed actions in the SESMP are oriented to shaping the assessments to be undertaken at the project level in ways that support appropriate action to address systemic and cumulative impacts identified in the SEA study. These include requirements to ensure that Terms of Reference for feasibility, design and environmental impact assessment (EIA) consultants engaged for project preparation stipulate such things as:

- Mandatory analytical attention to variables and factors with special relevance to evaluating and mitigating potential broad-scaled and cumulative impacts identified in the SEA study;
- Particular areas and levels of expertise needed to evaluate concerns raised in the SEA, such as expertise in critical habitat assessment and biodiversity offset design;
- Early engagement with particular stakeholders during feasibility and EIA studies, to enable advantageous alignment selection; and
- Procedures that should be followed to ensure rigor in key areas of impact identified in the SEA study, such as biodiversity assessment and mitigation planning.

Other measures prescribed in the SESMP relate to interagency cooperation, and partnerships for capacity-building, for example:

- Formation of agreements between DOST and the Department of Forests and Park Services to enable co-management of highways through protected areas and biological corridors;
- Joint development of an improved road accident database and road safety education programs by DOST, the Bhutan Construction and Transportation Authority, and the Royal Bhutan Police; and
- Partnership between DOST and an external partner to finance development of an agency-wide Climate Change Adaptation Strategy for DOST, to help adapt road asset management activity to a changing climate.

The SESMP assigns responsibility for leading and supporting implementation of each prescribed action to a specific entity, and specifies appropriate timing of implementation, as well as one or more performance indicators. These are collected in a responsibility matrix for ease of use in monitoring.

Monitoring

Monitoring requirements under the SESMP fall into two categories: compliance monitoring (checking to make sure prescribed mitigation actions are properly implemented) and effects monitoring (measuring the impact of the HMP on the biophysical and socioeconomic environments). Monitoring and reporting will be on a semi-annual schedule. Monitoring reports will be made available to stakeholders and the public through a dedicated web page set up for the SEA and SESMP processes.

Institutional Arrangements

A durable entity will be required to ensure implementation of the SESMP over the 15-year life of the HMP. It is proposed that an SESMP Oversight Committee (SESMPOC) should be established for this purpose. The SESMPOC should be outside and independent of DOST, as many of the actions prescribed in the SESMP are for DOST to implement, and in some cases require collaboration between DOST and other agencies coming under other ministries. It is proposed that the SESMPOC should be seated within the Ministry of Infrastructure and Transport (MOIT), with MOIT as its Permanent Chair. Membership of the SESMPOC would comprise representatives of 10 other agencies, all of which are stakeholders of the HMP and implicated in some way in implementation, mitigation or monitoring.

Capacity Development

DOST will be the lead implementor of the HMP, and also a central actor in implementation of the SESMP. The agency does not currently have an Environment Unit or similar office for environmental and social safeguards. It is proposed that a permanent Environmental and Social Safeguards Unit (ESSU) be established within DOST to facilitate competent and timely safeguards oversight of the large number of projects foreseen under the HMP, and for other projects coming under DOST's remit. The SESMP lays out the responsibilities and staffing needs of the ESSU. A permanent professional staff of four full-time specialists is recommended.

Cost Estimate

Because all mitigation actions indicated in the SESMP are administrative or coordinative in nature, significant financial outlays are not anticipated. Operation of the SESMPOC should have minor costs for convening meetings. Some incremental costs are anticipated for the effects monitoring, as data collection for some indicators will incur costs for equipment, fuel, coordination and training. Costs for necessary capacity-building should be assessed separately from the SESMP implementation costs, as the mandate of the proposed ESSU would be much broader than supporting SESMP implementation. An indicative annual cost for SESMP implementation is Nu. 1,590,000 (23,850,000 over 15 years).

Concluding Recommendations

The following recommendations are offered, taking account of all the information summarized above, including the findings of the impact assessment, as well as the actions prescribed in the SESMP, which it is assumed will be thoroughly and competently implemented:

Recommendation #1. The HMP is deemed generally favorable by the SEA study as compared to the alternative of doing nothing, but this should not be taken as an *a priori* endorsement of all projects indicated in the plan. Further evaluation is needed at the project level for all proposed capital investments, and stakeholders are entitled to expect that projects found upon further analysis to pose unacceptable risks will ultimately be removed from the HMP.

Recommendation #2. The SEA study report has assessed the HMP as proposed at the time of writing (January 2025). The SEA study should be updated in the event that significant revision or modification of the HMP is proposed.

Recommendation #3. Stakeholders should be kept informed of the implementation of the SESMP through regular and transparent disclosure of monitoring and review results. In the event that significant revision or modification of the HMP is proposed, stakeholder consultations must be carried out.

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I. INTRODUCTION

1. This Strategic Environmental Assessment (SEA) report has been prepared in relation to the proposed Bhutan National Highways Connectivity Master Plan to 2040 (HMP), which has been formulated as part of the Asian Development Bank (ADB) TA-6916 BHU: Master Plan for National Highway Connectivity. The firm David Lupton and Associates, Ltd. (New Zealand), in association with APECS Consultancy (Bhutan) and Maxwell Stamp (Bangladesh), was engaged to provide consulting services for the TA, including preparation of the HMP and SEA, under the supervision of the Department of Surface Transport (DOST).

A. Bhutan Highways Master Plan to 2040

2. A long-term vision for the road sector in Bhutan has been expressed through the Comprehensive National Development Plan for Bhutan 2030; the Road Sector Master Plan 2007–2027; the Road Act of Bhutan 2013; the Bhutan Transport 2040 Integrated Strategic Vision; the Road Classification and Network Information 2020; the Twelfth Five-Year Plan 2018–2023; and the Thirteenth Five-Year Plan 2024–2029. The Comprehensive National Development Plan for Bhutan 2030 (CNDP) emphasizes the importance of addressing rural–urban migration and seeking a more even balancing of development across regions, with targeted maximum travel times for the north–south corridors of 8 hours, and 16 hours for east-west corridors. The Twelfth Five-Year Plan aimed to (1) improve the national road network through consolidation and enhancement of the national highway grid and building new roads to fill missing links, such as those that would complete a long-envisioned second east-west highway in the southern part of the country; (2) improve national highways using environmentally friendly road construction and climate-ready technology; and (3) reduce travel time by means of bypass roads and tunnels. The Thirteenth Five-Year Plan has largely carried forth these same objectives.

3. The mission of the HMP is to identify feasible highway network improvements that support the aims articulated in the long-term vision for the road sector, and to provide a sound basis for prioritizing and planning investments to deliver on the strategic vision. The HMP comprises a Development Plan to drive the capital investment dimension of the mission, and a Maintenance Plan to define the necessary investments in highway maintenance.

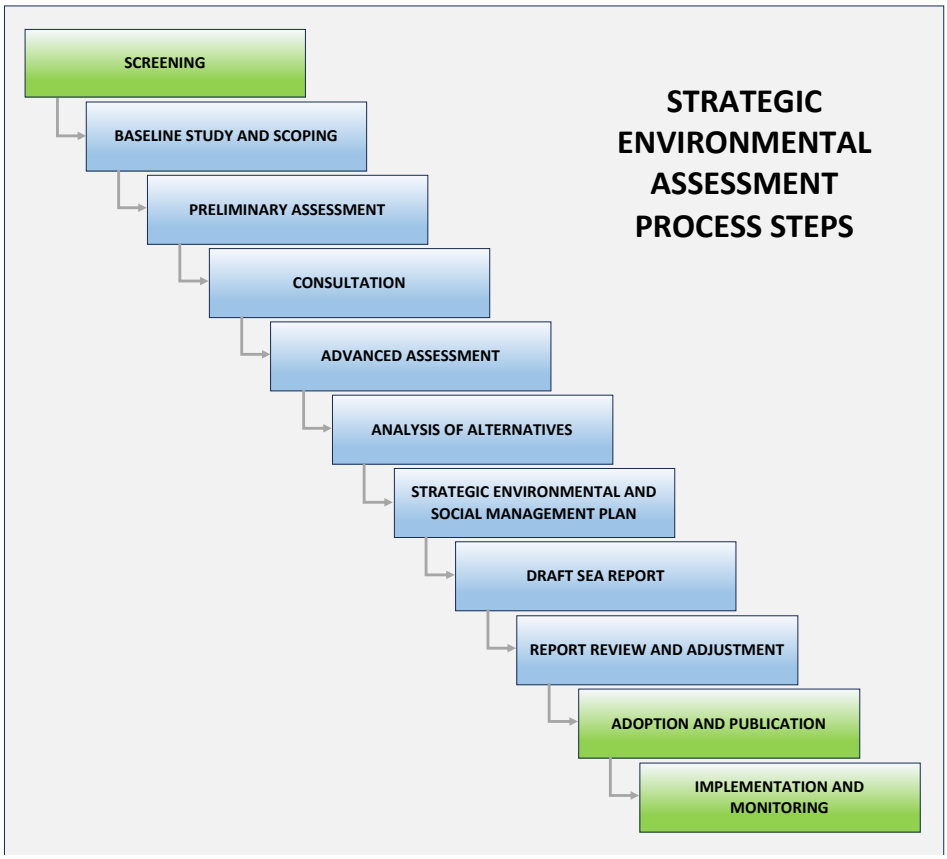
B. Strategic Environmental Assessment Process

4. Strategic environmental assessment is required for all proposed major plans, policies and programs (PPPs) that may have environmental effects, under the Regulation on Strategic Environmental Assessment (2002), pursuant to the Environmental Assessment Act (2000). A series of process steps was developed to guide the SEA for the HMP, based on insights drawn from the Regulation on Strategic Environmental Assessment (2002), the Draft National Guidelines for Strategic Environmental Assessment in Bhutan (2016), and international sources, most notably guidance material produced under the auspices of the International Association for Impact Assessment (IAIA). The process applied to the SEA study is represented by the flowchart in Figure 1. The SEA study covers the second through the ninth steps (in blue) of the overall SEA process.

5. The SEA study was conducted in tandem with formulation of the HMP, which is considered an SEA best practice, as it enables environmental and social considerations to inform and shape the subject PPP from the earliest stages, proactively avoiding many potential negative impacts. The SEA study team specialists (Environment and Climate Change Expert (International),

Environment Specialist (National) and Social Specialist (National)) were an integral part of the master planning team, and this facilitated close interaction and interchange throughout the HMP formulation process.

6. **Guideline for Strategic Environmental Assessment in the Road Sector.** One of the Consultant's responsibilities under TA-6916 was to develop a set of practical SEA guidelines specifically for the road sector in Bhutan, to support efficient preparation of strategic assessments for future PPPs. This output was produced and 'pilot-tested' over the course of the SEA study process for the HMP. The draft Road Sector SEA Guideline can be found in Appendix 1 of this SEA report, for reference.



Source: Consultant

Figure 1: Strategic Environmental Assessment Process Model

C. Information Sources and Analytical Focus

7. Information used in the SEA study was gathered from a broad array of sources, both domestic and international. Secondary information used to characterize existing conditions in the biophysical, socioeconomic and policy environments was gathered mainly from national statistical databases, plans, policy documents and websites. Baseline and assessment reports from past infrastructure development projects were also found useful. Shapefiles were obtained from various government agencies and web sources, and also through ADB. Climate projection data were obtained from the World Bank Climate Change Knowledge Portal. The TA team generated extensive primary data on the existing road network, existing traffic flows on the highway network, and the data flowing from preliminary alignment identification, cost estimation, traffic modelling

and economic analysis were essential inputs to the environmental analysis. Discussions with key informants within and outside of DOST, as well as the long experience of the national specialists on the TA team with various aspects of infrastructure development in Bhutan, were also invaluable sources of information and insight.

8. In keeping with the purpose and conceptual underpinnings of SEA, and taking direction from the Regulation on Strategic Environmental Assessment (2002), the assessment presented in this report was focused on identifying, characterizing and mitigating potential broad-scale, systemic and cumulative impacts. The key strength of SEA is in enabling high-level analysis of these kinds of impacts, which are less easily recognized and evaluated through project-level environmental impact assessment (EIA) studies. It is acknowledged throughout the present SEA study that detailed data collection, study and analysis will be required during feasibility and design stages for projects implemented under the umbrella of the HMP, to refine and confirm the significance of the impacts anticipated, assess project alternatives, and develop mitigation in context.

D. Stakeholder Engagement

9. Two-way communication with the representative entities whose mandates or constituencies may be affected by the implementation of a PPP is an essential element of the SEA process. The SEA study process was supported and enriched by consultation with a wide range of institutional stakeholders in the governmental, non-governmental, inter-governmental and private sectors, beginning with the scoping step. Stakeholder engagement conducted during the SEA study was enabled by close collaboration between DOST and the SEA study team.

10. **SEA Scoping Workshop.** A half-day SEA Scoping Workshop was held on 14 February 2024, at Hotel Migmar in Thimphu. The workshop was hosted by DOST, and featured presentations by the TA Consultants. Workshop participants learned about the highways master planning process and the parallel SEA process, and subsequently engaged in an extended discussion of the key themes that could animate the SEA study. Overall, 59 people (19% women, 81% men) representing 37 different stakeholder entities joined in the workshop; of these, 28 participants attended in person, and 31 joined remotely via a Zoom link. Entities represented at the workshop included government agencies, NGOs, multilateral organizations and dzongkhag administrations. Following the workshop, the TA Consultant produced an SEA Scoping Report drawing together findings from the workshop, additional targeted meetings with selected individual entities, desktop research and a field trip, and this was circulated for review and comment to all workshop participants and other interested parties via a web page set up for the SEA on the Ministry of Infrastructure and Transport (MoIT) website. The SEA Scoping Report reviewed by stakeholders is shown in Appendix 2 of this SEA report.

11. **SEA Consultation Workshop.** A second major stakeholder engagement took the form of an SEA Consultation Workshop, held on 14 October 2024, at the Thimphu Deluxe Hotel. The half-day event was an opportunity to seek further perspective on the major themes identified during scoping, to share updated information on the highways master planning, and engage stakeholders in discussion of preliminary assessment findings and mitigation possibilities. Forty-nine participants representing 33 stakeholder entities attended the workshop, with 28 joining in person, and 21 taking part remotely via Zoom link. As with the earlier SEA scoping Workshop, participants represented a broad range of entities, including government agencies, dzongkhag administrations, NGOs, and international partner organizations. A copy of the presentation used to structure discussion, and a list of workshop participants, are provided in Appendix 3.

Figure 2: SEA Scoping Workshop In-Person Participants

Figure 3: SEA Consultation Workshop In-Person Participants

II. LEGAL AND POLICY CONTEXT FOR STRATEGIC ENVIRONMENTAL ASSESSMENT

A. Rationale for Strategic Environmental Assessment

12. Strategic environmental assessment is typically applied to higher-order instruments of governmental initiative, including PPPs that provide the institutional and financing context for concrete investments and actions implemented through on-the-ground projects. The principal rationale for conducting SEA on PPPs is to foresee and proactively address environmental and social consequences well upstream of the formulation of projects. One criticism of project-level environmental impact assessment (EIA) is that stage-setting assumptions and decisions have typically already been set before the assessment begins, which limits the scope of the EIA study to help strengthen project formulation for better environmental and social outcomes. Conducting SEA on PPPs can help to overcome this weakness of project-level EIA. Upstream SEA can also identify critical issues and themes to be further investigated in project-level EIA, providing guidance for investigation and helping to ensure consistency and quality of EIA studies carried out on individual projects coming under a PPP.

B. Legal and Administrative Context for Strategic Environmental Assessment in Bhutan

13. **Environmental Assessment Act, 2000.** The legal mandate for SEA in Bhutan is established under the Environmental Assessment Act, 2000, specifically Articles 7 and 32.2. Article 7 stipulates that the RGOB shall ensure that environmental concerns are fully taken into account when formulating, renewing, modifying or implementing any policy, plan or program. Article 32.2 empowers the National Environment Commission or its successor agency to adopt requirements for strategic environmental assessment of policies, plans and programs of the RGOB. The Regulation on Strategic Environmental Assessment, 2002 was promulgated to spell out the requirements referenced in Article 32.2.

14. **Regulation on Strategic Environmental Assessment, 2002.** The Regulation on SEA defines SEA as "a systematic, flexible process of addressing the environmental aspects and consequences of proposed policies, plans and program initiatives at the earliest appropriate stage of decision making at par with economic considerations". The Regulation requires the governmental proponent of any PPP that "may have any significant effect on the environment" to undertake an SEA study in conjunction with the PPP's formulation. The Regulation also applies to modification and renewal of existing PPPs.

15. The SEA Regulation lays out broad principles for the SEA process, emphasizing (1) early identification and integration of environmental concerns; (2) consideration of alternatives, including the alternative of taking no action; (3) openness, transparency and accountability; and (4) proper documentation of study results. The Regulation does not establish a standard study process or list specific process requirements.

16. With regards to reporting, the SEA Regulation is more specific, and lists a number of required descriptive content elements, covering

(1) The PPP proposal and its policy objectives;

(2) Anticipated adverse environmental effects, including direct, indirect and cumulative effects;

(3) Feasible alternatives to the PPP proposal and a comparison of the environmental effects of the alternatives;

(4) Feasible methods to avoid, minimize or mitigate anticipated adverse environmental effects of the PPP;

(5) The potential overall effect on the environment assuming the successful implementation of described impact avoidance and mitigation measures;

(6) How the proposal complies with relevant guidelines, if any, published by the National Environment Commission or any other agency;

(7) The environmental benefits of the proposal and how the proposal advances the RGOB's objectives relating to sustainable development, environmental protection, preservation of cultural heritage, use of clean technologies, and economic benefits;

(8) Commitments for avoidance and mitigation of environmental effects and mechanisms for future monitoring and assessment.

17. Proposals for PPPs for which an SEA study is required must incorporate a statement report with the above minimum contents, either directly within the proposal document, or in a separate cross-referenced report.

18. **Draft National Guidelines for Strategic Environmental Assessment in Bhutan.** In 2016, the National Environment Commission engaged an international consultant to develop formal guidance to support implementation of the SEA Regulation, something that is provided for by Article 11 of the Regulation. The resulting National Guidelines for Strategic Environmental Assessment in Bhutan (Final Draft, 8 September 2016) have yet to be formally adopted by the RGOB, but have been referenced by the authors of some SEAs conducted on PPPs.[1]

19. The draft 2016 SEA guidelines largely follow previous guidance developed by international entities including the International Association for Impact Assessment (IAIA). The TA Consultant's review of the 2016 guidelines found that the document provides comprehensive and accurate background and conceptual information on SEA, but is also voluminous and not readily used as a how-to guide for agency personnel tasked with initiating, organizing and overseeing an SEA process.

20. **Draft Bhutan Road Sector Strategic Environmental Assessment Guideline.** The Consultant's Terms of Reference (ToR) under TA-6916 direct the preparation of a set of guidelines to facilitate the conduct of SEA in Bhutan. During the TA inception phase, this was clarified and narrowed to be a guideline for SEA of PPPs in the road sector specifically. Following review of the 2016 draft SEA guideline document, the TA Consultant defined two key objectives to ensure the utility and accessibility of the road-sector SEA guideline: (1) develop the guideline as a user-friendly tool incorporating step-by-step guidance and a process checklist; and (2) keep the guideline document focused, concise and no more than 20 pages in length. The draft Bhutan Road Sector Strategic Environmental Assessment Guideline was developed in parallel with the present SEA study, and is provided in Appendix 1 of this SEA report.

C. Laws and Regulations Governing Road Development in Bhutan

21. Strategic environmental assessment is a high-level, early-stage undertaking, and as such is not directly concerned with the logistics and legalities of project implementation. Ensuring that a project's implementation complies with all national laws, regulations, permitting requirements,

[1] Dalal-Clayton D.B. (2016) National Guidelines for Strategic Environmental Assessment in Bhutan, Final Draft, 8 Sept 2016, National Environment Commission, Royal Government of Bhutan, Thimphu.

standards and best practices is the job of project-level EIA. Nevertheless, an SEA study needs to be cognizant of the relevant legal instruments, as there is considerable scope for the study to identify proposed PPP elements that may run up against legal constraints during project implementation, and also to direct special focus during the project-level EIA process on measures to ensure strict adherence to a particular instrument, or purposeful collaboration with the agency responsible for overseeing it. Table 1 identifies and outlines the national environment-, health- and safety-related laws with direct bearing on the review, construction and operation of roads in Bhutan.

Table 1: Environment, Health and Safety Legislation and Rules Relevant to Road Development

Instrument	Key Content	Responsible Agency
Environment Assessment Act (2000)	Establishes requirements and process steps for obtaining advance environmental clearance for proposed projects, and also provides for monitoring of compliance by the National Environment Commission or its successors, and imposition of penalties for various types of infraction. The Act places the burden of compliance, including as regards assessment and related reporting, on the project proponent.	Department of Environment and Climate Change
Forest and Nature Conservation Act (1995)	Establishes authority to regulate land and resource use in Bhutan's forests. Defines several classes of forest land use based on permitted and prohibited activities. Provides the basis for the protected area system, and for management units enabling organized community and commercial exploitation of timber, firewood, non-timber forest products and some mineral resources.	Department of Forests and Park Services
Forest and Nature Conservation Rules (2006)	Pursuant to the Forest and Nature Conservation Act (1995), details rules, permitting processes, harvesting limits, and enforcement mechanisms to govern exploitation of resources in each forest class.	Department of Forests and Park Services
Land Act (2007)	Regulates the acquisition of land, buildings or other landed assets for purposes of public infrastructure development through a set of standard procedures that must be strictly followed with respect to identification of owners and otherwise interested parties of the land and assets in questions, quantifying required takings, and determining appropriate forms and amounts of compensation for lost assets and income. There are three sets of regulations pursuant to the Act, including the Land Rules and Regulations (2007), the Land Lease Rules and Regulations (2022) and the Land Exchange Rules and Regulations (2022), as well as a periodically updated schedule of Land Compensation Rates.	National Land Commission
Local Government Act of Bhutan (2009)	Grants dzongkhag, gewog and thromde governments limited powers to make and enforce local rules consistent with national laws to regulate land use, quarries and commercial enterprises in order to conserve community resources and protect environmental quality for the health, safety and well-being of their citizens. This establishes local governments as stakeholders and cooperants in road development.	Department of Local Governance and Disaster Management
Mines and Minerals Act (1995)	Establishes authority to promote mineral exploration and regulate exploitation of mineral resources. The Act almost always comes into play during road development, as it requires proponents or their contractors to obtain site clearances for quarries supplying the road works, and meet the associated environmental requirements for operations and closure.	Department of Geology and Mines
National Environment Protection Act (2007)	Provides for the establishment of an effective system to conserve and protect the environment. Guarantees citizens the fundamental right to a safe and healthy environment, with the equal and corresponding duty to protect and promote the environmental well-being of the country. Prioritizes application of concepts including intergenerational equity, the middle path to development, the	Department of Environment and Climate Change

Instrument	Key Content	Responsible Agency
	precautionary principle, the 3Rs, polluter pays principle, participatory approach to natural resource management, equitable sharing of costs and benefits of conservation, and payment for environmental services.	
Protected Area Zonation Guidelines of Bhutan (2020)	Building on the Forest and Nature Conservation Rules (2006), the guidelines clarify the rationale and objectives of four zone types applicable to protected areas, and detail the activities permitted and prohibited within each zone class, including procedures for applying for permission to carry on certain regulated activities, including infrastructure development. The guidelines also define the information requirements, criteria, administrative and scientific processes, and consultations involved in demarcating protected area zones.	Department of Forests and Park Services
Regulation for Environmental Clearance of Projects (2002)	Provides detailed guidance for project proponents with regards to compliance with the Environment Assessment Act (2000), including application instruments, information required, timelines for application review, minimum requirements for public disclosure and consultation with affected people and entities, and monitoring and reporting. Directs the establishment of environmental oversight units within proponents agencies to facilitate compliance during project implementation.	Department of Environment and Climate Change
Regulation on Occupational Health, Safety and Welfare (2022)	The comprehensive Regulation aims to ensure safe and healthful workplace conditions, and apply to employers and workers (citizens and non-citizens) of licensed manufacturing, mining and service enterprises, construction operations, corporate entities, and any other entity employing a large number of people at a work site.	Department of Labour
Road Act of Bhutan (2014)	Defines and delineates the respective rights and responsibilities of the Department of Roads and local governments, entities and individuals with regards to the establishment, upkeep, improvement and safe operation of roads. Grants local governments scope to propose and implement new roads, as well as approved road safety features such as sidewalks, bicycle lanes, overhead pedestrian crossings, crosswalks and speed humps. Governs the use of the right of way, including safety concerns such as encroachment.	Department of Surface Transport
Rules on Biological Corridors (2007)	The Rules define the rationale and management objectives of biological corridors, which are limited-use areas positioned as integral elements of the protected area system. Permitted and prohibited activities are identified.	Department of Forests and Park Services
Waste Prevention and Management Act of Bhutan (2009)	Delineates roles and responsibilities of various agencies in implementation of a sound waste management system covering collection, segregation, treatment, storage, transportation, reduction, reuse, recycling and safe disposal of solid, liquid and gaseous wastes. Establishes authority to levy charges on waste generators based on volume and hazard level, and to assess penalties for non-compliance. Prohibits unauthorized releases of wastes into the environment by individuals and organizational entities. Classifies wastes onto hazardous and non-hazardous categories, and assigns special responsibilities to generators and handlers of hazardous wastes.	Department of Environment and Climate Change
Waste Prevention and Management Regulation of Bhutan, 2012	Specifies procedures to implement the Waste Prevention and Management Act of Bhutan (2009). Develops detailed breakdowns of waste classes and mechanisms, practices and responsibilities for their management. Elaborates the roles of various agencies in regulating generation and management of selected categories of waste, and clarifies the responsibilities of local governments, commercial entities and individuals.	Department of Environment and Climate Change

Source: Consultant

D. Other Potentially Intersecting PPPs

22. Part of the context for any PPP is the constellation of other policy instruments with which it may intersect. It is not unusual for PPPs originating in different sectors to share overlapping objectives, offering the opportunity for synergies. PPPs with roots in different sectors may also have objectives that are contradictory, which may frustrate implementation for one or both PPPs. It is therefore useful to take account of the current field of PPPs in Bhutan to support assessment of the risks and opportunities that may arise from implementation of the HMP. Table 2 lists 31 PPPs that were identified and reviewed as part of the SEA scoping process, and classifies them according to their potential intersection with the HMP. This table is a simplified version of a more detailed review matrix, which is included in the SEA Scoping Report (see Appendix 2).

Table 2: Other PPPs and Their Potential Interaction with the Highways Master Plan

PPP	Potential Effect of HMP on PPP	
	Positive	Negative
Asiatic Black Bear Conservation Action Plan 2023-2033	Y	Y
Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (2023)	Y	N
Bhutan National Urbanization Strategy (2008)	Y	N
Bhutan Transport Integrated Strategic Vision 2040	Y	N
Black-Necked Crane Conservation Action Plan For Bhutan 2021-2025	N	Y
Climate Change Policy of the Kingdom of Bhutan 2020	Y	Y
Comprehensive National Development Plan (2019)	Y	N
Conservation Action Plan for Hornbills of Bhutan 2023-2033	N	Y
Draft Cultural Heritage Bill of Bhutan (2016)	Y	Y
Disaster Risk Management Strategy (2016)	Y	N
Draft Tourism Policy of the Kingdom of Bhutan (2019)	Y	Y
Economic Development Policy (2016)	Y	N
Elephant Conservation Action Plan for Bhutan 2018-2028	N	Y
Food and Nutrition Security Policy of 2023	Y	N
Golden Mahseer Conservation Action Plan for Bhutan 2022-2032	N	N
Kingdom of Bhutan First National Adaptation Plan 2023	Y	N
Low Emission Development Strategy (LEDS) – Surface Transport (2021)	Y	N
Mineral Development Policy (2017)	Y	N
National Action Plan to Combat Land Degradation (2014)	Y	N
National Biodiversity Strategies and Action Plan of Bhutan (2014)	N	Y
National Environment Strategy 2020-2030	Y	N
National Forest Policy (2009)	Y	Y
National Integrated Water Resources Plan (2016)	Y	Y
National Waste Management Strategy (2019)	N	N
Red Panda Conservation Action Plan for Bhutan 2018-2023	Y	Y
Renewable Natural Resource Marketing Strategy (2021)	Y	N
Renewable Natural Resources Strategy 2040 (2021)	Y	N
Road Sector Master Plan 2007–2027	Y	N
Thirteenth Five-Year Plan (pending 2024)	Y	N
Tiger Action Plan for Bhutan 2018-2023	Y	Y
White-Bellied Heron Conservation Action Plan 2022-2031	Y	Y

Source: Consultant

23. For most of the PPPs reviewed, the types of investments that are proposed for inclusion in the HMP can reasonably be expected to support the aims of the PPP. For nearly half of the PPPs reviewed, investments to be contemplated for the HMP may have some potential to counteract the aims of the PPP, due to the impacts inherent to road development. This is mainly applicable to PPPs that seek to conserve biodiversity, natural habitat, prominent individual wildlife species, or physical cultural heritage. For some of these PPPs, some supportive effects (e.g., use of new and improved roads to enhance anti-poaching, ecotourism and cultural tourism) are also possible.

E. International Commitments

24. Bhutan is a party to dozens of international agreements, with which its own national legislation must remain consistent. International agreements joined by Bhutan that have some relevance to environmental concerns and regulation are listed in Table 3.

Table 3: International Agreements Joined by Bhutan

International Agreement (in order of adoption date)	Bhutan Ratification or Accession
Convention on Wetlands of International Importance, 1971 (Ramsar Convention)	2012
Convention Concerning the Protection of the World Cultural and Natural Heritage, 1972	2001
Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1973	2002
Vienna Convention for Protection of the Ozone Layer, 1985 - Montreal Protocol on Substances That Deplete the Ozone Layer, 1987	2004 2004
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, 1989	2002
United Nations Framework Convention on Climate Change, 1992 - Kyoto Protocol, 1997 - Paris Agreement, 2015	1995 2002 2017
United Nations Convention on Biological Diversity, 1992 - Nagoya Protocol on Access to Genetic Resources and Benefit Sharing, 2010	1995 2013
United Nations Convention to Combat Desertification, 1994	2003
Convention for the Safeguarding of the Intangible Cultural Heritage, 2003	2005

Source: Composed based on information supplied on various United Nations websites

III. 2040 NATIONAL HIGHWAYS MASTER PLAN

25. This chapter provides an overview of the proposed HMP, covering the planning objectives, major criteria, methods and information sources, as well as the investment proposals contained in the two component sub-plans, the 2040 Development Plan and the 2040 Maintenance Plan.

A. Context, Goals and Objectives of the 2040 National Highways Master Plan

26. Bhutan's present road network consists of approximately 18,265 km of roads, of which national highways comprise 2,841 km. The national highways span three road classes: Asian Highway (AH), Primary National Highways (PNHs), and Secondary National Highways (SNHs) (see Figure 4). The national highway network reaches every one of the country's 20 dzongkhags (districts).

27. Development and upkeep of the national highways is primarily the responsibility of the Department of Surface Transport (DOST), under the Ministry of Infrastructure and Transport (MoIT). The Asian Highway and selected other national highway segments were built and are maintained by Project DANTAK, an arm of the Indian Ministry of Defense, under an agreement with the RGOB. Virtually all of Bhutan's road network has been built since the 1960s.

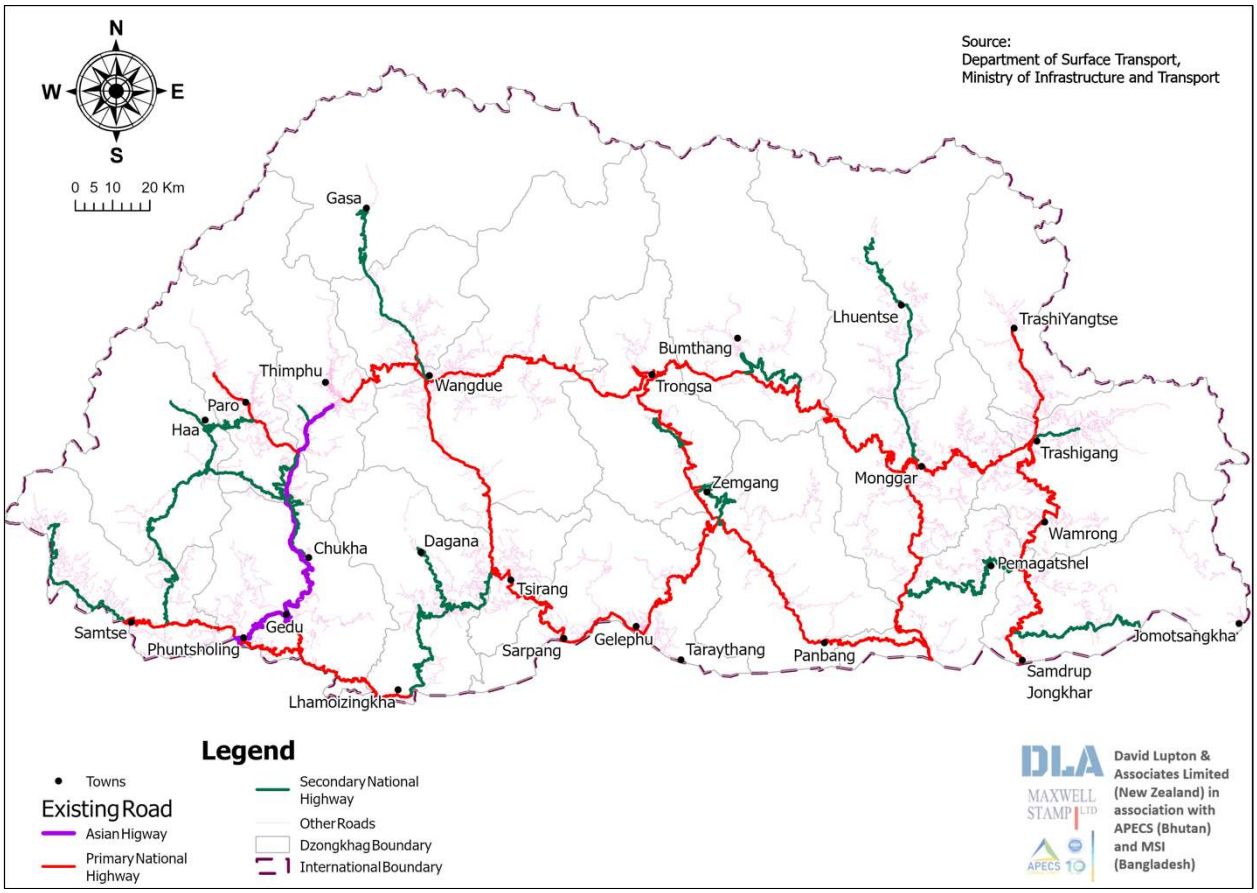


Figure 4: Bhutan's Current National Highways Network

28. Bhutan is a modestly sized country, spanning just 330 km from west to east, but road transport faces formidable challenges imposed by topography. Over 90% of the national territory

is mountainous, and underlying geology of uplifted sedimentary-origin rocks makes large swathes of the country prone to landslides. Trips by road between the capital Thimphu in the west and Trashigang in the east typically take upwards of 13–14 hours, and are usually undertaken in two legs. Many motorists making the trip from the capital to Samdrup Jongkhar in the southeast go by way of India to take advantage of better east-west roads there. Communities not located on the national highway network face even longer travel times if contemplating cross-country travel.

29. Travel times on the national highways are made long by the tortuous routes imposed by topography, but also by poor road conditions and frequent delays caused by slope failures and flash flood damage. As noted in Chapter I, major road sector policy instruments produced over the last two decades have targeted both network expansion and improvement of network conditions as means of shortening travel time and improving road connectivity for more people. This dual thrust provides the major context and impetus for the HMP.

B. Formulation of the 2040 National Highways Master Plan

30. The proposed HMP contains two separate but complementary elements: the 2040 Development Plan and the 2040 Maintenance Plan. The HMP applies only to Bhutan's national highways. Other parts of the national road network, while linked to and functionally integrated with the national highways, are not targeted for investment under either the Development Plan or Maintenance Plan, except where segments of lower-order roads are proposed for upgrading and reclassification as national highways.

31. The Development Plan and Maintenance Plan were formulated based on comprehensive and holistic analysis pulling together information on:

(1) Spatial extent and condition of the existing national and secondary highways and connecting dzongkhag roads;
(2) Governmental investment priorities articulated in Five-Year Plans, prior roads-sector plans, and the current government's policy statements;
(3) Present road network use, drawing on both traditional traffic count data and anonymized cellular telephone movement data;
(4) Socioeconomic conditions and trends shaping future travel demand, including demographic change, livelihoods and spatial and sector development plans;
(5) Long-term prospects for the development of non-road modes of transport, including rail, air, ropeways and river transport;
(6) Geophysical, ecological and physical cultural heritage constraints;
(7) Climate change projections and national climate change mitigation and adaptation objectives;
(8) Existing highway maintenance organization and challenges;
(9) Estimated construction and maintenance costs; and
(10) Governmental budgetary and human resource constraints.

32. Results of assessment in the areas listed above were used as inputs in a comprehensive network analysis, which assessed the feasibility of various investments in the national highways network. Proposed network improvements were evaluated for their efficacy in supporting the strategic vision and mission for the roads sector; their cost and cost-effectiveness; their practical feasibility in view of the institutional capacity of DOST and foreseeable financing options; their implications for the country's protected areas, biodiversity, rivers and forest cover; and their alignment with Bhutan's climate change mitigation and adaptation commitments under the Paris Agreement.

C. 2040 Development Plan

33. The Development Plan details a series of capital investments that the RGOB may consider developing over the 2025–2040 period to support realization of the long-term vision for the road transport sector. The portfolio of projects selected for inclusion in the Development Plan is the result of an extended sifting and winnowing process that began with a much larger number of project ideas proposed in various plans and discussions.

34. The Development Plan proposes eight classes of projects, as follows:

(1) New primary national highway links,
(2) New secondary national highway links,
(3) Bypasses and tunnels;
(4) Road widening;
(5) Slope stabilization works;
(6) Bridge replacements;
(7) Safety improvements; and
(8) Improved access roads to dry ports, railheads and industrial sites.

a. New National Highway Links

35. **Primary national highways.** Proposed new primary national highways include three new links that would close gaps in the long-envisioned Southern East-West Highway (Lhamoizhingkha–Sarpang, Gelephu–Tareythang, and Tareythang–Panbang), as well as an additional link to serve increasing traffic between Thimphu and Paro, which would be developed by upgrading a series of existing lower-order roads on the west bank of the Wangchhu and a portion of the Asian Highway on the east bank; all are shown on the map in Figure 5. Proposed new primary national highway links would add 246 km to the national network. These new roads would be built to PNH specifications, with pavement width of 7.5 m.

36. **Secondary national highways.** Five new secondary national highways have been proposed in the Development Plan, totaling 196 km. These new roads are proposed primarily to enhance interconnectivity between population centers of adjacent dzongkhags, but some also serve to provide an alternate or shorter route in the overall network configuration, resulting in travel time and distance savings for some trips. These roads would be built to the SNH standard, with pavement width of 5.5 m. These proposed new secondary national highways are shown in Figure 5.

37. Most of the proposed new primary and secondary national highway links are expected, based on the preliminary alignments used for the master planning exercise, to incorporate sections of pre-existing lower-order roads (mostly farm roads). Given the higher engineering standards for the national highways, these upgrades can be expected to require entirely new road structures in many locations, and to have many of the same environmental and resettlement impacts that would be expected from the opening of a new right-of-way (RoW) for a new highway project.

b. Bypasses and Tunnels

38. Three tunnels and one bypass road have been selected, from amongst a long initial list, for inclusion in the Development Plan. One of the tunnels (Gedu–Ganglakha, on the Asian Highway), is already undergoing detailed feasibility analysis by Project DANTAK. Two of the tunnels selected are short (Gedu–Ganglakha at 2.8 km, and Thumang at 0.8 km), and are anticipated to not only shorten travel distance and travel time on their respective highways, but also to mitigate long-

standing landslide risks. The Yesipang–Nahi Tunnel would be longer at 8.3 km, and require the upgrading of about 20 km of farm road at its eastern end. The lone bypass project would be a 1000-m suspension viaduct across a deep river valley near Trongsa, saving about 13 km of travel distance. The locations of all four projects are shown in Figure 5.

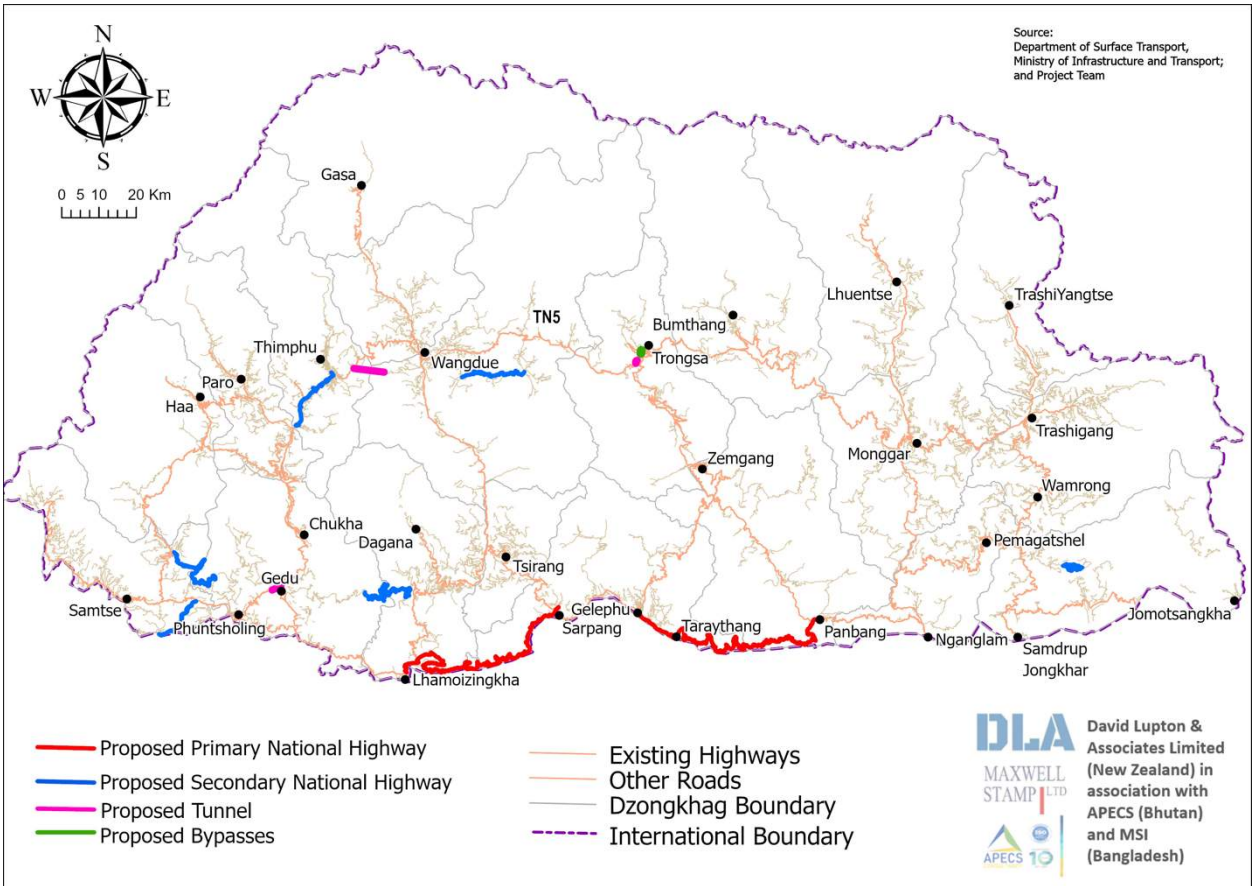


Figure 5: Proposed New Highways, Tunnels and Bypasses

c. Road Widening

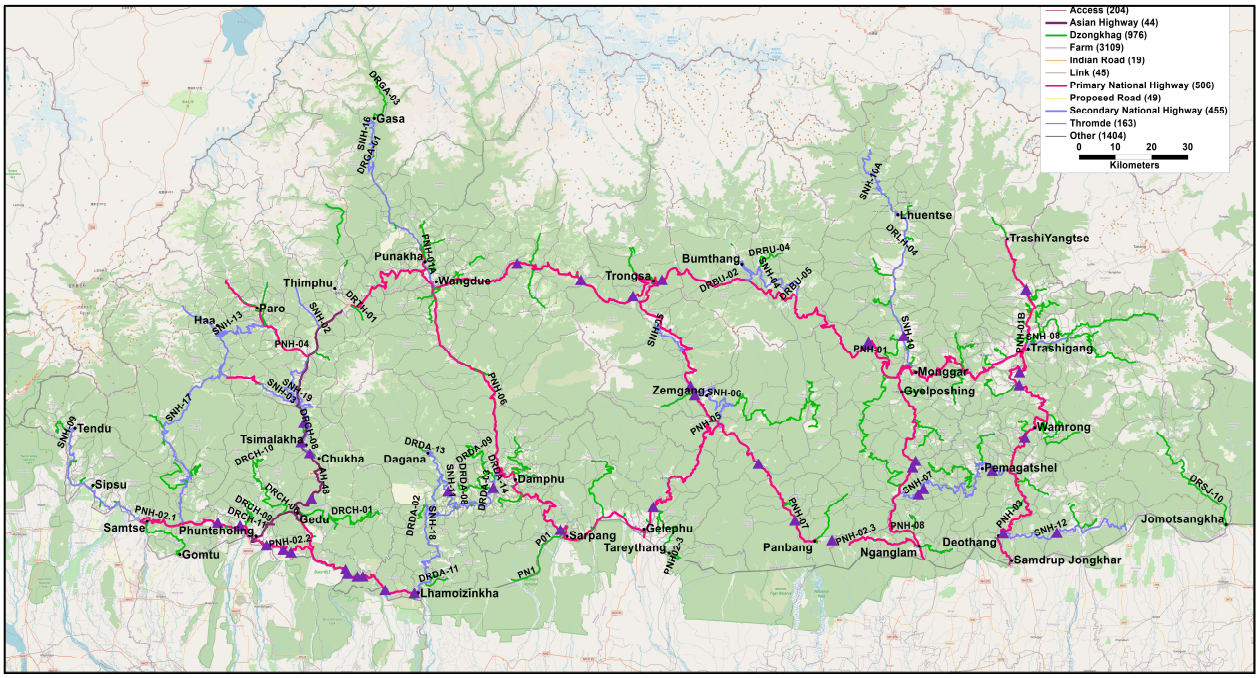
39. Nearly 800 km of national highway are proposed for widening to bring them up the respective standards for their class, with the aim of reducing delays and improving road safety. In all, 36 widening projects are proposed. The largest share (521 km) of widening works are targeted at secondary national highways that have pavement width more than 2 m narrower than the 5.5-m SNH standard. The locations of these works have not been mapped.

40. DOST's standard road-widening practice in hilly terrain is to cut further into the uphill side of the road and install retaining structures there, rather than expanding the road embankment on the downhill side. This is a sensible practice that limits the spatial extent of the works and keeps the potential for environmental impacts relatively low.

d. Slope Stabilization

41. Landslides and other types of slope failure are the leading source of risk to the reliability and safety of the national highways in Bhutan, and this is reflected in a portfolio of 44 slope stabilization projects in the Development Plan. The selected sites all have a documented history of unresolved slope failure problems. It is anticipated that stabilization works may range from

simple addition of retaining walls and bioengineering or rock bolting, all the way up to rock sheds and road realignment. The locations of the selected slope stabilization projects are shown on the map in Figure 6.



Sources: Consultant and DOST

Figure 6: Locations of Proposed Slope Stabilization Projects

42. Bridge Replacements and Upgrades

43. A list of 40 national highway bridges that are in need of replacement (or in some cases upgrading) was developed by the DOST Bridge Division, and the anticipated works have been included in the Development Plan. Over half (23) of the 40 bridges targeted are presently Bailey bridges, most of them single-lane. It is not known how many of the bridges will require full replacement, and how many can be upgraded in place. Either way, the bridge works can generally be expected to require riverbank excavation, at least some in-channel work to install footings and scour protection, concrete work, and sometimes also river-training works. The locations of the 40 proposed bridge projects are shown on the map in Figure 7.

e. Safety Improvements

44. As a mountainous country, Bhutan has great need for guardrails and other means of keeping vehicles on the road in spite of mountain weather and tortuous alignments with ubiquitous blind curves. There is a large safety investment backlog on the national highways, and the Development Plan aims to help address the gaps. Addition or improvement of safety infrastructure, including guardrails, signage, and pavement markings is proposed over a total linear road length of 518 km. The locations of these works have not been mapped.

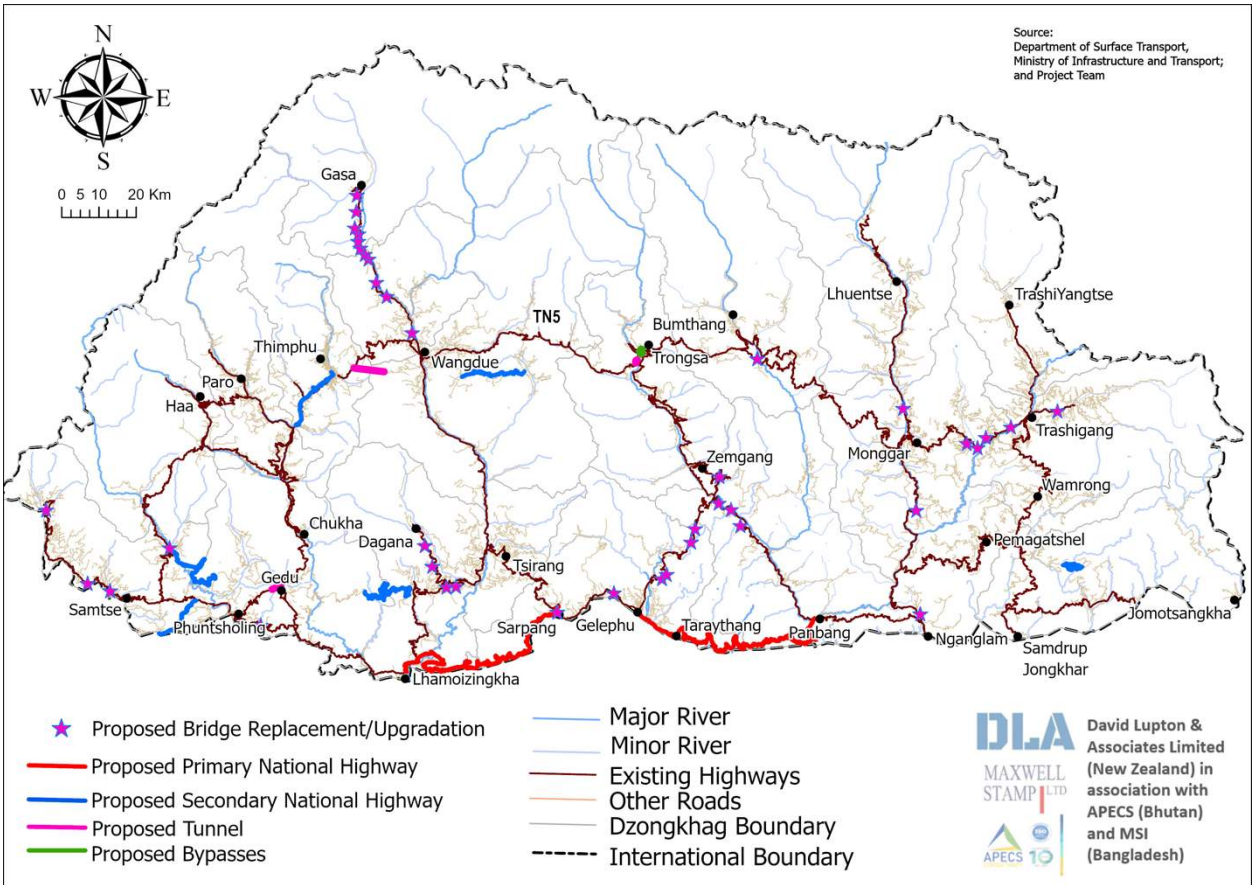


Figure 7: Proposed Bridge Replacement/Upgrading Projects

f. Improved Access to Dry Ports and Industrial Zones

45. Several locations along the southern border with India have been prioritized under RGOB industrial policy for development and expansion of mineral-based heavy industry, agricultural product processing and manufacturing, and cross-border trade. There is an existing dry port at Pasakha, and new dry ports are proposed at Samtse and Nganglam. Locations prioritized for new industrial parks or expansion of existing ones include Samtse, Pasakha, Gelephu and Motanga. Cross-border rail spurs from the Indian rail network have been proposed for Samtse and Gelephu. To be functional and beneficial to the country's economy, these locations will need good access to the national highways network, and the Development Plan makes a preliminary attempt to take account of and plan for the necessary road improvements, despite considerable unknowns regarding the viability and potential timing of such industrial projects. Approximately 90 km of heavy truck access roads are assumed in the Development Plan, and a generic unit cost per kilometer for these has been reflected in the cost estimate. Preliminary alignments were not developed, due to the uncertainty surrounding the proposals mentioned.

D. 2040 Maintenance Plan

46. Rough roads are a formidable constraint on average vehicle speed in Bhutan, and increase the operating cost and fuel consumption of vehicles. Rough roads are also less safe than smooth roads. Improving and consistently maintaining the condition of highway pavements is a critical

component of enhancing network reliability, reducing travel times, and ensuring the safety of road users.

47. The Maintenance Plan prescribes a 15-year periodic maintenance works regimen aimed principally at bringing average road surface condition across the national highways network to up to a higher standard, defined as International Roughness Index (IRI) 6–7, and subsequently keeping it within the new lower range. The average IRI across the national highway network is presently about 9–10. Although focused on pavements, the periodic maintenance proposal also includes activities that help prevent damage to pavements and the road structure, including clearing and maintenance of drains and culverts, as well as upkeep of slope protection structures and vegetation.

48. Under the proposed Maintenance Plan, maintenance activity would be significantly stepped up in the first six years (2025-2030 inclusive) in order to clear the existing maintenance backlog and achieve the initial overall average IRI improvement targeted. The latter part of the plan period (2031–2039 inclusive) would see maintenance dialed back somewhat from the 2025–2030 level, and settled into a consistent pattern capable of maintaining the targeted average IRI across the highway network through the remainder of the HMP planning horizon.

49. In addition to prescribing a regimen for improving and maintaining road surfaces (which come under routine maintenance), the Maintenance Plan makes a number of recommendations regarding new or increased budget allocations for major emergency repairs (under the monsoon restoration budget), routine and periodic maintenance on bridges (not presently budgeted for) and regular repair of road safety assets including guardrails, signage and pavement markings. The Maintenance Plan does not include the highways and bridges currently maintained by Project DANTAK.

E. Projected Cost

50. The projected cost to implement the full HMP, including both Development Plan and Maintenance Plan components, is about 185 million Nu. (see Table 12). About two thirds of the total projected cost would be for capital investments proposed in the Development Plan.

Table 4: Projected Cost of Highways Master Plan Investment

Plan Components	Cost (million Nu.)	Cost (million USD)
Development Plan		
PNH-02 completion	22,286	269
Thimphu-Paro Highway Expansion	1,742	21
Inter-Dzongkhag Connectivity SNHs	6,674	80
Road bypasses and tunnels	56,544	681
Bridge Replacement and Upgrading (40)	2,269	27
NH Access to Industrial Sites	2,633	32
Sub-Total Development Plan	**121,196**	**1,460**
Maintenance Plan		
Clear maintenance backlog	34,025	410
Essential maintenance-remaining years	15,975	192

Plan Components	Cost (million Nu.)	Cost (million USD)
Periodic maintenance-remaining years	21,698	261
Sub-Total Maintenance Plan	**71,697**	**864**
Total 2040 Master Plan	**184,582**	**2,224**

Source: Consultant

F. Proposed Investment Schedule

51. The implementation window for the investments proposed in the HMP is 15 years (2025-2040), although it is expected that some of the more complex and costly network expansion projects, e.g., the Nesipang–Nahi Tunnel and Trongsa Bypass, would only be started towards the end of the planning horizon, and would not be completed by 2040, and perhaps not for several years after that. The investment schedule is acknowledged to be tentative and provisional, in part because a considerable increase in budget allocations, and in the project management capacity of DOST, would be required to implement all of the proposed investments. All of the proposed capital development projects will require detailed feasibility studies, and the capital cost and economic viability of some project classes (e.g., slope stabilization and bridge works) will remain highly uncertain until these are completed. More detailed feasibility studies may also lead to different conclusions about some proposed projects than have emerged from the high-level economic analysis conducted to date. The proposed investment schedule is shown in Table 5.

G. Institutional Arrangements for Implementation

52. The works foreseen under the HMP will primarily be implemented by DOST, as the agency responsible for development and upkeep of most national highways. Project DANTAK will assume responsibility for some proposed works that affect the Asian Highway (such as the Gedu-Ganglakha Tunnel); which other proposals may be implemented by Project DANTAK is a matter for bilateral discussion between the governments of Bhutan and India.

53. As the overall cost of the Development Plan projects will foreseeably exceed the capacity of the national budget to accommodate new capital spending, it is anticipated that multilateral development banks (MDBs) including ADB, the World Bank and Japan International Cooperation Agency (JICA) will be called upon to provide financing and implementation support. At the time of writing, the World Bank is already enabling feasibility studies on one of the Southern East-West Highway (PNH-02) links (Gelephu–Tareythang), and feasibility and preliminary design work is set to begin soon on another (Lhamoizhingkha–Sarpang) with ADB support. Private-sector and governmental entities in industrial sectors may play a role in financing and developing access roads to connect industrial sites and dry ports to the national highway network.

Table 5: Proposed 15-Year Investment Schedule for Highways Master Plan

ID	Project Categories	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Total Million Nu.
	Improvements to existing road network	1,231	2,343	2,343	2,343	2,343	2,586	2,103	2,103	1,609	1,609	1,609	1,609	1,609	1,609	1,609	28,658
	Road widening: PNHs < 5.5 m (widen to 7.5 m)	1,231	1,231	1,231	1,231	1,231											6,155
	Road widening: SNHs < 3.5 m (widen to 5.5 m)						494	494	494								1,481
	Road widening: SNHs 3.5-5.5 m (widen to 5.5 m)						979	979	979	979	979	979	979	979	979	979	9,795
	Road safety improvements (W-Beam Crash barriers)		483	483	483	483	483										2,415
	Slope failure mitigation		629	629	629	629	629	629	629	629	629	629	629	629	629	629	8,811
	Road network expansion		2,281	2,821	2,821	3,256	3,389	3,656	2,958	3,322	2,141	6,812	6,679	6,412	6,250	6,134	58,933
PN1	Lhamoizingkha - Sarpang		1,181	1,181	1,181	1,181	1,181	1,181	1,181	1,181							9,451
PN2	Gelephu - Tareythang		1,099	1,099	1,099	1,099	1,099	1,099									6,597
PN3	Tareythang - Panbang								780	780	780	780	780	780	780	780	6,238
TP1	Thimphu (Olakha Underpass)-Khariphu-Chuzom									249	249	249	249	249	249	249	1,742
SN7	Gatena (Chukha) - Dorona (Dagana)					435	435	435	435	435	435						2,610
SN8	Khotokha-Phubjikha						133	133	133	133	133	133					799
SN9	Denchukha (Samtse) - Chimuna (Chukha)							267	267	267	267	267	267				1,601
SN12	Sarjung-Yarphu (Samdrup Jongkhar)								161	161	161	161	161	161			969
SN13	Gomtu-Pagli-Tading									116	116	116	116	116	116		696
BP4A	Trongsa Bypass											1,245	1,245	1,245	1,245	1,245	6,225
TN2	Gedu-Ganglakha																0
TN11	Thumang Tunnel			541	541	541	541	541									2,703
TN12	Yesipang-Nahi											3,861	3,861	3,861	3,861	3,861	19,304
	Bridge replacement / upgradation			454	454	454	454	454									2,269
	NH access to industrial parks, dry ports & railheads						263	263	263	263	263	263	263	263	263	263	2,633
	Total	**1,231**	**4,624**	**5,618**	**5,618**	**6,053**	**6,692**	**6,476**	**5,323**	**5,194**	**4,013**	**8,684**	**8,551**	**8,284**	**8,123**	**8,007**	**92,492**

Source: Consultant

IV. BASELINE CONTEXT OF THE HIGHWAYS MASTER PLAN

A. Existing Road Network of Bhutan

54. Bhutan currently has about 18,000 km of roads, of which about 26% are sealed. The country's roads are assigned to seven road classes: Asian Highway, Primary National Highway, Secondary National Highway, Dzongkhag Road, Urban Road, Farm Road and Access Road. Farm roads are the most prolific, accounting for approximately 60% of total road length. National highways (including the Asian Highway) comprise 2,841 km. A summary of roads by class is shown in Table 6, and a map of the road network appears in Figure 8.

Table 6: Summary of Road Network of Bhutan

Classification	Total Length (km)	Sealed Length (km)	Jurisdiction
Asian Highway (AH)	149	149	DANTAK
Primary National Highway (PNH)	1,531	1,531	DOST, DANTAK
Secondary National Highway (SNH)	1,161	943	DOST, DANTAK
Dzongkhag Road (DR)	2,073	1,165	DOST
Urban Road (UR)	417	403	Thromdes
Farm Road (FR)	11,257	151	Dzongkhags
Access Road (AR)	1,677	456	Mixed
Total	**18,265**	**4,798**	

Source: DOST, TA Consultant

55. **Jurisdiction.** Responsibility for roads in Bhutan rests with various entities. The Asian Highway within Bhutan is maintained and operated by Project DANTAK, an entity of the Indian Ministry of Defense, while the primary and secondary national highways are variously maintained and operated by the DOST and Project DANTAK. Responsibility for dzongkhag roads previously lay with the relevant dzongkhag administrations, but was transferred to DOST in 2024. Farm roads are the responsibility of the individual dzongkhags within which they lie, and urban roads are under the jurisdiction of the relevant thromdes. Access roads mostly provide links between the broader road network and sites including hydroelectric installations, hospitals, schools and forest management areas, and are built, maintained and operated by their owners.

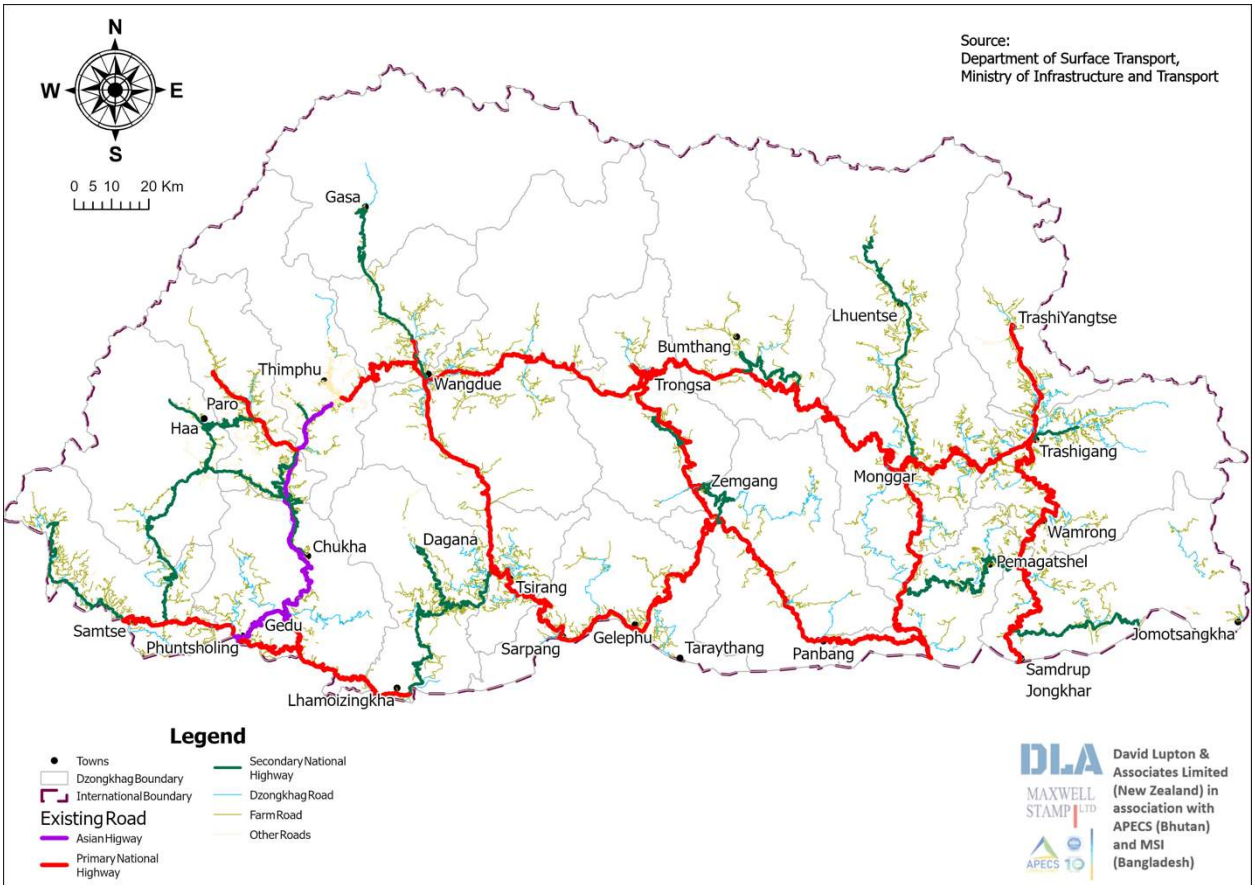


Figure 8: Road Network of Bhutan

56. **Design standards.** Minimum design standards for the four non-urban road classes are shown in Table 7. Only primary national highways are required to have at least two full lanes, although some secondary national highways also meet this requirement. The standards for primary national highways are applicable to the Asian Highway, although AH48 exceeds the standard in some locations. The design standards for access roads are the same as for farm roads, but many are built to a higher standard to serve their intended uses.

Table 7: Selected Design Standards for Roads in Bhutan

	Primary National Highways				Secondary National Highways				Dzongkhag Roads				Farm Roads			
Terrain classification[1]	L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design speed (km/h)	60	50	40	30	50	40	30	20	40	30	20	15	30	25	15	10
Traffic volume (cvpd)[2]	>200				100-200				30–100				<30			
ROW (m)	30				30				18.3				12.2			
Carriageway width (m)	5.5–7.5				3.75–5.5				3.5				3.5			
Max vertical gradient	8º				8º				10º				10º			

[1] L = Level (0–10º); R = Rolling (10–25º); M = Mountainous (25–60º); Steep (>60º)
[2] Commercial vehicles per day

Source: Ministry of Works and Human Settlement. 2020. Road Classification and Network Information of Bhutan.

57. **Road condition.** The condition of Bhutan's roads varies widely. The Asian Highway and all primary national highways are sealed, but suffer from a high prevalence of slope failures and drainage-related subgrade and pavement damage. Tortuous alignments are the norm due to challenging topography, and this constrains average vehicle speeds regardless of road condition. Fortunately, traffic volume is relatively light on most of Bhutan's roads, even the Asian Highway and primary national highways.

58. The secondary national highways are for the most part narrower and in worse condition than the primary national highways, although most are sealed. The country's dzongkhag roads are intermediate rural roads constructed to serve the seats and other large settlements of the sub-districts (gewogs) within each district (dzongkhag), linking the main dzongkhag towns to each other and to the highways network. Many of these roads are under-engineered and in poor condition; about half are sealed. Farm roads are mostly single-lane rural roads constructed to provide 'last-mile' access to isolated rural communities, and serve as feeders for dzongkhag roads and highways. These roads have typically been constructed without much engineering oversight. Less than 2% of the farm roads are sealed.

59. **Connectivity.** The map in Figure 8 illustrates that Bhutan's road network is quite low-density outside of the main highway corridors, with many large roadless gaps, and only one continuous primary national highway link in an east-west direction. Virtually no roads in Bhutan go straight from one point to another, instead following winding paths along complex topographical contours and through extensive switchback configurations. The practical implications are that it takes a long time to travel fairly modest distances, substantial portions of the country have very limited road access, and there is little redundancy of highway corridors that could allow people and freight to go a different way when there is a road closure. For many long- and medium-distance trips between the east and west parts of the country, it is faster to cross into India to make use of the higher-speed highways there than it is to travel between the same two points exclusively on the Bhutanese road network.

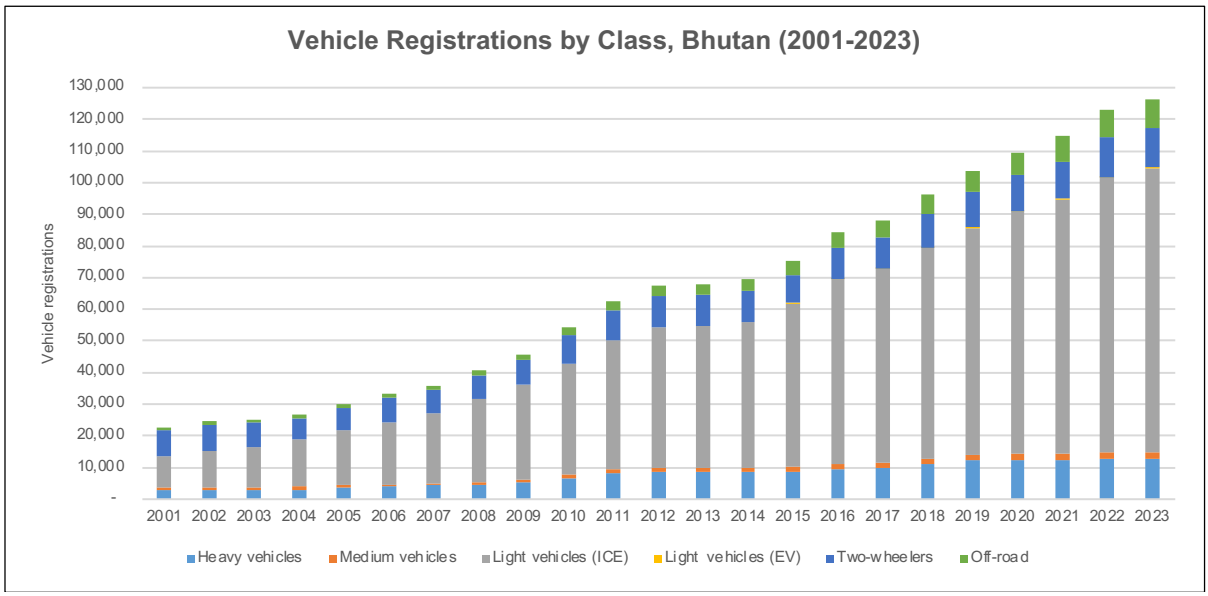
60. **Road safety.** The low speed of traffic on Bhutan's mountain roads means that high-speed crashes are uncommon, but motorists and pedestrians face a host of safety risks. Prevalence of sharp curves and lack of passing lanes translates to frequent blind passing and other risky driver behaviors. Due to a lack of sidewalks and the widespread practice of free-range grazing, potential for surprise encounters with pedestrians and livestock at blind corners is considerable. These risks are multiplied in high mountain areas where thick fog is frequent. In some areas, occasional presence of large wildlife such as elephants and gaurs on the roadway can lead to dangerous confrontations. Guardrails are generally missing in many places where they are needed, and often of poor design where present. Pavement markings, reflective road-edge and centerline markers, and signage are rarely sufficient, and lacking in many locations. Vehicles that leave the road often have a long way to fall, almost invariably leading to serious injuries and deaths. Minor rockfalls onto the road are frequent in many locations, and slope failures ranging in scale from localized slips to catastrophic road-destroying slides and debris flows create hazards for drivers during the monsoon.

B. Vehicle Fleet

61. The number of motor vehicles registered for use on Bhutanese roads has undergone rapid growth over the last two decades, with most of the growth accounted for by light vehicles (see Figure 9). The ratio of vehicles to population in Bhutan was 150 vehicles per thousand people in 2021, which is below the global by-country mean of 315 (median 220), but well above the mean

(105) and median (87) for the SAARC countries.[2] The transport sector accounted for 11.14% of the country's greenhouse gas emissions in 2015, and the total emissions from the sector are projected to double by 2050 under a business-as-usual scenario; this sharp growth would be led by 3.8-fold growth in emissions from light vehicles, a 3.6-fold increase from medium trucks, and a 3.0-fold increase from heavy trucks.[3]

62. Vehicle ownership in Bhutan has a strong regional skew, with 86% of vehicles registered to owners in the eight western dzongkhags. Approximately 45% of the vehicle fleet is powered by diesel engines.[4] Electric vehicle ownership is growing at a rapid annual rate (average 32.2%/yr from 2015–2023), but beginning from a very low baseline; as of 2023, electric vehicles accounted for less than 0.5% of the total fleet.[5]



Source: National Statistics Bureau (Statistical Yearbook of Bhutan, various years)

Figure 9: Growth in Vehicle Ownership 2001–2023

C. Non-Road Transport

63. Bhutan has one international/domestic airport in Paro, with flights to and from airports in India, Nepal, Bangladesh, Thailand and Singapore. There are domestic airports at Bumthang, Gelephu and Yongphula. The RGOB has taken preliminary steps towards expansion of the Gelephu airport, to enable it to serve long-haul air traffic. Development of airports is severely constrained by topography in almost all locations in Bhutan.

64. There are currently no railways in Bhutan, although proposals have been floated for various spur lines to connect industrial zones and proposed dry ports in the southern part of the country

[2] World Population Review. 2024. Cars by Country 2024. https://worldpopulationreview.com/country-rankings/cars-by-country.
[3] Department of Environment and Climate Change. 2023. Bhutan's Long-Term Low Greenhouse Gas Emissions and Climate Resilient Development Strategy.
[4] Ministry of Information and Communications. 2021. Low Emission Development Strategy for Surface Transport 2021.
[5] Data compiled from Statistical Yearbook of Bhutan (2006, 2007, 2011, 2017, 2023).

to the Indian rail network. Development of rail transport outside of the southern foothills area would require ambitious engineering due to steep topography and slope stability risks.

65. River transport in Bhutan is limited to local small craft capable of navigating swift currents and shallow channels. As almost all river segments in Bhutan are high-gradient, turbulent and given to strong seasonal fluctuations in flow, there is negligible potential for widespread development of this mode. Ropeways are used as a temporary mode of transport for materials in some difficult-to-access locations in Bhutan, such as construction and logging sites. Some interest has been expressed in exploring the potential for wider application of this mode.

D. Biophysical Environment

1. Geophysical Conditions

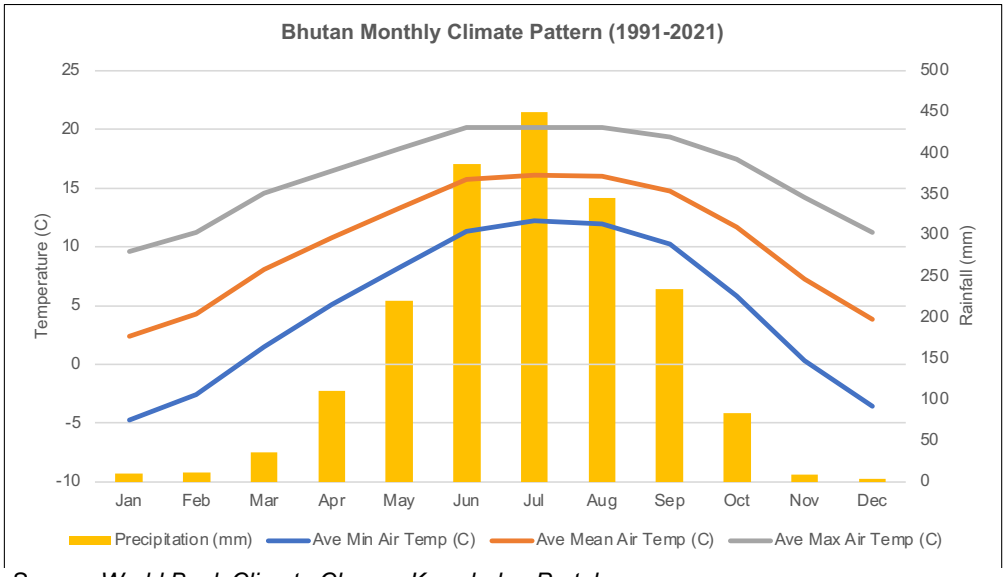
66. Bhutan is a difficult country in which to build and maintain roads. Nearly all of the national territory consists of steeply sloped mountainous terrain, and the underlying geology in many areas is characterized by inherently unstable uplifted soft sedimentary and sedimentary-metamorphic rock, especially in the southern half of the country. Landslides and debris flows are common even in areas undisturbed by human activity, and much more so where cross-slope cuts are made to permit road construction. With the exception of a few minor wetland areas, small alpine lakes, and those river segments that lie within a few kilometers of the southern border, most watercourses in the country run in steeply sided V-shaped valleys and gorges, leaving few feasible opportunities to place roads in river valleys.

67. Like all of the Himalayan Range, Bhutan is seismically active, and the historical and inferred records indicate occurrence of earthquakes up to Magnitude 7. Occasional earthquakes and more frequent lesser temblors contribute to the instability of steep slopes, and add to the challenge of maintaining road infrastructure.

2. Climate and Climate Change

a. Climate

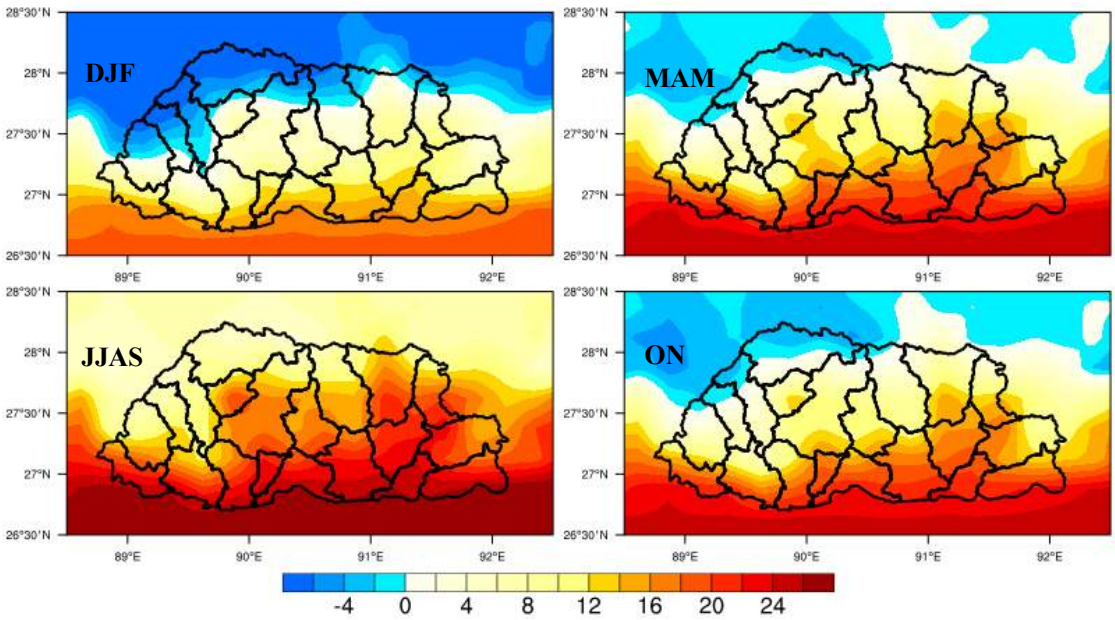
68. Bhutan sits at the convergence of the cold, dry Tibetan Plateau and the warm monsoonal Ganges-Brahmaputra Delta, and its climate shows characteristics and influences from both of these zones. The northern third of the country (the Higher Himalayan belt or zone) sits mostly above 3,000 masl, and is influenced by cold air descending off the adjacent Tibetan Plateau, particularly in the winter months of December to February. By contrast, Bhutan's narrow Southern Foothills belt, which lies mostly between about 100 and 1,500 masl and is less than 600 km from the Bay of Bengal, is warm during much of the year and clothed in tropical forest fed by monsoon rains that fall from June to September. An intermediate band of mid-elevation lands stretching nearly the full width of the country's midsection (the Inner Himalayan zone) experiences a generally mild climate that is a mix of temperate and subtropical climatic conditions. The country's complex topography allows these climatic zones to be stated only in general terms.



Source: World Bank Climate Change Knowledge Portal

Figure 10: Climatological Averages for Bhutan, 1991–2021

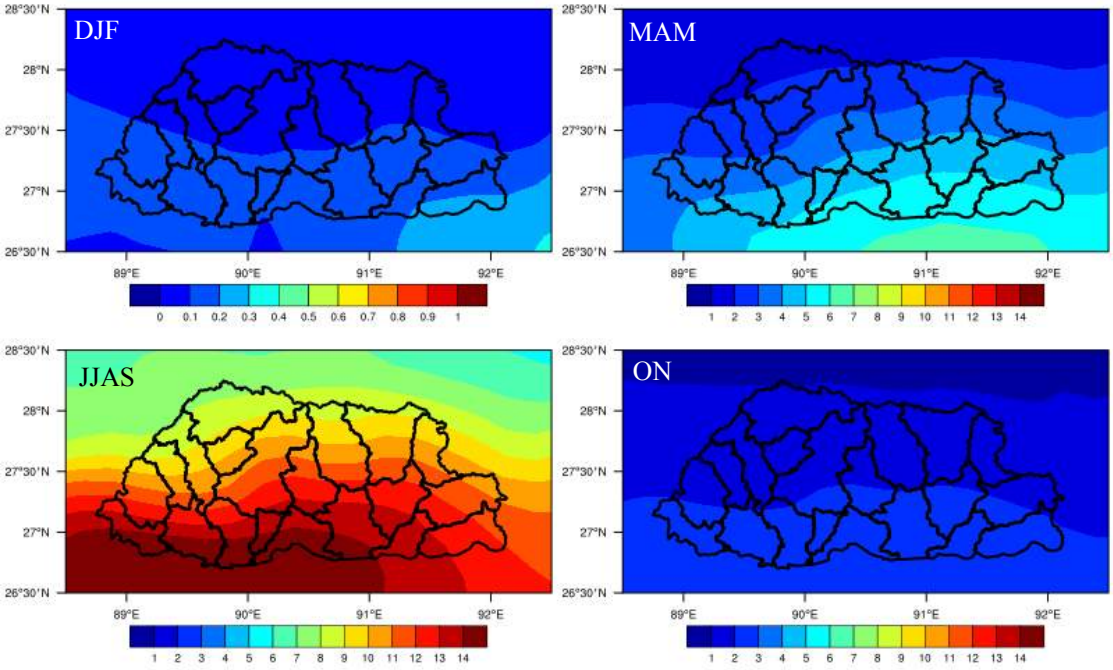
69. **Temperature regime.** Surface air temperature in Bhutan is strongly influenced by elevation, as well as the seasonal strengths of the southwest monsoon in the middle part of the calendar year and the Siberian winter high. Mean annual temperature (1991–2021) for the whole country is 9.3ºC, but average daily temperature ranges widely. Mean daily temperatures in summer reach as high as 25–26ºC in the far southern border zone, but remain below 10ºC along the northern border (see Figure 11). In winter, daily average temperatures are in the range of 12–14ºC in the far south, and dip below -6ºC in the far north.



Source: National Center for Hydrology and Meteorology. 2019. Report on the Analysis of Historical Climate and Climate Change Projection for Bhutan.

Figure 11: Spatial Distribution of Mean Temperature (ºC) by Season (1975–2005)

70. **Rainfall regime.** Bhutan's rainfall patterns are driven by the southwest monsoon, which sends warm, moist air from the Indian Ocean sweeping across the Indian subcontinent. The southwestern part of the country is most heavily affected by the monsoon rains, but the monsoon is the wettest part of the year for all areas (see Figure 12). About 74% of the year's precipitation falls from May to August, while 92% arrives between April and September.



Source: National Center for Hydrology and Meteorology. 2019. Report on the Analysis of Historical Climate and Climate Change Projection for Bhutan.

Figure 12: Spatial Distribution of Mean Annual Rainfall by Season (1975-2005)

b. Climate Change

71. Projection data for temperature and rainfall indicators, generated under the Coupled Model Intercomparison Project Phase 6 (CMIP6) and processed and packaged by the World Bank, were obtained from the World Bank Climate Change Knowledge Portal (CCKP) to generate insights as to the climatic evolutions that Bhutan may face in the coming decades.[6] Focus was placed on eight indicators with the strongest relevance to road infrastructure; these are shown in Table 8.

Table 8: Climate Indicators Selected for Relevance to Road Infrastructure

Indicator Name	Code	Description	Unit
Precipitation	pr	Aggregated accumulated precipitation.	mm
Average Largest 1-Day Precipitation	rx1day	The highest average precipitation amount in a 1-day period during each month in the data period.	mm
Average Largest 5-Day Cumulative Precipitation	rx5day	The average highest precipitation amount over a consecutive 5-day period during each month in the data period.	mm
Number of Days With Precipitation >= 50 mm	r50mm	The number of very heavy precipitation days during the aggregation period. A very heavy precipitation day is defined as any day in	days

[6] The information presented in this section is an overview of a more detailed climate change brief prepared by the TA Consultant to support climate-responsive formulation of the highways master plan. The climate change brief is included in Appendix 4 for reference.

Indicator Name	Code	Description	Unit
		which the daily accumulated precipitation is greater than or equal to 50 mm.	
Average Surface Air Temperature	tas	Average temperature over the aggregation period.	°C
Maximum of Daily Maximum Surface Air Temperature	txx	The single-day maximum value of the daily maximum temperatures over the aggregated data period.	°C
Warm Spell Duration Index	wsdi	The number of days in a sequence of at least six consecutive days during which the value of the daily maximum temperature is greater than the 90th percentile of daily maximum temperature calculated for a five-day window centered on each calendar day, using all data for the given calendar day-pentad from the data period for a reference climate.	days
Number of Ice Days (Tmax < 0°C)	id	The average aggregated number of days where the daily maximum temperature is < 0°C in the data period.	days

Source: Excerpted from World Bank Group. 2024. Metadata – Climate Change Knowledge Portal (CCKP).

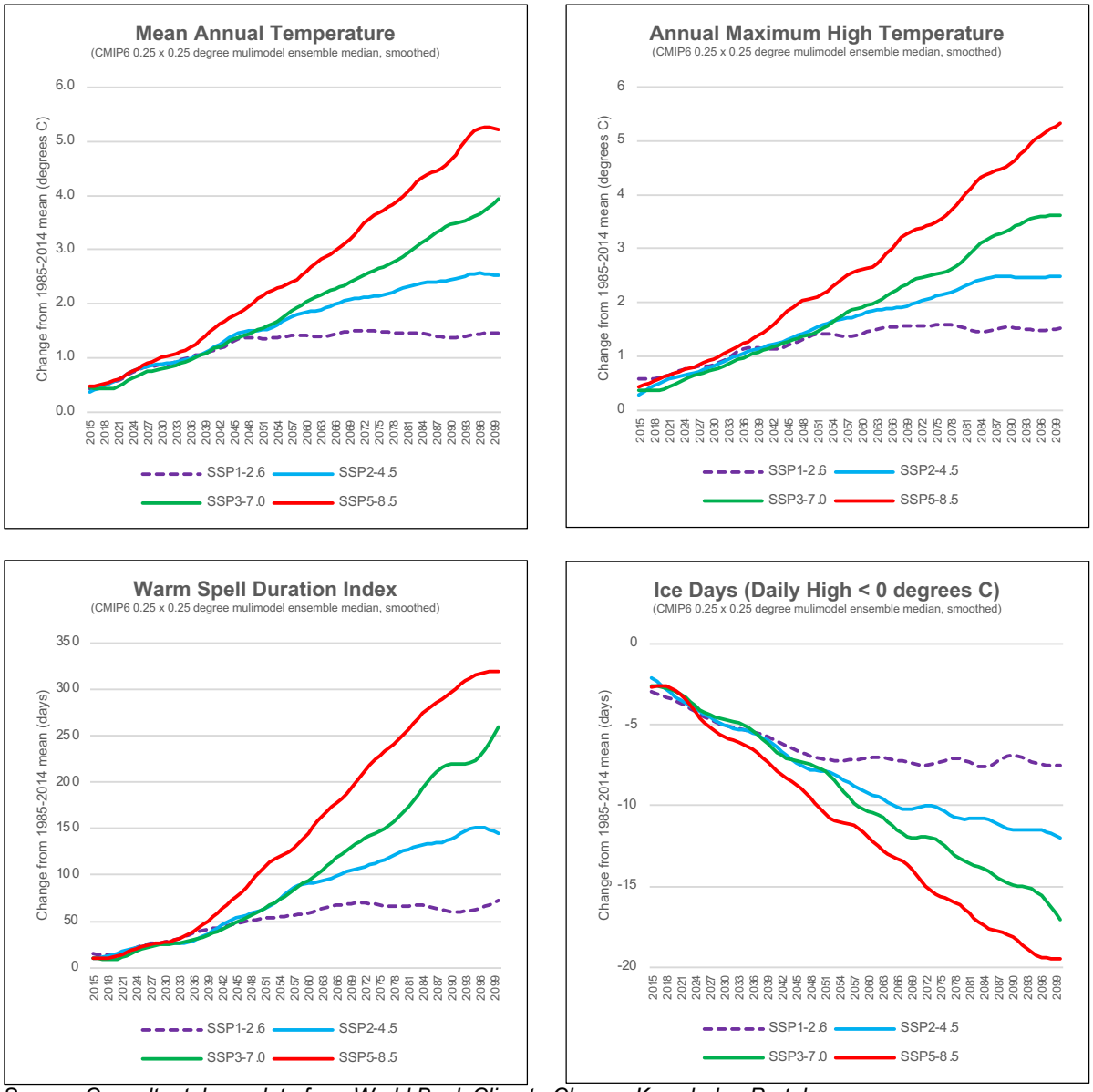
72. Projection data were gathered from the CMIP6 datasets for each of the indicators shown in Table 8, for both a 30-year baseline period (1985–2014) and an 85-year projection period (2015–2100), for each of the four representative Shared Socioeconomic Pathways (SSPs) prioritized for modeling by the Intergovernmental Panel on Climate Change (IPCC).[7] The data presented in the graphs below represent the median values generated for each parameter by the suite of approximately 30 global climate modeling groups (the multi-model ensemble median). For each indicator-SSP pairing, the projection data were compared to the baseline to characterize projected changes as anomalies from the baseline mean. The baseline data are modeled historical conditions generated by the same 30 global climate models, and the multi-model ensemble median was used. Empirical datasets from Bhutan's network of weather stations are insufficiently robust to permit comparison between the empirical mean and modeled projections.

73. **Temperature anomalies.** In common with the rest of the world, Bhutan is projected to experience a steady rise in mean annual surface temperature over the remainder of the present century under all but the most optimistic climate change scenarios. The generalized temperature increase is projected to be accompanied by an increase in the temperature reached on the hottest days, and in the duration of warm spells. Higher-altitude locations that normally experience freezing temperatures are likely to see fewer freezing days per year, and less frequent and durable deep freezes. These projected temperature trends are shown in Figure 13.

74. The projected temperature-related trends can be expected to increase the incidence and severity of forest fires, which may cause road closures and increase the risk of rockfalls and debris flows affecting the road network. Increasing temperatures at high altitudes are likely to accelerate glacial melting, changing river discharge patterns in ways that may affect bridges in some basins through higher peak flows or shifts in patterns of scour risk. A higher proportion of annual precipitation at higher elevations may fall as rain rather than snow, which would also contribute to altered river discharge patterns. Accelerated glacial melting increases the risk of glacial lake outburst floods, which may threaten bridge and road infrastructure in river basins with significant glacial ice mass. Some mid-altitude roads now affected by frequent freeze-thaw cycles may see

[7] SSP1-2.6 – 'Sustainability'; SSP2-4.5 – 'Middle of the Road'; SSP3-7.0 – 'Regional Rivalry'; SSP5-8.5 – 'Fossil-Fueled Development'

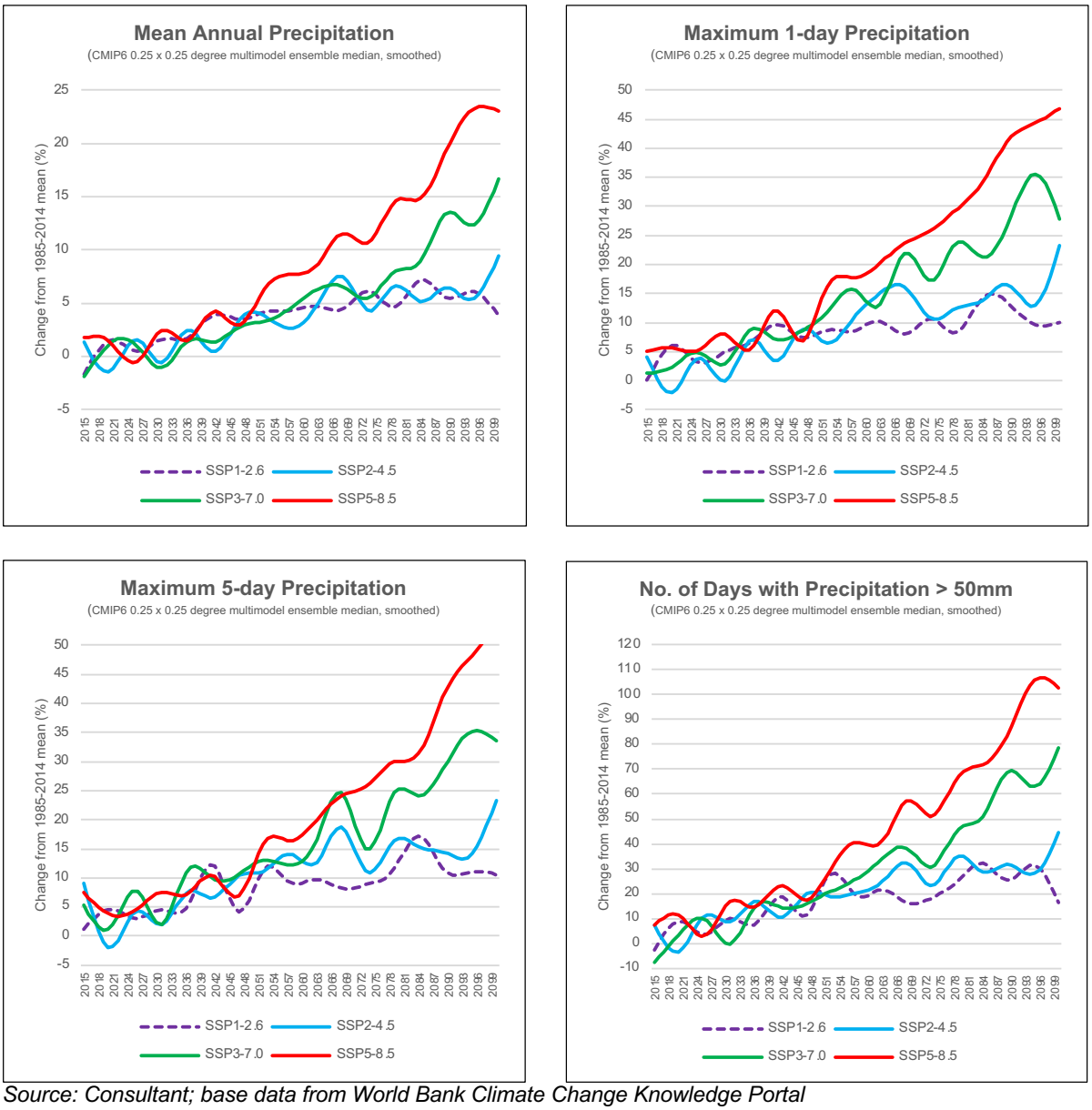
fewer of these, and some may even become frost-free year-round; deicing and snow removal needs may trend lower over time in some areas.



Source: Consultant; base data from World Bank Climate Change Knowledge Portal

Figure 13: Projected Temperature Anomalies for Bhutan, 2015–2100

75. **Precipitation anomalies.** Projected change in precipitation patterns over the remainder of the century is less linear than the steady progression expected for temperature, but the overall trend for all precipitation parameters is upward (see Figure 14). A significant increase in annual precipitation is projected under all four scenarios. Increases in maximum 1-day precipitation, maximum 5-day precipitation and the number of days with precipitation exceeding 50 mm suggest intensification of precipitation. It is likely that a greater proportion of annual precipitation will come during extreme rainfall events. Seasonal analysis not shown in Figure 14 indicates slightly higher growth in precipitation during the monsoon months than for the whole year.



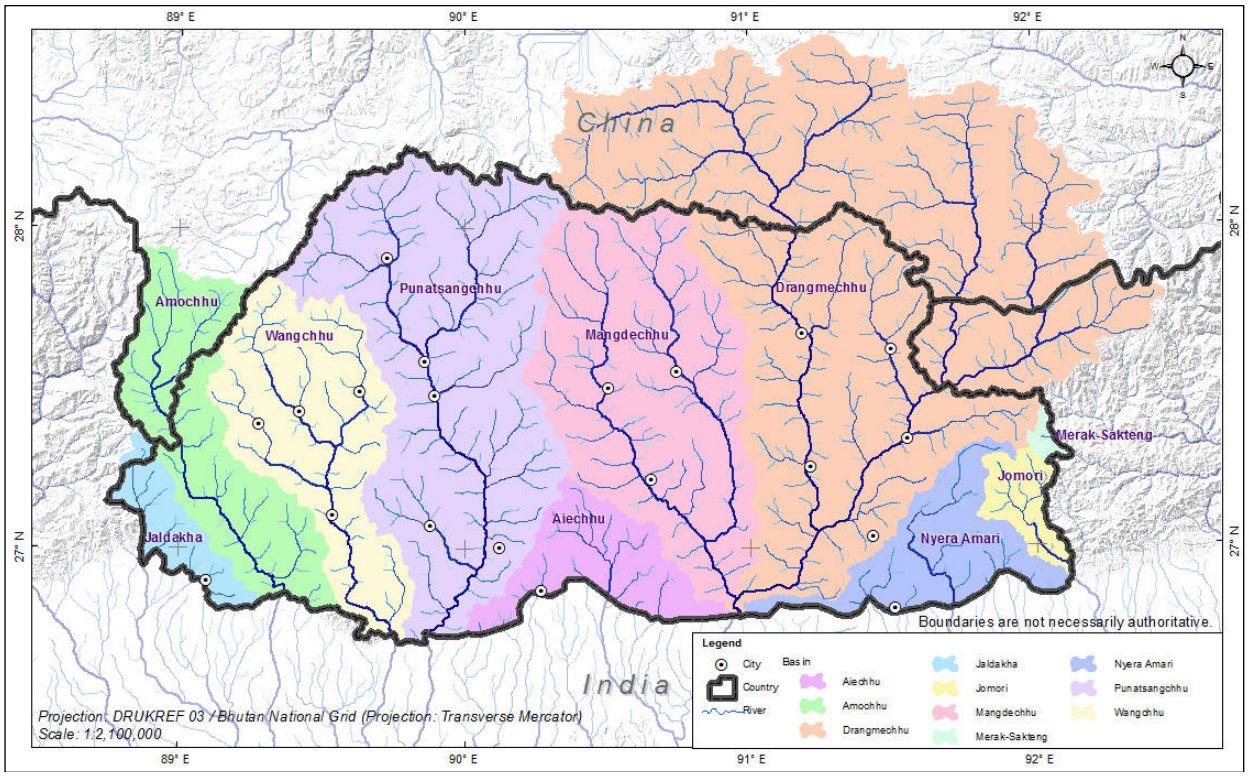
Source: Consultant; base data from World Bank Climate Change Knowledge Portal

Figure 14: Projected Precipitation Anomalies for Bhutan, 2015–2100

76. The projected precipitation changes illustrated in Figure 14 are indicative of growing challenges for road infrastructure, particularly with respect to drainage, flood risk, and landslide risk. Growth in mean annual precipitation will likely increase river discharges in general, and intensification of rainfall will almost certainly increase peak flows in most basins. In combination with increased glacial meltwater, these trends suggest greater flood risks to bridges on the main stems of rivers, and a higher incidence of culverts and bridges being washed out due to insufficient clearance and discharge capacity. More intense rainfall events would be expected to increase the severity of flash floods that similarly threaten under-designed bridges and culverts. Roadside drainage structures are likely to overflow more frequently, contributing to surface and subgrade damage and erosion-related slope stability risks. As precipitation and precipitation intensity increase, slope saturation will rise in general, and this can be expected to produce an increase in the frequency and magnitude of landslides, which are already the most serious threat to the resilience of the road network.

3. Water Resources

77. Bhutan has abundant surface water resources, due to high annual rainfall and the storage of large volumes of ice in glaciers distributed across the northern fringe of the country and in the upper Amochhu and Dragmechhu basins, which extend well into China (see Figure 15). The vast majority of the country's rivers and streams have exceptionally good water quality, thanks to extensive forest cover in watersheds and the relative paucity of large human settlements and polluting industries. Virtually all of Bhutan's rivers are high-energy, steep-gradient watercourses, and this translates to enormous hydropower potential. In addition to rivers and streams, Bhutan has many tarns and glacial lakes at high altitudes, and a modest number of wetland areas.



Source: National Environment Commission. 2016. National Integrated Water Resources Management Plan 2016.

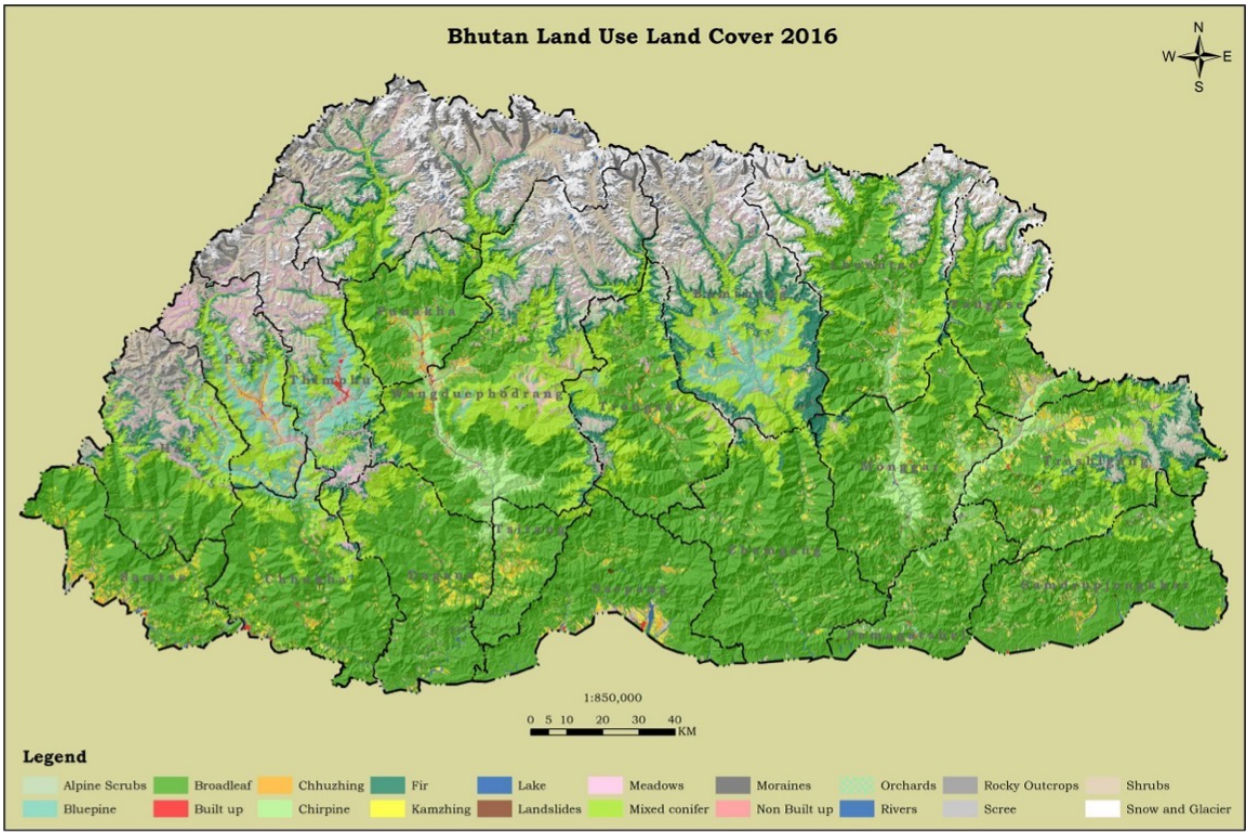
Figure 15: River Basins of Bhutan

78. Although surface water resources are plentiful in aggregate, water availability is a concern outside the monsoon season in some locations where settlements and cropland are perched on tablelands and mountainsides high above the nearest river, making water delivery for domestic and agricultural use expensive and technically difficult. Water storage has not been widely practiced; this is increasingly being explored for communities reliant solely on rainfall, ephemeral springs and intermittent streams and rivulets. Groundwater is infrequently exploited in Bhutan, except at natural springs. Little research has been undertaken on the distribution or dynamics of groundwater flows in Bhutan.[8]

[8] National Environment Commission. 2016. National Integrated Water Resources Management Plan 2016.

4. Land Cover and Land Use

79. Bhutan's constitution mandates the permanent maintenance of at least 60% of the national territory in a forested state, and as of 2022, land cover was classified as forest across 71.6% of the country. Forest cover in Bhutan showed a modest but consistent yearly increase over the 2000–2022 period, climbing from 65.5% in 2000; this contrasts with the global by-country forest cover percentage, which showed a steady year-over-year downtrend from 32.4% in 2000 to 31.1% in 2021.[9] Well over half (64.9%) of Bhutan's forest area in 2016 was classified as broadleaf forest; this cover class predominates in the lower-altitude southern portions of the country. Mixed conifer forests accounted for 19.1% of total forest cover in 2016, followed by other coniferous classes: fir (8.5%), blue pine (3.7%) and chir pine (3.7%). Lands vegetated primarily by shrubs and thus not classified as forest accounted for 9.7% of the country in 2016.[10] The distribution of forest types can be seen in Figure 16.[11]



Source: Department of Forests and Park Services (Forest Resources Management Division). 2017. Land Use and Land Cover of Bhutan 2016 – Maps and Statistics.

Figure 16: Land Cover and Land Use, 2016

[9] World Bank. World Development Indicators Databank, updated to 12/16/2024.
[10] Department of Forests and Park Services (Forest Resources Management Division). 2017. Land Use and Land Cover of Bhutan 2016 – Maps and Statistics. Thimphu.
[11] The Land Use and Land Cover analysis was updated in 2020, but the 2016 data and map are shown here because the 2020 analysis collapsed the forest cover and agricultural use categories, making the information less illustrative of the country's resource diversity than the 2016 version. Changes in overall percentages of forest cover and agricultural land from 2016 to 2020 are not significant to the baseline assessment.

80. A sizable portion of the northern reaches of the country is characterized by either alpine scrubs and meadows or areas of bare rock, moraine, scree, snow and ice where vegetation is sparse or non-existent. Such areas accounted for about 16% of the country's total area in 2016.

81. Just 2.75% of the national territory was cultivated land in 2016, of which about two thirds (64.6%) was rainfed (*kamzhing*), with most of the rest (30.2%) being irrigated and bench- terraced land (*chhuzhing*). Orchards made up 5.2% of the cultivated area. Cultivated land is concentrated along prominent rivers and road corridors. Built-up areas are very limited in Bhutan, covering just 0.19% of the country in 2016; this class includes all human-made impervious surfaces, including urban areas, roads, airports and buildings.

5. Biodiversity and Conservation Areas

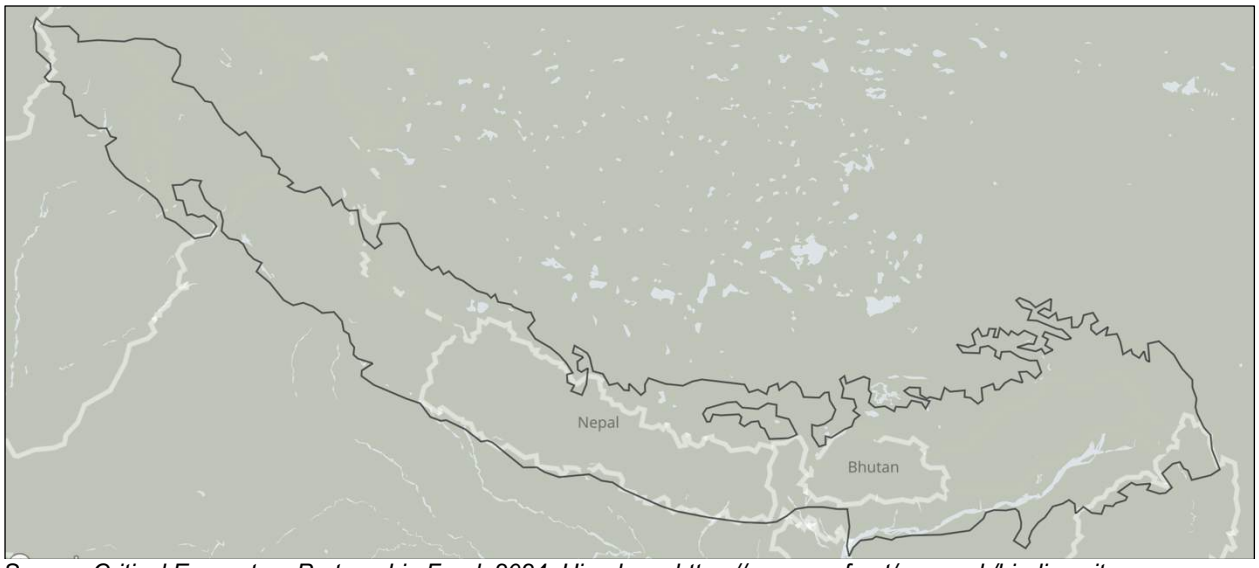
82. Bhutan is blessed with rich biodiversity, due to its altitudinal range, highly varied topography, and position at the intersection of the Indo-Malayan and Paleo-Arctic biogeographical realms.[12] Low historical human population, physical constraints on settlement and extractive land use, a high proportion of land under state ownership, and foresightful government policy have combined to preserve the country's natural heritage to an impressive degree. The country's high prevalence of wild forested landscapes providing safe refuge for myriad species is significant at the national, regional and global scales, and this is reflected in conservation interest and conservation-targeted financial resources directed towards Bhutan from international NGOs, bilateral aid agencies and multilateral institutions. A historical legacy of capable stewardship of wild species and spaces is a central element of Bhutan's image and branding, and an important pull factor for international tourism.

a. Species Diversity and Species of Concern

83. Some 11,248 wild species have been documented in Bhutan so far, a remarkable number for a relatively small territory. Bhutan is wholly within the Himalayas Biodiversity Hotspot (see Figure 17), one of 36 hotspots around the world which collectively comprise just 2.5% of the earth's land surface, yet contain more than half of the world's known plant species as endemics and over 40% of bird, mammal, reptile and amphibian species as endemics.[13]

84. Among Bhutan's thousands of known species are 134 species considered by the World Conservation Union (IUCN) to be in danger of serious population decline and eventual extinction. Globally threatened species in Bhutan include 21 species classified as critically endangered (CR), 43 endangered species (EN), and 70 considered vulnerable (VU).[14] Targeted national conservation plans have been developed for several high-profile species, including the Asian elephant (*Elephas maximus*), Tiger (*Panthera tigris*), White-bellied heron (*Ardea insignis*), Black-necked crane (*Grus nigricollis*), Asiatic black bear (*Ursus thibetanus*), Red panda (*Ailurus fulgens*), Golden mahseer (*Tor putitora*) and Hornbills (several species).

[12] Dinerstein, E. et al. 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm, BioScience 67(6): 534–545. https://doi.org/10.1093/biosci/bix014.
[13] Conservation International. 2024. Biodiversity Hotspots. https://www.conservation.org.
[14] Nepal, T.K. and Manita. 2021. An Updated Checklist of Globally Threatened Species in Bhutan as Listed in IUCN Red List of Threatened Species. Preprint, February 2021. DOI:10.20944/preprints202102.0124.v1.



Source: Critical Ecosystem Partnership Fund. 2024. Himalaya. https://www.cepf.net/our-work/biodiversity-hotspots/himalaya

Figure 17: Himalayas Biodiversity Hotspot

b. Bhutan's Protected Area Network

85. Bhutan has a world-leading protected area system with respect to both areal coverage and ecological connectivity. The protected area system is composed of 10 protected areas and nine biological corridors (see Figure 18). Approximately 52% of the national territory is under protective management within protected areas, giving Bhutan the highest percentage of protected land of any Asian country.[15]

86. **Protected areas.** Development of what is now a national protected area network began in 1964 with the reclassification of a game reserve covering the alluvial plains and foothills around the Manas River as the Manas Wildlife Sanctuary. This was followed in 1974 by the designation of the Jigme Dorji Wildlife Sanctuary, covering much of the northern part of the country, and establishment of a Reserved Forest in the area now occupied by the Phibsoo Wildlife Sanctuary. Following reviews of Bhutan's conservation efforts in the 1980s, a country-level system approach was adopted, and a major revision and expansion were set in motion from 1993 onwards. The Manas and Jigme Dorji Wildlife Sanctuaries were upgraded to national parks and Phibsoo was gazetted as a wildlife sanctuary. Thrumsingla (now Phrumsengla) National Park and Jigme Singye Wangchuck National Park were established to bring exemplars of mid-latitude temperate forest into the protected area system. The Toorsa (now Jigme Khesar) Strict Nature Reserve in the far west, and Jomoshangkha Wildlife Sanctuary in the far east, where established, and the Bumdelling Wildlife Sanctuary was created from lands previously part of the Jigme Dorji Wildlife Sanctuary. The Sakteng Wildlife Sanctuary was added to the protected area system in 2003, and part of the Jigme Dorji National Park was redesignated as the Wangchuck Centennial Park in 2008.[16]

[15] Conservation Corridor. 2023. Connectivity in National Policies: Bhutan. Corridor Policy Digest, July 31, 2023.
[16] History composed based on protected area profiles and management plans presented on the website of the Department of Forests and Park Services (https://www.DOFPS.gov.bt/).

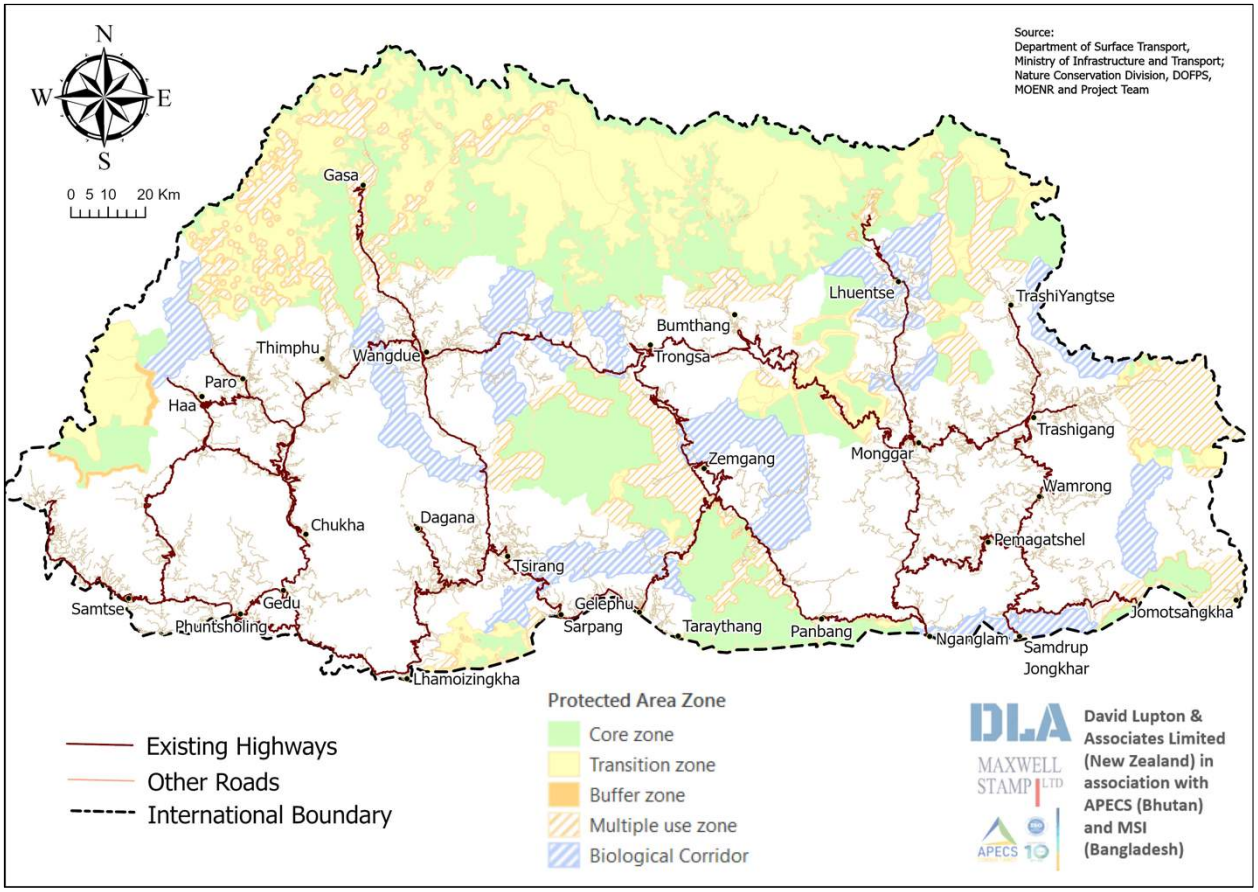


Figure 18: Protected Area Network of Bhutan

87. Protected areas in Bhutan are established pursuant to the Forest and Nature Conservation Act (1995) and its predecessor the Bhutan Forest Act (1969), and are administered by the Department of Forests and Park Services (DOFPS). All of Bhutan's protected areas are zoned, in accordance with the Protected Area Zonation Guidelines of Bhutan (2020). The characteristics, management objectives and permitted activities of the four zone classes applied in Bhutan are outlined in Table 9. The two most restrictive zone classes (core zone and transition zone) strictly prohibit most human activity, including infrastructure development.

Table 9. Protected Area Management Zone Classes in Bhutan

Description	Management Objectives	Permitted Activities
Core Zone		
Areas with features of high conservation significance, such as: • high biodiversity and/or endemism • refugia for threatened species • critical aquatic habitats • important feeding, salt lick and watering sites • important migration routes	Strict preservation; anthropogenic disturbance prohibited, with only two exceptions	• Approved ecological research • Approved habitat management
Transition Zone		
Areas with similar ecological values to core zones, but in which	Strict preservation most of the time, with limited windows for certain traditional resource uses	Approved, time-bound resource use including:

Description	Management Objectives	Permitted Activities
traditional resource use shapes the landscape		• Collection of non-wood forest produce • Seasonal grazing • Use of traditional/ancient trails • Seasonal firewood collection
Buffer Zone		
Strips of land around core and transition zones where these are near settled areas and infrastructure	Maintain low-intensity land use to 'cushion' the core or transition area from effects of intensive land uses	• Environmental education • Tourism • Traditional resource use • Recreation facilities • Timber extraction (with permits from all concerned agencies) • Non-timber forest product extraction (with permits from all concerned agencies) • Infrastructure development (with permits from all concerned agencies)
Multiple-Use Zone		
Areas within protected area where stakeholders agree to work together to manage land and resource use in a sustainable manner to benefit both people and wildlife; may include settlements, built-up areas, private lands and resource allocation areas for residents	Manage land and resource use, through cooperation between residents and park management authorities, to maintain significant conservation values while supporting residents' natural resource-based livelihoods	• Timber extraction (with written permission of DOFPS) • Quarrying for local uses (with written permission of DOFPS) • Developmental activity (with written permission of DOFPS) • Infrastructure including roads (with written permission of DOFPS)

Source: Department of Forests and Park Services. 2020. Protected Area Zonation Guidelines of Bhutan.

88. **Biological corridors.** Bhutan's protected area system is one of the few national protected area systems in the world with the potential to function as a true ecological network, as opposed to a disparate collection of isolated blocks of protected habitat. This is enabled by a series of legally designated biological corridors, first established in 1999. Each of the 10 protected areas is linked to at least one other protected area via a biological corridor.

89. Biological corridors are set aside specifically to maintain ecological connectivity between protected areas, and are intended to be managed in ways that enable the safe movement of wildlife and long-term flows of germplasm. New settlements, quarrying and mining, and leasing of land for grazing are prohibited in biological corridors, while numerous other categories of resource use and development activity are generally prohibited but subject to case-by-case permission granted by DOFPS. Building of roads and other infrastructure is among the categories of activity that require special permission to undertake.[17]

90. Management of the protected area system is supported by a multilateral financing arrangement called Bhutan for Life, which has made investments in building protective management capacity and developing internal revenue sources including ecotourism, sustainable extraction and payment for environmental services. Based on a Project Finance for Permanence (PFP) model, the program is set to culminate in a self-supporting protected area system and professional conservation corps capable of ensuring consistent and permanent protection.[18]

[17] Ministry of Agriculture, Department of Forests. 2007. Rules on Biological Corridors – Addendum to the Forest and Nature Conservation Rules 2006).
[18] Bhutan for Life Prospectus (undated).

c. Biodiversity Outside the Protected Area Network

91. As a lightly populated, well forested country with topography that seriously constrains intensive exploitation of natural resources, Bhutan retains very substantial biodiversity outside its network of formally protected areas. In addition to statutory protected areas and corridors, a number of other areas have been internationally recognized as Key Biodiversity Areas (KBAs) and Ramsar Wetlands of International Importance, and these are targeted for special attention by Bhutan's conservation agencies. Several areas of high conservation value (HCVs) have also recently been identified outside of the protected area system, and these are similarly of interest for conservation management by the relevant agencies (see Figure 19). Some of these non-statutory conservation sites overlap in whole or in part with statutory protected areas and biological corridors shown in Figure 18. Numerous segments of the national highways network traverse or border statutory and non-statutory protected areas.

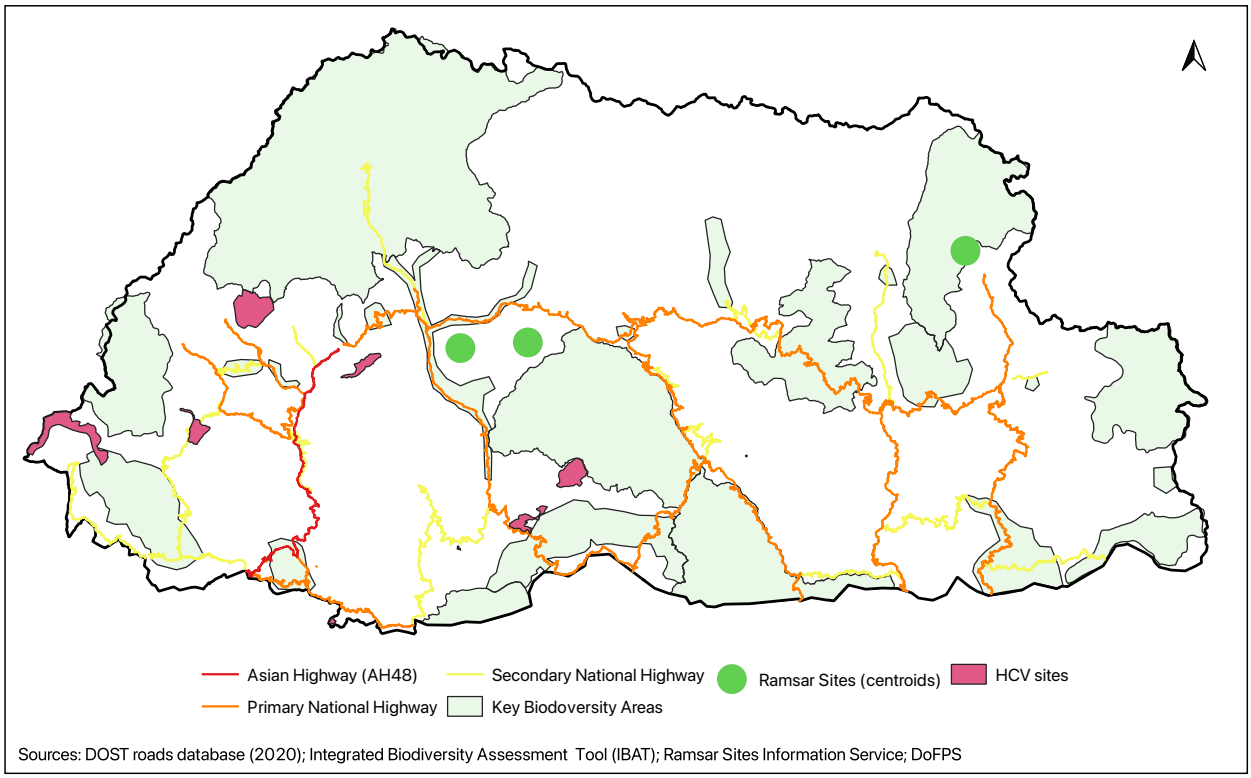


Figure 19: Key Biodiversity Areas, Ramsar Sites and HCVs

d. Regional Ecological Linkages

92. Contiguity with wild spaces outside the national boundary, in India and China, further enhances and broadens the ecological significance of Bhutan's fully interconnected protected area system. For some wide-ranging species such as the Tiger, Bhutan's protected landscapes can be understood as a critical link between remaining viable ranges in the western and eastern Himalayas, China and Southeast Asia. Physical connectivity such as that enabled by Bhutan's integral protected area system is taking on heightened significance as a means of accommodating and enabling the gradual shifting of migration patterns and spatial redistribution of ecosystem types that is already starting to take place under the influence of climate change.

E. Socioeconomic Conditions

1. Demographics

93. Bhutan is a sparsely populated country, with projected 2022 population of 763,200 people and overall population density of 19.0/km^2. The five most populous and densely populated dzongkhags are all in the western half of the country. Only three towns (all in the west) had populations over 10,000 people as of the 2017 national census: Thimphu (114,551), Phuentsholing (27,658) and Paro (11,448). These towns have good connectivity to the Asian Highway, the country's most advanced and reliable transport route.

94. The national population is experiencing modest growth, with projected average annual growth at +1.08% for the 2005–2022 period. Population growth appears to be slowing, as projected average annual growth for 2017–2022 is just +0.97%/yr, as compared to +1.13%/yr for 2005–2017. This trend may be attributable to a combination of low fertility (1.7 live births per woman in 2017) and increasing out-migration. Looking to future decades, the National Statistics Bureau projects a continuing gradual decline in the population growth rate. The projected trend in the national total population to 2047 is shown in Table 10.

Table 10: Projected Population Growth to 2047 (Bhutan)

Year	2017	2022	2027	2032	2037	2042	2047
Population[1]	727,000	763,000	797,000	827,000	851,000	869,000	884,000
Growth rate[2]	--	0.97%	0.88%	0.73%	0.58%	0.44%	0.32%

[1] Rounded to nearest thousand
[2] Annual average growth rate for previous five years

Source: National Statistics Bureau 2019. Population Projections Bhutan 2017-2047.

95. Bhutan's population is young on average, with median age 26.9 years as of the 2017 national census. The sex ratio is strongly skewed towards males (110 males for every 100 females in 2017); attribution for high sex ratios such as this is often difficult to determine, but dependence on foreign workers (nearly all male) in sectors such as construction may play a role in the case of Bhutan.

96. Migration is a topic of considerable concern in Bhutan. Rural–urban migration is reflected in population data which show strong growth in major towns and even relatively small towns, as compared to the national average, and population decline in areas outside of towns (see Table 11). The proportion of the national population living in the country's 10 largest towns rose from 21.6% in 2005 to 28.5% in 2017, and the proportion living in towns over 500 people rose from 52% in 2005 to 66.0% in 2017. An analysis conducted by the National Bureau of Statistics found that 38% of the national population was 'urban' in 2017, up from 31% in 2005.[19]

97. Rural–urban migration has been linked to a persistent and worsening labor shortage in Bhutan's agricultural sector, as well as growing problems in destination towns that are ill-prepared for rapid growth. However, it is also understood as an inevitable element of the country's transition from a primarily agrarian economy to one driven by manufacturing and services, which is in turn associated with gains in poverty reduction at the national level.[20]

[19] See National Statistics Bureau of Bhutan. 2018. Rural–Urban Migration and Urbanization in Bhutan.
[20] Ibid.

Table 11: Census Data Reflecting Rural–Urban Migration, 2005–2017

	Population 2005 Census	Population 2017 Census	Annual Average Growth 2005–2017
All of Bhutan	634,982	727,145	+1.12%/yr
In 10 largest towns	137,013	207,130	+3.44%/yr
In towns over 500 people[1]	330,456	479,735	+3.11%/yr
Not in towns over 500 people	304,526	247,410	-1.73%/yr

[1] Towns over 500 people in either 2005 or 2017, as classified based on national census data

Source: Base data from www.citypopulation.de and National Bureau of Statistics

98. International emigration, particularly of young people, is widely observed in Bhutan. Quantitative estimates of emigrant flows are difficult to generate via usual census methods, and the available data are thought likely to underestimate emigration. Based on the 2017 national census, India is the most frequent destination, accepting 39% of documented Bhutanese emigrants, followed by Australia (29%), the United States (10%), other Asian countries taken as a group (10%), and the Gulf States (8%). Emigrants to India have been mostly male, while women are more numerous emigrants to other countries, especially the Gulf States and the United States. Emigrants are mostly individuals seeking employment or education rather than entire households relocating. About half of recorded emigrants fall in the 20–29 age range.[21] Although associated with beneficial remittances, emigration from Bhutan has also been linked to labor shortages in the countryside and understood as a 'brain drain' with dire effects in the civil service especially. Data from the next national census in 2027 will be closely scrutinized for insights on emigration.

2. Income and Employment

a. Income

99. As of December 2023, Bhutan is considered by the United Nations to have graduated from Least Developed Country status to the Developing Country category, based on rising per capita income; improvements in health, education and equity indicators; and reduced levels of economic and environmental vulnerability.[22] Bhutan's per capita GDP was USD 3,920 in 2023, which compares favorably with the same measure in its South Asian neighbors Bangladesh (USD 2,652), India (USD 2,497) and Nepal (USD 1,316).[23] Table 13 shows the recent growth trajectory for nominal GDP and GDP per capita in Bhutan, which illustrates a marked dip in both as a result of the COVID-19 pandemic.

Table 12: GDP and GDP Growth, 2017–2023

Indicator[1]	2017	2018	2019	2020	2021	2022	2023	Growth rate[2]
GDP (million Nu.)	168,753	176,673	192,648	182,107	204,664	227,814	249,388	6.2%
GDP (million USD)	2,592	2,583	2,736	2,457	2,768	2,898	3,019	
GDP per capita (Nu.)	229,424	240,576	259,748	243,156	270,674	301,290	323,764	5.4%
GDP per capita (USD)	3,524	3,517	3,689	3,281	3,661	3,833	3,920	

[1] All GDP figures are nominal (current prices). [2] Average annual growth rate 2017–2023

Source: National Accounts Statistics, 2024

[21] Ibid.
[22] United Nations Department of Economic and Social Affairs. 2024. Least Developed Country Category: Bhutan Profile. https://www.un.org/development/desa/dpad/least-developed-country-category-bhutan.html.
[23] International Monetary Fund, World Economic Outlook October 2024. https://www.imf.org/external/datamapper.

100. The 2022 Bhutan Living Standards Survey found that the incidence of monetary poverty was 12.4% nationally. Just 1% of surveyed households nationally self-reported as 'very poor' in 2022 (as compared to 2.1% in the 2017 survey), while 13.2% self-reported as 'poor' (13% in 2017), 9.1% as 'not poor' (20.1 % in 2017), and 76.2% as 'neither poor nor not poor' (62.6% in 2017).[24]

b. Employment

101. The leading source of employment in Bhutan in 2022 was the combined agriculture, forestry and fishing sector, which accounted for 43.5% of the employed workforce. Almost all people employed in this sector were self-employed or worked in family operations. Other major employment sectors were public administration and defense (10.6%), wholesale and retail trade (9.5%), manufacturing (6.8%), construction (6.4%) and education (5.7%). Just over 30,000 people worked in the civil service in 2022. About 140,000 approvals were granted to foreign workers in 2022–2023, 90% of which were for employment in the 'craft and related trades' which includes construction.[25] In 2022, 25% of employed people worked in the public sector (including the armed forces), 74.7% were employed in the private sector, and 0.4% worked for NGOs or CSOs.[26]

102. Women made up 52% of the working age population in 2022, but were less likely than men to have paid employment (see Table 13). Overall unemployment was moderate in 2022, but youth unemployment (28.6%) was markedly elevated compared to other SAARC countries (average 17.4%) and the global average (14.2%).[27]

Table 13: Key Labor Market Indicators, 2022

Indicator	Male	Female	All
Working age population (15 and above)	233,437	251,529	484,965
Labor force participation rate (%)	73.4	53.5	63.1
Employment rate (%)	95.6	92.1	94.1
Unemployment rate (%)	4.4	7.9	5.9
Youth unemployment rate (%)	24.4	32.8	28.6

Source: National Statistics Bureau. Statistical Yearbook of Bhutan 2023.

3. Key Economic Sector Activity

a. Agriculture, Livestock and Forestry

103. Together, agriculture, livestock and forestry amounted to 14.7% of the national economy in 2022 (agriculture 6.8%, livestock 5.3%, forestry 2.6%).[28] Bhutan had an estimated 67,000 agricultural households in 2021.[29] Agricultural production is varied, and includes both tropical and temperate crops. The ten leading crops by tonnage in 2022 were irrigated rice, potatoes, maize, mandarin oranges, areca nut, chili, pumpkin/squash/gourd, ginger, cabbage and turnip.[30]

[24] National Statistics Bureau. Bhutan Livings Standards Survey 2022 and Bhutan Living Standards Survey 2017.
[25] National Statistics Bureau. Statistical Yearbook of Bhutan 2023.
[26] National Statistics Bureau. 2022 Labour Force Survey Report.
[27] World Bank. 2024. Unemployment, youth total (% of total labor work force ages 15–24), modeled ILO estimate. https://data.worldbank.org/indicator/SL.UEM.1524.ZS
[28] national Statistics Bureau. National Accounts Statistics 2023.
[29] National Statistics Bureau. Agriculture Survey Report 2021.
[30] National Statistics Bureau. Statistical Yearbook of Bhutan 2023.

104. Livestock is widely held in Bhutan, with 53,974 households and 175 institutional entities across all 20 dzongkhags owning at least some livestock in 2021. The most frequently owned livestock are Jersey cross cattle (30,000 holders), poultry (22,000), Nublang/Thrabum cattle (20,000) and goats (10,000). The top five dzongkhags for milk production in 2021 were Trashigang, Samtse, Wangdue Phodrang, Sarpang and Tsirang. Chicken accounted for just under half of all meat produced in the country in 2021, with beef comprising about one quarter, and pork one fifth. Fish made up about 5% of total meat production; aquaculture is concentrated in the three foothills dzongkhags of Sarpang, Dagana and Tsirang.[31]

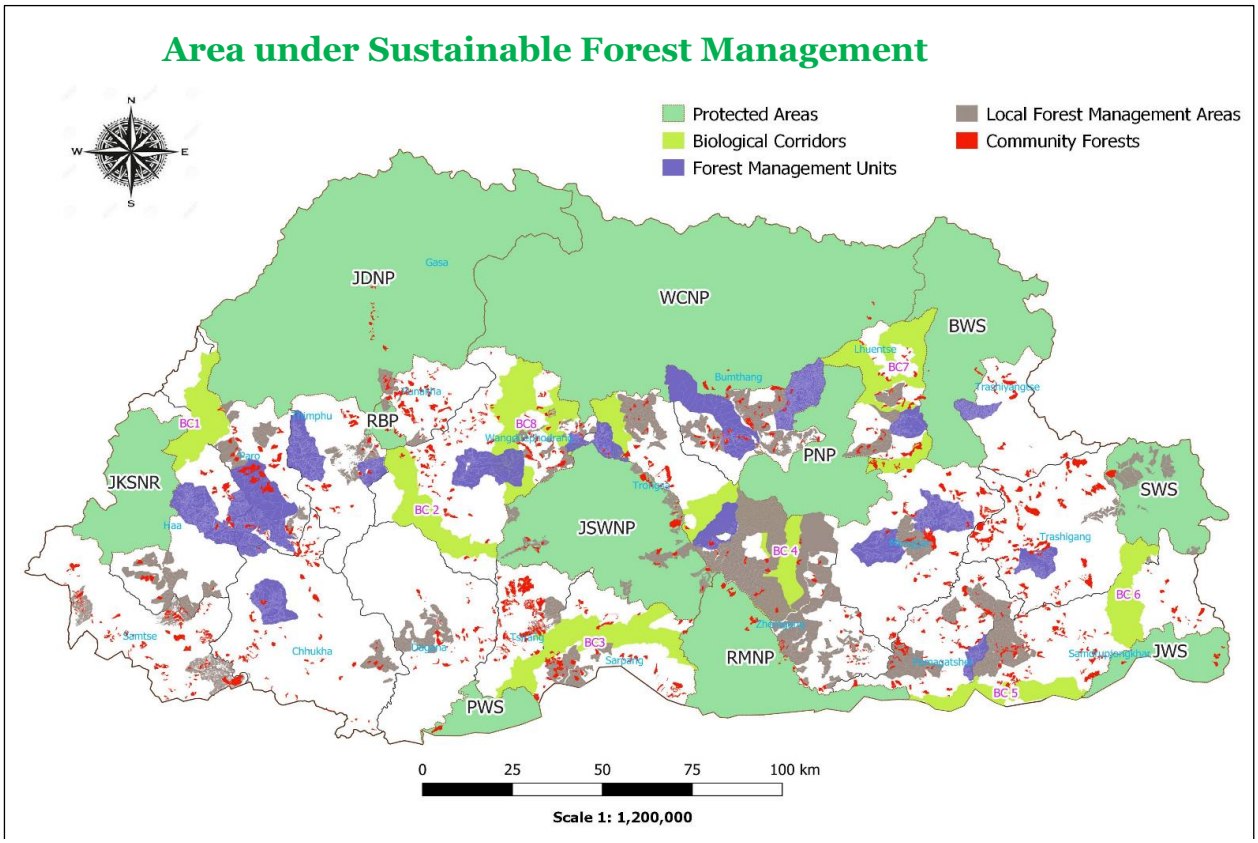
105. Most agricultural production serves local consumption, as access to domestic urban and export markets is constrained by high spoilage from long travel times, high transport costs, low by-producer volume and lack of inter-producer organization for consolidation and marketing.[32] The leading agricultural export in 2021 was whole cardamom; other exported goods included potatoes, oranges, ginger and betel nut. Livestock and livestock products do not figure among the country's major exports.[33]

106. Bhutan had approximately 2.7 million ha of forest land as of 2021, of which 22% was managed under officially designated extractive use regimes, which include Local Forest Management Areas (11%), Forest Management Units (7%) and Community Forests (4%).[34] Large areas of forest are managed as part of protected areas and biological corridors. Much of the country's forest area is difficult to access and manage for forestry purposes due to steep terrain and distance from roads.

107. The annual allowable cut from Forest Management Areas and Forest Management Units is apportioned to timber (67% in 2020) and firewood (33%). In 2020, 74% of the annual allowable cut was allocated to commercial uses, and 26% to local people's uses. A portion of the commercial harvest is undertaken by the government-owned Natural Resources Development Corporation. As of 2021, there were 856 Community Forests registered, involving 35,377 households;[35] it is not clear how many of these are functional and actively operating under an approved management plan. There is not a significant export market for wood or wood products, although some exporting of raw timber has been permitted in the last several years under a temporary scientific thinning program overseen by the DOFPS.

108. Non-timber forest product (NTFP) royalties are collected on 42 different categories of plants, plant materials and fungi legally gathered in Bhutan's forests. The most valuable of these by far is the fungus *Ophiocordyceps sinensis*, which is prized in Chinese and Tibetan medicine, and is one of Bhutan's leading exports by value. Other NTFPs for which royalties are paid include such materials as stones, boulders, gravel, sand, and soil. Royalties from plant and fungus materials approximately equaled royalties from stones, gravel, etc. in 2020.[36]

[31] National Statistics Bureau. Livestock Census 2021.
[32] Department of Agricultural Marketing and Cooperatives. 2021. Renewable Natural Resources Marketing Strategy.
[33] Ministry of External Affairs. Annual Trade Statistics 2021.
[34] Department of Forests and Park Services. Annual Forestry Statistics 2021.
[35] Department of Forests and Park Services. Annual Forestry Statistics 2021.
[36] Department of Forests and Park Services. Annual Forestry Statistics 2021.



Source: Department of Forests and Park Services. Annual Forestry Statistics 2021.

Figure 20: Areas Under Different Forest Management Regimes

b. Mining and Manufacturing

109. Mining activity in Bhutan is concentrated in the southern region, which had about 70% of all mining and quarrying establishments in 2017. Chukha and Samtse have notable concentrations of large and medium mineral-based industrial establishments, each with 21% of the national total of such entities.[37] Mining and mineral processing are mostly based around the limestones and other sedimentary-origin materials prevalent in the south, and produce such products as cement, gypsum, calcium carbide and ferrosilicon. Dolomite led total mineral extraction in 2022 with 37%, followed by limestone (34%), coal (11%), gypsum (10%) and iron ore (5%). Lesser amounts of marble, quartzite and boulders were also extracted. Mining and quarrying contributed about 1.8 of GDP in 2022.[38] Mineral commodities comprised eight of the top ten categories of goods exported to India in 2021, with a value of about USD 255 million, or about 81% of the total value of non-hydropower exports to that country. A similar proportion of the value of exports to Bangladesh was made up of mineral commodities.[39]

110. Manufacturing in Bhutan is dominated by the metals and non-metallic minerals sub-sectors, which together accounted for about three quarters of manufacturing activity in 2022. Food processing comprised about 14% of manufacturing.[40] Mineral-based industries made up 40% of all medium and large industrial establishments in 2023, while forest-based industries were more

[37] National Statistics Bureau. National Accounts Statistics 2023.
[38] National Statistics Bureau. National Accounts Statistics 2023.
[39] Ministry of External Affairs. Annual Trade Statistics 2021.
[40] national Statistics Bureau. National Accounts Statistics 2023.

prevalent among cottage and small enterprises (see Table 14).[41] Manufacturing contributed 8.7% of GDP in 2022.

Table 14: Production and Manufacturing by Material Base and Enterprise Size, 2023

	Agro-based	Forest-based	Mineral-based	Other
Medium and large industries	25%	6%	40%	29%
Cottage and small industries	29%	42%	7%	23%
All industry sizes	28%	39%	9%	23%

Source: National Statistics Bureau. Statistical Yearbook 2023.

111. Since at least the Eleventh Five-Year Plan, proposals for expanding Bhutan's industrial capacity have focused on promoting industrial growth poles in the southern border areas, where significant industry already exists and access to external markets is convenient via the nearby Indian road and rail networks. The towns of Samtse, Pasakha, Phuentsholing, Jigmeling, Gelephu, Nganglam, Samdrupjongkhar, Motanga have been targeted for development or expansion of industrial estates and industrial parks.[42]

c. Hydroelectricity

112. The leading economic sector by value is hydropower, which contributed 13.4% of national GDP in 2022, taking account of construction and operation income in addition to electricity sales. Electricity exports to India amounted to about USD 393 million in 2021, which comprised 42% of all exports; approximately 70% of the country's total hydroelectricity production in 2022 was exported to India. Total installed hydroelectric capacity, encompassing six large plants and 22 lesser facilities, is 2,334 MW; over 99% of this figure is accounted for by the six large plants. Four additional large plants are under development, and will collectively add 2,938 MW to installed capacity. Total hydropower potential in Bhutan is estimated at 36,900 MW. Over 99% of households in Bhutan have electricity, and about 95% use it as the main source of energy for lighting and cooking.[43]

d. Tourism

113. Tourism is a significant generator of income, with foreign exchange earnings from the sector reaching USD 88.6 million in pre-COVID 2019, and is seen as having good potential to help diversify and grow economic activity.[44] The RGOB favors a 'high value, low impact' tourism model. Direct government revenue from the Minimum Daily Package Rate (MDPR) levy on international tourists amounted to USD 23.4 million in 2019.[45] The hotels and restaurants sector, which is heavily dependent on flows of foreign tourists, contributed 1.2% to GDP in 2022, down from 2.6% in 2019, before the COVID pandemic. A total of 315,599 international tourists visited Bhutan in 2019, of which 78% were from South Asia, 11% from East Asia and the Pacific, 7% from Europe, 5% from the Americas, and less than 1% from Africa and the Middle East. By far the largest number of tourists from a single country were Indian, accounting for 73% of arrivals.

[41] National Statistics Bureau. Statistical Yearbook 2023.
[42] Ministry of Works and Human Settlements. 2019. The Project for Formation of Comprehensive Development Plan for Bhutan 2030, Final Report.
[43] National Statistics Bureau. Statistical Yearbook 2023.
[44] A post-pandemic recovery has been under way since 2022, but the 2024 update of the Statistical Yearbook, which will show tourist flows for 2022, 2023 and 2024, was not yet available at the time of writing. In this context, the reported 2019 levels are taken as the most reflective of actual tourist flows and revenue.
[45] National Statistics Bureau. National Accounts Statistics 2023.

114. Spring and autumn are the most popular seasons to visit Bhutan, with 32% and 30% of arrivals. Most Indian tourists (86% in 2022) arrive via one of the land borders, while almost all (95% in 2022) visitors from countries other than India arrive by air through Paro International Airport.[46] Table 15 shows the top five destination dzongkhags for tourists within Bhutan in 2019; the data suggest that the benefits from international tourism are not spread very evenly around the country, as about 90% of tourist arrivals and nights accrue to just these five dzongkhags, leaving just one tenth of tourist arrivals and nights for the other 15 dzongkhags combined.

Table 15: Destination Dzongkhags for International Tourists, 2019

Tourist Arrivals (2019)*		Tourist Nights (2019)*	
Dzongkhag	**% of Total**	**Dzongkhag**	**% of total**
Paro	26	Paro	33
Thimphu	26	Thimphu	25
Punakha	24	Punakha	19
Wangdue Phodrang	9	Bumthang	7
Bumthang	5	Wangdue Phodrang	7
All others	10	All others	9
* Includes only international tourists who paid the MDPR (229,663 arrivals, 417,551 nights)			

Source: National Statistics Bureau. Statistical Yearbook of Bhutan 2023

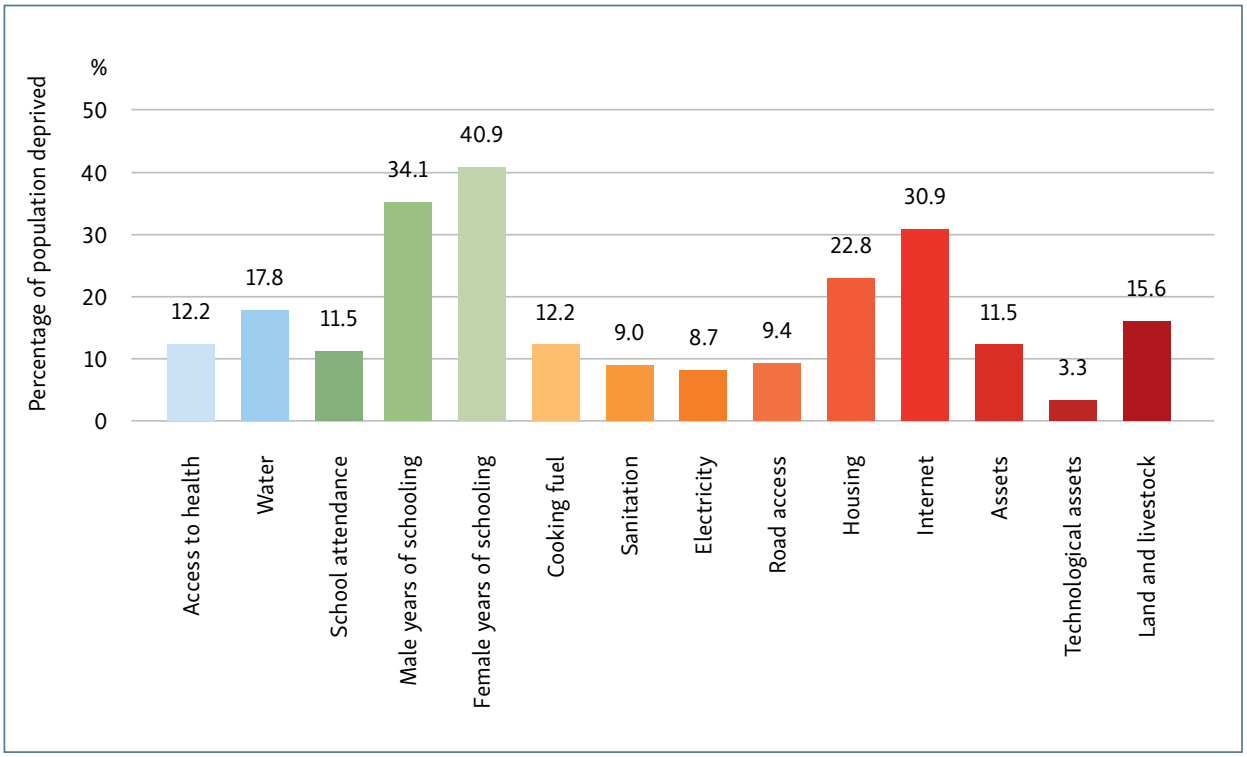
4. Social Equity

a. Poverty Distribution

115. The National Statistics Bureau uses a moderate multidimensional poverty index (MMPI) to assess well-being based on a suite of weighted indicators including health (access to health care services and clean water), education (school attendance and male and female years of schooling), and material living standards (cooking fuel, sanitation, electricity, road access, housing, internet, assets, technological assets, land and livestock).[47] Based on data from the 2022 Bhutan Living Standards Survey, 17.8% of the national population could be considered to be in a state of moderate multi-dimensional poverty, with a marked divide between urban (8.2%) and rural (23.9%) localities. Figure 21 shows the national findings (uncensored headcounts) across the indicators included in the MMPI, which indicate several areas in which particularly pronounced disparities exist; these include male and female educational attainment, internet access, housing, and access to clean water. Nearly 20% of rural households self-reported as 'very poor' or 'poor', compared to just 7.5% of urban households.[48]

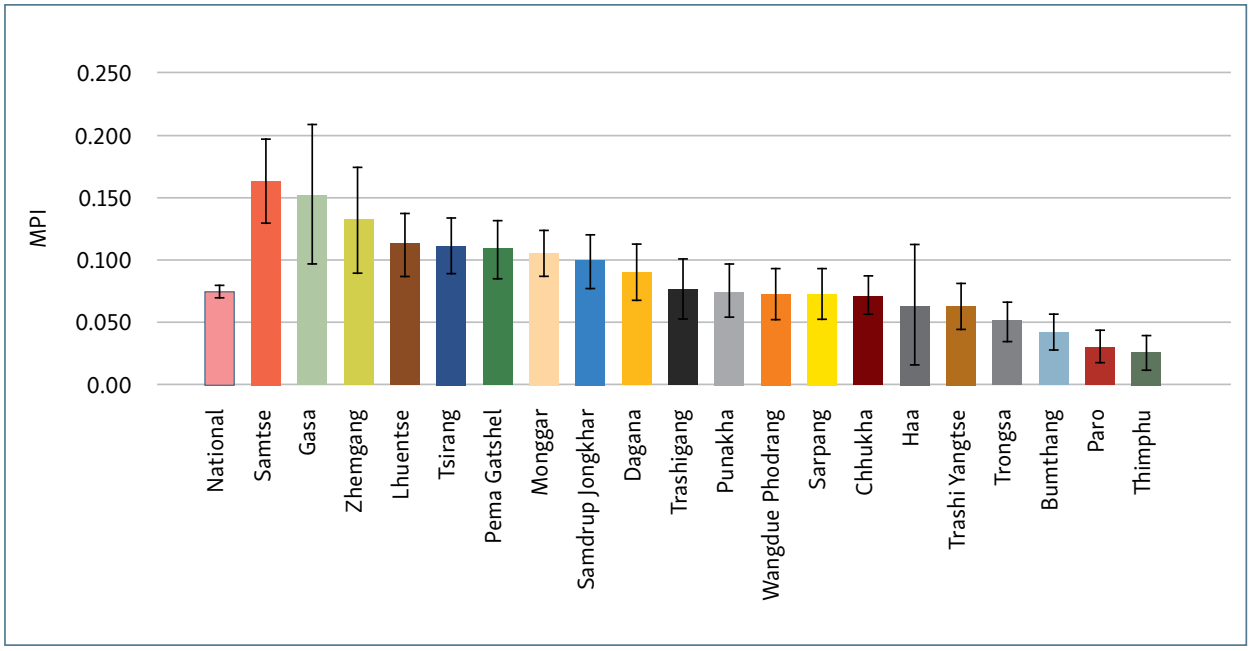
116. There are notable MMPI differences amongst the country's 20 dzongkhags (see Figure 22). Although it is not possible to definitively rank all dzongkhags due to overlapping standard deviations in the data, Samtse clearly has a greater incidence of moderate multidimensional poverty than 14 other dzongkhags (and roughly double the national average incidence), and Paro and Thimphu have a lower incidence than 14 other dzongkhags (and about half the national average). Samtse, Gasa, Zhemgang, Lhuentse, Tsirang, Pemagatshel and Mongar all have above-average incidence of MMPI, while Trongsa, Bumthang, Paro and Thimphu are all below the national average for MMPI incidence.

[46] National Statistics Bureau. Statistical Yearbook 2023.
[47] National Statistics Bureau and Oxford Poverty and Human Development Initiative. Multidimensional Poverty Index 2022.
[48] National Statistics Bureau. Bhutan Livings Standards Survey 2022.



Source: National Statistics Bureau and Oxford Poverty and Human Development Initiative. Multidimensional Poverty Index 2022.

Figure 21: Findings of Bhutan Livings Standards Survey 2022



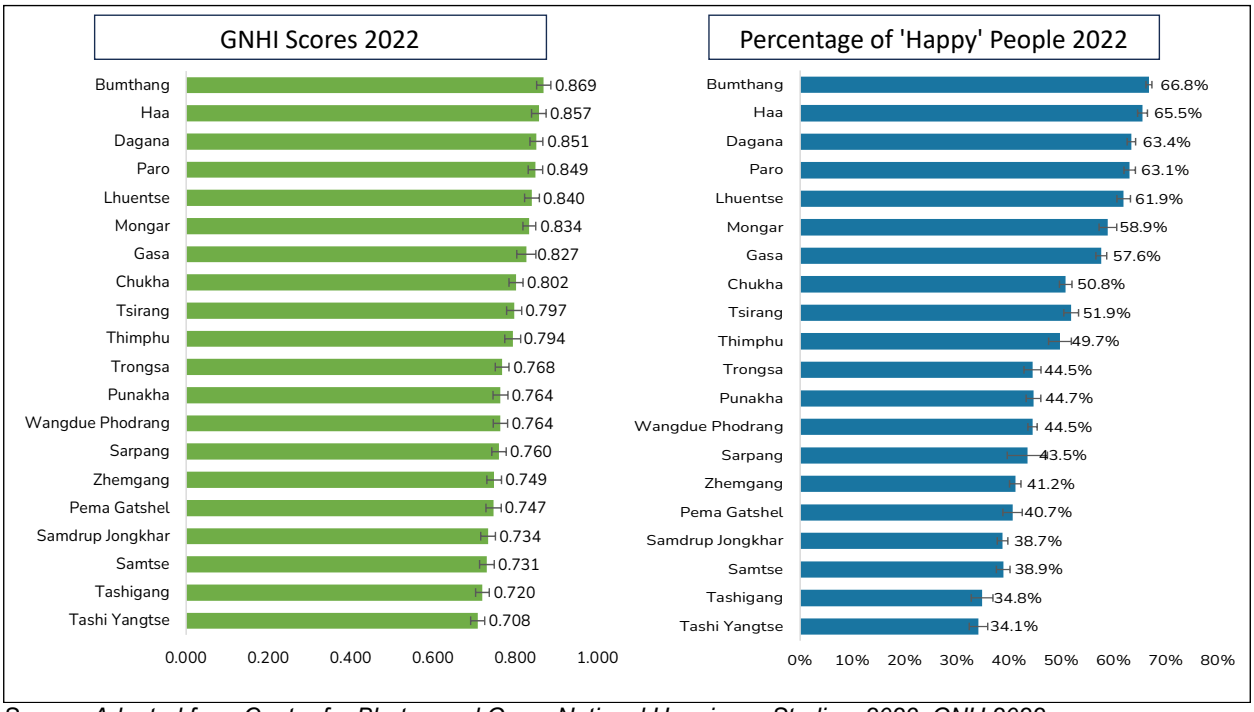
Source: National Statistics Bureau and Oxford Poverty and Human Development Initiative

Figure 22: Moderate Multidimensional Poverty Index by Dzongkhag (2022)

b. Happiness Distribution

117. The RGOB's Centre for Bhutan and Gross National Happiness Studies uses a holistic index to periodically measure the well-being of the population and assess the country's progress towards greater happiness. The Gross National Happiness Index (GNHI) is based on sampled individuals' direct survey responses regarding 33 indicators that together represent the nine domains of Gross National Happiness (GNH), which are psychological well-being, health, education, time use, cultural diversity and resilience, good governance, community vitality ecological diversity and resilience, and living standards.[49] Respondents reporting a perception of sufficiency on at least 66% of indicators are classified as 'happy'. The aggregate GHNI is scored on a scale of 0 to 1, with 1 representing a perfect score. National surveys using the GNHI were conducted in 2010, 2015 and 2022, and the results (2010 GNHI = 0.743; 2015 GHNHI = 0.756; 2022 GNHI = 0.781) indicate steady progress at the national level.

118. Happiness as measured by the GHNI survey has not been evenly distributed. Figure 23 shows the 2022 survey results, broken down by GNHI scores and percentage of respondents with personal scores of 66% or higher, representing happiness. The rankings indicate that people in the least happy dzongkhag (Trashiyangtse) are about 81% as happy as their counterparts in the happiest dzongkhag (Bumthang). A more pronounced disparity is revealed by the presentation by percentage of happy people, which is about two-thirds in Bumthang, but just one third in Trashiyangtse.



Source: Adapted from Centre for Bhutan and Gross National Happiness Studies. 2023. GNH 2022.

Figure 23: Gross National Happiness Index and 'Happy' People by Dzongkhag, 2022

119. The 2022 survey also found differences between urban and rural areas; people living in urban centers were found to be happier (GNHI = 0.796) than rural people (GNHI = 0.771), but as

[49] Centre for Bhutan and Gross National Happiness Studies. 2023. GNH 2022.

a higher proportion of the country's population (59%) lives in rural areas, more happy people overall are found in rural areas than in urban areas.

F. Cultural Heritage

120. Bhutan has a wealth of tangible and intangible cultural heritage, and this is both a major element of national identity and a draw for domestic and international tourists. The Department of Culture and Dzongkha Development (DOCDD) has so far documented 9,633 features of varying significance; the most numerous of these are *choetens* and *lhakhangs* (see Table 16). The documented cultural heritage features are generally concentrated along the major rivers and highway corridors, as these are largely coincident with historically populated areas and early routes for trade, exploration and ethno-religious dissemination (see Figure 24).

Table 16: Summary of Documented Cultural Heritage Features in Bhutan

Feature	Number documented		Feature	Number documented
Choeten	5,018		Dzong	54
Lhakhang	1,926		Lake	46
Prayer wheel	1,218		Nagtshang	25
Nye	529		Traditional village	7
Dangrim	482		Waterfall	4
Spring	137		Not classified	3
Bridge	83		Ruins	1

Source: Department of Culture and Dzongkha Development database (March 2024)

121. The DOCDD is in the process of evaluating, registering and assigning formal site designations to features and groups of features, in line with the Cultural Heritage Bill (2016). A total of 197 sites had been registered as of March 2024. Under the Bill, two designations have been defined: heritage buildings and cultural sites. The latter category is the broader of the two, and may be used to protect features and groups of features ranging from the locality scale up to landscape scale, and may include heritage buildings.

122. Sites are assigned a significance based on the particular values represented and the relevance at local, national and regional scales; those assessed as having highest significance are prioritized for protective management. For these sites, management plans based on a zoned (core/buffer) approach are to be developed. Land use and development are to be strictly limited in core zones centered on particular high-value features, and subject to various context-specific restrictions and management measures within the surrounding buffer zones.

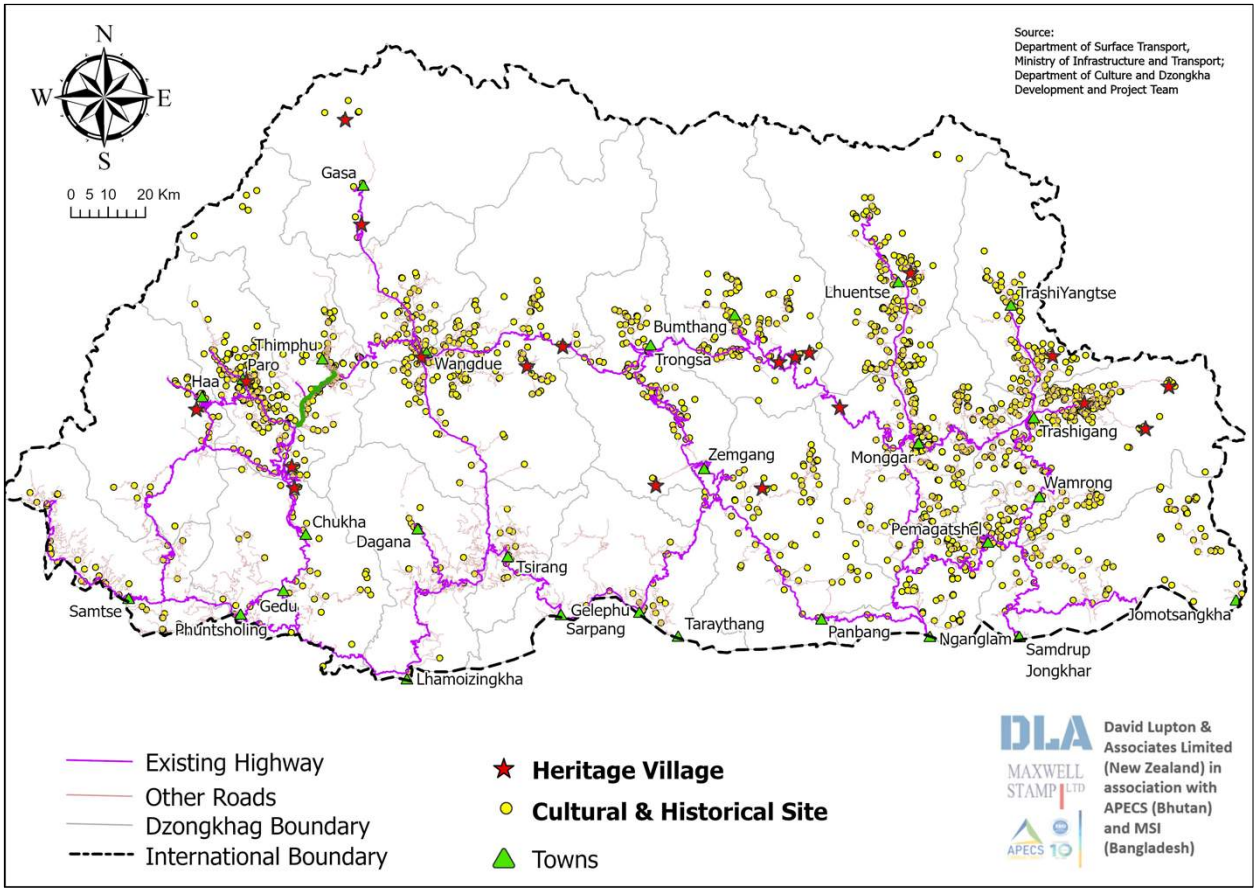


Figure 24: Distribution of Documented Cultural Heritage Features

V. ANTICIPATED IMPACTS OF THE HIGHWAYS MASTER PLAN

123. This chapter of the SEA report identifies, and considers the significance of, environmental and social impacts that may foreseeably arise as a result of the implementation of the investments proposed in the HMP. In keeping with the purpose and aims of SEA, the impact analysis is focused on broadly-scaled impacts with systemic or cumulative implications.

124. Drawing together insights from desktop compilation and review of baseline information, the SEA Scoping Workshop and targeted small-format meetings, a framework was developed to conceptualize the scope of the SEA and guide the assessment work (see the Scoping Report in Appendix 2) . The initial scope framework listed nine key themes in a rough order of priority (most important listed first), as follows:

(1) Wildlife and Biodiversity
(2) Climate Change Mitigation and Adaptation
(3) Water Resources
(4) Public Safety
(5) Equitable Development
(6) National Economic vitality
(7) Cultural Heritage
(8) Natural Resource Use
(9) Pollution and Waste

125. The initial ranking of themes was largely borne out as each theme was explored in more detail to conceptualize the nature and significance of impact potentials. The top three themes in the initial scope framework (wildlife and biodiversity; climate change resilience; and water resources) were found to stand apart from the rest with respect to the centrality and significance of anticipated impacts, and much of this chapter is devoted to these themes. However, all nine themes identified during scoping are discussed, and prescribed actions are developed and tabulated wherever significant impacts can be anticipated.

A. Wildlife and Biodiversity

1. Potential Impacts of HMP on Biodiversity and Biodiversity Conservation

126. The Development Plan identifies 13 new highway links for further evaluation and development by the RGOB, of which three are tunnels and one is a viaduct across a deep valley. Four of the new projects would traverse portions of the protected area network (see Figure 25). One of the three tunnels would be located in a KBA not overlapping with a protected area.

127. Potential to degrade biodiversity values will arise from all proposed road improvement projects, but given the significance of wildlife habitats selected for priority protection within the country's protected area network, threats to these areas from new roads present the greatest cause for concern, and are the focus of the impact assessment.

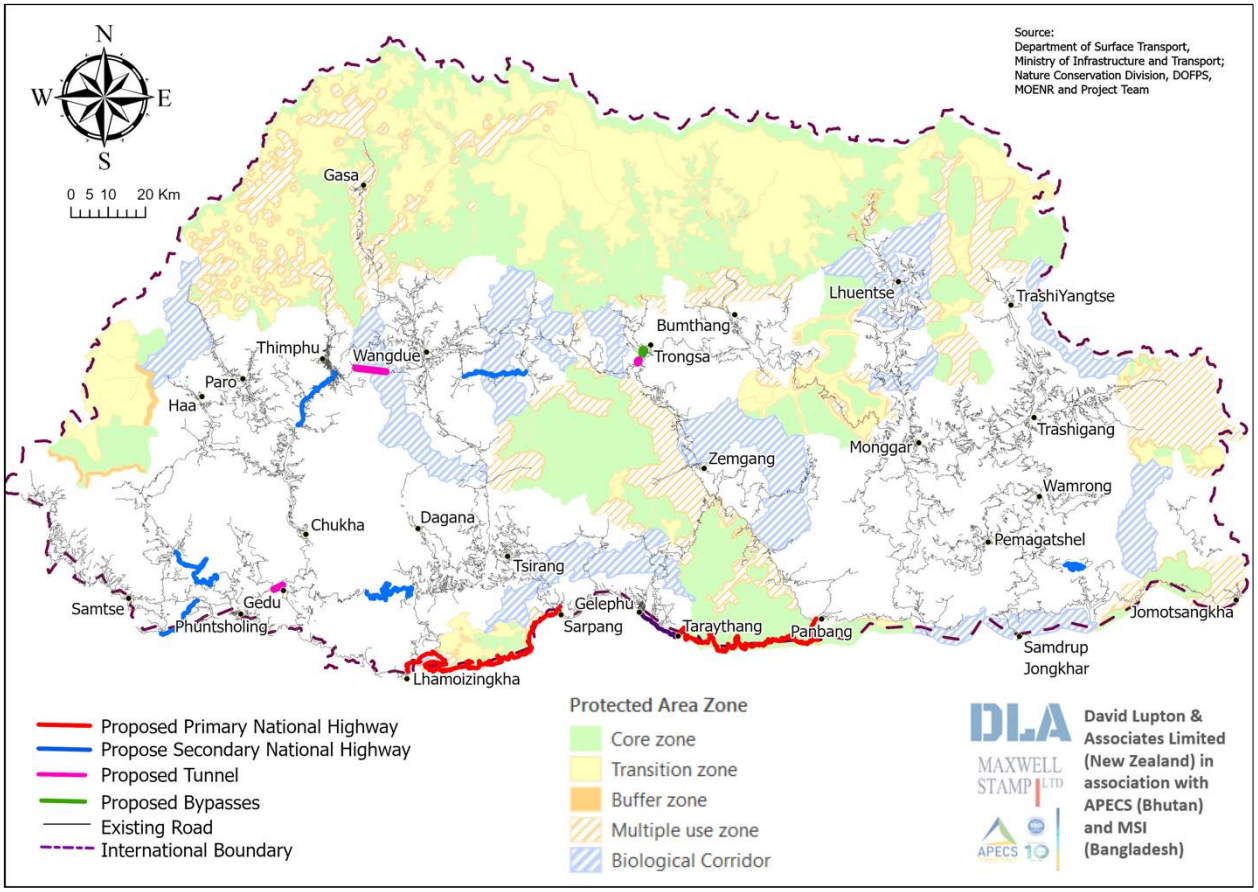


Figure 25: New Roads and Tunnels Proposed in the Development Plan

a. Impingements on the Protected Area Network

128. Bhutan's protected areas and biological corridors are not presently devoid of roads. Seventeen existing national highway segments cross a protected area or biological corridor, accounting for about 335 km of impingement. Most if not all of these are thought to have pre-dated the establishment of the protected areas in question, at least as lower-class roads. New national highway segments proposed under the Development Plan would add about 179 km of national highways (including greenfield development and upgrades of farm roads) through protected areas and biological corridors, a 53% increase in impingements.

129. Of the proposed new impingements, about 98 km are expected to traverse habitat areas designated as core and transition zones, the two most restrictive zone classes in Bhutan's protected area management system. Two of the proposed new highways would impinge on core and transition areas: the Lhamoizhingkha–Sarpang link through the Phibsoo Wildlife Sanctuary (PWS), and the Tareythang–Panbang link through Royal Manas National Park (RMNP). Per the Protected Area Zonation Guidelines of Bhutan (2020), building infrastructure in core and transition zones of protected areas is strictly prohibited. Thus, the proposed new highways in these protected areas would directly contravene existing national conservation policy. This is a significant cause for concern.

130. **Lhamoizhingkha–Sarpang (Phibsoo Wildlife Sanctuary).** The Lhamoizhingkha-Sarpang highway segment is proposed to skirt the southern edge of the Himalayan foothills, with most of the alignment taking advantage of favorable terrain in the narrow strip of alluvial plain that lies just

north of the Indian border. Of the proposed highway's 104-km overall length, about 79 km would be within the PWS.

131. The PWS is Bhutan's smallest protected area, and is noted for having the country's only remaining exemplar of sal (*Shorea robusta*) forest and only population of the Spotted deer (*Axis axis*). The sanctuary's subtropical semi-evergreen and moist deciduous forest, as well as grasslands, constitute some of the highest-potential elephant and large cat habitat in Bhutan, as well as a large portion of the known range of the Golden langur (*Trachypithecus geei*). Rivers within the sanctuary are known to support feeding (though not nesting) of the critically endangered White-bellied heron. A 2016 biodiversity assessment deemed the PWS to be critical habitat for Tiger and White-bellied heron, and possibly also for Asian elephant, Golden langur, Gaur (*Bos gaurus*), Golden mahseer, and the catfish *Pterocryptis barakensis*.[50] The PWS has the most bird species documented (nearly 500 species as of 2016) of any protected area in Bhutan.[51]

132. The PWS has regional significance as part of a broad conservation complex together with the Raimona National Park and Rupa and Chirang Reserve Forests in Assam, and links these other conservation areas with Bhutan's protected area network. These Indian protected areas are largely isolated from other wild habitat areas by intensive agricultural land use to the south, making the linkages to Bhutan especially important. Elephants, gaurs and other wide-ranging fauna are known to travel back and forth between the habitat areas on the Indian side and salt licks in the foothills within Bhutan, thus crossing the proposed highway's route.[52]

133. The preliminary alignment used for master planning purposes loosely follows an existing forest track, whose existence was used during the PWS zoning process to delineate a narrow multi-use zone, which is a 30-m strip along the track (a 150-m buffer zone is defined on each side of the multi-use zone strip). This multi-use designation would technically make the construction of a highway through the PWS legal, but due to the difference between the engineering demands of a simple jeep track and a primary national highway, it is anticipated that about 25 km of the new highway would ultimately have to impinge on core and transition zones (see Figure 26).[53] The existing unpaved track is used occasionally by park vehicles during the dry season, and does not itself constitute a significant landscape element with influence on wildlife movement or habitat use. Ecologically speaking, any new highway following the track's present route should be considered an entirely new road corridor through unmodified or lightly modified habitat.

134. The 2016 ecological survey cited above found that some lands nearest the border (where much of the preliminary alignment lies) have been subject to considerable illegal logging, and have lower biodiversity values than areas further from the border. Cross-border poaching (logging, fish poisoning, hunting) is a documented, through unquantified, problem in the southern fringe of the PWS.[54]

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[50] (1) Department of Forests and Park Services. 2022. Conservation Management Plan 2022-2032 – Phibsoo Wildlife Sanctuary.; (2) Dodds, N.L. and Karma Chogyel. 2016. Biodiversity Baseline Assessment – Phipsoo Wildlife Sanctuary. ADB and RGOB (Department of Roads and Department of Forests and Park Services.

[51] Banerjee, A. and R. Bandopadhyay. 2016. Biodiversity Hotspot of Bhutan and its Sustainability. Current Science 110(4): 521-527.

[52] Dodds, N.L. and Karma Chogyel. 2016. Biodiversity Baseline Assessment – Phipsoo Wildlife Sanctuary. ADB and RGOB (Department of Roads and Department of Forests and Park Services.

[53] The preliminary alignments used to support the master planning process were developed from desktop topographical analysis and minimum design standards for national highways, and are likely to change somewhat during detailed design. However, it is considered unlikely that an alternative route that entirely avoids core and transition areas could be found without significant departure from established design standards and consequent compromises on road safety, construction and maintenance costs, reliability and climate change resilience.

[54] Dodds, N.L. and Karma Chogyel. 2016. Biodiversity Baseline Assessment – Phipsoo Wildlife Sanctuary. ADB and RGOB (Department of Roads and Department of Forests and Park Services.

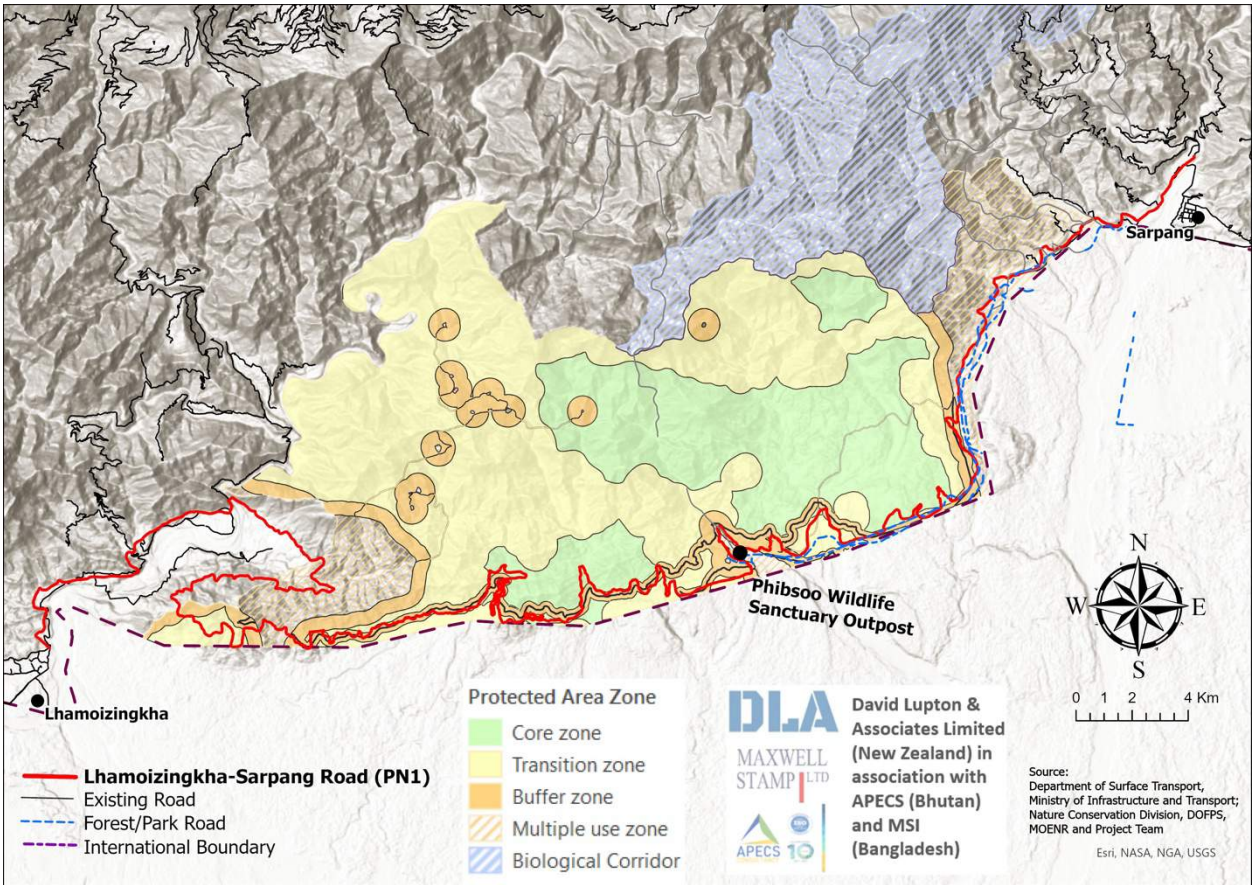


Figure 26: Proposed New Highway Link Through Phibsoo Wildlife Sanctuary

135. **Tareythang–Panbang (Royal Manas National Park).** Similar to the Lhamoizhingkha-Sarpang highway, the Tareythang–Panbang highway segment is proposed to trace a route at the interface between the Himalayan foothills and an alluvial plain that constitutes the northern edge of the ecologically rich Assam Duars. The preliminary alignment for the Tareythang–Panbang highway is about 83 km long, of which nearly 82 km would be within the boundary of the RMNP. About 73 km of the new national highway would be in the core zone of the RMNP.

136. The RMNP is often referred to as the 'conservation showpiece' of Bhutan, being the first and most famous of the country's protected areas. Conservation planning and management practices developed in RMNP have served as a template for conservation practice in the other units of the protected areas system. The RMNP has regional significance as the center of a conservation complex that also includes India's internationally recognized Manas Tiger Sanctuary (a World Heritage Site) and Bhutan's Jigme Singye Wangchuck National Park. The RMNP has itself been tentatively considered for designation as a World Heritage Site. The RMNP has populations of all eight of Bhutan's large cat species, and is thought to have the highest density of tigers of any conservation unit in the world.[55]

137. The RMNP has a large altitudinal range, from 70 masl in the south to 2714 masl on its highest peak in the foothills. Vegetation spans three major forest types (subtropical deciduous forest, warm broadleaf forest and cool broadleaf forest), as well as notable grassland areas in the

[55] UNESCO World Heritage Centre. Royal Manas National Park (RMNP) – Description. Property profile document in directory of tentative list sites proposed for designation as World Heritage Sites. https://whc.unesco.org/en/tentativelists/5698/.

southern alluvial plain that are prime habitat for Asian elephant, Hispid hare (*Caprolagus hispidus*), Wild water buffalo (*Bubalus arnee*), Indian rhinoceros (*Rhinoceros unicornis*) and the extremely rare Pygmy hog (*Porcula salvania*), which is found only in a small area spanning the border between the RMNP and the Manas Tiger Sanctuary. More than 550 species of vascular plants, 65 mammal species and 499 avian species have been recorded in the RMNP, making it a biodiversity powerhouse.[56]

138. As in the PWS, the park zoning map for the RMNP indicates a narrow multiple-use/buffer zone that follows an existing undeveloped track. As with the Lhamoizhingkha–Sarpang link, it is considered unlikely the proposed Tareythang–Panbang link could be made to fit the narrow multi-use strip without considerable relaxation of design objectives. The preliminary alignment loosely follows the strip but does not fit into in very many locations (see Figure 27). The existing track is not a developed road and is unlikely to have significant edge effect or any other effects on wildlife, so even if a way can be found during design work to make the new highway precisely follow the track, it would have to be considered an entirely new road in ecological terms.

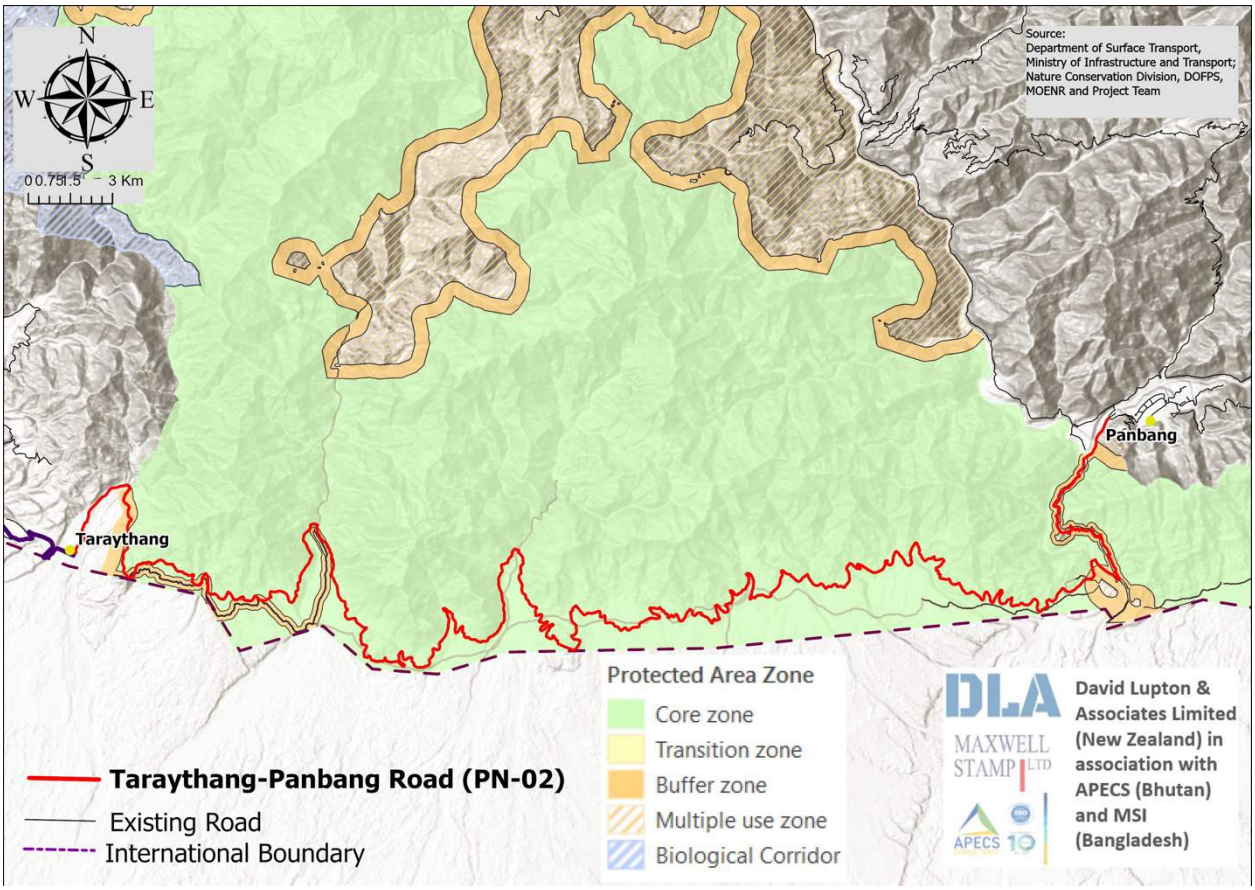


Figure 27: Proposed New Highway Link Through Royal Manas National Park

139. **Khotokha–Phubjikha (Biological Corridor 8).** A proposed new secondary national highway, the Khotokha-Phubjikha link would be an upgrade of an existing farm road over a distance of about 31 km, of which 13 km would be within Biological Corridor 8 (see Figure 29). The landscape is mostly open coniferous forest, and is lightly settled, with infrequent agricultural

[56] Department of Forests and Park Services. 2023. Royal Manas National Park Conservation Management Plan (July 2023 – June 2033).

fields and extensive pastured area. Biological Corridor 8 links the mid-elevation Jigme Singye Wangckuck National Park to the western corner of the higher-elevation Jigme Dorji National Park. The eastern terminus of the upgraded road would be near the edge of the Phobjikha wetlands, which are renowned as a refuge for the Black-necked crane (*Grus nigricollis*), a high-profile threatened species in Bhutan, and are designated both as a Ramsar site and as a KBA. The upgraded road would not impinge upon either the Ramsar site or KBA.

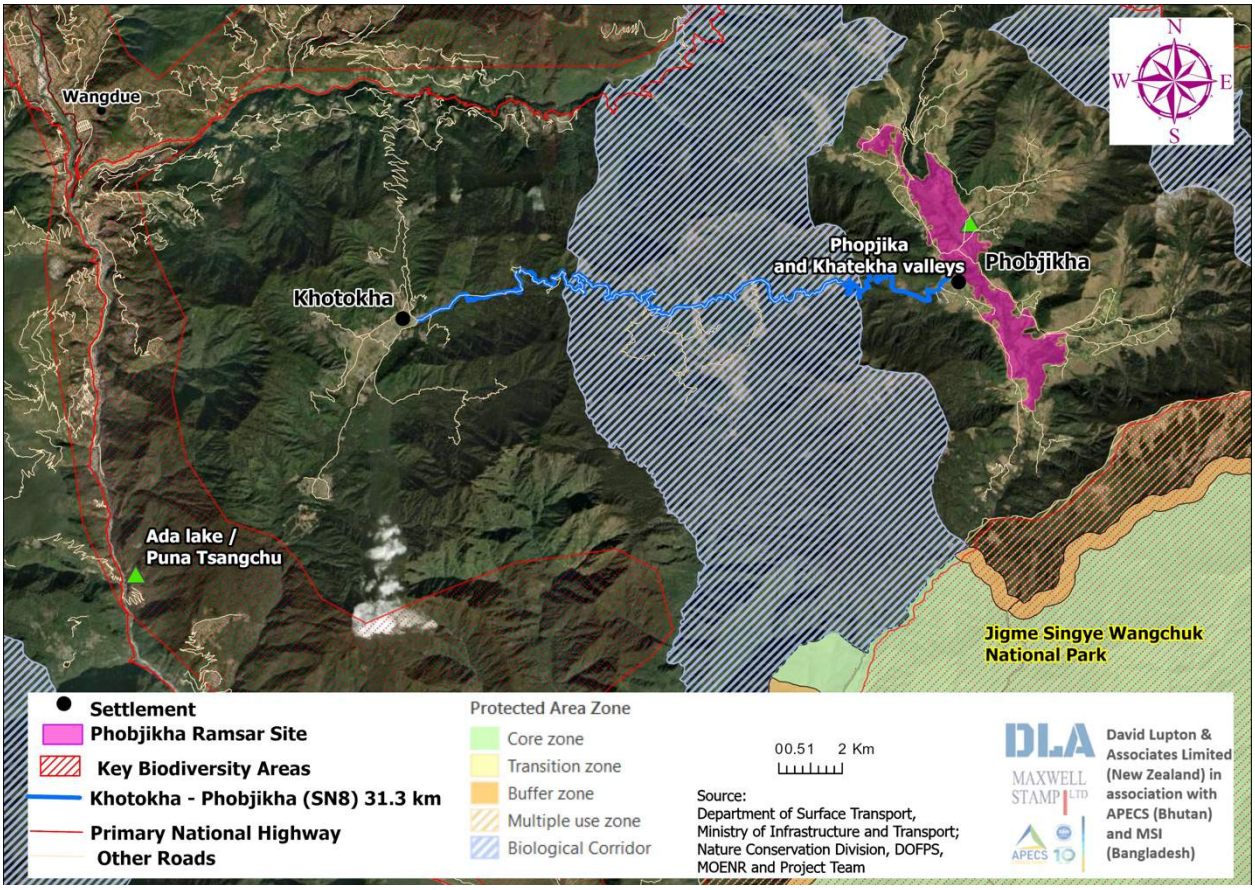


Figure 28: Proposed Phubjikha–Khotokha Link Through Biological Corridor 8

140. **Yesipang–Nahi Tunnel (Biological Corridor 3).** The proposed Yesipang–Nahi Tunnel would be 8.3 km long, and building it would require upgrading about 21 km of existing farm road to serve the tunnel's eastern end. About 5 km of the upgraded road length would take place within Biological Corridor 3 (see Figure 29). The area traversed by the existing farm road is a mosaic of steep slopes cloaked in coniferous forest interspersed with flatter areas that are intensively farmed. Biological Corridor 3 links Jigme Singye Wangckuck National Park to the eastern side of Jigme Dorji National Park.

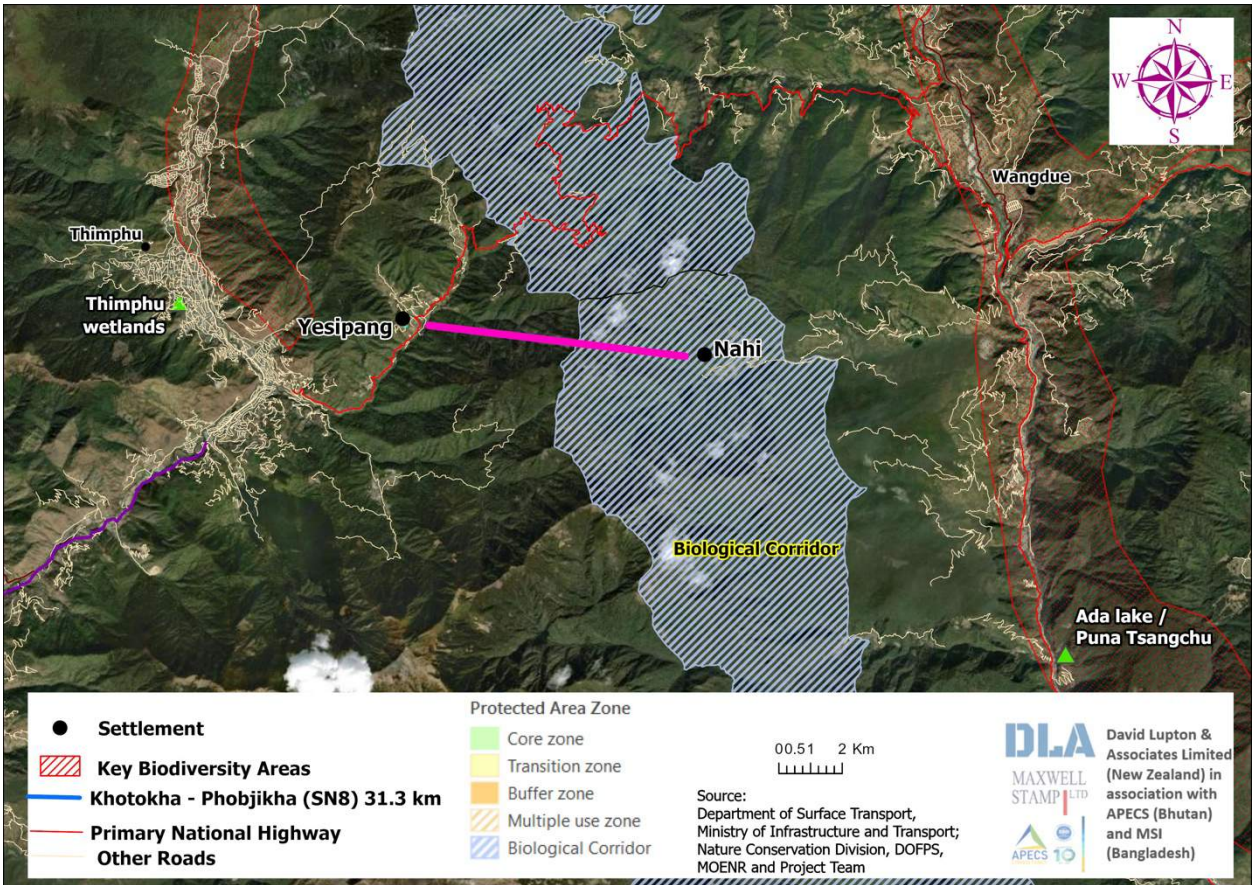


Figure 29: Proposed Yesipang–Nahi Tunnel in Biological Corridor 3

b. Impingement on Key Biodiversity Area

141. **Gedu–Ganglakha Tunnel (Kamji KBA).** The proposed 2.8-km Gedu–Ganglakha Tunnel would be built on the Asian Highway, allowing this important artery to avoid an area historically prone to major landslides. At the time of writing, the tunnel project is already undergoing feasibility study by Project DANTAK. The tunnel's location is within the Kamji KBA (see Figure 30), which is recognized for its exemplary warm deciduous forests and bird life. The Gedu-Ganglakha Tunnel would not require new approach road segments.

c. Impact Pathways and Their Significance

142. Roads can have lasting and far-reaching effects on wildlife habitats and biodiversity, most of them unfavorable, and indeed the endurance of Bhutan's biological diversity through the industrial age can be attributed in no small part to a historical lack of roads. The primary ways in which rural highways impact ecosystems and wildlife populations are (1) vehicle-wildlife collisions; (2) exacerbation of human-wildlife conflict; (3) direct habitat loss and impairment; (4) habitat fragmentation; (5) spread of invasive species; (6) enhanced natural resource exploitation; (7) land use change; and (8) construction impacts.[57] Each of these areas of impact is discussed below with reference to road network improvements proposed under the HMP.

[57] This list excludes impacts that would be more prominent concerns on high-volume roads and urban expressways, such as noise, contaminated runoff, air quality degradation and light pollution. The national highways network in Bhutan consists overwhelmingly of low-volume and moderate-volume paved rural roads.

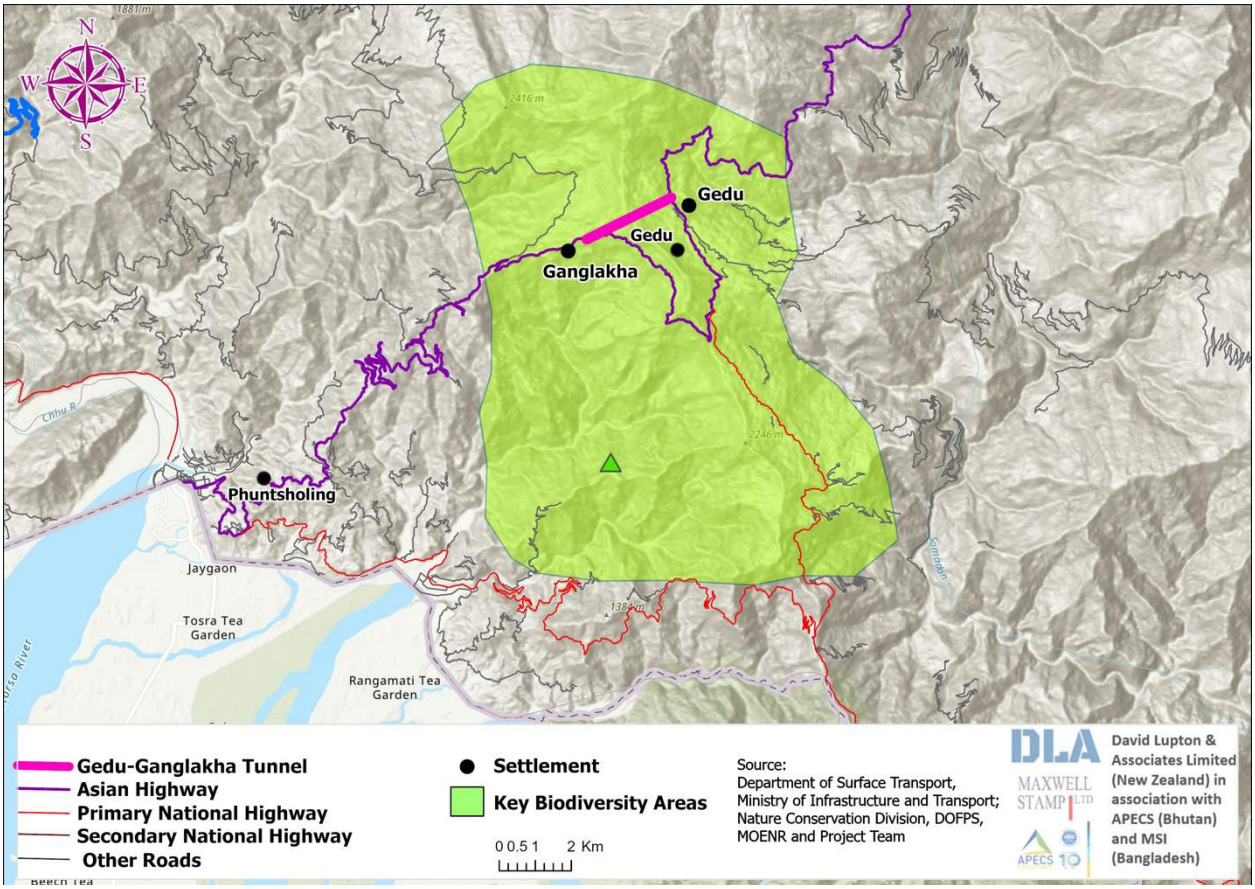


Figure 30: Proposed Gedu–Ganglakha Tunnel in Kamji KBA

143. **Vehicle-wildlife collisions.** Roads pose a direct threat to wildlife through collisions with moving vehicles. The significance of this impact varies between species but can be particularly severe for slow-moving animals (e.g., amphibians, reptiles); species that roam over large home ranges; and non-avian migratory species. In some cases, road mortality can significantly affect population dynamics and contribute to local extinctions.[58]

144. Direct wildlife mortality does not appear to be a large problem in Bhutan at present, and this is likely due to low average vehicle speed, low traffic volume, and a generalized avoidance of night driving. The top design speed for highways in Bhutan is just 60 km/hr, owing principally to the tortuous nature of alignments necessitated by mountainous terrain, and relatively few inter-urban highway segments in the country see traffic volumes over 1,000 vehicles per day. Many drivers prefer not to drive at night for safety reasons, and bus operators generally do not offer overnight trips without a stopover.

145. Table 17 shows the baseline average daily traffic on the projects proposed in the Development Plan, as predicted by the traffic model used to evaluate the expansion projects. The values shown in the table can be expected to be marginally higher by the time the projects are built, due to generalized traffic growth associated with economic growth, rising per capita income and increase in the vehicle fleet, and would keep growing over the life of the infrastructure. However, even with expected modest increases, the predicted traffic volumes on the proposed

[58] Federal Highways Administration. 2011. Wildlife Crossing Structure Handbook – Design and Evaluation in North America. Publication No. FHWA-CFL/TD-11-003.

roads range from very low to moderate. This may suggest that wildlife mortality from vehicle collisions is unlikely to be the most significant risk factor in most locations. However, many contextual factors contribute to wildlife-vehicle collision risk besides traffic volume and speed.[59] Vehicle-collision risk is highly location-specific and species-specific, and its significance must be assessed through careful study at the project level; this should be a priority of EIA studies for individual projects, especially those to be implemented in protected areas and biological corridors.

Table 17: Predicted Baseline Traffic for Proposed Development Projects

Proposed Project	Predicted Baseline ADT[1]
Lhamoizhingkha–Sarpang (PNH)	33
Gelephu–Tareythang (PNH)	2,406
Tareythang–Panbang (PNH)	9
Thimphu–Kariphu–Chuzom (PNH)	3,774
Gatena–Dorona (SNH)	2
Khotokha–Phubjikha (SNH)	36
Denchukha–Chimuna (SNH)	54
Sarjung–Yarphu (SNH)	22
Gomtu–Pagli–Tading (SNH)	600
Trongsa Bypass (bridge)	-
Gedu–Ganglakha (tunnel)	1,484
Thumang (tunnel)	754
Yesipang–Nahi (tunnel plus SNH upgrade)	2,377

[1] Number of vehicles per day if the project were built today; ADT at project opening would likely be marginally higher due to generalized traffic growth factors.

Source: Consultant's traffic modeling

146. **Human-wildlife conflict.** On existing roads in southern Bhutan, large wildlife including elephants and gaurs are known to pose safety risks to motorists, most often associated with confrontations that occur when a vehicle comes around a blind corner and encounters one or more individuals standing on the roadway. In these situations, an adult elephant or gaur may react aggressively, including by charging. Such confrontations sometimes result in injuries and vehicle damage. These kinds of interactions do not directly involve a loss of biodiversity values, but do represent a threat in the broader context of human-wildlife conflict.

147. Living with large wildlife requires a certain amount of goodwill on the part of people, which sustained conflict will tend to erode. Numerous rural communities in southern Bhutan have suffered crop losses, property damage and safety risks from the passage of wild elephants and gaurs, and anecdotal evidence suggests that the situation may be worse on the Indian side of the border, where human settlement is more dense and harassment of the animals is reportedly common. Confrontations on new highways built through elephant and gaur habitat in the Southern Foothills of Bhutan (Lhamoizhingkha–Sarpang, Gelephu–Tareythang and Tareythang–Panbang) are likely to contribute to a deepening of the adversarial relationship, to the detriment of these large species' movements, habitat access and well-being over the long term. This potential impact is difficult to quantify in advance, and its significance is uncertain, but mitigation planning for these new highways proposed in elephant and gaur habitat should nevertheless give serious

[59] For example, driver inattention; limited sight lines and visibility; qualities of roadside vegetation and road-proximate habitat; roadside topography; characteristics of wildlife migration routes and patterns; mobility of wildlife species present; and wildlife behaviors including road avoidance, startling responses, herd movement mentality, congregatory tendencies, confusion, habituation, and aggressive postures related to defense of young, defense of territory, and mating.

consideration to measures that can reduce potential for on-road interactions between motorists and dangerous large mammals.

148. **Direct habitat loss and impairment.** Building new highways through wildlife habitat inevitably takes away resources previously available to wildlife. Habitat loss is readily estimated by calculating the area of the RoW footprint within habitat areas. Assuming that areas not settled by people are unmodified or lightly modified habitat, the addition of 442 km of new national highways (standard RoW 30 m) will involve the direct loss of approximately 10 km^2 of good quality habitat. An indicative breakdown of direct habitat loss by current protective status is shown in Table 18. This can be taken as one indicator of the loss of biodiversity values from the HMP's implementation, recognizing of course that the magnitude and significance of biodiversity values lost will vary across habitat types, species and location.

Table 18: Indicative Direct Habitat Loss from New Highway Segments

Indicative direct habitat loss[1]	**ha**
Protected areas – Core zones	254
Protected areas – Transition zones	39
Protected areas – Buffer zones	134
Biological corridors	54
Unprotected areas (presently unsettled)	509
Projected approximate loss of unmodified and lightly modified habitat	**990 ha (9.9 km^2)**

[1] Based on preliminary desktop alignments. Assumes full clearance of 30-m RoW. Does not include road widening projects and road segments upgraded as part of new highway projects.

Source: Consultant

149. The calculation of direct loss above does not reflect the loss of habitat access and function for various species due to edge effects and disturbance-related habitat avoidance. The RGOB's main policy document on biological corridor design and management adopts the assumption that edge effects are likely to be significant up to 300 m from clearings such as road rights-of-way.[60] Taking this as a standard assumption, an area of habitat impairment resulting from development of the new highway segments proposed under the HMP can be estimated (see Table 19).

Table 19: Indicative Direct Habitat Impairment from New Highway Segments

Indicative area of habitat with functional impairment	**ha**
Protected areas – Core zones	5,085
Protected areas – Transition zones	780
Protected areas – Buffer zones	2,730
Biological corridors	1,074
Unprotected areas (presently unsettled)	10,131
Projected approximate loss of unmodified and lightly modified habitat	**19,800 ha (198 km^2)**

Source: Consultant

[60] Nature Conservation Division, RGOB. May 2010. Regulatory Framework for Biological Corridors in Bhutan. Part III: Policy Recommendations and Framework for Developing Corridor Management Plans.

150. The area of good quality habitat lost to RoW conversion and impaired to some degree by the imposition of new road corridors on the landscape (198 km^2) is not insignificant in aggregate; for perspective, the area of the PWS is 269 km^2. The area of habitat lost or impaired in protected areas including biological corridors would be about 102 km^2, which is about 0.5% of the total extent of the protected area network.

151. Although habitat conversion and edge effects are inevitable consequences of road development, options do exist for influencing their significance in context, and these should be carefully considered in EIA studies conducted during preliminary and detailed design of individual projects, especially those in protected areas and biological corridors.

152. **Habitat fragmentation and barrier effects.** New roads divide the habitat areas they cross into smaller, separated pieces, and this can have several consequences for the use of the habitat by wildlife species, particularly those for which the road is a barrier to movement. Road embankments are a formidable obstacle for many smaller and less mobile species, and even larger species such as elephants, for whom the physical obstacle should not be difficult to overcome, may avoid crossing out of risk aversion.[61] Arboreal species that move mainly through the forest canopy may be seriously affected by canopy gaps induced by the clearing of a highway RoW. The effective range of many species may be limited, and migration patterns disrupted. Patches of habitat cut off from larger contiguous areas may not be large enough to support viable populations of certain species, leading over the long term to increased inbreeding, decreased genetic diversity, and related reductions in fitness and adaptability in the isolated sub-population. For threatened species, the sectioning off of an entire sub-population may seriously weaken the species' long-term survival prospects at the regional and even global scale. Curtailed migration may also have far-reaching consequences for regional populations of non-avian species.[62]

153. The loss of biodiversity values to fragmentation effects may be possible to quantify for a specific subpopulation of a key species through careful ecological study, but it is not practical to do this for all species potentially affected by a road. Recent research suggests that the biodiversity values lost to fragmentation from linear infrastructure are frequently significant.[63] Mitigation aimed at enhancing the permeability of new road corridors to all manner of wildlife is often warranted on the basis of the precautionary principle alone. This is especially applicable to new roads proposed to cross protected areas and biological corridors that facilitate regional movement of high priority threatened species or are integral parts of regional conservation complexes, which is the case for some of the new highways proposed under the Development Plan.

154. **Proliferation of invasive species.** Both existing roads and new roads can act as conduits for the spread of invasive species. The spread of invasives is driven largely by the things people inadvertently or intentionally bring along with them when they use roads. Any settlement associated with new roads is liable to bring with it some measure of gardening, farming and keeping of pets, all of which may bring exotic species into a previously inaccessible environment. Seeds and other plant materials can hitch a ride on vehicles, and cargoes may contain non-native plant matter, insects, rodents and other small animals capable of reproducing if released. Another

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

[62] Federal Highways Administration. 2011. Wildlife Crossing Structure Handbook – Design and Evaluation in North America. Publication No. FHWA-CFL/TD-11-003.

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

known facilitator of invasives is the use of exotic plant species in roadside plantings. Plant species known for fast growth, spreading habit and resilience to harsh conditions are often excellent for erosion control, but unfortunately tend also to be very successful colonizers of new environments. Changing the practices of road agencies and contractors is a relatively easy thing to do, but unfortunately there are few practical tools for limiting other invasion pathways.

155. The potential significance of invasion risk associated with the new highways proposed in the Development Plan is difficult to assess at a systemic level. The risks are perhaps greatest in relation to roads across protected areas, which by definition have been less modified already. Some protected areas in Bhutan (notably the PWS) are already facing ecological change due to invasive plant species, and the proposed new highways may well have an unwelcome additive effect. Invasives risk is best assessed at the project level, and this should be a required topic for study in project-level EIA studies for each of the proposed new highways.

156. **Enhanced natural resource exploitation.** New roads, and to a lesser extent improvement of existing roads, make land and natural resources more easily accessible to people. In the case of natural areas, easier access provided by roads sometimes results in greater hunting pressure, and increased attempts to extract minerals, firewood, timber, and non-timber forest products. This applies to both legal and illegal activity.

157. Poaching is a known but not comprehensively quantified problem in Bhutan. Although much illegal taking of wildlife reportedly stems from human-wildlife conflict in agricultural and pasturing areas, hunting for food or for body parts sought after in the international wildlife trade also occurs. New highways in formerly difficult-to-access locations may have mixed implications for illegal hunting. On the one hand, access and subsequent getaway by poachers may be facilitated, while on the other, surveillance and enforcement by wildlife protection authorities can potentially be enhanced. The balance may depend largely on the capacity of wildlife protection authorities; the poachers are likely to win if the opening of the new highway is not intentionally complemented by commensurate, proactive allocation of resources to permanently increased anti-poaching activity.

158. Extraction of natural resources such as timber, firewood, gravel and sand can generally be considered to degrade habitat quality and biodiversity to some extent. Gathering of non-timber forest products such as mushrooms and medicinal plants has less-damaging effects, but may lead to modest ecological change if carried on intensively. New highways in previously inaccessible locations open up more natural resources to exploitation, lowering the cost-to-market and potentially increasing extraction pressure. Effective regulation of extraction can reduce biodiversity impacts while allowing development benefits to be pursued.

159. Bhutan has a well-developed regulatory framework that requires permits for almost all forest extraction by communities and individuals for local use, and logging for commercial purposes is carried out mainly by a state-owned enterprise and subject to scientific planning by DOFPS foresters. Given these factors, runaway resource extraction does not appear to be a significant biodiversity risk in relation to the highway network improvements proposed in the HMP.

160. Degradation by extensive livestock grazing is thought to be a significant threat to the biodiversity values of forest lands in many parts of Bhutan, but has not been well studied.[64] As a diffuse activity, grazing is difficult to monitor and control. The relationship between highways and incidence of grazing is not a straightforward one; grazing is closely associated with agricultural settlement, which can certainly be facilitated by new and improved highways, but farm roads are likely to be a more direct enabler. In any case, it is probable that at least some new highway links

[64] World Bank. 2019. Bhutan Forest Note – Pathways for Sustainable Forest Management and Socio-Equitable Economic Development.

proposed in the HMP will have some potential for worsening the extensive forest grazing problem, and this should be studied in context.

161. **Land use change.** It is the rare road that does not bring with it the impulse to make use of the adjacent land, and in the absence of robust land use control, the footprint of a new road can quickly grow from a thin ribbon to a wide swath of settlement. Over time, lesser tracks and side roads appear, and natural habitats are degraded and eventually disappear on a landscape scale, effectively ending regional migrations for most species. Informal settlement often plays a role in road-related land use change where enforcement of property rights (state or private) is weak. Privately held land along new and improved highways will typically increase in value, and draw the interest of speculators and investors.

162. Informal settlement and land grabbing are not among the leading drivers of land use change in rural Bhutan, as they are in some other countries of similar economic status. This may be attributable in large part to competent forest regulation and low levels of official corruption, but can probably also be linked to modest population growth and rural-urban migration. Neither the addition of new road links or other network improvements proposed in the HMP would be expected to dramatically change these general historical tendencies, but it is likely that significant biodiversity risks could arise in specific circumstances as a result of induced land use change, and this potential should be investigated as part of project-level EIA studies.

163. **Impacts from works.** Construction of roads and bridges has numerous potential environmental impacts, some of which have (mostly minor and temporary) implications for biodiversity conservation. Construction impacts are generally well understood and readily mitigated, and it is the job of project-level EIA studies and ensuing construction supervision to specify and ensure proper implementation of appropriate measures, per the mitigation hierarchy and in line with international best practice and Bhutan's own guidelines for Environmentally Friendly Road Construction (EFRC). Works impacts are a manageable project-specific risk, and do not require system-level analysis or mitigation.

d. Cumulative Effects

164. Cumulative effects result from the coincidence and combination of stressors linked to two or more sources of impact, and their existence may serve to increase the significance of impacts anticipated from a particular development. Cumulative effects are sometimes not well conceptualized or assessed during project-level EIA studies, due to insufficient scope in the EIA consultants' ToR, as well as difficulty obtaining solid information about other planned, ongoing and completed projects, which are usually under the remit of different proponent agencies and consulting teams. The preceding discussion of the multiple biodiversity impact areas has hinted at cumulative effects by considering the risks mainly at national and regional scales, and the present section draws out a particular cumulative potential for further analysis. This concerns the new highway links proposed in the Development Plan to further the longstanding RGOB objective of completing the Southern East-West Highway (PNH-02).

165. The Development Plan proposes three projects seen as the 'missing links' in PNH-02: Lhamoizhingkha–Sarpang, Gelephu–Tareythang, and Tareythang–Panbang. When completed, these three projects will join with other highways constructed in the past two decades to impose a continuous band of highway corridor across the southern fringe of the country. In addition, six of the 36 highway widening projects proposed in the HMP would be carried out on segments of the Southern East-West Highway. If not appropriately implemented, this cross-country strip of highway has the potential to act as a 'belt of impedance' for wildlife, compromising north-south ecological interchange between Bhutan's protected and unprotected wild spaces and the rich but increasingly isolated protected areas and reserve forests of the Assam and West Bengal Duars

(see Figure 31). This regionally-scaled, transboundary cumulative impact heightens the importance of maximizing the permeability of the proposed PNH-02 'missing link' projects, and would tend to justify more aggressive action to enhance permeability than might be indicated by individual project-specific EIA studies conducted in isolation.

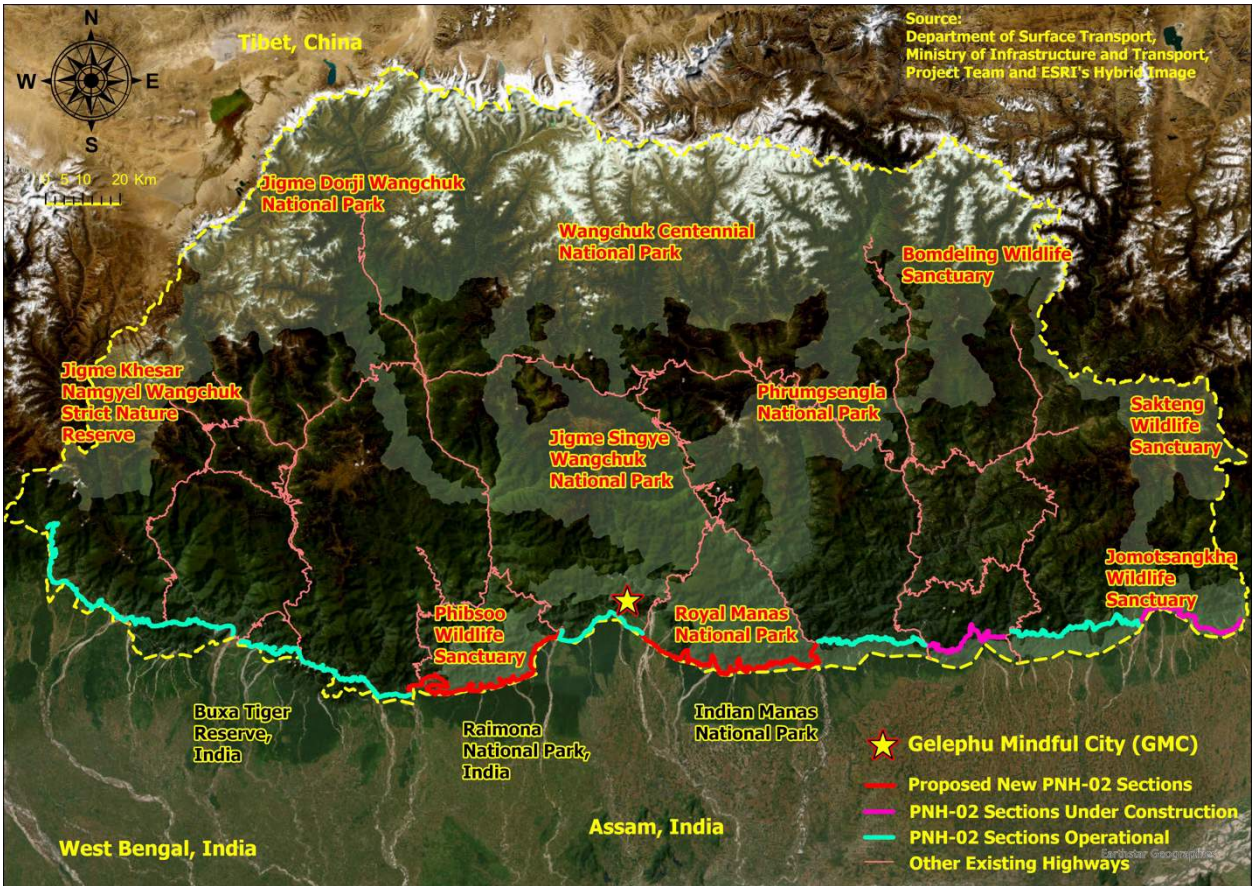


Figure 31: Broader Conservation Context of Proposed New PNH-02 Projects

166. A further cumulative impact that must be considered is the combination of the PNH-02 completion projects with the proposed Gelephu Mindfulness City (GMC). This new urban entity, if realized as currently envisioned, would be developed in stages over 100 years and have an eventual population of up to 1 million people. Centered on the present location of Gelephu town, the GMC would sit astride several rivers, in the space between five protected areas: PWS, RMNP and Biological Corridor 3 in Bhutan, and the Rupa/Chirang Reserve Forests and Manas National Park in India. The GMC is envisioned as a new kind of urban area infused with cutting edge ecological design principles and features prioritizing ecological connectivity, but would still be expected to displace wildlife habitat and also act as a barrier to east-west movement of wildlife through the area.[65] Although the GMC is unlikely to be even marginally built out before the end of the HMP planning horizon in 2040, it is appropriate to conceptualize the impacts of the new highways and the new city as additive impacts occurring within the same broad time-space.

167. In addition to displacing wildlife habitat and restricting wildlife movement over a large area, development of the GMC will foreseeably increase traffic on the future segments of PNH-02 to its

[65] Department of Surface Transport. 2024. Gelephu–Tareythang Road – Environment and Social Impact Assessment (ESIA) for Disclosure and Consultation (22 Nov 2024). Accelerating Transport and Trade Connectivity in Eastern South Asia (ACCESS) Project, Bhutan.

east and west, and on PNH-05 (Gelephu–Wangdue) and PNH-04 (Gelephu–Trongsa); all of these roads will cross protected areas or biological corridors. Awareness of this possible additional future pressure on rich wildlife habitat lends urgency to the notion that the Southern East West Highway corridor should be permeable by design.

168. Planned industrial developments in the southern border area are likely to affect the availability and quality of presently unprotected habitat used and traversed by wildlife, although the feasibility and timelines of such initiatives are not well understood at this time. Expansion of several existing industrial parks is foreseen (supported in some cases by development of dry ports), and the mineral resources of the southern foothills are the primary target for expansion of the mining industry. Although each industrial development site may not on its own require a large taking of natural habitat, the collective effect of industrial developments across the southern border zone is likely to mean that protected areas become even more important as refugia and migration corridors over time. Industrial projects should be identified and considered in the context of cumulative impact assessment for each of the proposed new PNH-02 links, based on updated information available at the time of project evaluation. The same should apply to widening projects proposed in the southern foothills zone.

e. Conservation Management Co-Benefits

169. Some roads in protected areas around the world support conservation management objectives, for example by enabling fire control and habitat management, enhancing surveillance and enforcement of anti-poaching laws, and facilitating nature-based tourism that generates revenue for conservation management. It has been suggested that the proposed new highways across protected areas in Bhutan could serve some of these purposes. For example, the 2016 baseline assessment of the PWS suggested that the cross-border poaching and illegal logging activity that evidently occurs along the southern edge of the sanctuary could likely be more closely surveilled and countered by PWS rangers if an improved road were built in the vicinity of the border. The report also suggested that ecotourism operations could be enabled by development of a road, and a portion of the proceeds could be earmarked for enhanced monitoring and enforcement.[66] These arguments were echoed in discussion between the SEA study team and DOFPS in March 2024.

170. The co-benefits argument has considerable merit, but it should be acknowledged that a national highway is a blunt instrument for supporting protected area management. Conservation management objectives like increased anti-poaching efforts and wildlife viewing may be better served by carefully designed, fit-for-purpose networks of lesser park roads and tracks, which could precisely target sites of special management interest, while also having much lower cost and potential for ecological impacts. The suggested resource management co-benefits of national highways through the core and transition areas of Bhutan's protected areas should be weighed carefully against alternative means of delivering these benefits, and not just assumed as project benefits in isolation. This should be integrated in EIA studies at the project level.

2. Mitigation Options

171. Mitigation of the impacts discussed above should follow the mitigation hierarchy, which prioritizes prevention (avoidance), and where complete prevention is not possible, minimization as a second priority. Only after opportunities for prevention and minimization have been pursued

[66] Dodds, N.L. and Karma Chogyel. 2016. Biodiversity Baseline Assessment – Phipsoo Wildlife Sanctuary. ADB and RGOB (Department of Roads and Department of Forests and Park Services.

to the maximum extent feasible should a residual impact be identified, and compensatory measures considered.

a. Avoidance of Impacts

172. The only option for absolute avoidance of biodiversity losses from road development is to not build a road at all. Taking this decision is often supported by other concerns related to technical and economic feasibility. Indeed, several other proposed highways evaluated for inclusion in the Development Plan that presented biodiversity concerns were dropped from consideration due to a concurrent lack of economic viability. But environmental and economic (or other) rationales are often not aligned, and understanding tradeoffs becomes central to mitigation decision-making. Building new highways in protected areas, especially through their most valued zones, is in general not considered a good ecological practice anywhere in the world, and the decision not to avoid this action can normally be justified only by strong countervailing economic benefits or major strategic imperatives.

173. The high-level economic analysis conducted on network expansion proposals to support HMP formulation predicted low economic viability for both the Lhamoizhingkha–Sarpang (EIRR= -10%) and Tareythang–Panbang (EIRR= -6%) links.[67] Co-management benefits including enablement of anti-poaching efforts and ecotourism development are proposed as potential countervailing economic benefits for these new highways, but have not been quantified. Potential strategic imperatives may include reduced vulnerability to policy changes in India (regarding border crossing formalities and tolling on Indian highways presently used for most trips between the southern Bhutanese border towns), and provision of road connectivity to the assumed future GMC, but these benefits are uncertain and have not been fully conceptualized or quantified.

174. It is important that the tradeoffs in relation to the new highway links through protected areas are explicitly accounted for and subject to thorough analysis in EIA studies during the feasibility stage, and that alternative courses of action are included in the analysis. It is international best practice (and the law in most countries) to give due consideration in EIA studies to the implications of reasonable alternatives to the proposed project under review, including the alternative of doing nothing (the 'no-project' alternative). It is worth noting that there are alternative ways of getting from Lhamoizhingkha to Sarpang (the existing SNH route to the north of the PWS via Dagapela, Sunkosh and Damphu) and from Tareythang to Panbang (the existing route to the north and east of RMNP via Tingtibi), and improving these routes (both of which are already proposed for widening under the HMP) should be fully investigated as an alternative to building new highways through core and transition zones of protected areas. Continued use of the existing routes through India (perhaps supported by a bilateral agreement to limit toll costs and border formalities for Bhutanese vehicles) should also be weighed carefully as part of the alternatives analysis.

175. For the new highways across protected areas proposed in the Development Plan, EIA studies must include the following, at a minimum:

(1) Detailed ecological field studies spanning multiple seasons to fully characterize anticipated biodiversity impacts of the new highway, and its possible alternatives (including existing routes in both Bhutan and India);

(2) Thorough data-based analysis of the magnitude of expected benefits from travel time and travel cost savings relative to alternative routes (including existing routes in both Bhutan and India);

[67] EIRR = Economic Internal Rate of Return

(3) Inclusion of updated biodiversity-related mitigation and compensation (offsetting) costs in economic feasibility calculations;[68]

(4) Quantitative estimation of benefits from ecotourism operations enabled by the new highway, based on realistic ecotourism development proposals linked to the proposed new highway, relative to benefits from ecotourism enabled by alternative transportation options, such as improvement and expansion of low-impact seasonal park roads;

(5) Estimation of anti-poaching benefits from the new highway, relative to anti-poaching benefits enabled by other transportation options, such as improvement and expansion of low-impact seasonal park roads;

(6) Assessment of the capacity of protected area management authorities to effectively achieve anticipated ecotourism and anti-poaching objectives, under both the new highway scenario and alternative scenarios, such as improvement and expansion of low-impact seasonal park roads; and

(7) Identification and justification of any strategic rationales supporting the development of the new highway through a protected area, including economic and policy risk assessment for alternative routes using the Indian highway network.

b. Minimization of Impacts

176. Several options exist for minimizing loss of biodiversity values to roads, and these are characterized below.

177. **Biodiversity-informed alignment selection.** As noted earlier, the highway alignments drawn for purposes of developing the HMP are of necessity preliminary, and can be expected to change at least somewhat during preparation of preliminary and detailed designs at the project level. During the feasibility and detailed design processes, there will be opportunities to adjust alignments for several possible reasons, and avoidance of especially high-value biodiversity features (e.g., migration routes, salt licks, nesting and roosting areas, rich foraging habitat, etc.) can be one of them, provided that high-quality ecological field surveys are carried out to identify such features. For this to happen, it is essential that the feasibility study and design consultants for each of the individual proposed network expansion projects (not just those in protected areas) engage sufficient biodiversity expertise, and allocate sufficient budgets and time for multi-season field studies. This must be indicated in the feasibility and design consultants' ToR.

178. **Reduced RoW clearance.** The standard RoW width for national highways in Bhutan is 30 m, but the width of the road formation will be less than this in many locations, especially those with relatively gentle topography. Limiting RoW clearance to the bare minimum required to accommodate the roadway formation wherever possible will reduce overall conversion of habitat, reduce edge effect and canopy gaps, and make the road a less formidable barrier to movement for risk-averse species. Limiting RoW clearance should be a design criterion and reflected in roadway detailed designs, rather than being a general directive aimed at contractors. Accordingly, this measure should be indicated in the design consultants' TOR.

179. **Maintaining permeability of the road to wildlife.** Any measure that makes it easier and safer for wildlife to move across a road corridor will help to minimize wildlife mortality, human-wildlife conflict and fragmentation effects. Various kinds of wildlife crossing structures have been trialed in different contexts, often with considerable success, and the feasibility of integrating such measures should be carefully evaluated for all new highways proposed in the Development Plan, especially those that would cross a portion of the protected area network. Other measures to

[68] Preliminary hypothetical estimations for mitigation and offsetting were used in the high-level feasibility analysis conducted as part of Development Plan formulation; these will need to be re-done based on in-context ecological information and consultation with relevant conservation stakeholders.

enhance the ability of animals to cross over the road, without necessarily using a specialized crossing structure, should also be considered. Specific measures thought most likely to have scope for practical application on the proposed new highways are outlined briefly below.

180. The need for and location of the various measures identified below can be properly evaluated only through ecological field studies conducted during each project's detailed design, and such evaluation must be a prescribed component of the respective project-level EIA studies. The design consultants engaged for each project must have appropriate biodiversity expertise and time allocations to carry out such studies, and this must be indicated in their TOR.

181. ***Large mammal underpasses.*** Large mammals such as elephants and gaurs are not in much danger of being killed on a relatively low-speed highway, but providing convenient passage across the road corridor may help to reduce barrier effects and limit potential for dangerous confrontations. High-clearance steel arch elephant underpasses (see Figure 32) were installed in stream channels on two highways constructed in 2012–2014 in the Southern Foothills (Raidak–Lhamoizhingka and Samdrupcholing–Samrang), and their use by elephants, gaurs and numerous smaller wildlife species has been documented. This measure should be evaluated for widespread use on all three new highways proposed in elephant habitat (Lhamoizhingkha–Sarpang, Gelephu–Tareythang and Tareythang–Panbang), as well as widening projects in the southern foothills zone, during project-level EIA studies.

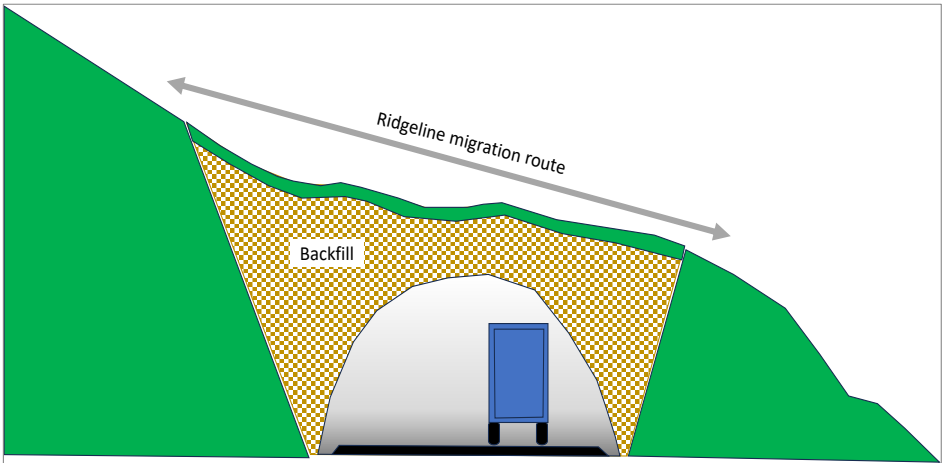
Figure 32: Large Mammal Underpass on Raidak–Lhamoizhingkha Road

182. ***Avoidance of box drains, long continuous guardrails, and steep embankments.*** In elephant habitat, box drains and long continuous guardrails should be avoided, as these have been shown to seriously impede safe passage of baby elephants, leading to injuries and entrapment, and related agitation and congregation of their herds on the road. This risk must be considered and mitigated through alternative design prescriptions in the EIA study for each of the new highways proposed in elephant habitat. Box drains are also quite inhospitable to small animals including turtles and tortoises, snakes, frogs, toads and small rodents.

183. Steep embankment slopes are an impediment to wildlife movement, including movement off the road to avoid collision or confrontation with approaching vehicles. Forest officers in Dagana (Raidak–Lhamoizhingkha Road) have experimented in recent years with 'off-ramps' on segments of the highway known for confrontations. The ramps have typically been formed by reshaping the roadside topography in opportune spots to facilitate rapid egress in the event of the sudden

appearance of a vehicle (most ramps are placed at blind corners). This approach has been applied to an existing road as a post hoc mitigation measure, but could be incorporated proactively in roadway designs in select locations where favorable topography and high wildlife density coincide. Identification of suitable locations to enhance permeability and 'escapability' through lower-profile embankments, lower-gradient embankment slopes and wildlife ramps can only be done at the detailed design stage.

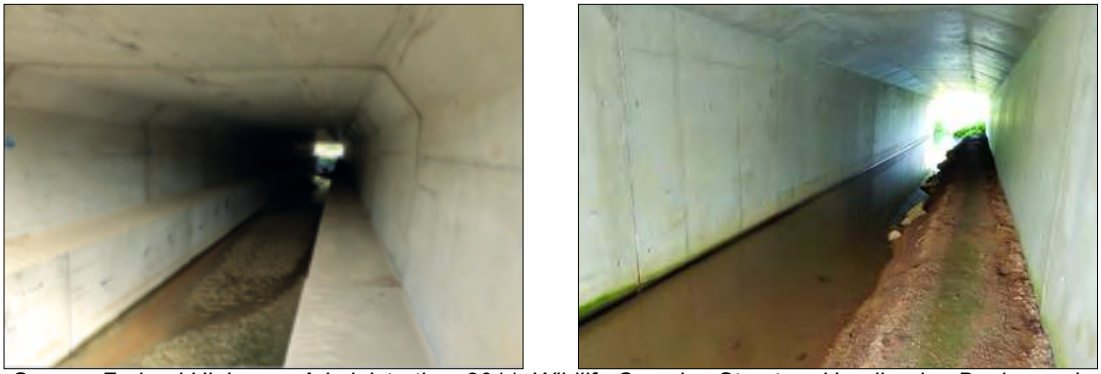
184. ***Ridgeline overpasses.*** Ridgelines are often prime movement corridors for wildlife species that regularly move up and down altitudinal gradients. In southern Bhutan, ridgelines have been found to be well used by deer, gaurs, elephants and other species. Where road alignments cut across ridgelines, high, steep cuts are typically made, and these not only impede passage, but pose a fall risk for some species. At least one instance of an elephant sustaining serious injuries after falling from a high road cut has been documented in Bhutan. Where cuts are necessary in ridgelines known to be important wildlife movement routes, a wildlife overpass should be considered. This is most feasible where a box cut is required, as the need to build a ramp on the downhill side is avoided (see Figure 33). The need for overpasses at ridgelines along each of the project alignments will have to be evaluated based on multi-season ecological studies conducted during the design work for each network expansion or widening project.



Source: Consultant

Figure 33: Schematic of Steel-Arch Overpass Enabling Ridgeline Migration

185. ***Modified culverts.*** Rivers, streams, washes and gullies typically serve as corridors for movement of wildlife, including aquatic, amphibious and non-amphibious animals. Culverts often present a barrier to such movements, due to constricted and concentrated water flow, small interior size, and lack of dry footing for water-averse species. Changing the design of culverts to make them more hospitable (e.g., widening to reduce constriction and concentration of flow and reduce claustrophobic effects, providing raised benches for dry passage even during wet periods) has been shown to increase their utility for wildlife passage, and reduce the frequency of over-road small animal crossing. The need for modified culverts along each of the project alignments will have to be evaluated through ecological and topographical studies during the design work for each individual project, but it can be assumed that many stream crossings and cross-drainages will be good candidates for installation of structures with modified designs.



Source: Federal Highways Administration. 2011. Wildlife Crossing Structure Handbook – Design and Evaluation in North America. Publication No. FHWA-CFL/TD-11-003.

Figure 34: Examples of Modified Culvert Designs Enabling Wildlife Passage

186. ***Dry culverts for small animals.*** In selected locations, under-road crossing structures located away from watercourses and depressions may be justified to enable safe passage of small mammals, reptiles and amphibians, many of which are vulnerable to being hit by vehicles due to low mobility, and may experience strong barrier effects due to limited ability to climb steep embankment slopes. Opportunities for useful installation of such dry crossings may be limited in steep terrain, so it is anticipated that this minimization measure would be applicable mainly on the three new highways proposed for the southern fringe of the country, where alignments traverse relatively flat lowland forest and grassland. The need for and placement of dry culverts for small wildlife will have to be assessed in-context based on ecological study to be undertaken during detailed design of individual projects.

Source: Federal Highways Administration. 2011. Wildlife Crossing Structure Handbook – Design and Evaluation in North America. Publication No. FHWA-CFL/TD-11-003.

Figure 35: Examples of Dry Culverts for Safe Under-Road Passage of Small Animals

187. ***Aerial crossings for canopy species.*** Non-volant species that spend most or all of their lives in the forest upper canopy, such as primates, red pandas, some rodents and some reptiles, are particularly prone to fragmentation effects where roads are wide enough to create a significant canopy gap. In some contexts, placement of lightweight canopy bridges at select locations may minimize curtailment of mobility, and associated community and population isolation.[69] In the Bhutanese context this measure is likely to be most applicable to areas characterized by deciduous and mixed forests and less steep terrain. The need for and location of aerial crossing structures can be properly evaluated only through ecological field studies conducted during each project's detailed design, but given the likely presence of threatened canopy species (e.g., Golden langur, Red panda) in some of the project areas, it is probable that this will be an appropriate measure in selected locations.

Source: Wildlife Conservation Society. https://newsroom.wcs.org/

Figure 36: Example of Aerial Crossing Structure

188. **Formal cooperation with conservation authorities.** For highways proposed to cross protected areas, co-management of road operation by DOST and DOFPS could offer considerable biodiversity protection benefits. A formal co-management agreement could enable park management units to implement a number of wildlife protection tools; these are outlined below.

189. ***Driver education.*** Park managers could require vehicles to stop at the park entry points for education on the importance of observing the speed limit; appropriate responses to presence of wildlife on or near the roadway; behavioral tendencies of certain collision-prone wildlife species such as deer; and park rules regarding such things as roadside stopping, unauthorized entry to roadside habitats, littering and collecting. A staffed facility at each park entry point would be required.

[69] Wildlife Conservation Society. 2024. WCS Builds Aerial Wildlife Crossing to Protect Endangered Primates on a Highway that Cuts through the Brazilian Amazon. https://newsroom.wcs.org/News-Releases/articleType/ArticleView/articleId/20478/WCS-Builds-Aerial-Wildlife-Crossing-to-Protect-Endangered-Primates-on-a-Highway-that-Cuts-through-the-Brazilian-Amazon.aspx#.

190. ***Vehicle inspection.*** DOFPS could be granted authority to set up permanent checkpoints (at the park entry points) or temporary checkpoints (at key locations along the roadway) to enable inspection of vehicles for evidence of poaching and wildlife trafficking.

191. ***Night closure.*** Wildlife collision risk is much higher at night than during daylight hours, in almost all contexts. This is a combination of higher wildlife activity and reduced ability of drivers to see wildlife on and near the road. For low-volume highways that pass through protected areas, it may be feasible for park managers to simply close the highway at night, with a gate at each boundary crossing, either year-round or just during peak migration periods. This measure could be expected to greatly reduce wildlife mortality risk in these high-value habitat areas.

192. Co-management of national highways through protected areas by DOST and DOFPS should be formalized through a formal Memorandum of Agreement (MOA). As the purpose of the inter-agency cooperation would be to mitigate anticipated impacts of highway projects, at least the capital costs associated with establishing the necessary infrastructure (gates, education facility, accommodations for guards) should be included in project costs. Determination of a mutually agreeable cost structure and financing mechanism (including for incremental staffing and other operational costs) is a matter for negotiation between the DOST and DOFPS, to take place during the detailed design stage of the relevant project. The MOA would have to be executed prior to the end of detailed design, so the costs could be included in the project budget.

193. **Controlling induced settlement and free-range grazing.** The potential for new and improved highways to induce establishment or growth of settlements, or to enable exacerbation of forest grazing, is highly context-specific. EIA studies for individual new highway projects in forested areas, especially those within or near protected areas and biological corridors, should carefully consider the potential for these induced effects, taking into account the biodiversity values of the forest areas traversed, land tenure, land suitability, relevant local economic factors, and the enforcement capacity of the relevant forest management division. Where proactive mitigation is found justified, this should be developed in the project-specific environmental management plan (EMP). The conduct of this induced effects analysis should be specified as a required topic in the ToR for project-level EIA studies.

c. Compensation for Residual Biodiversity Impacts

194. The minimization measures discussed above will not reduce road impacts on biodiversity values to negligible levels. Animals will still cross the proposed highways, albeit less than they would without crossing structures, and fragmentation and its effects will remain a physical fact, even if minimized by reduced RoW clearance and permeability measures. Compensatory measures will therefore have to be considered to address the residual impacts remaining after minimization measures have been applied. ADB and other multilateral MDBs generally require that infrastructure projects follow the procedures prescribed under the International Finance Corporation (IFC) Performance Standard 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources, or equivalent procedures in their own safeguard frameworks, in this regard.[70] This standard specifies that projects implemented in natural habitat must ensure no net loss of biodiversity values, and those implemented in habitat critical to threatened species must ensure a net gain of biodiversity values.

195. Performance Standard 6 (PS6) defines natural habitat as "…areas composed of viable assemblages of plant and/or animal species of largely native origin, and/or where human activity has not essentially modified an area's primary ecological function and species composition."

[70] The World Bank's Environmental & Social Framework ESS 6 (2018) and ADB's newly adopted Environmental and Social Framework ESS 6 (to come into force in January 2026) incorporate requirements substantially equivalent to IFC PS6.

(PS6, Para. 13). Under this definition, virtually all of Bhutan outside of urban areas, rural settlements, farmland, pastures, tree plantations and infrastructure footprints can reasonably be assumed to qualify as natural habitat. Highway projects implemented with financing from MDBs and bilateral institutions that adhere to PS6 will have to implement compensatory mitigation measures sufficient to verifiably counteract the anticipated residual impacts on biodiversity, ensuring no net loss of biodiversity values despite the loss and impairment of natural habitat. The compensatory measures would typically be formulated in the context of a Biodiversity Management Plan (BMP) for the project, which may be separate from or integrated with the project EMP.

196. Critical habitat is defined in PS6 as "…areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes." (PS6, Para. 16) Bhutan is home to at least 136 globally threatened species, of which 43 are endangered and 21 critically endangered, as assessed in the IUCN Red List of Threatened Species.[71] Many of these are endemic to Bhutan and have extremely limited ranges. Several of the endangered and critically endangered species present in Bhutan are likely to trigger a critical habitat determination for land traversed by one or more of the highway projects proposed in the Development Plan, based on exceedance of thresholds specified in PS6.[72] Some of the proposed projects are therefore likely to be required to implement compensatory mitigation sufficient to verifiably ensure a net gain in relevant biodiversity values. Compensatory measures capable of achieving net gain of biodiversity values are expected to be formulated under the auspices of a Biodiversity Action Plan (BAP), which is typically a long-term plan independent of the project EMP.

197. Compensatory mitigation for residual loss of biodiversity values may take many forms, up to and including biodiversity offsets. Restoration offsets compensate for losses attributable to a project by rehabilitating habitats or species nearby. Protection offsets compensate for losses by guaranteeing permanent and effective preservation of habitats or species in other locations; this typically involves land purchase or reclassification, as well as capacity investments in relevant protective management entities. Creation or replacement offsets establish new habitat mimicking the lost habitat in areas where no such habitat existed before; this is most commonly used for wetlands and coral reefs. Finally, compensation packages for stakeholders likely to be affected by lost biodiversity are proposed in some contexts; compensation might consist of cash, community investments and other types of desired benefits.[73] The cost of biodiversity offsets is typically borne by the proponent of the project driving the biodiversity losses, and is appropriately reflected in overall project cost.

198. Compensatory mitigation costs can be credibly estimated only after detailed ecological study and extensive consultation with relevant stakeholders, during the project's detailed design phase.[74] Costs are influenced by the nature and magnitude of lost and degraded biodiversity values; the conservation designation of the lands affected; the compensatory mitigation designs

[71] Nepal, T.K. and Manita. 2021. An Updated Checklist of Globally Threatened Species in Bhutan as Listed in IUCN Red List of Threatened Species. International Journal of Science and Research 10(2): 1640–1646.
[72] For example, the 2016 baseline assessment of PWS, cited earlier, found that the PWS contains qualifying critical habitats for at least two species, and probably more. It is very likely that a similar finding will come out of critical habitat assessment for the propsoed Tareythang–Panbang route through RMNP.
[73] Business and Biodiversity Offsets Programme (BBOP). 2009. Biodiversity Offset Design Handbook. BBOP, Washington.
[74] Provisional offset costs were estimated for each new highway considered for inclusion in the Development Plan, to support true-cost accounting in the high-level economic feasibility analysis conducted during plan formulation.

preferred by stakeholders; and institutional arrangements and capacity building needed to establish, manage, monitor and verify the compensatory mechanism.

199. Determination of defensible measures to compensate for anticipated residual impacts on biodiversity requires high-caliber expertise. The detailed design consultant engaged for each of the projects under the HMP must have such biodiversity expertise within its project team, including biodiversity specialists with experience in critical habitat assessment, offset design and preparation of BAPs. This must be clearly indicated in the ToR for the detailed design consultancies, and the project implementation budget and schedule must include allocations adequate to enable multi-season ecological studies. The PS6 (or equivalent) standard should ideally apply regardless of whether an external financing entity requires it, and even in the case of exclusive government financing.

d. Cumulative Effects Assessment and Mitigation

200. The discussion of possible cumulative effects earlier in this section highlighted the relevance of regionally-scaled analysis of cumulative effects in relation to the projects proposed to fill the 'missing links' in the Southern East-West Highway (Lhamoizhingkha–Sarpang, Gelephu–Tareythgang, Tareythang–Panbang). Each of these projects needs to be considered in the context of the larger PNH-02 buildout (including proposed widening projects on completed sections), and also the proposed development of the GMC, and it will be important for the project-level EIA studies to consider how these regional (and transboundary) cumulative potentials should influence the mitigation strategy for each project. Specifically, development of mitigation should examine, and reflect as appropriate, the following possibilities:

(1) That the PNH-02 corridor may become an increasingly formidable cross-country barrier over time due to generalized traffic growth, progressively degrading transboundary migration and interchange vital to the increasingly isolated wild tracts remaining in the Assam Duars;

(2) That development of the GMC may progressively impede east-west and north-south ecological connectivity between protected areas and other high-value conservation spaces of south-central Bhutan and northern Assam;

(3) That development of the GMC may generate heavy construction-related traffic over a multi-decade period, including on PNH-02, as well as accelerate long-term growth in non-construction-related traffic over the long term;

(4) That planned industrial developments in the southern border area, such as dry ports, industrial parks and mines may make unprotected habitat areas less suitable for wildlife movements, increasing reliance on resources and migration corridors in protected areas.

201. Although mitigation strategies for new highways need to be developed with much more precise and detailed empirical information than can be accessed in the context of a high-level SEA study, it is anticipated that closer consideration of the cumulative effects potentials listed above is likely to indicate a need for more aggressive effort put towards enhancing the permeability of the Southern East-West Highway corridor highways than might otherwise be indicated by EIA studies conducted without the benefit of regional cumulative awareness.

202. The above prescriptions for cumulative impact assessment and aggressive mitigation notwithstanding, it should be acknowledged that project-limited mitigation for these particular projects is unlikely to be a fully adequate vehicle for mitigating the potential big-picture, transboundary biodiversity impact of Southern East-West Highway completion. Making the new highway links substantially permeable can minimize the direct impacts on ecological connectivity

from these particular projects, but not eliminate them, and will have virtually no potential to address the anticipated broader cumulative effects.

203. A solid solution for the shortcoming just identified would be to use the compensatory mechanism of the BAPs developed for the Lhamoizhingkha–Sarpang and Tareythang–Panbang projects to identify and implement add-on mitigation for existing portions of the highway corridor. It is anticipated with a high degree of confidence that both of these projects will involve critical habitat, and will thus require the preparation of a BAP encompassing measures to offset residual biodiversity impacts and verifiably ensure net gain of biodiversity values. Given that many of the same endangered species and similar habitat qualities exist in various locations along the southern border, it is probable that an offset program for residual biodiversity impacts for the new highway links could be designed (at least in part) around retrofitting existing portions of the Southern East-West Highway with permeability enhancements. This approach would benefit from the biodiversity expertise that will already be engaged for the assessments of these projects, as well as the long-term institutional oversight mechanisms typical of BAPs. This is recommended for evaluation as part of the EIA studies for the Lhamoizhingkha–Sarpang and Tareythang–Panbang.

e. Summary of Prescribed Actions

204. A diverse body of prescriptions and recommendations has been indicated over the preceding sections on biodiversity impacts. These are collected in a summary table below for clarity. Each line item in Table 20 is carried forward to the Strategic Environmental and Social Management Plan (SESMP) in Chapter VII.

Table 20: Prescribed Actions (Wildlife and Biodiversity)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	Ensure that ToR for feasibility-stage and design-stage EIA consultants make provision for adequate inputs of high-caliber international and national biodiversity expertise, including expertise in critical habitat assessment and offset design
2.	Ensure that ToR EIA consultants indicates that biodiversity assessment and mitigation shall follow the procedures specified in IFC Performance Standard 6 (or an equivalent requirement), including as applies to critical habitat assessment and preparation of Biodiversity Management Plans and Biodiversity Action Plans to meet no net loss and net gain objectives, regardless of the project financing source.
3.	Ensure that time allocations for feasibility studies and detailed design are sufficient to enable ecological field studies to take place over multiple seasons, and that the ToR for feasibility-stage and design-stage EIA consultants require multiple-season ecological studies.
4.	Ensure that ToR for the EIA consultants require thorough consideration of alternatives to projects in protected areas, including, at minimum: (i) Detailed ecological field studies spanning multiple seasons to fully characterize anticipated biodiversity impacts of the new highway, and its possible alternatives (including existing routes in both Bhutan and India); (ii) Thorough data-based analysis of the magnitude of expected benefits from travel time and travel cost savings relative to alternative routes (including existing routes in Bhutan and India); (iii) Inclusion of biodiversity-related mitigation and compensation (offsetting) costs in economic feasibility calculations; (iv) Quantitative estimation of benefits from ecotourism operations enabled by the new highway, based on realistic ecotourism development proposals linked to the proposed new highway, relative to benefits from ecotourism enabled by improvement and/or addition of low-impact seasonal park roads; (v) Estimation of anti-poaching benefits from the new highway, relative to anti-poaching benefits enabled by improvement and/or addition of low-impact seasonal park roads; and

	Prescribed Actions
	(vi) Assessment of the capacity of protected area management authorities to effectively achieve anticipated ecotourism and anti-poaching objectives, under both the new highway scenario and alternative scenarios; and (vii) Identification and justification of any strategic rationales supporting the development of the new highways through protected areas, including economic analysis and policy risk assessment for alternative routes using the Indian highway network.
5.	Ensure that ToR for feasibility study and detailed design consultants for new highways in protected areas specify avoidance of high-value biodiversity resources and features as top-priority criterion in alignment selection and design.
6.	Ensure that ToR for design consultants indicate reduced RoW clearance (where feasible) as a design criterion to be reflected in roadway designs, i.e., not left to discretion of contractors.
7.	Ensure that ToR for EIA consultants require in-context analysis of invasive species risks, as well as development of mitigation measures where risk is found to be significant.
8.	Ensure that ToR for design and EIA consultants require feasibility evaluation of measures for maximizing the permeability of new road corridors for wildlife, including but not limited to: (i) Large mammal underpasses; (ii) Ridgeline overpasses; (iii) Modified culverts; (iv) Dry culverts for small species; (v) Aerial overpasses for canopy-dwelling species; (vi) Gentle embankment slopes; (vii) Wildlife off-ramps at blind corners; (viii) Avoidance of box drains; (ix) Avoidance of long continuous stretches of guardrail; and (x) Reduced width of RoW clearance.
9.	Ensure that ToR for feasibility-stage EIA consultants require analysis of potential for threats to local biodiversity values from induced settlement and associated free-range livestock grazing, taking account of (at minimum) land tenure, land suitability, enabling economic factors, enforcement capacity of the relevant forest management division, and the biodiversity values present.
10.	Ensure that ToR for feasibility-stage EIA consultants require cumulative impact assessment for all projects and groups of projects. For projects in the Southern East-West Highway corridor, the cumulative impact assessment must consider, at minimum: (i) Regional-scale implications of continuous PNH-02 for north-south transboundary ecological interchange; (ii) Anticipated impedance of wildlife movement by planned development of Gelephu Mindfulness City; (iii) Foreseeable local and regional traffic (construction and non-construction) increases associated with development of Gelephu Mindfulness City; and (iv) Planned industrial developments in the southern border zone, such as dry ports, industrial parks and mines.
11.	Stipulate in the ToR for design-stage EIA consultants engaged for the Lhamoizhingkha-Sarpang and Tareythang–Panbang projects that retrofitting existing portions of the Southern East-West Highway to enhance permeability shall be evaluated for eligibility and utility as an offset measure for direct and cumulative residual biodiversity impacts from those projects, including field studies as may be required to identify priority locations and permeability measures, to be included as appropriate in the Biodiversity Action Plans for those projects.
COOPERATION AND COORDINATION	
12.	DOST shall enable meaningful cumulative impact assessment by assisting EIA consultants to obtain relevant and up-to-date documentation from other development projects (past, ongoing and proposed), including those coming under the remit of other agencies and sectors in Bhutan (and India if necessary).

	Prescribed Actions
13.	DOST and DOFPS shall explore the formation of agreements enabling interagency co-management of new highways through protected areas, and execute any Memorandum of Agreement enabling co-management prior to the relevant project's detailed design, so design features and costs necessary to support co-management can be incorporated in the project design and budget as appropriate.

B. Climate Change Adaptation and Mitigation

205. As a party to the Paris Agreement of 2015, Bhutan has committed to permanently maintaining a negative or neutral greenhouse gas (GHG) emissions balance, and to pursuing proactive measures to adapt to new challenges expected to result from global climate change. The implications of the HMP for Bhutan's ability to meet these commitments is a central concern of the SEA study.

1. Paris Agreement Alignment Context and Procedures

206. In 1992, 197 countries agreed to the United Nations Framework Convention on Climate Change (UNFCCC). Some two decades later in Paris, a legally binding treaty (the Paris Agreement) under the UNFCCC was adopted by 196 countries at the 21st annual UNFCCC Conference of Parties (COP). The principal aim of the Paris Agreement, as stated in its Article 2, is "to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty, including by: (a) Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; (b) Increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production; and (c) Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."[75] The Paris Agreement entered into force on 4 November 2016. Bhutan signed the Paris Agreement in April 2016, and ratified its accession in November 2017.

207. Following the signing of the Paris Agreement, all major MDBs including ADB committed to making their operations and financed initiatives consistent with and supportive of (i.e., aligned with) the objectives of the Paris Agreement, and began work on a shared MDB approach to alignment. A joint MDB Paris Agreement Alignment (PAA) Framework was announced at the 2018 COP24 in Katowice, Poland. Subsequent collaboration between the MDBs produced a series of joint methodological principles statements to guide alignment of their individual operations with regards to direct investment lending, intermediated financing, general corporate purpose financing and policy-based lending (PBL), in June 2023.

208. In order to support application of the joint MDB principles to its own operations, ADB has been developing and refining an internal Guidance Note on Implementing Operations' Alignment with the Paris Agreement at ADB. At the time of writing, the Guidance Note is on its seventh iteration (V1.7). The Guidance Note includes an annex with sector-specific guidance, and Section IV of that annex seeks to interpret, clarify, contextualize and expand upon the joint MDB principles as applicable to the transport sector. The Guidance Note (V1.7) is focused on direct lending operations, and does not yet provide much direction regarding PAA for PBL operations.

[75] Paris Agreement to the United Nations Framework Convention on Climate Change, December 12, 2015, T.I.A.S. No 16-1104, 3156 U.N.T.S. 54113.

a. Joint MDB Methodological Principles for Assessment of PAA

209. The MDB PAA Framework defines six building blocks (BBs) of alignment: alignment with mitigation goals (BB1); contribution to adaptation and climate-resilient operations (BB2); accelerated contribution to the transition through climate finance (BB3); engagement and policy development support (BB4); reporting (BB5); and alignment of internal activities (BB6). The first two of these are directly applicable to borrower projects and programs financed by the MDBs. To be considered aligned with the Paris Agreement, direct investment operations and PBL must be aligned in relation to both BB1 and BB2.

210. The core of PAA as applicable to BB1 and BB2 is a series of binary tests that yield one of two answers; aligned or not aligned. To be considered aligned, a proposed initiative must be found aligned for all of the tests; a single exception is sufficient to declare the initiative not aligned. For initiatives with multiple components, the initiative will be considered based on the overall objective, but all components must be aligned.

211. The above applies to both direct lending operations and policy-based lending, but separate assessment steps have been defined for these two financing modalities. The ADB Guidance Note (V1.7) indicates that for initiatives that include both direct project lending and policy-based lending at the sector or national level, both assessment processes should be applied. The HMP is fundamentally a national- and sector-level instrument, intended to assist the RGOB in prioritizing investment in the roads sector, and explicitly positioned as updated guidance supporting the country's Comprehensive National Development Plan. As it is not known at the time of assessment what role ADB may eventually play in financing implementation of construction or maintenance works prioritized in the HMP (or which projects the RGOB will ultimately choose to implement), direct lending is not a relevant modality at this stage. Therefore, this PAA assessment follows the assessment steps specified for PBL. The principal guidance for this is the Joint MDB Methodological Principles for Assessment of Paris Agreement Alignment of New Operations – Policy-Based Lending Operations (V1.0, June 2023).

b. Alignment Assessment Criteria

212. **BB1 – Alignment with Mitigation Goals.** The climate change mitigation goals of the Paris Agreement are framed by mean global temperature targets, and commit the parties to contribute to the meeting of those targets by decarbonization, through some combination of reducing carbo emissions and increasing carbon sinks. An initiative is considered aligned with the Paris Agreement's mitigation goals when it either (i) actively contributes to decarbonization in all circumstances by reducing emissions or increasing sinks; (ii) is expected to generate negligible emissions and therefore have no impact on decarbonization; or (iii) can be expected to produce non-negligible emissions but is consistent with national decarbonization pathways that are in turn compatible with the Paris Agreement goals, and also has a low risk of locking in emissions-intensive patterns. An initiative will not be considered aligned if it will support activities that contradict the mitigation goals of the Paris Agreement, and/or is likely to lead to a significant risk of carbon lock-in when compared to lower-carbon alternatives.

213. The MDBs have developed an agreed List of Activities Considered Universally Aligned with the Paris Agreement's Mitigation Goals or Not Aligned with the Mitigation Goals, and checking a proposed initiative against these lists is the first step in PAA assessment in relation to BB1. The proposed policy initiative is evaluated against two criteria:

(1) ***Criterion 1a:*** Does the PBL reform program consist of policy actions that support activities that actively contribute or do-no-harm to decarbonization pathways in line with the mitigation goals of the Paris Agreement in all circumstances? (i.e., 'universally aligned activities')?

(2) ***Criterion 1b:*** Does the PBL reform program consist of policy actions that support activities that contradict the mitigation goals of the Paris Agreement (i.e., 'universally non-aligned activities')?

214. If the proposed PBL initiative is on the 'universally aligned' list (affirmative in relation to Criterion 1a), it is automatically considered aligned and does not require further assessment. If it is on the 'not aligned' list, it is automatically ruled out and requires no further assessment unless it is adjusted and re-assessed. If an initiative is not on either list, or has components that are not, then the assessment proceeds to the second step.

215. The second assessment step in relation to BB1 involves considering the proposed initiative's foreseeable emissions outcomes. The proposed policy-based support is evaluated against two further criteria:

(1) ***Criterion 2a:*** Do the policy actions supported by the PBL program lead to a significant increase in GHG emissions? Do they introduce or reinforce persistent barriers to use/ transition to lower-carbon means to achieve stated development objectives (i.e., there is a significant carbon lock-in risk)?

(2) ***Criterion 2b:*** Are risks/barriers identified being adequately mitigated?

216. If the answers are affirmative in relation to Criterion 2a, and/or negative for Criterion 2b, the proposed PBL initiative is considered not aligned with the Paris Agreement.

217. **BB2 – Alignment with Climate Adaptation and Resilience Goals.** The Paris Agreement explicitly recognizes that the effects of climate change already present urgent need for adaptation to build resilience. A proposed PBL initiative is considered aligned with climate adaptation and resilience goals of the Paris Agreement if its design incorporates fit-for purpose resilience features responding to risks from current or future climate change impacts, in accordance with national contexts, capabilities and priorities. Two criteria are applied in relation to BB2:

(1) **Criterion 1a:** Are risks from climate hazards likely to have an adverse effect on the development objective(s) of the PBL reform program's policy actions?

(2) **Criterion 1b:** If yes, does the design of the policy action(s) reduce the risk to an acceptable level, considering climate resilience/adaptation good practices?

218. To be considered aligned with the goals of the Paris Agreement, a proposed PBL initiative must anticipate climate hazards relevant to the investments and other actions that are among its intended outputs and outcomes, and address them proactively through its own design.

2. Assessment of Highways Master Plan Alignment with Paris Agreement

a. BB1 – Alignment With Mitigation Goals

219. **Criterion 1a: Does the PBL reform program consist of policy actions that support activities that actively contribute or do-no-harm to decarbonization pathways in line with the mitigation goals of the Paris Agreement in all circumstances? (i.e., 'universally aligned activities')?** Under the transport sector, the list of universally aligned activities includes three sub-categories of activities that are of relevance to roads. These activity categories and their applicability to the HMP are presented in Table 21.

Table 21: Selected Universally Aligned Activities and Their Applicability to HMP

	Universally Aligned Activity	Applicability to HMP
1	Electric passenger or freight transport	Promotion of electric vehicle adoption is not a major focus of the HMP. Inclusion of activities that would tend to facilitate electric vehicle adoption, e.g., charging stations on selected road segments, would contribute to a positive alignment determination for the HMP, but would not be sufficient to do so on its own.
2	Roads with low traffic volumes providing access to communities which currently do not have all-weather access (for example, connecting farmers to markets or providing access to a rural school, hospital, or better social benefits) – except if there is any risk of contributing to deforestation.	This category is only indirectly applicable to activity proposed under the HMP, since the focus of the HMP is on upper-tier roads (primary national highways and secondary national highways) rather than on roads that provide 'last mile' accessibility (dzongkhag roads, farm roads and access roads). Accordingly, this category would not qualify the HMP as an aligned PBL initiative.
3	Road upgrading, rehabilitation, reconstruction, and maintenance without capacity expansion.	Significant components of the overall infrastructure investment recommended under the HMP would fall within this category, and this would contribute to an overall finding of alignment for the HMP, but would not be sufficient to do so on its own. Some capacity expansions (widening and new highways) are proposed.

Source: Consultant

220. Based on the analysis in Table 21, the HMP can be considered partially aligned because some of its components match up with items on the list of universally aligned activities. This partial alignment is an insufficient basis for bypassing further assessment tests.

221. **Criterion 1b: Does the PBL reform program consist of policy actions that support activities that contradict the mitigation goals of the Paris Agreement (i.e., 'universally non-aligned activities')?** The list of universally non-aligned activities comprises just four categories, none of which are applicable to the HMP:

(1) Mining of thermal coal;
(2) Electricity generation from coal;
(3) Extraction of peat; and
(4) Electricity generation from peat.

222. There is no reason to believe that the HMP will support any of the activities in the list above. The non-applicability of these categories means that the HMP is not automatically non-aligned, and can proceed to further assessment steps. It does not mean the HMP is aligned.

223. **Criterion 2a: Do the policy actions supported by the PBL program lead to a significant increase in GHG emissions? Do they introduce or reinforce persistent barriers to use/ transition to lower-carbon means to achieve stated development objectives (i.e., is there a significant carbon lock-in risk)?**

224. ***Estimated carbon emissions.*** The first part of Criterion 2a is answered with reference to projected emissions derived from highway network improvement projects proposed under the HMP. Carbon dioxide emissions have been estimated for both traffic and works (construction and maintenance). Overall network traffic emissions were estimated based on the vehicle-kilometer data outputs from the network model, combined with information and assumptions on traffic composition; fuel consumption; fleet electrification; traffic growth rate (7%); and indirect emissions.[76] Emissions generated by construction works indicated in the Development Plan were calculated based on preliminary material quantities information, as well as reference values

[76] The 7% network traffic growth rate assumption was adopted to align with the assumption used in the economic evaluation of proposed projects.

gathered from various sources for fuel use in construction processes and embodied carbon in materials. Maintenance works emissions were estimated from quantities of asphalt cement and tack coat, the largest contributors to emissions from maintenance activity. Overall emissions were estimated for both the base scenario (no network improvements) and a future scenario reflecting the proposed network improvements. Table 22 details the information and assumptions used in projection of emissions from both works and traffic. It is to be emphasized that the emissions calculations are based on high-level, preliminary information of the kind available at the master planning stage, and that there are multiple sources of uncertainty in play; the results presented below should be taken as broadly indicative projections rather than precise predictions.

Table 22: Summary of Base Information and Assumptions in CO_2 Estimation

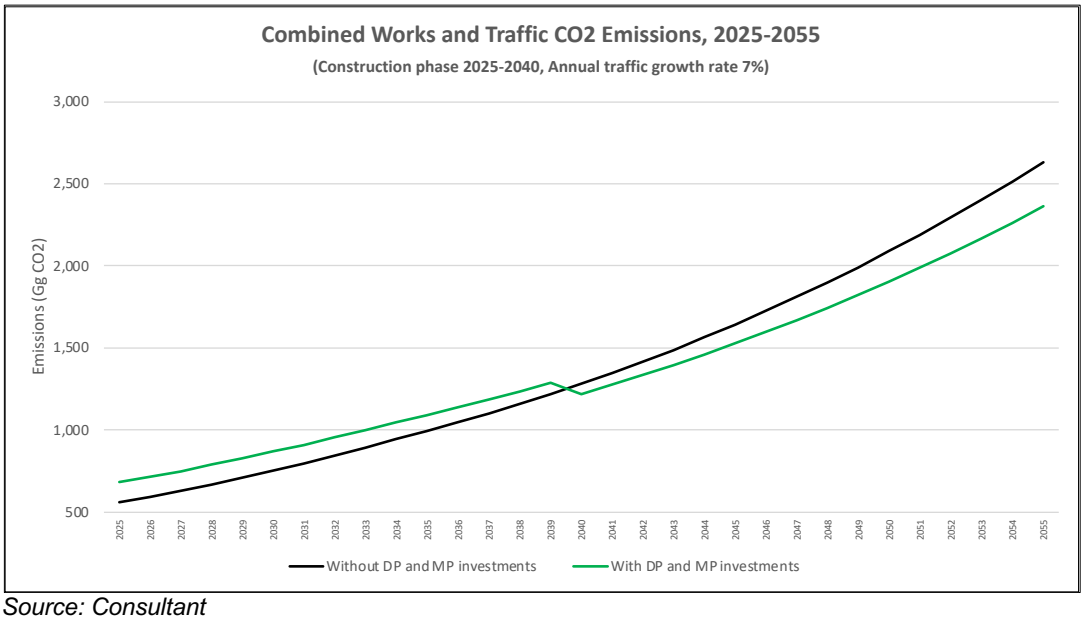
Emissions Contributor	Information Basis	Key Assumptions
Construction Works Emissions		
Materials	▪ Preliminary by-project quantities estimates	▪ Projects, once designed, will ultimately be more or less the same as the early conceptual designs suggest in terms of alignment and scale of works
Embodied emissions	▪ Reference values from the literature	
Direct energy use	▪ Reference values from the literature	
Maintenance Works Emissions		
Materials	▪ Quantities estimates for asphalt cement and tack coat	▪ Resurfacing constitutes a large majority of maintenance works in terms of materials, and thus is a reasonable proxy for maintenance works in emissions calculations
Embodied emissions	▪ Reference values from the literature	
Direct energy use	▪ Reference values from the literature	
Traffic Emissions		
Traffic composition	▪ Traffic count data	▪ Traffic composition constant across network
Vehicle-kilometers (vkms)	▪ Output of traffic assignment model, (derived from cell phone tracking data, converted to vehicles and calibrated against traditional traffic count data)	▪ Margin of error in traffic assignment modeling acceptable for high-level indicative analysis
Per-vkm CO_2	▪ HDM-4 emissions predictions per 1,000 vkm, calibrated for Bhutan and disaggregated by vehicle class	▪ Median altitude class applied ▪ Average road roughness IRI=9-10 (baseline) and IRI=6-7 (with maintenance improvements)
Traffic growth	▪ National vehicle registration data ▪ Macro-economic trends and policy analysis	▪ Traffic growth 5%, compounded annually
Electric vehicle transition[1]	▪ National vehicle registration data ▪ Macro-economic trends and policy analysis ▪ Reference values from the literature	▪ Passenger cars: +2%/yr from 2025 ▪ SUVs and pickups: +2%/yr from 2030 ▪ Buses and trucks: +2%/yr from 2035 ▪ Tractors/power tillers: +2%/yr from 2040 ▪ Specialized vehicles: +2%/yr from 2035
Fuel ('well to tank')	▪ Global reference value from the literature	▪ Reference value applicable to fuel from Indian refineries
Electrical energy (EVs)	▪ HDM-4 EV energy use per 1,000 vkm (extrapolated from passenger cars to other vehicle classes) ▪ Electrical grid factor for Bhutan	▪ Margin of error in extrapolation not sufficient to significantly change outcome of calculations
Vehicle manufacture	▪ Reference values for different vehicle classes derived from the literature	▪ Difference between reference and actual values minor

[1] Assumptions pertain to the change in by-class composition of traffic on the national highway network, which can be expected to lag considerably behind change in EV import patterns.

Source: Consultant

225. Figure 37 shows a comparison of estimated emissions for the base scenario and with all Development Plan projects implemented, and the maintenance works regime indicated in the Maintenance Plan also adopted. Construction works were assumed to be spaced evenly over the 2025-2040 period, and emissions savings effects of the projects were assumed to have a corresponding phase-in period of 15 years, beginning in 2031. Maintenance emissions for the baseline 'Without DP and MP investments' scenario assume a constant continuation of the maintenance regimen deemed attainable under the FY 2024-2025 maintenance budget, and maintenance emissions under the 'With DP and MP investments' scenario after 2040 assume a continuation of the pattern established in the second half (2031-2039) of the Maintenance Plan horizon.

226. Works emissions would significantly elevate overall emissions from the national highways relative to the baseline growth scenario, with the net effect tapering off somewhat as emissions savings from new projects and improved road conditions on existing highways are progressively realized after 2030. The end of construction works in 2040 would bring an abrupt re-balancing of net emissions, with emissions savings approaching full realization and exerting downward pressure on emissions growth. By the end of the analysis window in 2055, cumulative emissions savings attributable to the network improvement investments would amount to about 892 Gg CO_2. Annual savings in 2055 relative to the baseline scenario would be approximately 266 Gg. The capital and maintenance investments proposed under the HMP are thus not anticipated to generate significant net emissions, and may even make a modest contribution to Bhutan's efforts to mitigate GHG emissions under the Paris Agreement. Based on this analysis, the first Criterion 2a question can be answered in the negative, as a significant increase in net emissions would not be expected.



Source: Consultant

Figure 37: Network Emissions With and Without Investments, 2025–2055

227. ***Carbon lock-in risk.*** The second Criterion 2a question can safely be answered in the negative. Improvement of highways does not in any way act as a barrier to the electrical vehicle transition, which is the cornerstone of the RGOB's emissions reduction strategy for surface

transport.[77] There is limited scope for the HMP to directly promote the transition, which will be enabled mainly by policy controls on vehicle emissions standards and vehicle imports, and market-driven provision of charging infrastructure. However, project-level EIA studies for network expansion projects coming under the HMP should assess the need for provision of charging infrastructure in project settings where the market may be slow to allocate it, such as remote rural locations, and mandate provision for charging stations as needed in project designs.

228. There is limited potential for a broad modal shift to rail transport in Bhutan, given the difficulty and expense of rail development in mountainous terrain. Although future population growth and industrial development could perhaps make interurban rail development economically feasible, this is unlikely to be the case for decades, well beyond the time horizon of the HMP. That said, there are concrete proposals to extend spur lines of the Indian rail network across the border into Bhutan in two locations, and dry ports are envisioned for these locations. This limited modal shift opportunity has been recognized in the HMP, and upgrades of approximately 90 km of existing road are proposed specifically to enhance articulation of the railheads with the national highway network. Based on the foregoing, Criterion 2a does not present an obstacle to a positive alignment determination for the HMP.

229. **Criterion 2b: Are risks/barriers identified being adequately mitigated?** No carbon lock-in risk has been identified.

b. BB2 – Alignment With Climate Adaptation and Resilience Goals

230. **Criterion 1a: Are risks from climate hazards likely to have an adverse effect on the development objective(s) of the PBL reform program's policy actions?** Bhutan is widely acknowledged to be highly vulnerable to adverse effects of climate change, due in large part to a preponderance of steep and unstable terrain. Climate change risks to road and bridge infrastructure in Bhutan, along with adaptation measures considered in development of the HMP, are characterized in Table 23. The risk conceptualization is based on analysis of projection data generated under the Coupled Model Intercomparison Project, Phase 6 (CMIP6).

Table 23: Climate Change Risks to Bhutan's National Highways

Risk Origin	Risk Characterization
Risks linked to changes in temperature regime	
Hotter days and longer warm spells (general) (tas +2.4–4.7°C) (txx +2.4–4.6°C) (wsdi +140–253 days)	• Enhanced pavement deterioration • Bridge deck expansion exceeds design tolerance, leading to structural damage
Hotter days and longer warm spells (more frequent forest fires) (tas +2.4–4.7°C) (txx +2.4–4.6°C) (wsdi +140–253 days)	• Higher erosion-associated slope failure risk in years following upslope and downslope fires due to reduced vegetative cover • Higher peak runoff discharges in years following fires in above-road catchment areas due to reduced absorption and infiltration
Higher temperatures at high altitude (permafrost melting)	• Negligible risk to national highways, as all are below 4,000 masl (lower limit of permafrost in Bhutan)
Higher temperatures at high altitude (increased glacial meltwater)	• Bridges and associated protective structures on rivers with significant upstream glacial area (Pa Chhu, Mo Chhu, Pho Chuu, Punatsangchhu, Mangde Chhu, Chamkhar Chhu, Kuri Chhu, Manas Chhu) may be subject to increased scour

[77] See (1) Department of Environment and Climate Change. 2023. Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy; and (2) Ministry of Information and Communications. 2021. Low Emission Development Strategy for Surface Transport.

Risk Origin	Risk Characterization
	• Bridges and approaches on rivers with significant upstream glacial area may become more vulnerable to flood damage • Risk to national highways (road segments) is overall quite low in Bhutan due to limited river proximity
Higher temperatures at high altitude (increased risk of glacial lake outburst floods)	• Highway bridges over main stems of Mo Chhu, Pho Chuu, Punatsangchhu, Mangde Chhu, Chamkhar Chhu, Kuri Chhu, Manas Chhu may have increased exposure to GLOF risk due to possible glacial lake expansion in their catchments, but RGOB monitoring and proactive mitigation efforts at high-risk lakes reduce the risk
Fewer freezing days (id -11 to -18 days)	• Pavement and sub-grade deterioration linked to freeze-thaw and de-icing is likely to decline in significance at the network level over time as more of the national highway system becomes frost-free year round
Risks linked to changes in precipitation	
Higher overall precipitation (pr annual +6–19%) (pr monsoon +6–21%)	• Slopes above and below roads may become more prone to failure due to higher average and peak soil saturation, causing more frequent major and minor road damage • Bridges and associated protective structures may be subject to increased scour due to higher mean and peak flows in rivers • Bridges and approaches may become more vulnerable to flood damage due to higher mean and peak flows in rivers (risk to other highway segments is overall quite low in Bhutan due to limited river proximity)
Higher rainfall intensity (rx1day +15–40%) (rx5day +16–41%) (r50mm +31–87%)	• Drainage structures may overflow more frequently, leading to increased incidence of pavement and subgrade damage, erosion and slope failure • Slopes above and below roads may fail more often and with greater severity due to more frequent incidence of high soil saturation, causing more frequent major and minor road damage • Bridges may be more vulnerable to washout and scour due to higher peak discharge in rivers
Indicator codes: tas = Mean annual surface temperature; txx = Maximum of daily maximum surface air temperature; wsdi = warm spell duration index; id = number of ice days; pr = Annual aggregated accumulated precipitation; rx1day = Average largest 1-day precipitation; rx5day = Average largest 5-day cumulative precipitation; r50mm = Number of days with precipitation >= 50 mm	

Source: Consultant

231. Criterion 1a can be answered in the affirmative; without proactive mitigation, risks from climate hazards will have an adverse effect on the successful development and durability of the highway network.

232. **Criterion 1b: If yes, does the design of the policy action(s) reduce the risk to an acceptable level, considering climate resilience/adaptation good practices?** The resilience of transport infrastructure is a cornerstone of DOST's institutional mandate, and climate-proofing road infrastructure is listed as a priority item in Bhutan's current National Adaptation Plan.[78] Accordingly, strengthening the climate change resilience of the national highway network was adopted as a key objective of the highways master plan process.

233. The focus on resilience is reflected in the central place of adaptation-supportive projects in the Development Plan. Forty-four sites where the reliability of a highway link could be enhanced by slope stabilization works were included in the project portfolio, as were 40 bridges that will be replaced with new or upgraded ones, which will presumably be climate-proofed during their design. In addition, a proposed new bypass road and one of the tunnels included in the Development Plan should contribute to resilience by providing alternative routes on one of the

[78] Royal Government of Bhutan (Department of Environment and Climate Change). 2023. National Adaptation Plan (NAP) of the Kingdom of Bhutan.

country's most important arteries (PNH-01) in the event of a weather-related closure. Two of the three tunnels in the Development Plan will address major existing landslide vulnerabilities that will be exacerbated by projected changes in the precipitation regime. These adaptation-supportive investments collectively account for over half of the Development Plan's total proposed capital investment (see Table 24).

Table 24: Adaptation-Supportive Investments in Development Plan

	Project Class	No. of Projects	Investment cost (million Nu.)	% of Total Capital Investment
1	Slope stabilization works	44	8,811	7.3
2	Bridge replacement/upgrades	40	2,269	1.9
3	Tunnels	3	50,320	41.5
4	Bypass roads	1	6,225	5.1
	All	**88**	**67,625**	**55.8**

Source: Consultant

234. The proposed investments highlighted above should make a substantial contribution to Bhutan's efforts to strengthen the resilience of the national highway network, in line with its stated climate change adaptation goals. In general, timely, proactive and competent road maintenance should also enhance resilience (which is why maintenance is on the list of universally aligned activities shown in Table 21), and the stepped-up regimen proposed in the Maintenance Plan for the national highways should be a significant move in this direction. The particular contents of the Development Plan and Maintenance Plan support a finding of Paris Agreement Alignment with respect to Criterion 1b for climate change adaptation.

c. Conclusion of Assessment

235. In the foregoing analysis, the HMP has been assessed against six criteria; the findings are summarized in Table 25. None of the findings indicate any reason to consider the HMP contrary to the aims of the Paris Agreement or to Bhutan's efforts to meet its commitments under that agreement. The HMP is therefore deemed to be aligned.

Table 25: Summary of Paris Agreement Alignment Assessment

Building Block	Criterion	Aligned?
BB1 – Alignment with mitigation goals	Criterion 1a –Supports universally aligned activities	YES
	Criterion 1b – Does not support universally unaligned activities	YES
	Criterion 2a – Will not generate significant net emissions, does not have significant carbon lock-in risk	YES
	Criterion 2b – n/a (absence of significant lock-in risk)	-
BB2 – Alignment with climate adaptation and resilience goals	Criterion 1a –Climate risk reduction central objective of policy action, consistent with National Adaptation Plan)	YES
	Criterion 1b – Design of policy action reduces risks to acceptable levels	YES

Source: Consultant

3. Options for Enhancing Climate Change Resilience

236. As detailed above, the HMP incorporates considerable investment, spread across 88 projects and an enhanced maintenance program, that should help to strengthen climate change adaptation efforts. But climate resilience can also be strongly influenced by infrastructure design and implementation, and further enhancement of resilience can be achieved by actions in these

areas. This is true both in the context of the projects and maintenance regimen proposed in the HMP for the 2025–2040 period, and in relation to all of DOST's road asset management activities within the 2025-2040 period and continuing beyond.

237. **Design.** Climate resilience through design pertains particularly to drainage, bridge and culvert clearances and capacities, and slope protection. The Consultant reviewed recently updated (2019) DOST design guidelines for road drainage, and concluded that the augmentations of cross-drainage frequency and culvert sizes indicated in the guidelines are reasonable measures suitable to managing projected increases in precipitation and precipitation intensity.[79] The updated guidelines also recognize the need to adapt design discharge calculations to reflect the latest climate projections at the time of design. Thorough application of these existing guidelines will be an important part of ensuring that all projects proposed in the development plan (not just those highlighted as being adaptation-supportive) avoid preventable climate risks and contribute to the overall resilience of the highway network and the country. It will also be critical to ensure that a thorough climate risk and adaptation study is conducted for each project or group of projects during design, to provide detailed, up-to-date information and insight to needed by planning and design teams.

238. **Construction.** Other DOST manuals on application of bioengineering and environmentally friendly road construction (EFRC) were also reviewed, and found to contain sound guidance which, if used in the development of new infrastructure, could make a meaningful contribution to adaptation of the national highways in the face of changes indicated by analysis of the CMIP6 projection data.[80] To ensure consistently thorough application of these useful guidelines, the ToR for design consultants on all proposed projects should require that the bioengineering and EFRC guidelines be 'designed in' (complemented as appropriate with international best practice guidance) as part of road designs and quantity estimation to provide enforceable direction to contractors. In addition, the ToR for construction contractors must require adherence to the practices indicated in the EFRC guidelines.

239. **Adapting road asset management for climate change.** It is of course somewhat narrow to conceive of adaptation just in the context of the implementation of the activities proposed in the HMP. DOST will continue to be responsible for the national highways after 2040, and the global temperature rise driving diverse climate change effects is unlikely to level off for decades to come, even under the most optimistic emissions scenarios. Meanwhile, responsibility for the country's dzongkhag roads has recently been transferred from the dzongkhag administrations to DOST, giving the agency an additional 2,073 km of roads to prepare for the coming intensification of temperature- and precipitation-related infrastructure risks. It will be essential for DOST to begin adapting its entire road asset management system for climate change.

240. Several general implications for DOST's road asset management expenditures can be inferred from analysis of current climate change projections. These include:

(1) Routine maintenance budgets will have to increase over time to address increasingly frequent and severe damage from landslides, smaller slope failures, flash floods, debris flows, drainage structure overflows, etc.;

(2) The monsoon restoration fund will have to grow over time as slope failures and bridge washouts increase in frequency and magnitude;

[79] See: Guidelines on Design, Construction and Maintenance of Road Infrastructure Incorporating Climate-Resilient Features (December 2019)

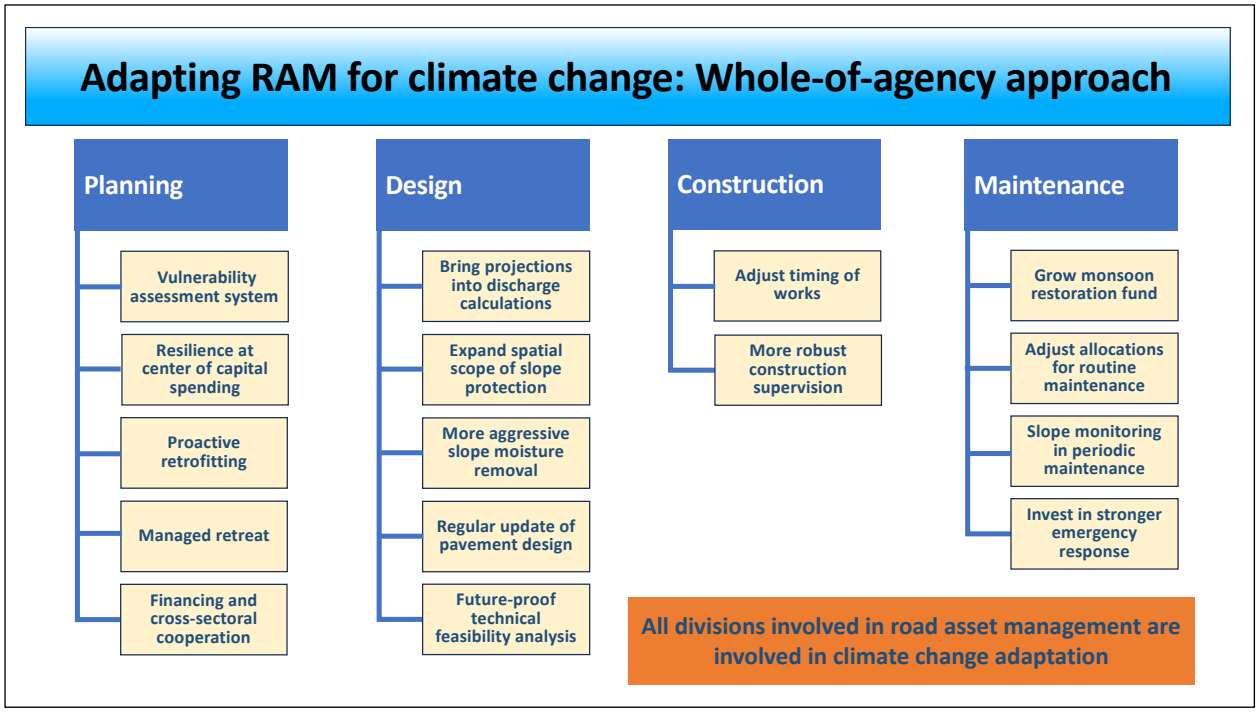
[80] See: (1) Environmentally Friendly Road Construction (EFRC) Manual – Bio-Engineering in Bhutan (September 2005); and (2) Environmentally Friendly Road Construction (EFRC) Field Handbook – Bioengineering Works (September 2005).

(3) Per-km capital costs will rise due to the need for more expansive and robust slope protection, more and higher capacity drainage structures, and more aggressive use of bioengineering; and

(4) Emergency response needs and costs will rise, as the challenge of getting fully ahead of climate change impacts is enormous in a place as mountainous as Bhutan, and there will be more catastrophic events to manage even with proactive climate-proofing.

241. These readily anticipated climate-driven trends in expenditure indicate that greater allocations to the agency will be required from the RGOB central budget process, or that more outside financing will have to be procured to help cover items that can be addressed through capital expenditure. It is likely that both mechanisms will play a role.

242. Adaptation will require more than increasing budgets; new approaches and practices should be considered to expand DOST's road asset management toolkit. Figure 38 shows a summary of adaptation measures applicable to each of four spheres of activity in road asset management, developed in October 2024 by the TA-6916 Consultant as part of a training module on Climate Change Adaptation in Road Asset Management.[81] The diagram, which does not by any means constitute an exhaustive list of options, emphasizes that there are many possibilities for institutional adaptation to confront climate change challenges, and they span essentially the whole agency.



Source: Consultant

Figure 38: Framework for Approaching Adaptation of Road Asset Management in Bhutan

243. It is recommended that DOST leadership, in consultation with DOST staff and the leadership of the MoIT, begin thinking systematically about these kinds of institutional adaptations, and work towards developing an agency-wide Climate Change Adaptation Strategy to guide innovation and investment in this area. Such a strategy development effort could well be

[81] A half-day training workshop on topic was conducted with engineers representing all five divisions in DOST headquarters, as well as several engineers from the DOST regional offices. A copy of the Powerpoint presentation used to structure group discussion is provided in Appendix 5 for further reference.

supported by climate financing available under one of the global climate financing mechanisms, or by an MDB as a component of project financing for one or more of the projects proposed in the HMP.

244. A number of the items listed in Figure 38 would be appropriately supported by focused training (preferably on-the-job training) for DOST personnel. Useful training topics could include:

(1) Accessing, interpreting and using climate change projection data;
(2) Adapting design to changing hydrological conditions;
(3) Qualitative and quantitative risk assessment methods;
(4) Bringing climate change adaptation into feasibility analysis
(5) Formulating, assessing and prioritizing climate resilience investments; and
(6) Accessing and implementing climate financing.

245. It is recommended that DOST seek collaboration and support, either through one of the multilateral climate financing mechanisms or through a technical assistance with one of the MDBs, to develop a continuing education program for its engineers and planners to expand the agency's capacity to meet climate challenges proactively.

a. Summary of Prescribed Actions

246. Recommendations discussed in the preceding sections are collected in a summary table below for clarity. Each line item in Table 26 is carried forward to the Strategic Environmental and Social Management Plan (SESMP) in Chapter VII.

Table 26: Prescribed Actions (Climate Change Mitigation and Adaptation)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	Ensure that ToR for feasibility study and design consultants require preparation of a detailed climate risk and adaptation study for each project or group of projects, incorporating analysis of the most up-to-date climate change projection information available, and that the findings are reflected in designs, cost estimates and feasibility analysis.
2.	Ensure that ToR for design consultants require review, and application to project designs as appropriate, of DOST Guidelines on Design, Construction and Maintenance of Road Infrastructure Incorporating Climate-Resilient Features (December 2019); Environmentally Friendly Road Construction (EFRC) Manual – Bio-Engineering in Bhutan (September 2005); and Environmentally Friendly Road Construction (EFRC) Field Handbook – Bioengineering Works (September 2005), or successor guidance material, together with applicable international best practice guidance.
3.	Ensure that ToR for construction contractors require adherence to DOST Guidelines on Design, Construction and Maintenance of Road Infrastructure Incorporating Climate-Resilient Features (December 2019); Environmentally Friendly Road Construction (EFRC) Manual – Bio-Engineering in Bhutan (September 2005); and Environmentally Friendly Road Construction (EFRC) Field Handbook – Bioengineering Works (September 2005), or successor guidance material, together with applicable international best practice guidance.
4.	Ensure that ToR for EIA and design consultants engaged for network expansion projects require assessment of need for public sector provision of electric vehicle charging stations, and provide for charging infrastructure in the project design as appropriate.
COOPERATION AND COORDINATION	
5.	DOST and MoIT should seek the collaboration and support of a bilateral or multilateral partner to develop and implement a comprehensive Climate Change Adaptation Strategy for DOST.
6.	DOST and MoIT should seek the collaboration and support of a bilateral or multilateral partner to develop and implement a continuing education program for DOST personnel to increase capacity for internal agency

	Prescribed Actions
	development of new and advanced approaches to adapting aspects of road asset management to anticipated climate change.

C. Water Resources

1. Potential Impacts of HMP on Water Resources

a. Groundwater Flows and Watersheds

247. Concerns were raised during scoping for the SEA study about the potential for new road projects to limit groundwater flows and negatively affect valued springs; alter watershed dynamics affecting the reliability of surface flows used for irrigation and domestic use; and impinge upon pre-existing irrigation conveyances. These concerns were not raised in relation to any particular project being considered for inclusion in the HMP. Impacts such as the ones mentioned are highly site-specific, and do not represent a systemic risk; as such, they are appropriately analyzed at the project level, during the EIA studies. These concerns having been raised, it will be prudent for all EIA studies carried out for new highways proposed under the HMP umbrella to carefully consider potential for impacts on groundwater flows, watershed dynamics and irrigation systems.

b. Cumulative Effects of Bridge Works

248. Projects proposed in the Development Plan include 40 bridges requiring full replacement or comprehensive upgrading works, in addition to another 45 new bridges that would be part of proposed new highway segments. These bridges would be the principal and most direct exposure of projects proposed in the HMP to the country's river systems. Risks associated with this exposure would include both construction-phase risks and operation-phase risks.

249. The main construction-phase risks to water quality and aquatic habitat quality in rivers during bridge works are (1) siltation from site erosion and releases of loose sediment to the watercourse during excavation and piling works, installation of scour protection, and river training works; (2) siltation and changes in water chemistry from concrete process water; (3) contamination associated with use of motorized equipment in and around water, as well as storage of fuels and lubricants at the work site; (4) pollution (sewage and solid waste) from improperly managed construction camps; and (5) noise and disturbance from piling and other activities. Most of these impacts are somewhat amenable to minimization, but are unlikely to be eliminated entirely. Depending on the scale of works, some may endure on an intermittent basis for a number of years.

250. Longer-term bridge risks to the value of rivers as aquatic habitat include (1) alteration of the pre-existing dynamics of erosion, accretion and sediment transport, which may take many years to reach a new dynamic equilibrium; (2) modifications of pre-existing channel shape that result in water velocity changes that permanently or intermittently inhibit habitat suitability or migrations; and (3) spills from road accidents during operation. The significance of these risks is highly dependent on the scale of the bridge and contextual factors such as topography and existing river dynamism (which shape the extent of river training needed), as well as the volume and composition of operation-phase traffic (which influence spill risk).

251. The impacts identified above can only be assessed in-context, and this is the job of project-level EIA studies. However, all bridge works can be expected to produce at least some of these impacts. Given their intrinsic physical movement capacity, their basic agglomeration function, and their concentrated use as wildlife corridors, river systems have a special propensity for enabling

linkages between impacts at disparate sites. This makes cumulative effects especially important to consider for projects affecting rivers.

252. The Development Plan proposes a total of 85 bridge projects including new bridges on new highway links, and a prudent starting point for cumulative impact assessment is to understand their distribution, and the distribution of other non-bridge impact sources that may significantly affect the health of the rivers they span. Figure 39 shows all bridge projects proposed under the Development Plan, as well as the locations of operating, under-construction and proposed hydropower projects, and locations of towns with a 2017 population over 5,000 people. In Bhutan, riverbed mining for sand, gravel and boulders is another important source of water quality impacts and habitat degradation, but many such mining operations are intermittent, and no mapping of mining sites is available.

253. The map in Figure 39 suggests moderate potential for cumulative effects on water quality and aquatic life on the main stem rivers in a small number of river basins. For example, the Punatsangchhu Basin will absorb the effects of 15 bridge projects, two towns over 5,000 population, two operating hydroelectric plants, and as many as three new hydroelectric projects (one already under construction and two under development permit review). The lower reaches of the combined Mangdichhu/Chamkharchhu Basin will receive impacts from five bridges, one town over 5,000 people, two operating hydroelectric plants and as many as two new hydroelectric projects (one already under construction and one under review). And the Kirichhu/Gongri Basin will have seven bridge projects, one operating hydroelectric plan and as many as three new hydroelectric projects (one already under construction and two under review). It will be noted from the map in Figure 39 that the Maokhola Basin will host a large number of the new bridges identified in the Development Plan; most of these will be part of the Lhamoizhingkha–Sarpang, Gelephu–Tareythang and Tareythang–Panbang projects. This basin has a rather diffuse pattern downstream of the international border, with flow being distributed across at least four rivers that flow independently all the way south to the Brahmaputra River, so cumulative effects potential is likely low with regard to water quality, despite the large number of bridges in this basin.

254. It is very likely that the operating and under-construction hydroelectric projects will be more influential drivers of water quality and aquatic habitat quality impacts than the bridges proposed in the Development Plan, given their scale and nature of their impacts. Although virtually all hydroelectric projects implemented and proposed in Bhutan have run-of-river designs and therefore don't have the troublesome ecological consequences associated with large reservoirs, they do involve modest intake dams and spillways that require extensive in-river works over multiple years, and also introduce some change to downstream flow dynamics during both construction and operation. Hydroelectric projects are large, disruptive undertakings that permanently alter the river environment. That said, there may be some potential for bridges to have a significant additive effect during construction in locations where several bridge projects form a cluster with an under-construction hydroelectric project. Much of this potential will depend on the timing of works, and will be greatest if bridge projects in particular areas are packaged for simultaneous implementation during a period when works on nearby hydroelectric plants are in an intensive phase. Bridge design characteristics that permanently or intermittently affect the qualities of aquatic habitat may also have an additive effect in relation to river flow-related impacts of hydroelectric projects.

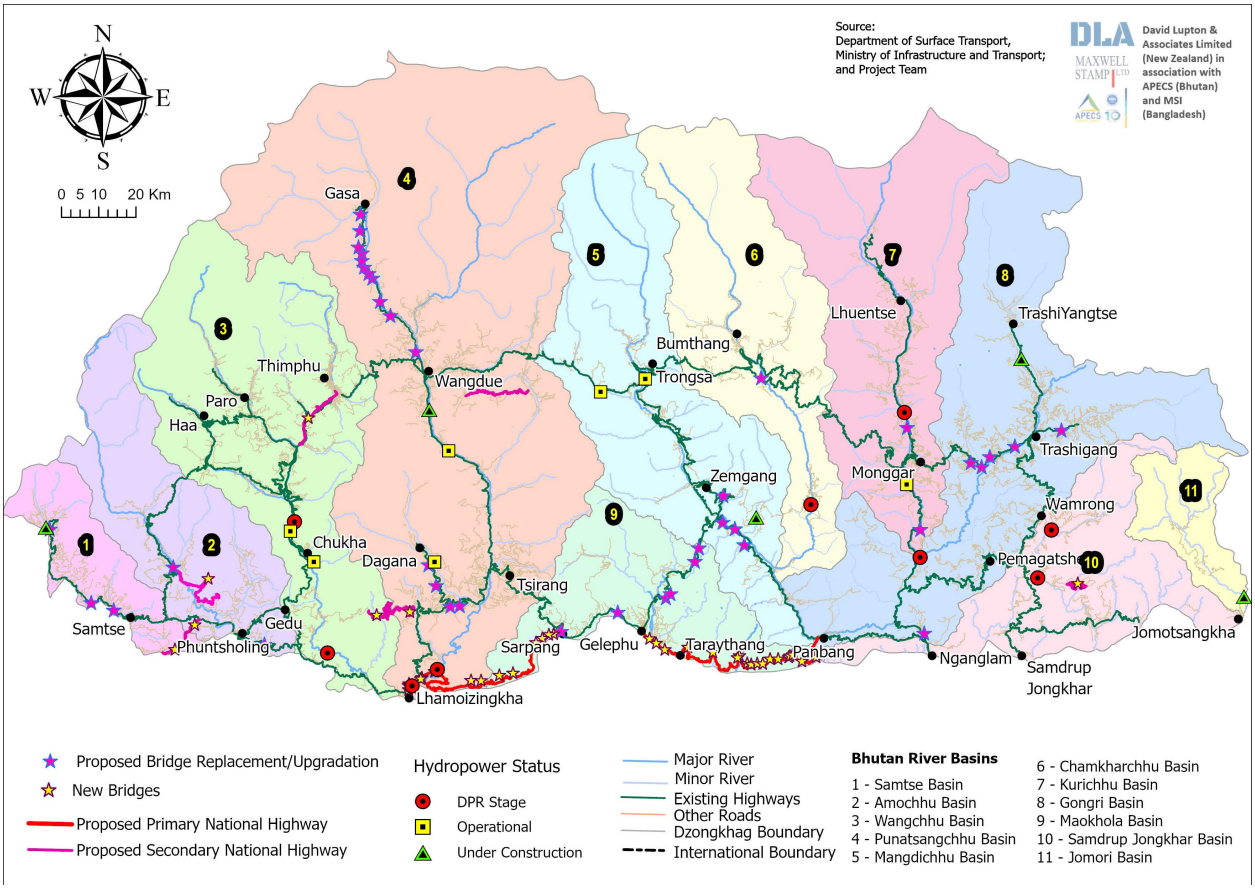


Figure 39: Distribution of Bridge Works and Other Impact Sources by River Basin

255. Riverbed mining works are likely to compound water quality and habitat quality impacts that may be anticipated from both bridge works and hydroelectric projects. Riverbed mining operations will vary widely in terms of their scale and duration, and any particular stretch of river may be affected by more than one operation. Simultaneous activity at bridge works, riverbed mining operations and hydroelectric construction sites could lead to substantial impairment of aquatic habitat.

256. Special attention must be directed at the potential effects of bridge, hydroelectric and riverbed mining works on one particularly sensitive wildlife species: the White-bellied heron (*Ardea insignis*). This critically endangered species depends on wild rivers, fishing in the shallows and nesting only in tall river-proximate Chir pine (*Pinus roxburghii*) trees. The species, whose global population is down to about 250 mature individuals (one third to one half of which are found in Bhutan), is notoriously sensitive to human disturbance, and is given to flushing at the slightest foreign noise or sudden visual intrusion. Availability of healthy fish populations and clear water are critical to successful feeding. Given the sensitivity of the White-bellied heron, the cumulative effects of bridge works (with and without hydroelectric projects and riverbed mining) have heightened importance, especially where works are carried out within the species' range (shown in Figure 40). Potential for both water quality and disturbance effects on the White-bellied heron should be an essential element of cumulative impacts assessment of bridge projects (or groups of bridge projects) during the feasibility and design stages.

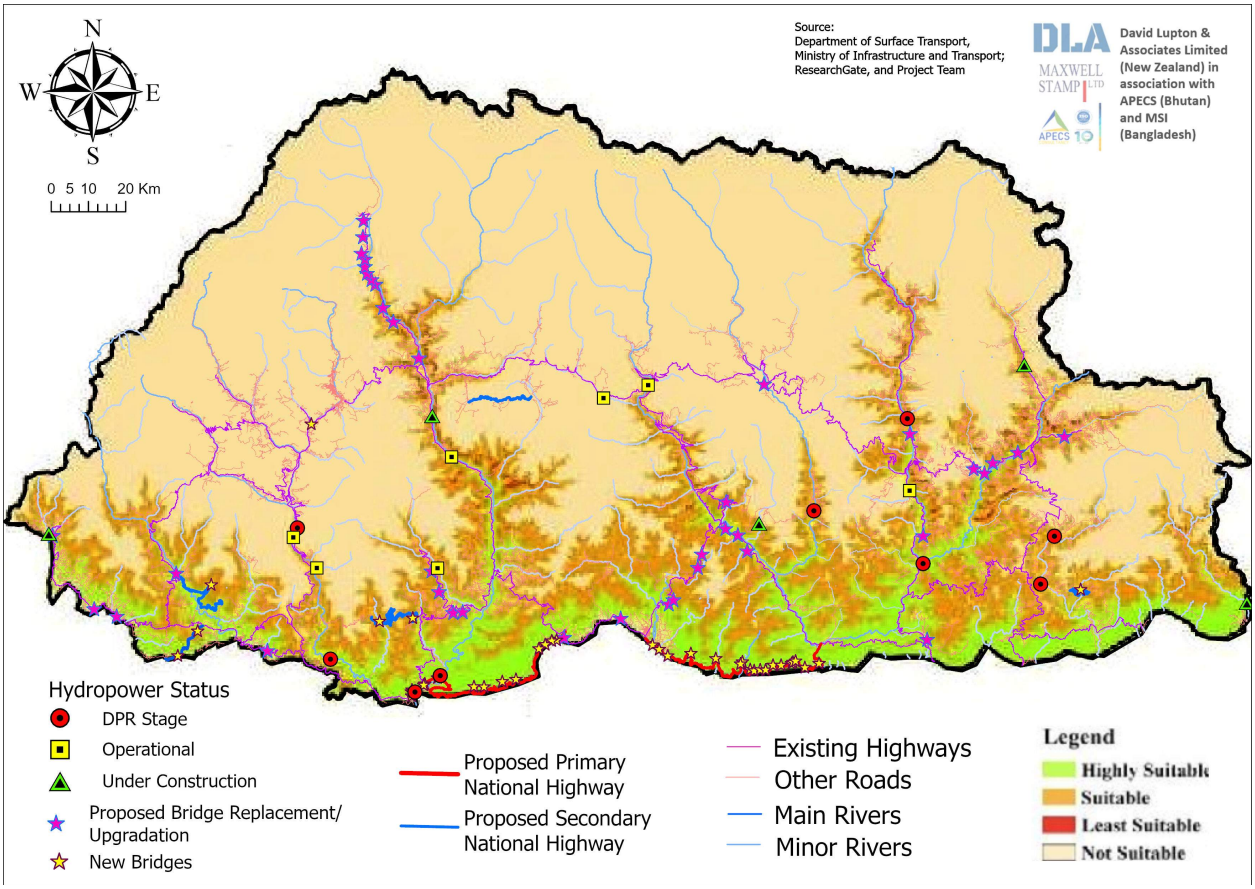


Figure 40: Bridge and Hydropower Projects and White-Bellied Heron Habitat Suitability

2. Mitigation Options

257. The preceding sections have acknowledged the uncertain significance of impacts on water resources from projects in the Development Plan at this early and high-level stage of assessment; the scope for specification of mitigation options in this SEA study report is limited to shaping and supporting cumulative assessment under the auspices of EIA studies to be conducted on individual projects or groups of projects at the feasibility study and detailed design stages.

258. Impacts on water quality and aquatic habitat from bridge projects can typically be minimized with sensitive design, foresightful phasing of works relative to the seasons, and good construction site management; measures falling into these categories can be identified and specified under the auspices of project-level EIA studies conducted during the feasibility study and design stage. With respect to the cumulative effects that may arise from multiple bridge works and hydroelectric projects being implemented in proximity to one another within overlapping timeframes, mitigation is likely to involve accommodation of the bridge projects (or groups of bridge projects) to the much larger hydroelectric projects and their associated impacts. The principal avenues of accommodation are likely to involve timing of works, and possibly also design considerations.

259. The 40 bridge replacement/upgrading projects in the Development Plan are identified as priority investments that should be completed early in the 2025-2040 plan implementation window. It is possible that the design and construction works for the bridges will be bundled under a number of packages. There may be significant potential to minimize cumulative effects by phasing the implementation of packages, or by phasing the works within packages, such that

high-impact in-river activities involved in bridge works do not overlap temporally with in-river works on upstream or downstream hydroelectric projects. This potential for minimization by phasing should be carefully evaluated as part of cumulative effects analysis carried out under the auspices of the EIA studies for bridge projects or groups of bridge projects. Coordination and information-sharing between the EIA consultants and the hydroelectric project proponent (Druk Green Power Corporation Ltd.) and its consultants will be needed to facilitate both the cumulative effects analysis and implementation of any phasing-related mitigation proposed for the bridge projects.

260. With regards to design measures, it is possible that the cumulative effects analysis will bump up the significance of bridge effects on the suitability of aquatic habitat (e.g., changes to the flow regime or erosion dynamics downstream), and indicate a need to consider more aggressive measures than might otherwise be justified by single-site impact assessment. Increasing bridge spans to avoid the need for river training or scour protection works might be an example of more aggressive mitigation through design. It is important that the need for this kind of design accommodation is considered in the context of cumulative effects assessment as part of the project-level EIA studies.

261. Potential effects on known and suspected riverine habitat of the White-bellied heron must be investigated as a matter of both site-level concern (i.e., will building or replacing a bridge in a particular location disturb a feeding or nesting site?) and cumulative concern (i.e., will building or replacing multiple bridges near each other and/or near one or more hydroelectric projects or riverbed mining operations generate harmful effects on habitat at the basin scale, potentially threatening a whole subpopulation?). Given the White-bellied heron's imperiled status (and its usefulness as an indicator of high-quality riverine ecosystems), this must be explicitly required of the EIA consultants for all bridge projects, including both the replacement/upgrading projects and the new bridges on proposed new highways. Entities with a mandate covering conservation of the White-bellied heron in Bhutan, including but not necessarily limited to DOFPS and the Royal Society for Protection of Nature, must be engaged in the assessment process.

a. Summary of Prescribed Actions

262. Recommendations discussed in the preceding sections are collected in a summary table below for clarity. Each line item in Table 27 is carried forward to the SESMP in Chapter VII.

Table 27: Prescribed Actions (Water Resources)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	Ensure that ToR for feasibility study and design consultants engaged for all new highways clearly require hydrological analysis of risks to groundwater flows and springs; water availability and water quality for community uses; and existing and planned irrigation systems.
2.	Ensure that ToR for feasibility study and design consultants engaged for bridge upgrade/replacement projects (or groups of such projects) require cumulative impact assessment in relation to possible cumulative effects with other bridge projects, as well as with other significant impact sources such as hydropower projects and riverbed mining. Key elements of cumulative impact assessment should include the packaging and timing of works in both the highways and hydropower sectors.
3.	Ensure that ToR for feasibility study and design consultants engaged for bridge upgrade/replacement projects (or groups of such projects) require thorough consideration of potential for impacts on the habitat of the White-bellied heron (*Ardea insignis*), including cumulative effects resulting from the presence of other infrastructure projects (other bridge works as well as operating, under-construction and proposed hydropower projects and riverbed mining operations) within the same river basin. EIA studies carried out by the consultants must include early and active engagement with entities concerned with conservation of the White-bellied heron in Bhutan, including but not necessarily limited to DOFPS and Royal Society for Protection of Nature.

	Prescribed Actions
COOPERATION AND COORDINATION	
4.	DOST shall enable meaningful cumulative impact assessment by assisting EIA consultants to obtain relevant and up-to-date documentation from other development projects (past, ongoing and proposed), including those coming under the remit of other agencies and entities in Bhutan, such as Druk Green Power Corporation, Department of Energy, Department of Water, and Department of Geology and Mines.

D. Public Safety

263. The Development Plan includes significant direct and indirect investments in public safety. The most obvious is the proposal to spend 2,415 million Nu. (about 2% of the overall Development Plan cost estimate) on safety improvements including guardrails and pavement markings on 518 km of national highways, which represents almost one fifth of the national highways network. Other investments in slope failure mitigation (44 projects worth 8,811 million Nu.) and highway widening and upgrade projects covering 778 km (17,800 million Nu.) should also substantially improve highway safety. Enhancements to DOST's highways maintenance regimen proposed in the Maintenance Plan, entailing an overall improvement of road surface conditions, will also help improve safety for highway users. It can be safely concluded that the HMP will enhance public safety.

264. The HMP report makes note of a number of actions that would usefully build upon the safety benefits achievable through infrastructure improvements, including improvement of the existing system for collection and management of road accident data; development of a multi-agency Road Safety Council to coordinate safety-related responsibilities and promote safety; and road safety educational programs delivered in school and community settings. These actions would be beyond the remit of DOST to implement, but would enhance and complement the positive safety effects of the HMP, and so are appropriately conceived as parallel initiatives that can be given a measure of impetus by inclusion under the monitoring mechanisms set up in the SESMP for the HMP. Specific actions are recommended directly in Table 28, and the recommendations are carried forward to the SESMP.

Table 28: Prescribed Actions (Public Safety)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	No applicable actions
COOPERATION AND COORDINATION	
2.	Bhutan Construction and Transport Authority to lead formation and operation of a Road Safety Council to coordinate actions of relevant agencies in improving safety conditions on Bhutan's road network.
3.	Bhutan Construction and Transport Authority to develop expanded and improved comprehensive road accident data collection system and database, in cooperation with Royal Bhutan Police (Traffic Division) and DOST.
4.	Bhutan Construction and Transport Authority to develop nationwide road safety public education program in cooperation with the Department of School Education, Royal Bhutan Police (Traffic Division) and DOST.

E. Equitable Development

265. Road connectivity is widely understood to have a special role to play in integrating marginalized rural populations with sub-national, national and regional economies, by facilitating

rural people's access to employment and markets, banking and credit, and public services including health care and education. Road access is a core indicator for one of the two broad-spectrum indices used to measure well-being in Bhutan, the Modified Multidimensional Poverty Index (MMPI).

266. The proposed improvements to the national highways proposed in the HMP should be expected to reduce travel time and travel cost for long-distance trips, and this should have the general effect of making the marginalized eastern half of the country more accessible from the wealthier northwest for investment, tourism and procurement of regional produce, while giving residents of the east better market access and more opportunities to capture revenue from growth in tourist interest. Bhutan's eastern dzongkhags have a wealth of heritage sites, distinctive intangible cultural heritage and interesting landscapes, yet receive a small fraction of aggregate tourist arrivals at present.

267. Road development does carry social equity risks when assets and livelihoods are displaced or otherwise affected, and arrangements for appropriate compensation and resettlement are not properly executed. Some of the proposed network expansion projects, including new roads and upgrading and widening, will take place in settled landscapes, and will require careful survey and compensation for lost assets, as well as resettlement in some cases. Bhutan has a well-developed and routinely applied procedural framework for compensation and resettlement, and further marginalization of project-affected rural people by lack of proper compensation should generally not be expected. This is a matter for project-level assessment, following established procedures.

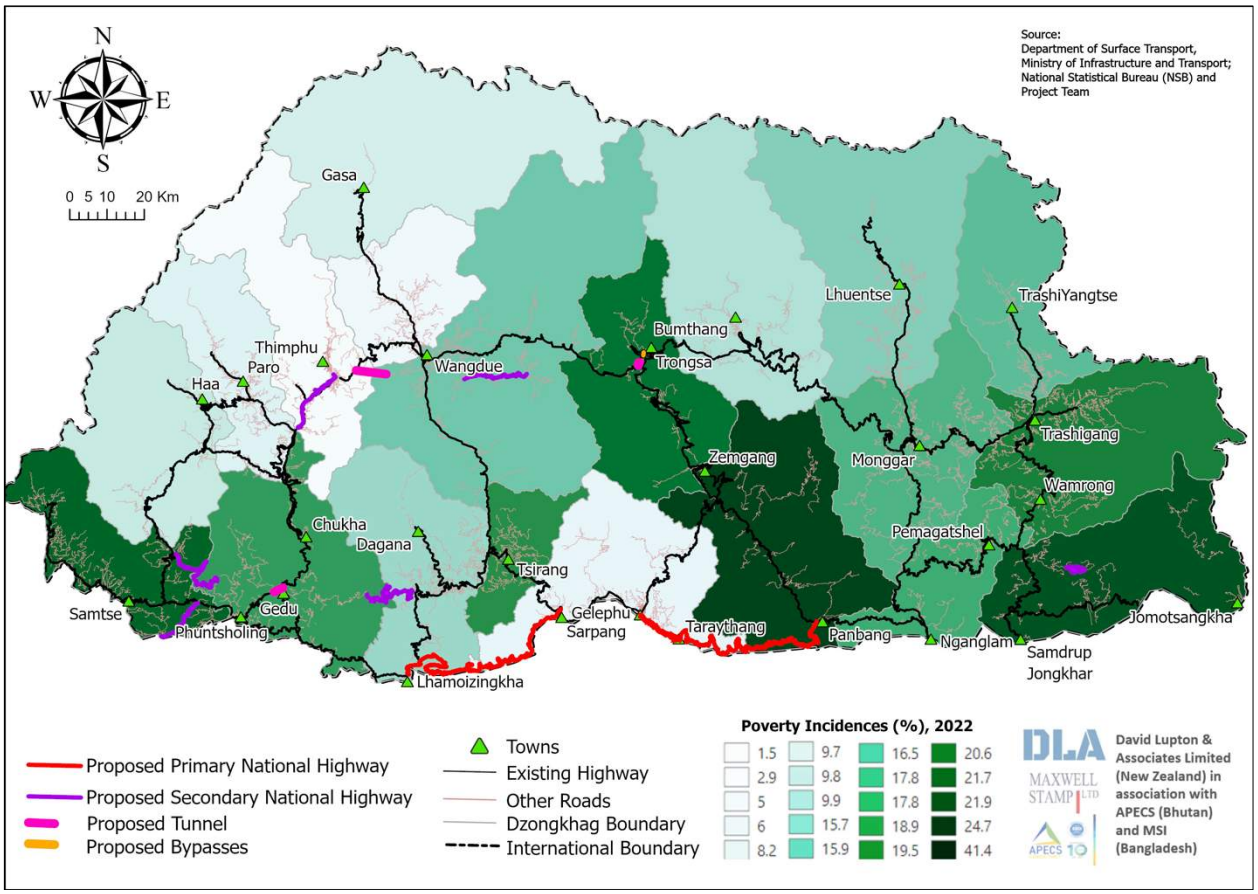


Figure 41: Relative Distributions of New Highway Projects and Poverty

268. Available data are insufficient to enable a fine-grained quantitative analysis of the equity implications of the group of projects proposed in the HMP, but it is possible to make a partial inference by overlaying the 13 new highway projects on a poverty distribution map, as has been done in Figure 41. The median dzongkhag poverty incidence as shown on the map is 16.2% (2022 data). The proposed new projects span 10 of the country's 20 dzongkhags, and all of the four dzongkhags with the highest incidence of poverty have at least one proposed new highway.

269. Table 2 shows the poverty incidence for each terminus of each project, as well as an average incidence for the two termini. The averages are compared to the median poverty incidence for all 20 dzongkhags. Of the 13 proposed new highway connectivity projects, six have an average poverty incidence below the median, and seven have averages that are above the median. By this crude measure at least, the distribution of new highway projects does not suggest a strong skew towards either wealthy or poor dzongkhags, and can probably be considered more or less neutral in terms of equity.

Table 29: Poverty Class of Dzongkhags Hosting New Projects

	Project Name	Poverty Incidence Terminus 1	Poverty Incidence Terminus 2	Poverty Incidence Average	Above/Below Median (16.2%)
1	Lhamoizhingkha-Sarpang	9.9	5.0	7.5	BELOW
2	Gelephu–Tareythang	5.0	5.0	5.0	BELOW
3	Tareythang–Panbang	5.0	41.4	23.2	ABOVE
4	Thimphu–Kariphu–Chuzom	1.5	1.5	1.5	BELOW
5	Gatena–Dorona	17.8	9.9	13.9	BELOW
6	Khotokha–Phubjikha	15.9	15.9	15.9	BELOW
7	Denchukha–Chimuna	21.9	17.8	19.9	ABOVE
8	Sarjung–Yarphu	24.7	24.7	24.7	ABOVE
9	Gomtu–Pagli–Tading	21.9	21.9	21.9	ABOVE
10	Trongsa Bypass	21.7	21.7	21.7	ABOVE
11	Gedu–Ganglakha Tunnel	17.8	17.8	17.8	ABOVE
12	Thumang Tunnel	21.7	21.7	21.7	ABOVE
13	Yesipang–Nahi Tunnel	1.5	15.9	8.7	BELOW

Source: Consultant

F. National Economic Vitality

270. An efficient and reliable highway network is critical to a modern integrated national economy, and there can be little question that both the capital investments and maintenance improvements in the HMP will help to reduce existing obstacles to transport-dependent economic activity. New highway links, road widening projects, and replacement and upgrading of low-capacity bridges will increase the proportion of the country that can be readily reached by freight trucks. And provision is made in the Development Plan for improvements necessary to enhance access between the national highway network and existing and planned dry ports, industrial parks and railheads in the southern border region; this should support the expansion of exports and lower the cost of some imports.

271. In addition to delivering economic benefits, highway network improvements also cost a lot of money to implement. Large investments in highway network expansion may ultimately be a drag on the national economy if the expenditures are not well balanced by benefits. Numerous proposed network expansion projects considered during formulation of the HMP were ruled out

on the basis of unacceptably high cost and complexity (mainly tunnels) and unfavorable results from cost-benefit analysis (mostly due to low propensity to attract traffic).

272. Table 30 shows the predicted Economic Internal Rate of Return (EIRR) for the network expansion projects that were ultimately selected, and which collectively account for nearly half of the total projected cost of the HMP investments. Strong economic benefits are suggested for five of the 13 projects (EIRR > 10%) and moderate benefits (EIRR 3–10%) for a further five projects. Negative EIRR was predicted for three projects: Lhamoizhingkha–Sarpang, Tareythang–Panbang, and the Thumang Tunnel.

Table 30: Predicted Economic Internal Rate of Return for Network Expansion Projects

Project Name	Cost (million Nu.)	EIRR
Lhamoizingkha-Sarpang (PNH)	9,451	-10%
Gelephu-Tareythang (PNH)	6,238	10%
Tareythang-Panbang (PNH)	6,597	-6%
Thimphu-Kariphu-Chuzom (PNH)	1,742	5%
Gatena - Dorona (SNH)	2,610	25%
Khotokha-Phubjikha (SNH)	799	5%
Denchukha-Chimuna (SNH)	1,601	3%
Sarjung-Yarphu (SNH)	969	46%
Gomtu-Pagli-Tading (SNH)	696	34%
Trongsa Bypass (bridge)	6,225	29%
Gedu-Ganglakha Tunnel	9,009	5%
Thumang Tunnel	2,703	-7%
Yesipang-Nahi Tunnel	38,608	13%

Source: Consultant

273. It is important to acknowledge that the economic analysis conducted on these proposed projects is preliminary and high-level. However, the results do cast a cloud of doubt over the prospects for a favorable return on investment for particular projects included in the HMP, and are thus suggestive of some possibly unjustified risk to the national purse. All of the proposed projects, including many other proposed investments (e.g., slope stabilization, bridge works, safety improvements, widening projects) that could not be subject to meaningful economic analysis at this early stage due to weak or non-existent data, will have to undergo further and more rigorous analysis prior to implementation, as per standard practice. It is to be expected that projects found to offer little in the way of economic benefit even after detailed project-specific economic evaluation will be removed from the HMP implementation program at that time.

G. Cultural Heritage

274. In a broad sense, it can be anticipated that improvement of the national highway network will be generally beneficial to the visitation, appreciation and promotion of tangible cultural heritage, due principally to travel time and travel cost savings. Available mapping of cultural sites in Bhutan (see Figure 42) shows several notable concentrations of sites and heritage villages around the country, including some dense clusters in the easternmost dzongkhags.

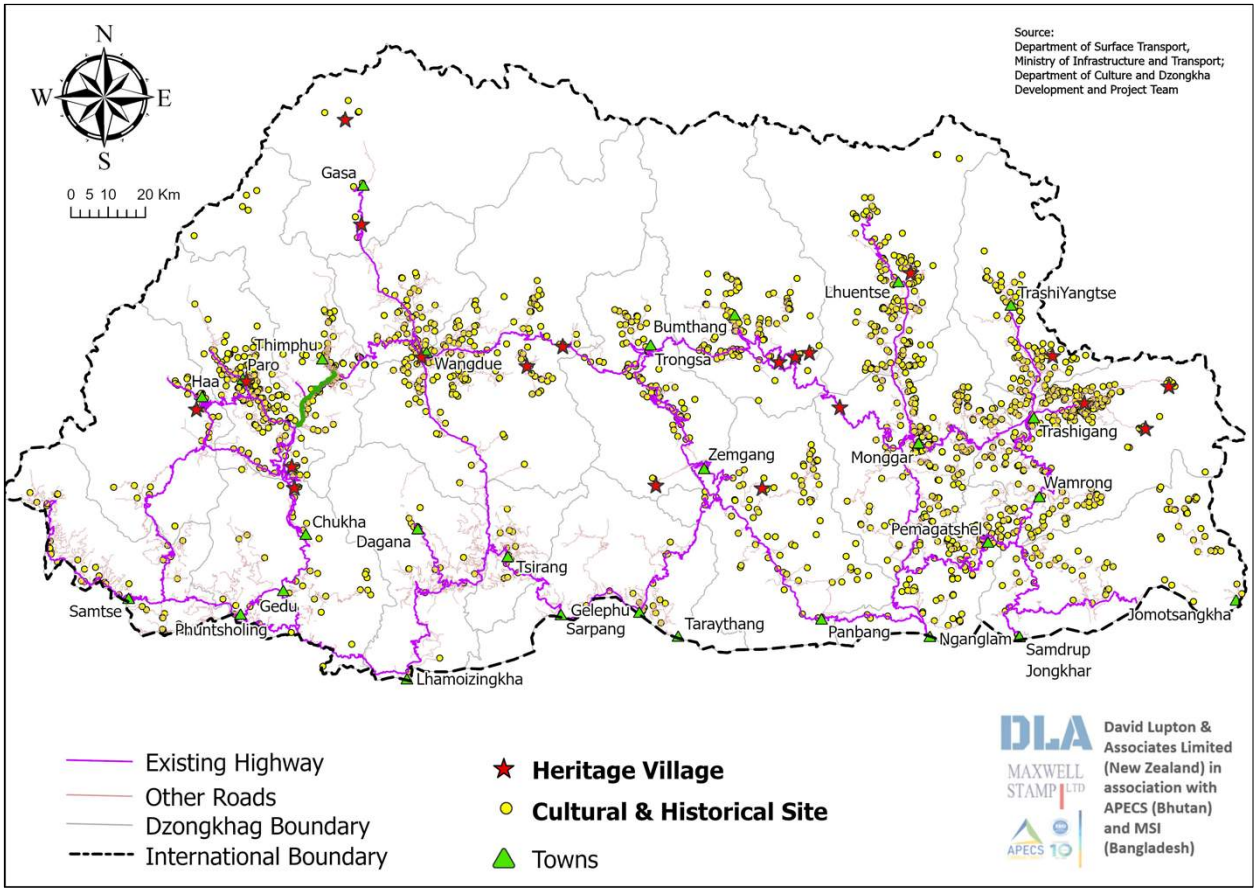


Figure 42: Distribution of Cultural Heritage Sites and Rural Heritage Villages

275. The accessibility of heritage sites is presently very uneven, with the result that visitation is concentrated in the western dzongkhags of Thimphu, Paro, Punakha and Wangdue Phodrang. Sites in the eastern dzongkhags, though numerous, are a long way from Thimphu and the lone international air gateway at Paro. The two-day drive from Thimphu and Paro is a considerable investment for would-be cultural tourists, especially international tourists on short package visits. A substantial reduction in east-west travel time, which is a key objective of the HMP, is likely to make visitation of eastern sites, by both domestic tourists from the more populous west and international tourists entering at Paro, less of an undertaking than it is at present.

276. The early-stage, high-level spatial analysis that has been possible in the SEA study does not indicate any particular risks to cultural heritage from the projects in the Development Plan, but it is acknowledged that all alignments and works locations are indicative at this time. More detailed consideration of risks to particular sites will have to be undertaken as part of project-level EIA studies during the feasibility study and design stages, and avoidance of risks to cultural sites should be an important consideration in alignment selection. It is standard EIA practice in Bhutan to review cultural site mapping and other information, and to consult with the DOCDD, to avoid impingement on cultural heritage sites and their associated management zones.

277. In addition to risks, new road projects can also be a source of opportunity to support site restoration and protection, along with enhanced visitation and appreciation, and this should also be an objective of alignment selection for new highway projects, as appropriate to the context. For this to happen, assessing opportunities for heritage site support (not just risk avoidance) should be an explicit objective of feasibility studies, and proactive engagement with the Department of Culture and Dzongkha Development from the earliest stage should be mandated

in the ToR for feasibility study consultants for any new highway project. This prescribed action is indicated in Table 28, and carried forward in the SESMP (Chapter VII).

Table 31: Prescribed Actions (Cultural Heritage)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	Ensure that ToR for feasibility study engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Culture and Dzongkha Development, to both avoid risks to physical cultural resources, and enable consideration of alignment options that could support the Department's aims with regard to promotion and development of priority sites.
COOPERATION AND COORDINATION	
2.	No applicable recommendations.

H. Natural Resource Use

278. Roads provide access to natural resources, and enable their transport to markets. In the absence of property rights enforcement and effective regulation, these functions of roads tend to support over-exploitation of any natural resource for which there is significant local human need or market demand. While Bhutan's natural resources have been protected in part by inaccessibility and high transport costs, they have also benefitted from the existence of a stable and well-defined land tenure system, well-developed natural resource protection rules and procedures, low levels of official corruption, and cultural norms that favor moderation and respect for non-human Nature. Such factors may help explain why Bhutan has not experienced runaway resource extraction even in areas well-endowed with roads, and there is little reason to expect that incremental expansion and improvement of the national highway network will fundamentally change any of them. Despite a general expectation of lower cost-to-market for most commodities sourced in the country's rural expanses, the HMP seems unlikely to pose a significant risk of dangerous increases in unsustainable exploitation of natural resources.

279. From the perspective of communities, private enterprises and government entities involved in natural resource extraction and in processing and marketing of natural resources, the capital investments and maintenance improvements proposed in the HMP will generally be understood as positive interventions. For agricultural producers, reduced travel time and cost, as well as greater network reliability, should reduce risk of produce spoilage in transport and make it more feasible to sell to a greater variety of markets including urban ones and export-oriented processors and manufacturers. Agricultural inputs sourced from outside the country or through urban suppliers, such as fertilizers and farm equipment, should become marginally less expensive at the farm gate due to lower transport costs. Bhutan's agricultural sector faces numerous other constraints besides those that relate to transport, including fragmentation of parcels, an aging and shrinking agricultural workforce, human-wildlife conflict, historical emphasis on supporting subsistence agriculture, low levels of innovation and investment on the part of private sector processors, and generally weak value chains.[82] It is difficult to predict if highway network improvements will be sufficient on their own to drive significant change in agricultural production.

280. With regards to forest products, the same cost savings in marketing should accrue. Highway widening and upgrading projects, as well as bridge replacements and upgrades, should increase the range of forest areas accessible to heavy trucks, yielding efficiencies in access to urban markets and processors, and in some cases to direct export markets for timber and wood

[82] (1) Ministry of Agriculture and Forests. 2021. RNR Strategy 2040.; (2) Ministry of Agriculture and Livestock. 2023. Food and Nutrition Security Policy of Bhutan 2023.

products. The map in Figure 43 illustrates the potential for the new highways in the Development Plan to support forest industry activity; several of the new roads will provide new access to the highway network for producers in existing Forest Management Units, Community Forests, and Local Forest Management Areas. The significance of the potential boost from the highway network improvements may be muted, given the importance of other constraints on the forest sector, which include labor shortages, competition from low-cost Indian and Chinese suppliers of wood products including plywood and furniture, and a lack of strong traditions of enterprise, innovation and investment.[83]

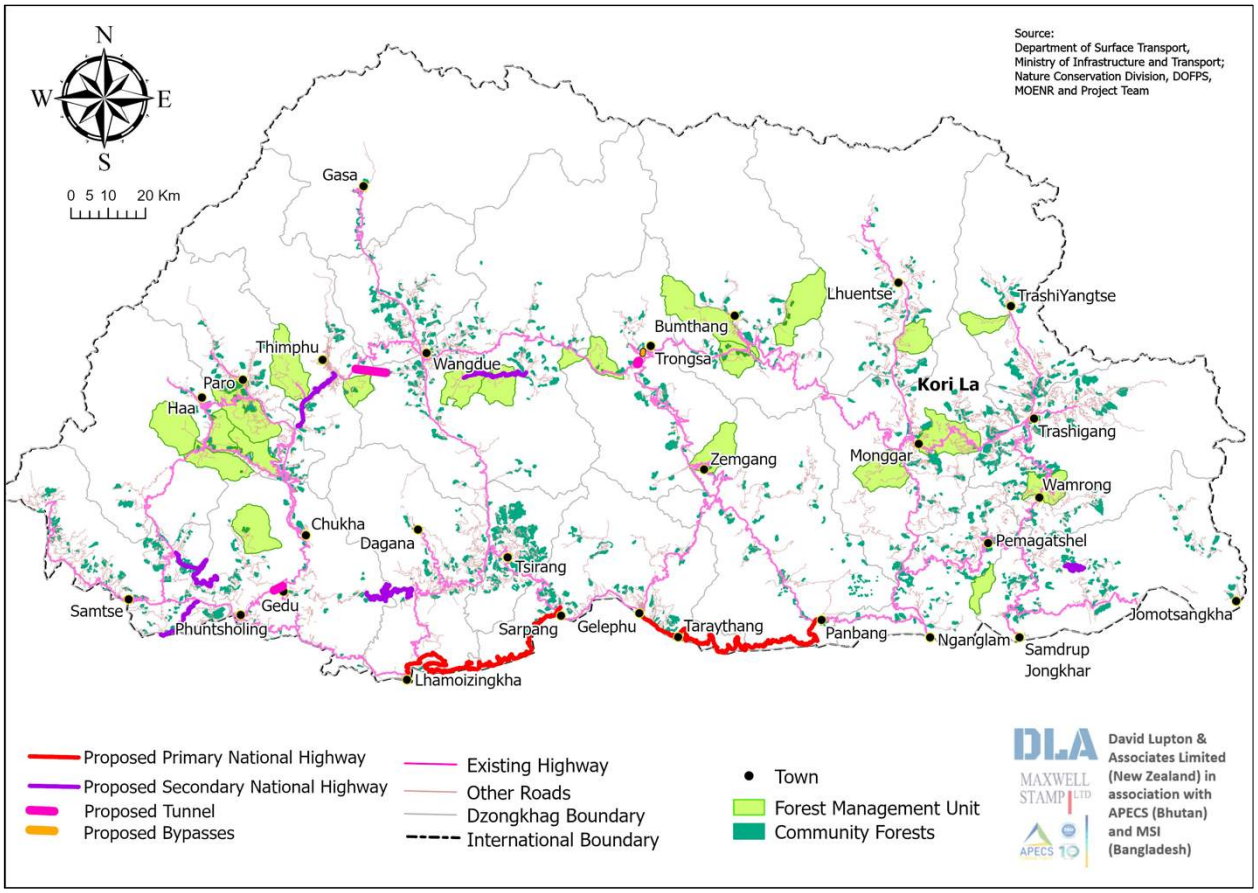


Figure 43: New Highway Links and Forest Management Areas

281. Available data on the mining industry in Bhutan (especially the locations of proposed mines and mining growth areas) is insufficient to support a similar spatial analysis of potential for benefits, but it can be assumed that mineral producers and processors will benefit from improved highway conditions, especially widening and bridge upgrades and replacements, which will facilitate truck transport. The proposed improvement of access from the national highways network to planned dry ports, industrial parks and railheads should be especially favorable to the mining and mineral processing sectors.

282. Although the foregoing discussion does not indicate a need for mitigative action, the development of new highway links may represent a modest opportunity for enhancing benefits to natural resource producers. The alignments used in assessment and selection of the projects in

[83] World Bank. 2019. Bhutan Forest Note – Pathways for Sustainable Forest Management and Socio-Equitable Economic Development.

the Development Plan are preliminary and indicative, and it is to be expected that multiple alternatives for each may be identified and assessed during feasibility studies and detailed design. Enhancing opportunities to support benefit capture from sustainable natural resource extraction should be one of the objectives in alignment selection, and relevant resource industry stakeholders should be engaged at the earliest stage of feasibility studies to provide insights to the alignment identification and selection process. This is indicated as a prescribed action in Table 32, and carried forward in the SESMP.

Table 32: Prescribed Actions (Natural Resource Use)

	Prescribed Actions
PROJECT-LEVEL FEASIBILITY, DESIGN AND EIA STUDIES	
1.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Agriculture and the Department of Agricultural Marketing and Cooperatives, to enable consideration of possible alignment options that could support these departments' aims with regards to supporting marketing and processing of agricultural produce.
2.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Geology and Mines, to both avoid limitation of planned mineral development activity, and enable consideration of possible alignment options that could support the Department's aims with regard to development of priority resources.
3.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Forests and Park Services, to both avoid limitation of existing and planned forest management activity in Forest Management Units, Community Forests, Local Forest Management Areas and Reserved Forest, and enable consideration of possible alignment options that could support the Department's aims with regard to management of forest resources.
COOPERATION AND COORDINATION	
4.	No applicable recommendations.

I. Pollution and Waste

283. A certain amount of concern about various forms of direct and indirect pollution associated with highways development was voiced during the SEA scoping workshop in February 2024, and these were grouped into a single theme for subsequent exploration. The types of pollution and pollution pathways mentioned included vehicular emissions; airborne dust from unsealed roads (including, though not exclusively, during construction); solid waste pollution and sewage pollution from tourism development enabled by increasing mobility and access; and water pollution resulting from increasing use of agricultural chemicals, also indirectly made possible by increasing ease of transport. Each of these is discussed briefly below.

284. **Vehicular emissions.** Air quality degradation from vehicles in Bhutan is most frequently mentioned in reference to urban centers, particularly Thimphu, where there are sufficient concentrations of vehicles to sometimes produce noticeable effects. Bhutan's national highways are all low-volume to moderate-volume roads that pass through rural landscapes, and significant ground-level air quality degradation is probably experienced in relatively few locations, and on an intermittent basis. This is not really a systemic matter. Some mitigation of such localized air quality degradation is possible at the project level, and this is appropriately assessed and formulated through project-level EIA as needed, on a case-by-case basis.

285. On a broader level, it might be argued that expansion and improvement of the national highways may enable growth in the overall vehicle fleet, leading to more air pollution in general. This may be true, although other factors enabling growth in vehicle ownership, including population growth, economic growth, per capita income growth, and vehicle prices and import

duties, are likely to be more important. In the detailed analysis of carbon emissions reported on earlier, the projects and maintenance regime proposed in the HMP were deemed likely to slow the growth of emissions relative to the baseline growth scenario, largely due to operational emissions savings accruing from a more efficient network.

286. **Airborne dust.** Road dust can be an extremely bothersome and unhealthy problem, but all the national highways in Bhutan are sealed, or intended to be so. The stepped-up maintenance regimen proposed in the HMP should generally tend to reduce the proportion of national highway surfaces that generate significant dust over time. Construction dust is a readily mitigated impact that is typically addressed as standard procedure through project-level EIA.

287. **Pollution from tourism development.** The suggested indirect link between road development and increased pollution from poorly managed solid and human waste is logical. As argued above, the proposed improvements to the national highway network will, in aggregate, tend to spur an increase in tourism, particularly in the eastern part of the country, which will become increasingly accessible to domestic and international tourists. Many rural localities are ill-equipped to manage solid and human waste as it is, and increased tourist arrivals does seem likely to exacerbate the problem in at least some places. That said, there are national policy instruments in place to improve waste management no matter what the drivers, and there is no basis at the present time for assessing the actual significance of the assumed causal chain. In view of this, it is appropriate to let existing waste management policy instruments function, rather than propose intervention in relation to a roads sector plan.

288. **Pollution from agricultural chemical use.** The other hypothesized indirect link between highway network improvements and water quality resulting from increasing use of chemical inputs in agriculture is too uncertain to justify formulation of an intervention as part of a roads sector plan. Many factors besides road access may influence the purchase of agrochemicals, their use and misuse, and the significance of effects on surface waters.

VI. ANALYSIS OF ALTERNATIVES

289. The HMP is a composite of project proposals of several different types (new highways, slope stabilization works, highway widening and upgrading, safety improvements, bridge upgrades and replacements, tunnels and bypasses, industrial zone access links) serving several different objectives (filling gaps in the network, providing connections between adjacent dzongkhags, improving reliability, enhancing safety, reducing travel time and cost, strengthening climate change resilience, and supporting industrial growth and cross-border trade). The proposed plan was formulated by balancing these multiple objectives within an overall budget frame and timetable, guided by high-level information and analysis. It is acknowledged that refinement of the plan will have to be guided by more fine-grained analysis and project evaluation in future. In this context, only one version of the HMP is formulated at this stage, as the level of information available is insufficient to develop meaningful comparison between comprehensive alternatives. Accordingly, the principal comparison that can be made with regards to environmental implications is between the HMP As Proposed, and the No Master Plan Alternative.

A. Implications of the HMP As Proposed

290. The HMP as proposed to the RGOB by the Consultant and reviewed by DOST and ADB, would entail substantial, meaningful improvement to Bhutan's national highways network. The anticipated advantages or opportunities intrinsic to the Preferred Alternative can be summarized as follows:

(1) Reduced travel time and cost, resulting in economic benefits at national and sub-national scales;

(2) Improved access and reduced cost-to-market for natural resource-based livelihoods and industry, strengthening economic diversification and vitality;

(3) Enhanced public safety due to investments in landslide mitigation, bridge replacement and upgrading, guardrails and pavement markings, and improved road condition;

(4) Strengthened resilience in the face of climate change as a result of investments in slope stabilization, bridge upgrades and replacements, and improvements to the overall maintenance regimen, which can be understood to support Bhutan's National Adaptation Plan and adaptation commitments under the Paris Agreement;

(5) Net carbon emissions savings relative to 'business as usual', contributing to Bhutan's carbon emissions reduction strategies and commitment to permanent carbon neutrality under the Paris Agreement;

(6) Improved accessibility of cultural heritage sites from major tourist source nodes, resulting in increased potential for cultural heritage appreciation and culture-based tourism; and

(7) Possible facilitation of anti-poaching activity and ecotourism development in some locations to generate revenue for enhanced conservation of biodiversity.

291. In addition to opportunities, the HMP As Proposed is acknowledged to carry some risks, most of which can be well mitigated through careful EIA work during project implementation. Some risks are likely to be manifest as residual impacts that cannot be fully mitigated. The most problematic risks, which are linked to the inclusion of particular projects in the HMP, are as follows:

(1) Compromised integrity of the national protected area network as a result of new highway projects through protected areas and biological corridors, including core and transition zones;

(2) Reduced long-term potential for ecological interchange between Bhutan's conservation landscapes and those in Assam and West Bengal due to development of new highways along the southern border; and

(3) Contribution to macro-financial risks to the national budget, due to the development of projects with low economic viability.

292. It is possible that the projects presenting the outstanding risks listed above will become less problematic as a result of modifications identified through detailed project-level study (particularly with regards to environmental and economic analysis). If this turns out to be the case, the HMP As Proposed can be considered broadly positive.

B. Implications of the No Master Plan Alternative

293. The alternative of not implementing the proposed new national highways master plan would avoid the new risks to the country's biodiversity and fiscal health from the projects that are anticipated to be problematic in these regards. The No Master Plan would, however, also entail the worsening of some existing problems facing the highway network, and be a missed opportunity to contribute to meeting some of the central challenges faced by the country. Adopting the No Master Plan Alternative would likely mean:

(1) Continued under-investment in highways maintenance, bridges and slope stabilization, leading to declining economic resilience and rising public safety risks;

(2) Increasing vulnerability to the anticipated effects of climate change;

(3) Reduced opportunity for the surface transport sector to contribute to the country's efforts to keep overall carbon emissions below the countervailing capacity of carbon sinks;

(4) Continued difficulty in building an integrated, dynamic, diversified and inclusive national economy; and

(5) Possible missed opportunities to counteract poaching in the southern border region and develop a sustainable revenue base for biodiversity conservation through ecotourism development.

294. It is of course possible that a portion of the resources to be devoted to implementing the HMP As Proposed could be put towards road asset management activities (for example, investment in improvements to dzongkhag roads) that would ameliorate some of the risks associated with the No Master Plan Alternative, but that is hypothetical in the absence of any concrete planning initiative.

C. Other Possible Alternatives

295. It has been clear from analyses in Chapter V that the most problematic risks inherent to the HMP As Proposed are associated with a small number of the projects included in the Development Plan component. This might reasonably raise the question of whether the HMP could be favorably reformulated at this stage by, for example, dropping projects that will impinge on protected area core and transition zones, or removing projects for which there is good reason to doubt economic viability. The Lhamoizhingkha–Sarpang and Tareythang–Panbang projects fall into both categories, at least based on the high-level analysis conducted so far.

296. This kind of reformulation was not seriously pursued at this stage because the information available and depth of analysis possible at the master planning stage are insufficient to definitively pass judgement on the two projects at issue, which have been identified as RGOB priorities. The

Lhamoizhingkha–Sarpang and Tareythang–Panbang projects are both understood as fundamental components of the completion of a Southern East-West Highway, which has been a centerpiece of Bhutan's road sector policy for at least two decades. Several other highways have already been built, or are under construction, to fill in other gaps in the long-envisioned cross-country route in the country's southern border zone. The Gelephu–Tareythang project has advanced to the detailed design stage, supported by technical assistance from the World Bank. And the Lhamoizhingka–Sarpang project has, at the time of writing, entered the project development pipeline, with feasibility and design consultancy tenders issued in late 2024 under ADB project preparation assistance. There is, in other words, considerable momentum pushing inclusion of the Lhamoizhingkha–Sarpang and Tareythang–Panbang projects in the HMP. The recent public launching of the vision for the GMC has reinforced the momentum behind the Lhamoizhingkha–Sarpang and Tareythang–Panbang projects. The GMC itself appears to be envisioned as a kind of hub, and will naturally require access from multiple directions. The Lhamoizhingkha–Sarpang and Tareythang–Panbang projects would take care of the westward and eastward linkages supporting that concept.

297. In view of these circumstances, excluding the Lhamoizhingkha–Sarpang and Tareythang–Panbang projects from the HMP could not be justified on the basis of the high-level environmental and economic analysis conducted to date. The more detailed feasibility and design studies (including EIA studies) for these highway projects will provide ample opportunity to better assess engineering constraints, refine cost estimation, further develop the traffic projections, and better understand the significance of potential impacts on particular habitats and species. These further studies will also be required to investigate alternatives to these projects, including improvements to existing routes around the respective protected areas, and continued reliance on roads across the border in India. It is possible that findings of those studies will force a reckoning and reformulation, and also possible that the studies will reveal better-than-expected economic feasibility and less-severe-than-feared impacts on biodiversity. The SESMP (coming up in Chapter VII) has devoted considerable attention to ensuring that the project-level feasibility and EIA studies tackle the risks head-on with high-caliber expertise, ample time allocations for ecological studies, rigorous economic analysis, special attention to understanding and mitigating cumulative effects, and thorough consideration of alternative means of enabling east-west movement of people and goods in the southern part of the country.

D. Conclusions

298. In view of the summaries laid out above, the HMP As Proposed can be viewed favorably relative to the No Master Plan Alternative, despite its risks. The risks associated with the No Master Plan Alternative are consequential and worrying, and taken all together, probably outweigh the risks of the HMP As Proposed, especially if it is assumed that all mitigation indicated in the SESMP for the HMP as Proposed is thoroughly implemented. Further, and much more detailed, evaluation will be required as part of project-level feasibility studies to determine what changes (e.g., project subtractions, additions or substitutions) may be advisable to lower the risks associated with the HMP as Proposed. Any reformulation based on more detailed analysis is more likely to strengthen the favorable contrast between the HMP as Proposed and the No Master Plan Alternative than it is to tip the balance in favor of the No Master Plan Alternative.

VII. STRATEGIC ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

299. The purpose of the SESMP is to ensure that the measures indicated in the impact and mitigation discussions in Chapter V are fully and faithfully carried forward as the HMP moves into and through implementation. Much like a project-level Environmental Management Plan, the SESMP defines required actions and assigns responsibility for their implementation (and confirmation of effective implementation) to the appropriate parties. The timing of implementation and monitoring is indicated. Measures identified in Chapter V fall into two broad categories: (1) those that pertain to the project-level feasibility studies, detailed design and associated EIA studies; and (2) those that concern inter-institutional collaborations to enhance or enable impact prevention, or to implement aligned initiatives parallel to the HMP.

A. Institutional Roles and Responsibilities in SESMP Implementation

300. The HMP is an initiative of the RGOB, with DOST as its principal implementing entity, though not necessarily its exclusive institutional owner. Several other entities both within and outside of the RGOB will have roles to play in enabling, supporting, financing, implementing and monitoring the HMP, and implementation of the SESMP for the HMP will likewise require inputs from multiple entities. The focus here is on the implementation of the SESMP.

a. SESMP Oversight Committee

301. As highways master plans are prepared only periodically and on a relatively long and irregular return interval, there is no permanent body for directing and overseeing implementation and monitoring of their associated environmental and social safeguards needs. The SESMP indicates a variety of actions that should be carried out over the 15-year life of the HMP, and a durable entity is required to ensure that all such actions are indeed taken. It is proposed that an SESMP Oversight Committee (SESMPOC) should be established for this purpose. The SESMPOC should be outside and independent of DOST, as many of the actions prescribed in the SESMP are for DOST to implement, and in some cases require collaboration between DOST and other agencies coming under other ministries.

302. It is proposed that the SESMPOC should be set up under the unit responsible for the audit function within the Ministry of Infrastructure and Transport (MOIT). The SESMPOC would be required to meet occasionally to review documentation pertaining to the accomplishment of actions stipulated in the SESMP; a semi-annual meeting interval is provisionally suggested based on the kinds of measures specified in the SESMP. The membership of the SESMPOC is proposed to include representation from agencies with important stakes and collaborative roles as identified and discussed in Chapter V of this SEA report, and/or oversight roles with respect to key resources affected, as follows:

(1) Ministry of Infrastructure and Transport (Permanent Chair)
(2) Department of Surface Transport
(3) Department of Forests and Park Services
(4) Department of Environment and Climate Change
(5) Department of Culture and Dzongkha Development
(6) Department of Water
(7) Department of Geology and Mines
(8) Department of Disaster Management

(9) Department of Energy
(10) Royal Bhutan Police
(11) Bhutan Construction and Transport Authority

b. DOST

303. As the principal implementor of the HMP, DOST is also responsible for carrying out, or leading implementation of, many of the actions prescribed in the SESMP. This means that DOST will have to document and report on its activity, so that its compliance with the SESMP can be verified by the SESMPOC. DOST will also be responsible for bringing significant new environmental and social concerns or conditions that may arise over the HMP's 15-year implementation period, and which may affect the nature or severity of impacts from HMP projects, to the attention of the SESMPOC.

c. Other RGOB Agencies

304. Several government agencies besides DOST will have responsibilities under the SESMP, most of which will be carried out in collaboration with DOST. These agencies will be responsible for participating in said collaborations, and also for participating in the SESMPOC. As inter-agency collaborations will generally be covered under the activity reports prepared by DOST for review and verification by the SESMPOC, these other agencies would not have formal reporting responsibilities of their own.

d. Partner Entities

305. Partner entities include institutions outside the RGOB that provide technical support, as well as monetary and in-kind financing, for activities and programs of the RGOB. Partner entities with expected relevance for the SESMP include Project DANTAK, MDBs including ADB, JICA and the World Bank, and the Bhutan Trust Fund for Environmental Conservation. It is proposed that the partner entities be granted some form of observer status in relation to the work of the SESMPOC, to encourage coordination and transparency, and information-sharing.

B. Impacts Management Plan

306. The basis of the management plan is the actions that have been prescribed in Chapter V as a means of mitigating the negative impacts found to be significant, and in some cases of enhancing anticipated positive impacts. All prescribed actions indicated in Chapter V are gathered together in the responsibility matrix in Table 33. Responsibilities for implementing each action are assigned, and a timeframe for implementation is indicated. One or more performance indicators, for use in monitoring, are also formulated for each prescribed action. All of the prescribed actions are essentially administrative, for which tangible implementation costs are likely to be negligible.

Table 33: Impacts Management Plan Responsibility Matrix

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
A. IMPLEMENTATION READINESS					
1.	Establish SESMP Oversight Committee (SESMPOC) within MOIT, with minimum representation as follows: (1) Ministry of Infrastructure and Transport (Permanent Chair) (2) Department of Surface Transport (3) Department of Forests and Park Services (4) Department of Environment and Climate Change (5) Department of Culture and Dzongkha Development (6) Department of Water (7) Department of Geology and Mines (8) Department of Disaster Management (9) Department of Energy (10) Royal Bhutan Police (11) Bhutan Construction and Transport Authority	MOIT	DOST	Immediately upon adoption of HMP as RGOB policy	▪ SESMPOC participant representatives nominated ▪ SESMPOC bylaws adopted ▪ Effects monitoring framework refined and agreed ▪ SESMPOC Monitoring Focal Point nominated ▪ Monitoring and periodic review reports format agreed
2.	Establish permanent Environmental and Social Safeguards Unit (ESSU) within DOST, with four full-time professional staff (Safeguards Manager, Environment Specialist, Gender and Social Inclusion Specialist, Climate Change Specialist)	MOIT	DOST	Within 2 years of HMP adoption	▪ Permanent ESSU with four full-time professional staff operational
B. WILDLIFE AND BIODIVERSITY					
3.	Ensure that ToR for feasibility-stage and design-stage EIA consultants make provision for adequate inputs of high-caliber international and national biodiversity expertise, including expertise in critical habitat assessment, offset design, and preparation of BAPs.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ EIA consultants engaged have the expertise indicated
4.	Ensure that ToR EIA consultants indicates that biodiversity assessment and mitigation shall follow the procedures specified in IFC Performance Standard 6 (or equivalent requirements), including as applies to critical habitat assessment and preparation of BMPs and BAPs to meet	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ EIA studies reflect adherence to IFC PS6, including preparation

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
	no net loss and net gain objectives, regardless of the project financing source.			▪ Before approval of detailed designs	of critical habitat assessments and BMPs/BAPs as appropriate
5.	Ensure that time allocations for feasibility studies and detailed design are sufficient to enable ecological field studies to take place over multiple seasons and two years, and that the ToR for feasibility-stage and design-stage EIA consultants require multiple-season ecological studies.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ Time allocations for project preparation enable ecological studies over multiple seasons and two years ▪ TOR used in tender for EIA consultant make provisions as indicated
6.	Ensure that ToR for the EIA consultants require thorough consideration of alternatives to projects in protected areas, including, at minimum: (i) Detailed ecological field studies spanning multiple seasons to fully characterize anticipated biodiversity impacts of the new highway, and its possible alternatives (including existing routes in both Bhutan and India); (ii) Thorough data-based analysis of the magnitude of expected benefits from travel time and travel cost savings relative to alternative routes (including existing routes in Bhutan and India); (iii) Inclusion of biodiversity-related mitigation and compensation (offsetting) costs in economic feasibility calculations; (iv) Quantitative estimation of benefits from ecotourism operations enabled by the new highway, based on realistic ecotourism development proposals linked to the proposed new highway, relative to benefits from ecotourism enabled by improvement and/or addition of low-impact seasonal park roads; (v) Estimation of anti-poaching benefits from the new highway, relative to anti-poaching benefits enabled by improvement and/or addition of low-impact seasonal park roads; and (vi) Assessment of the capacity of protected area management authorities to effectively achieve anticipated ecotourism and anti-poaching	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ EIA studies include all modes of analysis indicated for the analysis of alternatives

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
	objectives, under both the new highway scenario and alternative scenarios; and (vii) Identification and justification of any strategic rationales supporting the development of the new highways through protected areas, including economic analysis and policy risk assessment for alternative routes using the Indian highway network.				
7.	Ensure that ToR for feasibility study and detailed design consultants for new highways in protected areas specify avoidance of high-value biodiversity resources and features as top-priority criterion in alignment selection and design.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Preferred alignments in protected areas avoid high-value biodiversity resources and features
8.	Ensure that ToR for design consultants indicate reduced RoW clearance (where feasible) as a design criterion to be reflected in roadway designs, i.e., not left to discretion of contractors.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Any feasible reduced clearance directives are indicated in project design drawings
9.	Ensure that ToR for EIA consultants require in-context analysis of invasive species risks, as well as development of mitigation measures where risk is found to be significant.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Invasive species risks assessed in EIA studies
10.	Ensure that ToR for design and EIA consultants require feasibility evaluation of measures for maximizing the permeability of new road corridors for wildlife, including but not limited to: (i) Large mammal underpasses; (ii) Ridgeline overpasses; (iii) Modified culverts; (iv) Dry culverts for small species;	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Permeability enhancement measures evaluated in EIA studies and incorporated in design drawings and cost estimates as needed

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
	(v) Aerial overpasses for canopy-dwelling species; (vi) Gentle embankment slopes; (vii) Wildlife off-ramps at blind corners; (viii) Avoidance of box drains; (ix) Avoidance of long continuous stretches of guardrail; and (x) Reduced width of RoW clearance.				
11.	Ensure that ToR for feasibility-stage EIA consultants require analysis of potential for threats to local biodiversity values from induced settlement and associated free-range livestock grazing, taking account of (at minimum) land tenure, land suitability, enabling economic factors, enforcement capacity of the relevant forest management division, and the biodiversity values present.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated
12.	Ensure that ToR for feasibility-stage EIA consultants require cumulative impact assessment for all projects and groups of projects. For projects in the Southern East-West Highway corridor, the cumulative impact assessment must consider, at minimum: (i) Regional-scale implications of continuous PNH-02 for north-south transboundary ecological interchange; (ii) Anticipated impedance of wildlife movement by planned development of Gelephu Mindfulness City; (iii) Foreseeable local and regional traffic (construction and non-construction) increases associated with development of Gelephu Mindfulness City; and (iv) Planned industrial developments in the southern border zone, such as dry ports, industrial parks and mines.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultants make provisions as indicated ▪ Cumulative impact assessment is included in EIA studies and covers at least the factors mentioned
13.	Stipulate in the ToR for design-stage EIA consultants engaged for the Lhamoizhingkha-Sarpang and Tareythang–Panbang projects that retrofitting existing portions of the Southern East-West Highway to enhance permeability shall be evaluated for eligibility and utility as an offset measure for direct and cumulative residual biodiversity impacts from those projects, including field	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of	▪ TOR used in tender for EIA consultants make provisions as indicated ▪ Evaluation of permeability enhancements on other segments of Southern East-West Highway as possible offsets

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
	studies as may be required to identify priority locations and permeability measures, to be included as appropriate in the Biodiversity Action Plans for those projects.			detailed designs and BAPs	included in EIA study for the relevant projects, and integrated in the BAPs as appropriate to the evaluation
14.	DOST shall enable meaningful cumulative impact assessment by assisting EIA consultants to obtain relevant and up-to-date documentation from other development projects (past, ongoing and proposed), including those coming under the remit of other agencies and sectors in Bhutan (and India if necessary).	DOST	MOIT	▪ During EIA studies	▪ Meaningful cumulative impact assessment is included in EIA studies
15.	DOST and DOFPS shall explore the formation of agreements enabling interagency co-management of new highways through protected areas, and execute any Memorandum of Agreement enabling co-management prior to the relevant project's detailed design, so design features and costs necessary to support co-management can be incorporated in the project design and budget as appropriate.	DOST DOFPS	MOIT MOEE	▪ During feasibility studies for relevant projects	▪ MOU signed prior to start of detailed design for relevant projects ▪ MOA signed before end of detailed design for relevant projects
C. CLIMATE CHANGE MITIGATION AND ADAPTATION					
16.	Ensure that ToR for feasibility study and design consultants require preparation of a detailed climate risk and adaptation study for each project or group of projects, incorporating analysis of the most up-to-date climate change projection information available, and that the findings are reflected in designs, cost estimates and feasibility analysis.	DOST	Financing MDB, as applicable DECC DDM	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Detailed climate risk and adaptation study prepared, and findings reflected in project designs. and cost estimates
17.	Ensure that ToR for design consultants require review, and application to project designs as appropriate, of DOST Guidelines on Design, Construction and Maintenance of Road Infrastructure Incorporating Climate-Resilient Features (December 2019); Environmentally Friendly Road Construction (EFRC) Manual – Bio-Engineering in Bhutan (September 2005); and Environmentally Friendly Road Construction (EFRC) Field Handbook – Bioengineering Works (September 2005), or successor guidance material, together with applicable international best practice guidance.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project	▪ TOR used in tender for design consultants make provisions as indicated

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
18.	Ensure that ToR for construction contractors require adherence to DOST Guidelines on Design, Construction and Maintenance of Road Infrastructure Incorporating Climate-Resilient Features (December 2019); Environmentally Friendly Road Construction (EFRC) Manual – Bio-Engineering in Bhutan (September 2005); and Environmentally Friendly Road Construction (EFRC) Field Handbook – Bioengineering Works (September 2005), or successor guidance material, together with applicable international best practice guidance.	DOST	Financing MDB, as applicable	▪ Before tendering construction works	▪ TOR used in tender for construction contractors make provisions as indicated
19.	Ensure that ToR for EIA and design consultants engaged for network expansion projects require assessment of need for public sector provision of electric vehicle charging stations, and provide for charging infrastructure in the project design as appropriate.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each network expansion project	▪ TOR used in tender for EIA and design consultants make provisions as indicated
20.	DOST and MoIT should seek the collaboration and support of a bilateral or multilateral partner to develop and implement a comprehensive Climate Change Adaptation Strategy for DOST.	DOST	MOIT	▪ Before Q4 2026	▪ Discussions initiated with appropriate partner or partners
21.	DOST and MoIT should seek the collaboration and support of a bilateral or multilateral partner to develop and implement a continuing education program for DOST personnel to increase capacity for internal agency development of new and advanced approaches to adapting aspects of road asset management to anticipated climate change.	DOST	MOIT	▪ Before Q4 2026	▪ Discussions initiated with appropriate partner or partners
D. WATER RESOURCES					
22.	Ensure that ToR for feasibility study and design consultants engaged for all new highways clearly require hydrological analysis of risks to groundwater flows and springs; water availability and water quality for community uses; and existing and planned irrigation systems.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for design consultants make provisions as indicated ▪ Hydrological analysis included in EIA and/or detailed design study
23.	Ensure that ToR for feasibility study and design consultants engaged for bridge upgrade/replacement projects (or groups of such projects) require cumulative impact assessment in relation to possible cumulative	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project	▪ TOR used in tender for design consultants make provisions as indicated

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
	effects with other bridge projects, as well as with other significant impact sources such as hydropower projects and riverbed mining operations. Key elements of cumulative impact assessment should include the packaging and timing of works in both the highways and hydropower sectors.			▪ Before approval of detailed designs	▪ Cumulative impact assessment duly considered in EIA studies for relevant projects
24.	Ensure that ToR for feasibility study and design consultants engaged for bridge upgrade/replacement projects (or groups of such projects) require thorough consideration of potential for impacts on the habitat of the White-bellied heron (*Ardea insignis*), including cumulative effects resulting from the presence of other infrastructure projects (other bridge works as well as operating, under-construction and proposed hydropower projects and riverbed mining operations) within the same river basin. EIA studies carried out by the consultants must include early and active engagement with entities concerned with conservation of the White-bellied heron in Bhutan, including but not necessarily limited to DOFPS and Royal Society for Protection of Nature.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for EIA consultant make provisions as indicated ▪ Detailed assessment of risks to White-bellied heron nesting and feeding sites included in EIA studies for relevant projects ▪ Meaningful early engagement with stakeholders in White-bellied conservation documented in EIA studies for relevant projects
25.	DOST shall enable meaningful cumulative impact assessment by assisting EIA consultants to obtain relevant and up-to-date documentation from other development projects (past, ongoing and proposed), including those coming under the remit of other agencies and entities in Bhutan, such as Druk Green Power Corporation, Department of Energy, Department of Water, and Department of Geology and Mines.	DOST	MOIT	▪ During EIA studies	▪ Meaningful cumulative impact assessment is included in EIA studies
E. PUBLIC SAFETY					
26.	Bhutan Construction and Transportation Authority to lead formation and operation of a Road Safety Council to coordinate actions of relevant agencies in improving safety conditions on Bhutan's road network.	BCTA	DOST	▪ Before Q4 2027	▪ Formation of Road Safety Council initiated by end of 2026
27.	Bhutan Construction and Transportation Authority to develop expanded and improved comprehensive road accident data collection system and database, in cooperation with Royal Bhutan Police (Traffic Division) and DOST.	BCTA	DOST	▪ Before Q4 2027	▪ Expanded and improved road accident data collection system and database implemented

	Prescribed Actions	Lead Entity	Supporting	When to Implement	Performance Indicator(s)
28.	Bhutan Construction and Transportation Authority to develop nationwide road safety public education program in cooperation with the Department of School Education, Royal Bhutan Police (Traffic Division) and DOST.	BCTA	DOST	▪ Before Q4 2027	▪ Nationwide road safety education program developed and initiated
F. CULTURAL HERITAGE					
29.	Ensure that ToR for feasibility study engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Culture and Dzongkha Development, to both avoid risks to physical cultural resources, and enable consideration of alignment options that could support the Department's aims with regard to promotion and development of priority sites.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for design consultants make provisions as indicated ▪ Meaningful early engagement with DOCDD documented in EIA study
G. NATURAL RESOURCE USE					
30.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Agriculture and the Department of Agricultural Marketing and Cooperatives, to enable consideration of possible alignment options that could support these departments' aims with regards to supporting marketing and processing of agricultural produce.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for design consultants make provisions as indicated ▪ Meaningful early engagement with DOA and DOAMC documented in EIA study
31.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Geology and Mines, to both avoid limitation of planned mineral development activity, and enable consideration of possible alignment options that could support the Department's aims with regard to development of priority resources.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for design consultants make provisions as indicated ▪ Meaningful early engagement with DGM documented in EIA study
32.	Ensure that ToR for feasibility study consultants engaged for all new highways clearly require early engagement regarding initial alignment options with the Department of Forests and Park Services, to both avoid limitation of existing and planned forest management activity in Forest Management Units, Community Forests, Local Forest Management Areas and Reserved Forest, and enable consideration of possible alignment options that could support the Department's aims with regard to management of forest resources.	DOST	Financing MDB, as applicable	▪ Before tendering consultancies for each project ▪ Before approval of detailed designs	▪ TOR used in tender for design consultants make provisions as indicated ▪ Meaningful early engagement with DOFPS documented in EIA study

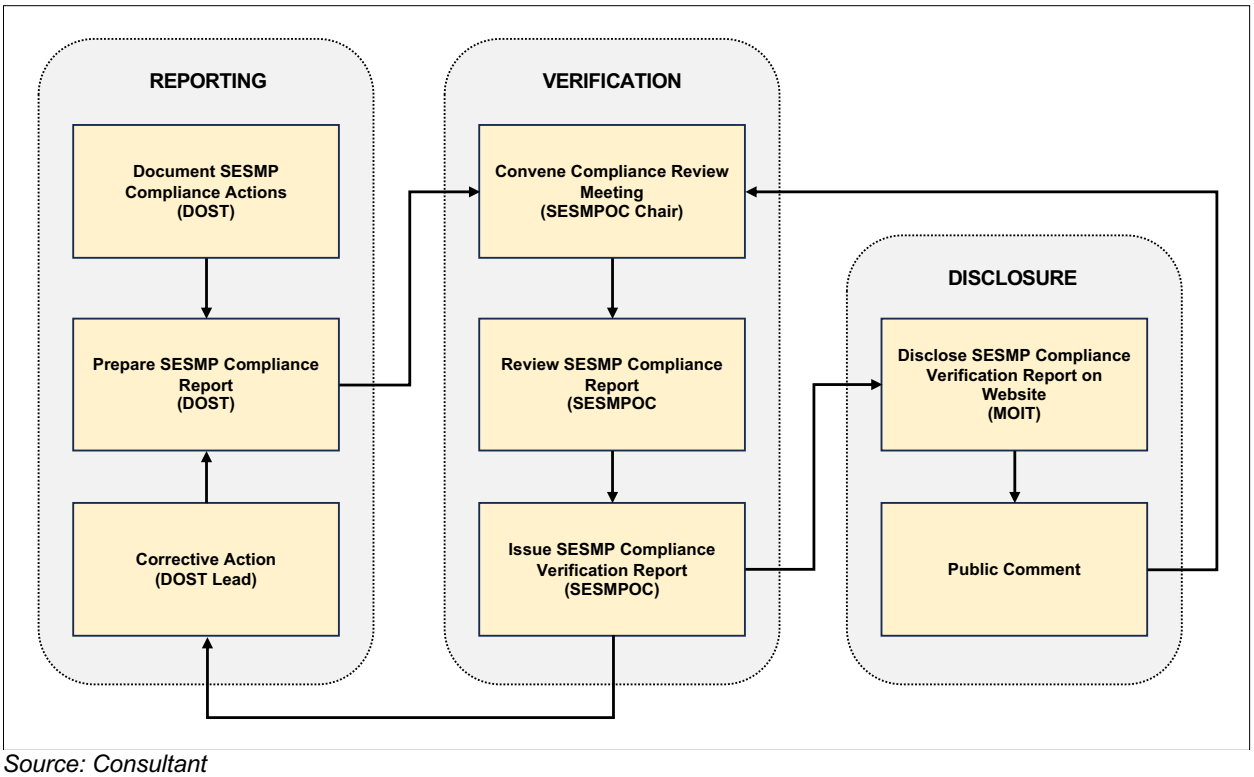
C. Monitoring Plan

307. The Regulation on Strategic Environmental Assessment (2002) requires the development and implementation of a plan to monitor the environmental and social effects of the subject PPP. Monitoring should normally comprise both compliance monitoring (to confirm implementation of prescribed mitigation) and effects monitoring (to assess whether the subject PPP is having the desired effects (including non-effects) on the country's environmental and social conditions. In view of the long implementation timeframe for the HMP, a periodic review function is also advisable to consider the practical applications of accumulated monitoring results.

a. Compliance Monitoring

308. A compliance monitoring function and mechanism are needed for the SESMP to ensure that the prescribed actions are effectively followed up, implemented and accounted for. All of the measures prescribed in the impacts management plan are essentially administrative, and no field monitoring will typically be needed to verify their implementation (field monitoring will be necessary and prescribed as part of the EIA process for individual projects).

309. The proposed monitoring mechanism for SESMP compliance has three steps, each of which is reflected in Figure 44: (1) reporting on compliance activity from DOST to SESMPOC; (2) verification of compliance by SESMPOC (and of corrective action if needed); and (3) public disclosure of verification monitoring results by SESMPOC.



Source: Consultant

Figure 44: SESMP Compliance Monitoring Process

310. **SESMP Compliance Report.** DOST is indicated as the principal implementor of almost all of the actions prescribed in the impacts management plan, as either the sole or lead responsible entity. The appropriate first step in the iterative SESMP monitoring process is for DOST to

document and describe (and where necessary, explain and justify) the actions taken to comply with each assigned action in Table 33. A short SESMP Compliance Report (which may appropriately be in tabular format) shall be prepared by DOST and circulated to the SESMPOC membership in advance of each semi-annual meeting of that committee. The report shall be presented at the meeting. In addition to documenting compliance actions, the SESMP Compliance Report should raise any emerging conditions that may affect the applicability or effectiveness of the SESMP, for the consideration of the SESMPOC.

311. **SESMP Compliance Verification Report.** The SESMPOC will convene a semi-annual meeting to review and verify the SESMP Compliance Report presented by DOST. In the case of unsatisfactory performance regarding any of the SESMP items, the SESMPOC will discuss and formulate appropriate corrective action, and indicate this in its SESMP Compliance Verification Report. Any corrective actions should be clearly described, with responsibilities assigned and an implementation timeline indicated. The SESMP Compliance Verification Report should be brief (tabular format would be appropriate), self-explanatory (so readers outside the SESMPOC can readily understand its purpose), and in non-technical language accessible to the average person. Each SESMP Compliance Verification Report will include an attestation of agreement, to be signed by the designated representative of each entity holding membership in the SESMPOC. Any refusals to sign shall be accompanied by an attachment to the SESMP Verification Monitoring Report indicating the reasons for refusal.

312. **Public Disclosure.** Each semi-annual SESMP Compliance Verification Report will be publicly disclosed on a MOIT webpage dedicated to the HMP. The HMP webpage should make available, for the entire HMP implementation period (2025–2040), the HMP document, the SEA Report, and the accumulated SESMP Compliance Verification Reports. Each posting of a new SESMP Compliance Verification Report should be accompanied by a notice on the MOIT main website home page, inviting public comment during a defined timeframe. Comments received should be included in the next meeting of the SESMPOC.

b. Effects Monitoring

313. **Parameters and indicators.** The principal challenge in defining an effects monitoring program is to ensure that it measures parameters (1) that are practical and inexpensive to measure periodically over at least a 15-year period; (2) that are limited in number, so the monitoring effort can be sustained; (3) whose observed variation can be clearly attributed to the PPP's implementation; and (4) whose measurement can generate information useful in identifying necessary adjustments to the PPP or support formulation of a successor PPP. Parameters that meet these criteria are identified, along with associated indicators, measurement methods, measurement frequency and measurement responsibility, in Table 34.

314. The effects monitoring framework shown in Table 34 is a preliminary proposal; it will be up to the SESMPOC to refine the framework and agree on specific responsibilities for measurement, compilation, and reporting. The SESMPOC Chair will also need to designate an effects monitoring focal point to receive monitoring data from the various member agencies and compose a semi-annual report on findings.

315. **Effects Monitoring Report.** The semi-annual effects monitoring report would appropriately be a brief and accessible 'snapshot' of indicator levels and cumulative trends, and should be disclosed together in a package with the semi-annual SESMP Compliance Verification Report.

Table 34: Proposed HMP Effects Monitoring Framework

Effect Parameter	Effect Indicator	Measurement/Data	Frequency	Responsibility for Measurement	Incremental Cost[1]
Wildlife road mortality	Incidence of vehicle-wildlife collisions	Roadkill survey (observational) on selected roads	• Weekly survey on selected roads • Data processing every 6 months	• DOST Regional Offices to integrate roadkill surveys in road surveillance routine • DOFPS district officers to provide assistance with species identification	Negligible
Human-wildlife conflict	Incidence of on-road confrontations with large mammals on highway	Investigate and characterize incidents on selected roads as they are reported to police, DOFPS or DOST (collect first-person and secondary verbal accounts)	• Incidents on selected roads documented and entered in database as they occur • Incidents summary report every 6 months	• DOFPS district offices, with additional incident data supplied by police and DOST as applicable	Nu. 150,000 per year on average for fuel
Barrier effect	Differential use of habitat by selected indicator species	Basic comparative camera trapping surveys of presence and habitat use by selected indicator species (road-proximate vs. road-distant)	• 1-month camera trap survey conducted every 6 months in selected locations	• Camera trap management by DOFPS district officers • Survey design and data compilation by DOFPS HQ	Nu. 1,000,000 per year on average for fuel, training, equipment
Climate resilience	Road closure incidents attributable to weather	Existing Bhutan Road Watch app dataset	• Data processing every 6 months	• DOST	Negligible
Public safety	Road accidents	Existing road accident database	• Data processing every 6 months	• BCTA	Negligible
Public safety	Road accident mortality	Existing road accident database	• Data processing every 6 months	• BCTA	Negligible
Economic equity	Number of person-visits to cultural heritage sites in dzongkhags outside of Thimphu, Paro, Wangdue Phodrang and Punakha	Record visitor numbers to selected representative indicator sites in 16 peripheral dzongkhags	• Daily documentation of visits to selected representative sites • Data processing every 6 months	• Cultural site managers to keep daily records of visitor numbers • Data collection system and data compilation by DOCDD HQ	Nu. 200,000 per year on average for training and liaison with site managers
Economic equity	Number of tourist nights in dzongkhags outside of Thimphu, Paro, Wangdue Phodrang and Punakha	Tourist night data collected by National Statistics Bureau	• Data acquisition and processing every six months	• DOST	Negligible
Economic vitality	Travel times on selected long-distance routes	Driver surveys on selected roads	• Survey every six months	• DOST	Nu. 200,000 per year

[1] Cost for collecting data that is not already routinely collected, or for augmenting existing collection. Amounts are indicative.

c. Periodic Review

316. Given the long implementation timeline of the HMP, it is recommended that the SESMPOC should periodically take stock of the cumulative results from compliance and effects monitoring, and evaluate whether the results warrant any mid-stream changes to the PPP itself (e.g., addition, subtraction or substitution of projects) or to the mitigation being applied (e.g., development of additional mitigation or enhancement measures to address unfavorable effects trends). A formal Periodic Review is proposed for this purpose, to be conducted every five years during the life of the HMP. Each Periodic Review should result in the preparation and disclosure of a Periodic Review Report, detailing the trends review and any modifications that are proposed for consideration. The third Periodic Review Report would appropriately orient its proposals to supporting formulation of the HMP's successor plan.

D. Ongoing Stakeholder Engagement

317. Many of the key institutional stakeholders in the HMP are represented in the makeup of the SESMPOC, and it is proposed that some others should be granted a form of observer status. However, some means of keeping the full range of stakeholders informed regarding the SESMP's implementation will be needed for the full life of the HMP. The dedicated web page for the HMP on the main MOIT website should be used by the SESMPOC to post semi-annual compliance monitoring and effects monitoring reports, as well as Periodic Review Reports. All postings must be accompanied by notices on the MOIT home page. The web page should also be used as a vehicle to solicit comment from interested parties on any of the SESMP reporting.

318. In the event that significant revision or modification of the HMP is proposed during the life of the plan, consultations with stakeholders must be undertaken. The format of the consultations may depend on the extent and nature of proposed revisions, and should be designed as appropriate at the time of need.

E. Capacity Needs

319. DOST will be the principal implementor of the many component projects of the HMP, and also the main player in implementation of management and monitoring actions required by the SESMP. These responsibilities will entail extensive oversight and information management activity, as all component projects will have to undergo environmental and social safeguards review to satisfy both national project clearance requirements and the safeguards requirements of external financing entities. Project-level safeguards assessments will be performed by outside consultants per usual practice, but DOST will have to ensure procurement of appropriate expertise, provide support to the assessment process, review safeguards assessment reports, and steer projects through the clearance and loan approval processes. DOST does not presently have an in-house Environment Unit or Safeguards Unit, and is not well prepared to handle the foreseeable oversight work just described. It also bears mention here that responsibility for all of the country's dzongkhag roads has recently been reassigned from the respective dzongkhag administrations to DOST. This will require DOST to manage environmental and social safeguards review and monitoring for works on over 2,000 km of additional roads.

320. In view of the above, the time is ripe for investment in permanent environmental and social safeguards capacity within DOST. The anticipated adoption of the HMP is a timely opportunity to formulate and fund a DOST Environmental and Social Safeguards Unit (ESSU).

321. **Environmental and Social Safeguards Unit.** The ESSU should comprise four full-time, dedicated professional staff, one of whom should occupy a lead position. It will not be appropriate for the ESSU to consist (by either design or attrition) of a single 'safeguards focal person', as this would not only be an inadequate allocation for the expected workflow, but would also leave the agency's safeguards oversight vulnerable to staff turnover. The ESSU professional staff should be experienced safeguards specialists, and should not have other duties within the agency. The proposed ESSU full-time professional staff positions are shown in Table 35. It is proposed that the ESSU should be constituted under the DOST Audit Office or the DOST Planning and Development Division, to maintain a measure of independence from engineering units.

Table 35: Proposed Environmental and Social Safeguards Unit Professional Staff

Position	Key Duties	Key Qualifications
Safeguards Manager (Full-time)	• Lead DOST's safeguards compliance program, ensuring timely and professional review, clearance and monitoring of proposed projects • Supervise, guide and support subject area specialists (environment, GESI, climate change) • Manage liaison with other DOST units, project management units and project safeguards consultants • Advise and support DOST representative on SESMPOC with regards to compliance and effects monitoring for HMP • Advise DOST Director-General as needed on safeguards matters	• Master's degree in field related to environment, social equity, or climate science • At least 10 years professional safeguards experience in the context of internally and externally financed infrastructure projects in Bhutan
Environment Specialist (Full-time)	• Conduct technical review of all project environmental assessment reports and field monitoring reports • Ensure that environmental monitoring reports prepared by project management units are on time and meet the requirements of national and financing entities' reporting requirements • Provide guidance to environment, health and safety officers assigned to on-site monitoring under project management units • Assist Safeguards Manager with completion of compliance and effects monitoring inputs under the SESMP for the HMP	• Bachelor's degree in environmental science, environmental management, environmental engineering or related field • At least 5 years professional safeguards experience in the context of internally and externally financed infrastructure projects in Bhutan
Gender and Social Inclusion (GESI) Specialist (Full-time)	• Conduct technical review of all project social assessments, resettlement plans, gender assessments and gender action plans • Ensure that resettlement surveys and monitoring reports prepared by project management units are on time and meet the requirements of national and financing entities' reporting requirements • Organize resettlement monitoring and prepare monitoring reports as needed to meet national and financing entities' reporting requirements • Review gender action plans prepared by project management units, ensuring Liaise with GESI consultants on project teams to address	• Bachelor's degree in social science field • At least 5 years professional safeguards experience in the context of internally and externally financed infrastructure projects in Bhutan
Climate Change Specialist (Full-time)	• Conduct technical review of climate change risk and adaptation assessments prepared by project consultants, ensuring their adequacy and confirming that their recommendations are appropriately reflected in project designs • Advise DOST engineering units on climate change mitigation and adaptation matters, including by acquiring and analyzing up-to-date climate change projection data and providing occasional state-of-practice briefs and guidance on climate-adaptive infrastructure design	• Bachelor's degree in climate science, environmental science, environmental engineering, or related field • At least 5 years professional safeguards experience in the context of internally and externally financed infrastructure projects in Bhutan, including

Position	Key Duties	Key Qualifications
	• Advise and assist DOST in identification of climate financing opportunities and development of financing proposals	preparation of climate risk and adaptation assessments

F. SESMP Implementation Costs

322. As indicated above, the compliance monitoring process is administrative in nature, with no field monitoring likely to be required; the information needed to confirm compliance will be supplied by the SESMPOC member agencies themselves (principally DOST), and no significant incremental cost over and above normal operations would be expected. Compliance monitoring would thus not need a budget. The proposed effects monitoring activity will require a budget to cover collection of those classes of data that are not already routinely collected (as indicated in Table 34). The SESMPOC can be expected to incur minor costs, associated mainly with convening meetings, and a modest operating budget is suggested. A breakdown of indicative annual expenditure for SESMP implementation is shown in Table 36.

323. Costs associated with necessary capacity-building in DOST should be assessed separately, as the proposed ESSU is needed regardless of the HMP being implemented, and the unit's SESMP-related activities would constitute a small portion of overall duties.

Table 36: Indicative Cost of SESMP Implementation

Item	Indicative Annual Incremental Cost (Nu.)	Indicative 15-Year Cost
SESMPOC operating costs	40,000	600,000
Compliance monitoring	-	-
Effects monitoring	1,550,000	23,250,000
Total	**1,590,000**	**23,850,000**

Source: Consultant

VIII. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

324. This SEA study report has examined a national highways master plan composed of 127 proposed projects spanning several project classes, as well as safety improvements and a 15-year highway maintenance program. In keeping with the purpose of SEA, the assessment has focused on potential for broadly-scaled, systemic and cumulative impacts. The analysis has been guided by nine broad themes identified and ranked through a scoping exercise conducted in the early part of the SEA study. The main conclusions of the study are summarized below, by theme.

325. **Wildlife and Biodiversity.** Significant concerns have been raised regarding potential threats to the integrity of the national protected area system and to transboundary ecological connectivity, particularly in relation to two proposed highway projects that would cross core and transition areas of highly-valued protected areas in the southern foothills area. Cumulative effects are likely to be significant for network expansion projects proposed in the south of the country, in combination with effects from completion of other highway links in the Southern East-West Highway, as well as clusters of industrial projects and the eventual development of the GMC. Further and more detailed analysis will be required at the project level to determine the significance of the impacts foreseen. Measures have been proposed in the SESMP to provide specific guidance to project-level assessment, and help ensure rigorous and comprehensive analysis.

326. **Climate Change Mitigation and Adaptation.** The SEA study assessed the implications of the proposed HMP for Bhutan's efforts to meet goals and international commitments with regard to emissions reduction and climate change adaptation. This included a Paris Agreement Alignment assessment. The HMP was found likely to make a positive contribution to national carbon emissions reduction goals, as the expected emissions savings from improved network efficiency outweigh the expected works emissions, yielding a modest net emissions savings. Numerous adaptation-supportive investments, including slope stabilization projects, bridge upgrades and replacements, and improved maintenance will unambiguously contribute to Bhutan's stated goal of strengthening the climate resilience of its infrastructure. The SESMP suggests some institutional innovations to help enhance DOST's ability to build and maintain climate-adapted roads, both on and off the national highway network.

327. **Water Resources.** The principal concern identified with respect to the country's surface waters is the potential for cumulative effects arising from simultaneous bridge replacement and upgrading works, riverbed mining operations, and hydropower project works in certain river basins. Degradation of water quality and habitat quality, as well as disturbance of sensitive populations of the highly endangered White-bellied heron, are considered possibly significant risks. The timing and spatial clustering of such works will be important factors in determining the significance of cumulative effects, and this will have to be assessed in detail during feasibility and design studies for bridges (or groups of bridges). The SESMP provides some direction in this regard.

328. **Public Safety.** The HMP is expected to be broadly beneficial to public safety, given proposed investment in slope stabilization, bridge upgrading and replacement, guardrails, pavement markings, and pavement condition. Some inter-institutional collaborations are proposed in the SESMP to build upon the infrastructural improvements.

329. **Equitable Development.** The highway network improvements proposed in the HMP can be considered likely to improve prospects for development in marginalized areas of Bhutan, principally by reducing travel time and travel cost for long-distance trips. Reduced east-west travel

time in particular should increase potential for people and enterprises in the eastern half of the country to benefit from increased tourist flows and better access to urban markets. A basic spatial analysis of proposed works suggests that the distribution of projects is approximately neutral with regards to the socioeconomic status of affected dzongkhags.

330. **National Economic Vitality.** The proposed investments collected under the HMP umbrella are collectively very likely to improve economic prospects by enhancing the reliability of the network and removing existing barriers to market access and economic activity. There is some reason for concern about a small number of the projects included in the HMP, for which preliminary economic analysis suggests negative feasibility. The high-level analysis conducted to date is not sufficient to rule these potentially problematic projects out at this stage. Detailed and rigorous economic analysis at the project level may suggest modification of the HMP, including subtraction of projects that pose unacceptable economic risk.

331. **Cultural Heritage.** Highway development often has some potential to threaten the integrity of cultural heritage sites, but this is appropriately addressed through project level EIA studies. In a broader sense, the proposed improvements to national highway network should enable appreciation and visitation of cultural heritage, by increasing accessibility to a greater number of sites, particularly in the eastern part of the country. The SESMP provides some guidance for early engagement with DOCDD during project feasibility studies to both prevent impingement on sites, and identify project alignment options with particular propensity to support visitation.

332. **Natural Resource Use.** The proposed highway network improvements are not considered likely to trigger unsustainable extraction of natural resources, although potential for this should be assessed in project-level EIA studies. New highway links, road widening projects and maintenance improvements should enhance the potential for rural natural resource-based development, as transport costs and low accessibility are constraints presently experienced in natural resource sectors. The SESMP proposes engagement with, and inputs from, relevant agencies during feasibility studies to help maximize prospects for new highway projects to bring benefits to natural resource-dependent communities and enterprises.

333. **Pollution and Waste.** Road-associated forms of pollution were considered to have limited significance in the context of the HMP, which concerns rural inter-urban highways rather than urban roads. Indirect impacts of highway improvement, such as increased development in areas lacking proper solid waste and sewage management facilities is acknowledged, but considered part of a nearly ubiquitous problem more appropriately addressed by existing waste management policy than through mitigation strategies for a transport sector plan. Wastes and pollution associated with construction are appropriately mitigated at the project level.

334. **Summary Conclusion.** Taken together, the findings outlined above comprise a generally favorable assessment of the HMP as currently proposed, with some notable caveats that will await more detailed, in-context study to definitively evaluate. Chapter VI of the SEA study compares this picture to the alternative of not implementing any new master plan for improving the highway network (the 'No Master Plan' alternative), and finds that the risks associated with the 'No Master Plan' alternative on balance probably substantially outweigh the risks identified for the HMP as proposed. Numerous prescriptions and recommendations have been included in the SESMP, most of which indicate the need for rigorous study of each component project during the feasibility study and design stages, and provide guidance for such studies. Thorough implementation of all measures indicated in the SESMP will be required to ensure that the foreseeable risks are managed successfully.

B. Recommendations

The following recommendations are offered, taking account of all the information summarized above, including the findings of the impact assessment, as well as the actions prescribed in the SESMP, which it is assumed will be thoroughly and competently implemented:

Recommendation #1. The HMP is deemed generally favorable by the SEA study as compared to the alternative of doing nothing, but this should not be taken as an *a priori* endorsement of all projects indicated in the plan. Further evaluation is needed at the project level for all proposed capital investments, and stakeholders are entitled to expect that projects found upon further analysis to pose unacceptable risks will be removed from the HMP.

Recommendation #2. The SEA study report has assessed the Master Plan as proposed at the time of writing (January 2025). The SEA study should be updated in the event that significant revision or modification of the HMP is proposed.

335. **Recommendation #3.** Stakeholders should be kept informed of the implementation of the SESMP through regular and transparent disclosure of monitoring and review results. In the event that significant revision or modification of the HMP is proposed, stakeholder consultations must be carried out.

APPENDICES

Appendix 1 – Draft Bhutan Road Sector Strategic Environmental Assessment Guideline

Appendix 2 – SEA Scoping Report

Appendix 3 – SEA Consultation Workshop Presentation and Participant List

Appendix 4 – Technical Brief: Climate Change Assumptions for Master Planning

Appendix 5 – Climate Change Adaptation Training Workshop Presentation

Bhutan Road Sector Strategic Environmental Assessment (SEA) Guideline

Date: 17 January 2025
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David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

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FIGURES AND TABLES

ABBREVIATIONS

EIA	Environmental Impact Assessment
PPP	Policy, Plan or Program
SEA	Strategic Environmental Assessment
SESMP	Strategic Environmental and Social Management Plan

I. INTRODUCTION

A. Context and Rationale for Road Sector SEA Guideline

1. This Bhutan Road Sector Strategic Environmental Assessment (SEA) Guideline has been prepared as an interim deliverable under Asian Development Bank TA-6916 BHU: Master Plan for National Highways Connectivity, 001 Consultancy Services (56001-001). The Consultant's Terms of Reference (ToR) indicate that the Consultant shall, among other things, "Develop draft general guidance for carrying out SEA under the government regulation on SEA." (p.5). The task was clarified during the Consultant's inception mission as pertaining specifically to SEA for policies, plans and programs (PPPs) in the road sector in Bhutan.

2. The inclusion of the Road Sector SEA Guideline's preparation amongst the components of the Technical Assistance reflects the reality that future road master plans and other comprehensive instruments proposed to guide development of Bhutan's road sector will be required to undergo SEA. The Royal Government of Bhutan's Regulation on Strategic Environmental Assessment (2002) stipulates that any agency that formulates, renews, modifies, or implements any PPP that may have a significant effect on the environment shall perform an SEA before the proposal will be considered for adoption. Sector-specific SEA guidance should enable such assessments to proceed efficiently and yield solid oversight.

B. Objectives of Road Sector SEA Guideline

3. The goal of this SEA Guideline is to help personnel of the Ministry of Infrastructure and Transport, the Department of Surface Transport and any other agency with road-sector responsibilities (e.g., Bhutan Construction and Transportation Authority, Royal Bhutan Police) prepare for and implement the SEA process for road-sector PPPs, which may include such things as comprehensive countrywide master plans; more limited master plans for specific road asset classes, regions, or asset management activities; network resilience or efficiency programs; and new national policies governing the management and safe use of roads. The Guideline has been designed as an accessible and practical explanatory manual. Specific objectives of the Guideline are to strengthen the user's understanding and appreciation of:

- What SEA is and why it is useful;
- Proponent agency ownership of the SEA process;
- SEA process steps that should generally be undertaken, by whom and in what order;
- How the SEA process should interact with the PPP formulation process;
- The role of SEA study consultants;
- Expected engagement with PPP stakeholders;
- What outputs should be expected and the purposes each output will serve; and
- Criteria by which the quality of an SEA report can be assessed.

4. Section II of the Guideline provides a brief overview of the conceptual underpinnings of SEA. The bulk of the Guideline document is in Section III, which defines an 11-step SEA process and guides the user through each one in turn. Finally, Sections IV and V provide practical tools for navigating the SEA process: an SEA Process Checklist, and a framework for assessing the completeness and quality of SEA reports. These tools should be of use to both PPP proponent

agencies charged with orchestrating, supervising and evaluating the SEA process, and to consultants engaged to carry out SEA studies.

C. Development of Road Sector SEA Guideline

5. The Road Sector SEA guideline was developed first and foremost on the basis of the Regulation on Strategic Environmental Assessment (2002); insights were also drawn from the draft Guidelines for Strategic Environmental Assessment in Bhutan (2016). A comprehensive review of guidance documents produced by international, intergovernmental, governmental, non-governmental and academic entities from around the world, as well as a selection of SEA reports prepared in various sectors, rounded out the informational basis for guideline development. The guidance contained in the Road Sector SEA Guideline was 'pilot-tested' through the completion of the SEA study for the Bhutan National Highway Connectivity Master Plan.

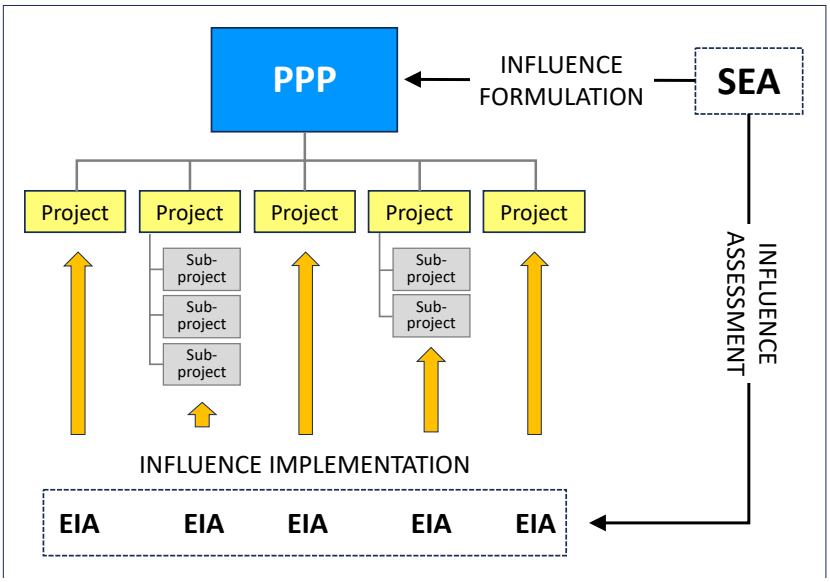
II. STRATEGIC ENVIRONMENTAL ASSESSMENT

6. **Purpose of SEA.** The purpose of SEA is to enable critical foresight that can inform the design of the higher-order, broadly-scaled governmental initiatives, including policies, plans, and programs (PPPs), which provide the institutional context and funding frameworks for concrete investments and changes implemented through on-the-ground projects or other actions. Conducting SEA on a PPP facilitates the proactive identification of environmental and social consequences well upstream of the formulation of projects, sub-projects and other vehicles of PPP rollout and delivery, including systemic and cumulative effects that are difficult to conceptualize and remedy during implementation-phase assessment.

7. **SEA approaches.** Two broad conceptual approaches to conducting SEA have been observed globally: impacts-oriented SEA and objectives-oriented SEA. The former is understood as an outgrowth of environmental impact assessment (EIA) practice, and focuses on the proactive identification and mitigation of the effects of a PPP on receptors in the biophysical and socioeconomic environments. The latter is more deeply integrative, defining broad environmental and social objectives as explicit aims of the PPP, so their achievement can be pursued as part of the PPP's implementation and measured by PPP implementation indicators. Bhutan's Environmental Assessment Act (2000) and the supporting Regulation on Strategic Environmental Assessment (2002) conceptualize SEA requirements in terms that align more closely with the impacts-oriented approach, and this Road Sector SEA Guideline follows that lead.

8. **Relationship of SEA and EIA.** EIA has been widely practiced around the world for decades, and has become a standard expectation and requirement of project development in virtually all countries. A common criticism of EIA is that there is typically little scope for unpacking and challenging the assumptions and decisions that underlie a proposed project's formulation, with the focus of the EIA study largely limited to figuring out how to manage the impacts of the project as formulated. Effective SEA can get at the upper-level assumptions and decisions from a position upstream of project formulation. Project-focused EIA also tends to be limited in its ability to address cumulative impacts, due to the practical and legal difficulties of imposing coordinated mitigation with other projects. With its wider perspective and mandate to focus on systemic and cumulative effects, SEA can identify ways in which project design and implementation phasing can be pre-shaped to limit cumulative potential. SEA can also provide direction to project-level EIA studies, for example by indicating needs for particular expertise or attention to factors contributing to systemic and cumulative effects. The management plans produced by project-level

EIA can be powerful vehicles for implementing prescriptions that come out of the SEA process with respect to addressing systemic and cumulative effects. The complementary relationship between SEA and EIA is visualized in Figure 1.



Source: Consultant

Figure 1: Relationship of SEA and EIA

III. STRATEGIC ENVIRONMENTAL ASSESSMENT PROCESS

A. Responsibility for the Strategic Environmental Assessment

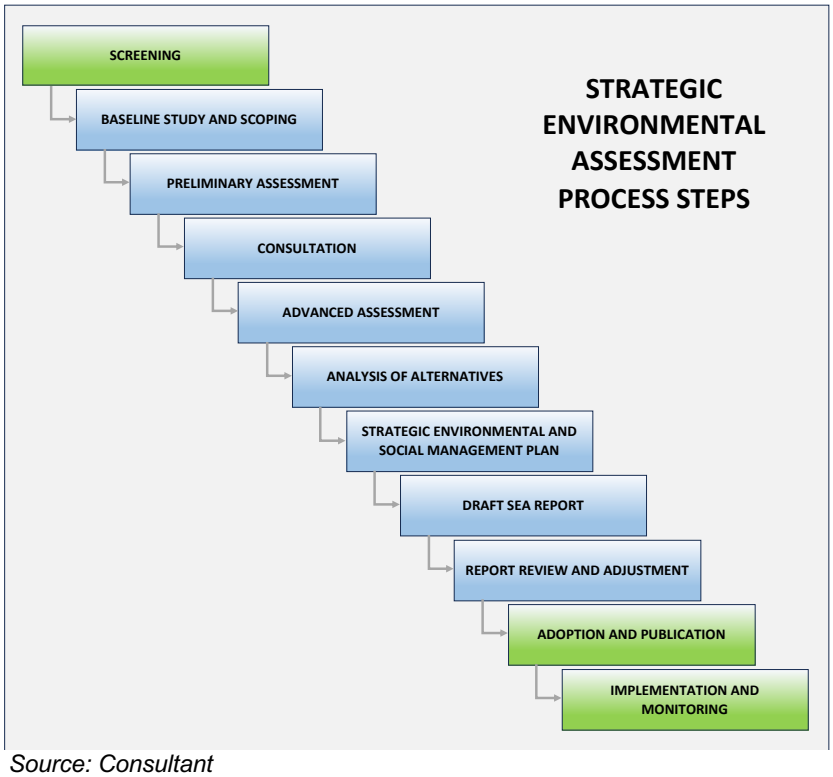
9. An SEA is the responsibility of the proponent agency or agencies charged with developing (or overseeing development of) the subject PPP, just as EIAs for projects are the responsibility of the public-sector and private-sector entities that propose and aim to implement them. An SEA study can generally be expected to require expertise beyond what is available (or readily freed up) in most government agencies, so it is typical for consultants to be engaged to conduct the SEA study under the supervision of the proponent agency. The SEA study does not account for the entirety of the SEA process, and the proponent agency must expect to lead execution of the SEA process, including the engagement and supervision of the SEA study consultants.

B. SEA Process Steps

10. There is no universal or standard process for conducting SEA, and how a PPP proponent and its SEA study consultants approach SEA will depend on a number of factors relating to, for example, the nature and scale of the subject PPP; the sector in which the PPP is being developed; the range and depth of stakeholder interest; the planning process used to formulate the PPP; guidance provided by national regulations or guidelines; examples set by SEA processes and studies previously carried out in the same national context; and the availability of information for setting benchmarks and monitoring indicators. This section of the Road Sector SEA Guideline outlines a process that takes direction from, and is compatible with, the language used in the

Regulation on Strategic Environmental Assessment (2002), and was found useful for the SEA conducted in 2023-2025 for the Bhutan National Highway Connectivity Master Plan. The process model should be understood as a framework to support compatibility of a road sector SEA with the regulatory requirements in Bhutan, that can nevertheless be adapted to reflect the kinds of contextual factors mentioned above.

11. Figure 2 shows an 11-step representation of the SEA process as detailed in this Road Sector SEA Guideline. Steps 2 through 9 (in blue) cover the SEA study portion of the overall SEA process. Each of the steps in the diagram is explained in turn below.



Source: Consultant

Figure 2: SEA Process Steps

1. Screening and Preparation

12. **Screening.** SEA screening is a process by which the proponent agency determines whether a proposed PPP should undergo an SEA. In Bhutan, screening road-sector PPPs is simplified by the existence of the Regulation on Strategic Environmental Assessment (2002), which explicitly mandates SEA for the formulation, renewal, modification or implementation of all PPPs with potential for significant environmental impacts. Potential for environmental effects is inherent to the development and use of roads, and it is unlikely that a PPP of any import proposed for the road sector would be deemed not to require an SEA. The screening determination should be confirmed with the Department of Environment and Climate Change, which is the agency responsible for administering the Regulation on Strategic Environmental Assessment.

13. **Institutional arrangements.** In some cases, it may be advisable to set up a multi-party mechanism such as a steering committee to oversee the SEA process. Whether this is appropriate will depend on the degree of cross-sector involvement foreseen for the subject PPP's

aims and design, and also on the level of up-front concern that other agencies may have about the potential impacts of the subject PPP. If a steering committee or other multi-party mechanism is considered desirable, it should be fully established at the beginning of the SEA process, before proceeding to any of the subsequent steps.

14. **Engagement of consultants.** A positive SEA screening result is the PPP proponent's cue to prepare for the SEA study by procuring the services of a qualified SEA consultant. The SEA consultants may be engaged under the same contract package as planning consultants engaged to assist the proponent agency to develop the PPP. This is not required, but is beneficial, as it enables close interaction between respective experts working to formulate the PPP and to assess its environmental implications. In the unusual event that PPP formulation is to be completed in-house without the assistance of planning or policy consultants, or if planning consultants and SEA consultants are engaged independently under separate contract packages, it is critical for the SEA study consultants to have good access to the PPP formulation team; this can be enabled by relevant provisions in the consultants' contracts.

15. **Provisional sum.** The full scope of impact potentials and the kinds of research tasks needed to evaluate each will not be definitively known during screening, although many will be reasonably foreseeable even at this early stage. It is advisable to have a provisional sum mechanism in place to enable supplemental studies to be carried out in a timely manner, should the need for specialized inputs emerge during subsequent steps in the SEA process.

16. **Accessible online communication setup.** Another key action during this first step of the SEA process is to set up a website, or web page under the proponent agency's website, for the purposes of communication with stakeholders of the PPP throughout its formulation, assessment and implementation. This will become a central means of disclosing information, and will serve as the principal publicly accessible depository for outputs from the SEA process. The proponent agency's social media communications can be used to direct stakeholder attention to the web site or web page, especially when a new document is posted. The proponent agency will need to maintain and use the website or web page for the full life of the PPP.

2. Baseline Studies and Scoping

17. Baseline studies are necessary to understand the multiple contexts (environmental, social, cultural, economic, policy) of the PPP, and scoping is necessary to understand which context elements are likely to be most worthy of attention in the SEA study. Baseline development and scoping are intertwined and mutually affirming processes, and for that reason are appropriately considered a single process step rather than separate, sequential steps.

18. **Baseline studies.** Baseline development should focus on identifying and characterizing the environmental and social resources and systems in the part of the country the PPP may have the potential to affect, or which may influence the ways in which the PPP's effects are experienced. This should include, but not be limited to, attention to biophysical conditions and resources, socioeconomic conditions and trends, cultural considerations, and the constellation of PPPs in the road sector and other sectors that may interact in some way with the subject PPP. Available secondary information, coupled with primary data generated as part of the PPP formulation process, will usually be sufficient to build a baseline useful for high-level assessment purposes. Subsequent project-level EIA studies will generally require more data collection, including of primary data.

19. **Scoping.** Scoping is the interactive process of identifying and defining the themes that are likely to be most significant to the SEA, and which the SEA study's design should accordingly prioritize for analysis. Scoping is an important window for involvement of a PPP's key stakeholders in the SEA process, and a vital opportunity for the SEA study team to focus the study on impacts and opportunities that matter most to stakeholders, while avoiding unnecessary expenditure of time and resources on less important themes. Scoping may be accomplished using various engagement tools, such as workshops, one-on-one and small-group meetings to discuss particular themes, perception surveys, and field visits to sites with illustrative value; ideally, two or more of these forms of engagement should be used.

20. **Stakeholder identification.** Stakeholder identification is an important first step in scoping, and should continue as scoping proceeds. Definition of the stakeholder group depends very much on the nature and spatial scope of the PPP. One useful method is to look at what resources and systems might reasonably be affected by the PPP and asking what societal groups and institutions benefit from them or have interests in their management. Another method is to survey the landscape of existing major PPPs and identify those which have objectives that could be expected to either counteract or support the subject road-sector PPP to some significant degree; institutional actors who have played a role in the development of PPPs with significant potential for such interactions can likely be counted as stakeholders of the road-sector PPP.

21. A particular challenge for SEA, which is usually oriented to assessing impacts of very broad-scale PPPs that may affect virtually everyone in the whole country, is finding ways to engage a suitably broad cross-section of stakeholders. SEA study budgets and timelines may or may not be adequate to permit scoping meetings in large numbers of localities. A common and appropriate adaptation is to identify a broad range of representative stakeholders, i.e., institutional entities that represent either a resource base or social sector (e.g., natural resource agencies and NGOs, social development agencies and NGOs, and business groups) or a political constituency (e.g., dzongkhag, gewog and thromde administrators and elected representatives) to participate in scoping. In some situations, web-based surveys may be useful for capturing a measure of direct public input as a supplement to engaging with representative stakeholders.

22. **Interaction of baseline development and scoping.** Initial baseline development gives the SEA study team a basis for structuring more fact-finding, including through discussion with knowledgeable stakeholders. Scoping is an important means of validating and enriching the SEA team's initial understanding of baseline conditions, as stakeholders who take part in scoping typically have access to specialized information resources, as well as deep experience-based insights about past and existing conditions that may indicate a need for additional information-gathering to build out the baseline. It is therefore necessary for scoping and baseline research to be conducted concurrently as the first step of the SEA process after screening.

23. **Scoping Report.** The combined baseline and scoping process should culminate in the production and sharing of a Scoping Report that outlines the findings of both scoping and baseline research, and explains the next steps in the SEA process. The Scoping Report is a vital tool for building a shared understanding between the SEA study team, the proponent agency, and all stakeholders of what the SEA study will focus on. For the SEA study team, the Scoping Report provides a roadmap for the assessment to come, and for stakeholders, it provides reassurance that they have been heard and that the SEA study will address what is important to them. The Scoping Report should be shared directly with stakeholders whether they participated actively in scoping or not, and advertised and made available for broader public consumption through the website or web page. Review and comment by stakeholders should be invited, so the SEA study team can take the input into account as it moves forward to the first impact assessment step.

3. Preliminary Assessment

24. **Analytical scope.** Impact assessment pairs contextual information with expert knowledge and judgement to anticipate and characterize likely outcomes of a proposed activity. Impact assessment is the core of the SEA process, and is in the hands of the SEA study team. Because SEA pertains to higher-order instruments, and is often done before firm commitments have been made to implement particular component projects, it is appropriate for impact analysis to focus on big-picture impact pathways, broad-scale processes and relationships, and cumulative and systemic effects. Precise measurement and fine-grained analysis of impact potentials in particular places is largely reserved for subsequent project-level EIA studies. In practical terms, this means that the analytical work of impact assessment will rely mainly (though not exclusively) on data aggregated at the national and district levels, and broadly scaled spatial information.

25. **Interaction with PPP planning team.** It is ideal for impact assessment to proceed in tandem with, or at least parallel to, PPP formulation, and this is why there are two steps for assessment in the SEA process model shown in Figure 2: preliminary assessment and advanced assessment. If some environmental analysis is ongoing during PPP formulation, findings can be communicated to the planning team at an early stage, and the input of informed expertise may be a decisive factor in formulation decisions. On the other hand, there may be a large number of project or policy measure concepts floating around during the early stages of PPP formulation, and the SEA study team's resources are unlikely to be sufficient to do a thorough assessment of each; this can come later, once the proposed PPP has coalesced and solidified around a firm set of projects or measures that have a reasonable chance of withstanding scrutiny and ending up in the final PPP.

26. **Assessment criteria.** In order for the SEA specialists to make a useful contribution to (and exert influence on) the PPP formulation process, key environmental and social criteria should be conceptualized and communicated to the planning team. These criteria will be informed by the scoping results, and by the expert judgement of the SEA consultants. If a formal multi-criteria analysis is to be used for the PPP formulation, the criteria will enter directly into the decision matrix. If a less rigid formulation process is to be used, then the criteria developed by the SEA specialists will still help to structure deliberations about what to include in the PPP.

27. **Supplemental studies.** If a critical unforeseen information need emerges during preliminary assessment that cannot be met with the expertise and resources on hand, one or more supplemental studies may be needed. When this occurs, prompt action on the part of the SEA consultant (to prepare the study Terms of Reference) and the proponent agency (to approve the use of funds from the Provisional Sum) will be necessary to avoid delaying the progress of both the SEA study and PPP formulation.

28. **Validation check-in.** The preliminary assessment step is a good time for the SEA consultants to check in with the proponent agency, and the steering committee if one has been set up, with an informal meeting or workshop. This is a useful mechanism for keeping the supervising entities informed about the progress of the assessment, conferring about impacts that may have a negative effect on the PPP's formulation or raise stakeholder concerns, and for discussing any assistance that may be needed from the proponent agency. It is also an opportunity to define expectations and logistics regarding the about the upcoming consultation step.

4. Consultation

29. Just as it is important for environmental assessment to feed into PPP formulation while it is underway, stakeholder input to the impact assessment process is most useful if it comes before the work of impact assessment has been completed. Sharing preliminary assessment findings with stakeholders can be a good way for the SEA team to solicit insights and information about new concerns that have emerged, and to seek their affirmation that the assessment is on the right track. It will usually be worthwhile to conduct consultations together with the PPP formulation team, so that stakeholders can also give feedback on the PPP itself.

30. Consultation with stakeholders may take numerous forms, including workshops, smaller meetings, focus group discussions, one-on-one and small-group interviews, and perception surveys. Workshops are the most efficient method when there is significant material to share with the stakeholders, as will be the case when presenting initial formulations of the PPP and/or preliminary assessment findings. Remote engagement with far-flung stakeholders has become relatively easy since free video-conferencing software became commonplace, and this can greatly expand the potential of workshops, meetings and interview-based engagement.

31. Although it is part of the SEA study conducted by the SEA consultant, stakeholder consultation should be enabled by cooperation between the SEA consultant and the proponent agency. At the very least, representatives of the proponent agency should officially host large-format engagement such as workshops, as face-to-face contact between agency personnel and stakeholder representatives helps to build familiarity and trust. Trust can become very important later on when the planning and assessment have been completed and the consultants go away, and the proponent agency and stakeholders have to cooperate on implementation of the PPP.

5. Advanced Assessment

32. More focused impact assessment can be pursued once the PPP formulation process has narrowed the scope of projects or measures to what will realistically be in the final PPP, and can also proceed with the benefit of feedback received during stakeholder consultations. The PPP can now be taken as a firm proposal, and its likely effects as a comprehensive entity can be anticipated and characterized. Potential for cumulative effects can be more clearly understood, and particular points of significant concern can be highlighted as outliers in an aggregated picture. Statements of anticipated impact can be generated, and suitable mitigation can be formulated for each significant impact identified.

33. **Significance of impacts.** Determining the significance of an impact is a matter for expert judgement, taking account of receptor resource characteristics, intensity of proposed on-the-ground actions and activities, probabilities regarding both desired effects and unintended consequences of the PPP, and stakeholder insights. It is important for the evidence and rationale used in arriving at a determination of significance to be well presented in the SEA report, so the audience can decide whether to have confidence in the findings.

34. **Types of mitigation measures.** As indicated in Figure 1 above, mitigation measures developed out of the assessment steps in the SEA study are likely to fall into two general categories: (1) measures that would modify the PPP itself in order to forestall anticipated negative impacts (or enhance positive ones); and (2) measures that would strengthen, shape or direct some aspect of project-level EIA in order to help address an anticipated systemic or cumulative risk. Measures that would modify the PPP might include, for example, dropping or modifying a

particularly problematic project proposed as part of the PPP, or prescribing an alternative phasing of projects to limit potential for cumulative impacts. Coordination between the proponent and other agencies can also be prescribed to manage cumulative impacts. These types of measures can be thought of as 'mitigation by design'. Measures that would modify the project-level EIA process rather than the PPP itself can be considered 'post hoc mitigation', and might include, for example, special requirements to be indicated in the Terms of Reference for the consultants engaged for feasibility, EIA and design work to ensure that priority concerns are subject to especially rigorous study, and that time allocations for project preparation are sufficient to allow for the extra rigor. On-the-ground mitigation is rarely directly specified in SEA, which is a high-level analysis based on high-level information, an insufficient basis for defining practical measures to be used in specific locations.

35. **Specification of prescribed actions.** Measures for mitigating or enhancing anticipated impacts should be specified as precisely as possible to limit scope for misunderstanding and corner-cutting during implementation. It is sometimes useful to separate measures into multiple parts to ensure clarity, even though it may make the list of measures seem onerous. If a measure is to be the responsibility of more than one entity, the mode of cooperation between the entities required for successful implementation should be built into the specification. Mitigation and enhancement measures should be formulated as prescriptions rather than recommendations, to support accountability. Measures should only be stated as recommendations when the entity assigned responsibility may not have a high degree of control over the implementation context (such as when cooperation with entities external to the SESMP scope is required), or when the proposed measure is complementary or supplementary in nature, rather than essential.

36. **Uncertainty and further study.** It is important to recognize that some assessment findings may be provisional, and flagged for confirmation or disconfirmation by further, more detailed study and evaluation during project preparation. This can be a reflection of both the data available at the SEA stage and the tentativeness of the actual content of the subject PPP. Some projects or policy measures proposed under the PPP may not yet be well defined (particularly those proposed to come on stream late in a multi-year implementation phase), and decisions about implementation of some projects or policy measures may be contingent on uncertain future budget processes or continuation of past economic trends. It may also be that some projects and measures are not clear winners or losers coming out of preliminary economic or other analysis during formulation, and will only be ruled out or ruled in after consideration in a full feasibility study. This is a normal aspect of SEA, and requires careful presentation of findings.

37. **Validation check-in.** Near the end of the advanced assessment step is another good time for an informal meeting or workshop to discuss the more advanced findings and the mitigation being considered. The proponent agency can begin to get a sense for how the SEA findings are going to shape the PPP's implementation, and how significant the work of impact management may be. The SEA consultant can get feedback ahead of jumping into specifying mitigation planning.

6. Analysis of Alternatives

38. The Regulation on Strategic Environmental Assessment (2002) expressly requires consideration of the environmental implications of alternative courses of action to the proposed PPP, including the alternative of taking no action. The purpose of this exercise is to step back and reflect on whether the PPP as proposed is the most suitable means of addressing the policy problem at hand, from an environmental perspective. This is a comparative analysis, oriented to

confirming a Preferred Alternative that stands above other alternatives. The form this comparative analysis takes will depend in part on the methodology by which the PPP is formulated.

39. Some planning and policy-making processes are built around generation and subsequent comparison of multiple scenarios or alternative solutions to the policy problem, using some variant of multi-criteria analysis. Where this is the case, the applicability of impacts identified for the PPP as proposed can be reconsidered in relation to each alternative scenario or solution, and comparisons can be made. Typically, scores on environmental and social criteria will already have been assessed as part of the multi-criteria analysis, and these can be discussed.

40. Where the approach to PPP formulation is something other than multi-criteria analysis (or other comparison-driven methodology), it is possible that only one solution to the policy problem will have been proposed. In this context, the central comparison is between the PPP as proposed and the null alternative (the 'take no action' alternative). The comparison between the environmental implications of these two alternative courses of action should take into account the impacts that would be avoided or foregone due to the PPP's implementation. Such avoidance may or may not be an objective of the PPP, but is nevertheless consequential to the comparison.

41. In some cases it may be possible for the SEA consultant to formulate one or more additional plausible alternative scenarios for comparative purposes, but this requires careful judgement and access to good in-context information about alternative modes of service or policy delivery. Scenarios that have not actually been researched and developed as proposals are purely hypothetical, and will not make particularly realistic benchmarks.

7. Development of a Strategic Environmental and Social Management Plan

42. The Strategic Environmental and Social Management Plan (SESMP) translates the findings and mitigation proposals developed in the SEA report's assessment chapter into actionable and enforceable prescriptions, and assigns responsibility for their implementation. The SESMP is analogous to the Environmental Management Plan prepared as part of a project-level EIA.

43. **Oversight arrangement.** A key task of the SESMP is to define the entity or entities that will be responsible for overseeing the SESMP's implementation, including monitoring and reporting functions. PPPs are typically intended to be long-term instruments, and many do not have a management unit assigned to implement them, although there may be multiple Project Management Units or Project Implementation Units formed to implement their component parts. It is therefore usually necessary to establish a new and durable oversight body for the SESMP.

44. The structure, scope and responsibilities of the oversight body, as well as its positioning within the governmental administrative structure, should be described in the SESMP. Depending on the PPP, it may be appropriate for the oversight body to be a committee or other multi-stakeholder structure, as this can build in broad representation of sectors implicated in or affected by the PPP, and can strengthen transparency and accountability. Any operating costs should be described and estimated.

45. **Mitigation responsibilities.** The SESMP should identify all entities that will be required to play a role in implementing prescribed measures, whether as lead implementor, co-implementor or in a supporting, reinforcing or consultative role. Responsibilities should be assigned to each measure individually so there can be no ambiguity about who is responsible for what. The required timing of implementation should also be indicated for each assigned measure. A tabular matrix is

typically used to facilitate clear, measure-by-measure assignment of responsibilities. Performance indicators should be specified for each measure, to facilitate monitoring.

46. **Monitoring.** The SESMP must contain a monitoring plan, and this should mandate two forms of monitoring: compliance and effects. Compliance monitoring means confirming that the measures prescribed in the SESMP are being implemented properly and in a timely manner. Effects monitoring measures the impacts the PPP's implementation is having on aspects of the biophysical and socioeconomic environments. These are quite different processes, and use distinct methods.

47. Compliance monitoring is typically straightforward, and can follow from the responsibilities matrix listing all the prescribed actions, which will ideally already specify performance indicators. The responsibility matrix can be adapted to serve as a monitoring checklist. A critical aspect of compliance monitoring is what happens when non-compliance is identified; the monitoring regime must include a pathway for seeking and confirming corrective action.

48. Effects monitoring for an SESMP should aim to be practical, economical and achievable. Most PPPs will have potential to affect many different biophysical and socioeconomic attributes of the environment, and it is not practical or cost-effective to measure all of them. Attribution is a significant challenge, as most measurable environmental parameters may vary for many reasons besides the influence exerted by a PPP's implementation. The practical applications of monitoring data, and the audience for monitoring reports, must also be considered. The point of effects monitoring is to give stakeholders a sense, without much time or effort on their part, of whether the PPP is having positive/improving or negative/worsening effects, and bombarding them with data on dozens of indicators on a regular basis is unlikely to achieve this or be welcomed. For these reasons, it is advisable to select a limited number (5-15) of environmental indicators to measure. Monitoring indicators should ideally be:

(1) Practical for entities named in the SESMP to measure periodically over a multi-year period, in all seasons;
(2) Already measured for some other purpose by a government entity that is part of the oversight body or will agree to share the data at no or low cost;
(3) Suitable for showing unambiguous attribution, i.e., variation in the parameter measured can be plausibly linked to some aspect of the PPP's implementation; and
(4) Easy for the lay person to understand.

49. The SESMP should indicate which indicators are proposed to measure which environmental effects, how they are to be measured, how often, and by whom. Annual costs associated with measurement should be estimated.

50. **Capacity needs.** Entities assigned to implement prescribed measures in the SESMP may not have the technical or administrative capacities necessary to meet their obligations. In this case, measures aimed at developing such capacities should be specified in the SESMP. Appropriate measures could include training, hiring additional staff, provision of equipment and supplies (or a budget for such items), or even creation of new professional units. The SESMP should indicate what capacity-building is needed and indicate what it should entail. It may be appropriate for the cost of capacity-building to be paid for under the SESMP implementation budget, if the capacities established will mostly or exclusively support SESMP-related activity (this may be the case especially for training and equipment). If the new capacities will have broader applications in addition to SESMP implementation activities (as will likely be the case if a new

professional unit is established), then the budget for capacity-building may appropriately come from other sources, such as an increase in the entity's staffing allocation from the parent agency.

51. **Cost estimate.** As many or all of the measures prescribed in an SESMP are likely to be essentially administrative tasks assigned to existing government units, determining a cost for each tends to be difficult. In many cases, prescribed measures may modify existing workflows without adding substantially to overall workload. Costs estimated for inclusion in the SESMP implementation budget should be limited to significant quantifiable incremental costs, which represent the costs associated with tasks that go over and above 'business as usual' for the implementing entities.

52. Costs for additional studies to be carried out as part of feasibility studies and EIA studies at the project level, as may have been indicated in the SESMP, can appropriately be subsumed within project costs in most cases. Any additional study mandated in the SESMP that has a broader purview and whose findings may be significant to implementation of multiple projects, or to the PPP as a whole, will probably be most suitably paid for out of the SESMP budget, and reflected in the SESMP cost estimate.

8. Draft SEA Report

53. **Finished product.** Once Steps 2 through 7 have been completed, the SEA consultant will be in a position to assemble the comprehensive Draft SEA Report. This should be a complete and polished draft report, which will be disseminated to stakeholders for review. Stakeholders do not have endless time available for reading and re-reading incrementally improved drafts, and will appreciate the opportunity to review and comment upon a finished product without outstanding gaps and analytical loose ends.

54. **Executive or non-technical summary.** The Draft SEA Report should have an executive summary (sometimes called a non-technical summary) included in its front matter. The executive summary should provide a succinct guide to the main report, in a language and style readily accessible to decision-makers and stakeholders who may not have backgrounds in environmental or social sciences. The executive summary should not repeat material verbatim from the main text, and should be no more than 10% as long as the main text. The executive summary must highlight key findings and should state conclusions and recommendations that are of practical relevance to decision-makers.

9. Report Review and Adjustment

55. **Feedback mechanism.** The proponent agency (or steering committee) will conduct a thorough review of the Draft SEA Report and provide timely feedback to the SEA consultants. The Draft SEA Report should be disseminated by the proponent agency to all stakeholders previously identified for inclusion in scoping and consultation, and comment should be solicited within a specified timeframe. The Draft SEA report may additionally be presented in a public stakeholder forum such as a workshop or other form of meeting, to maximize potential for stakeholder feedback. It should be emphasized to stakeholders that this is the final chance to provide feedback before the SEA Report and its embedded SESMP are finalized.

56. **Review by responsible stakeholders.** Key stakeholder It is especially important that the Draft SEA Report be carefully reviewed and commented upon by stakeholders who have been assigned any kind of role in the SESMP. It is the responsibility of the proponent agency to engage

with these stakeholder entities and seek their confirmation that they are aware of, understand, and agree to the roles assigned to them in the SESMP.

57. **Final SEA Report.** The SEA consultants will make any adjustments to the SEA report that may be appropriate, based on review comments from stakeholders and from the proponent agency or steering committee. The proponent agency or steering committee will confirm all comments have been appropriately. The SEA Report will then be considered final, and the SEA study consultants will exit the SEA process.

10. Adoption and Publication

58. The subject PPP will be formally adopted by the Royal Government of Bhutan, and the SEA Report must be incorporated by reference in the published adoption decision, so it is an officially recognized component of the PPP and the measures prescribed in the SESMP become enforceable conditions of the PPP's approval. The proponent agency should ensure that the Final SEA Report is properly referenced in the adoption decision, and entered into the official record along with the PPP document.

11. Implementation and Monitoring

59. **Setup of oversight body.** The SESMP will come into effect upon adoption, and the oversight body assigned to manage the SESMP implementation and monitoring, as well as engagement with stakeholders, should be set up immediately. The oversight body will need to develop internal bylaws and policies to govern its operations in line with what has been prescribed in the SESMP, including its monitoring and reporting schedules. A system for standardized disclosure and archiving of monitoring reports on the website or web page should be set up. The operating budget, including any disbursements anticipated to cover incremental costs for implementing entities, will need to be established and refined, and fiduciary responsibilities established.

60. **Updates in case of PPP adjustment.** In the event that the PPP requires significant adjustment or revision, it may be necessary to update the SEA study and SESMP to reflect this. The oversight body's policies should include a mechanism to trigger a consultation with the Department of Environment and Climate Change to discuss any proposed changes to the PPP, so it can be determined whether an SEA update is required, and if so, how it should be scoped.

IV. SEA PROCESS CHECKLIST

61. The following checklist (Table 1) is provided as a tool to support comprehensive planning and implementation of an SEA process, and promote clear and shared understanding of the delineation of roles and responsibilities of those involved. The checklist is suitable for use by both the proponent agency and the SEA consultant. The proponent agency (or steering committee) may find it desirable to create a checklist tailored to a specific PPP formulation process or its own preference, in which case the version presented here can be used as a template.

Table 1: SEA Process Checklist

STRATEGIC ENVIRONMENTAL ASSESSMENT PROCESS CHECKLIST					
Process Elements		**Responsibility**		**Initiated**	**Complete**
		Lead	**Support**		
Key **C:** SEA Consultant; **OB:** SESMP Oversight Body; **PA:** Proponent Agency; **SC:** Steering Committee (if used)					
STEP 1: SCREENING AND PREPARATION					
1.1	Confirm SEA necessary for PPP per Regulation on Strategic Environmental Assessment EA (2002)	PA	-		
1.2	Establish steering committee (if deemed necessary)	PA	-		
1.3	Procure services of SEA consultant	PA	-		
1.4	Set up provisional sum mechanism	PA	-		
1.3	Set up website or web page for SEA process	PA	-		
STEP 2: BASELINE STUDY AND SCOPING					
2.1	Gather and review relevant secondary information	C	PA		
2.2	Assemble baseline profile	C			
2.3	Stakeholder identification	C	PA		
2.4	Scoping workshop and other meetings, etc.	C	PA		
2.5	Prepare Scoping Report	C	-		
2.6	Disseminate Scoping Report to stakeholders	PA	-		
STEP 3: PRELIMINARY ASSESSMENT					
3.1	Formulate environmental and social criteria	C	-		
3.2	Participate in PPP formulation discussions and decision-making	C	-		
3.3	Generate preliminary statement of anticipated impacts	C	-		
3.4	Validation check-in	C	PA		
STEP 4: CONSULTATION					
4.1	Seek stakeholder feedback on preliminary PPP and preliminary statement of anticipated impacts via workshops, meetings, etc.	C	PA		
4.2	Take stock of suggested refinements and new avenues of assessment	C	-		
STEP 5: ADVANCED ASSESSMENT					
5.1	Conduct focused assessment on advanced-stage PPP components and activities	C	-		
5.2	Characterize potential impacts of PPP as proposed	C	-		
5.3	Define and prescribe actions necessary to mitigate or enhance impacts	C	-		
5.4	Develop refined statement of anticipated impact with mitigation applied	C	-		
5.5	Validation check-in	C	-		
STEP 6: ANALYSIS OF ALTERNATIVES					
6.1	Define plausible alternatives to proposed PPP	C	-		
6.2	Assess alternative scenarios in relation to same impact set anticipated for proposed PPP	C	-		
STEP 7: DEVELOPMENT OF STRATEGIC ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN (SESMP)					
7.1	Define institutional arrangements for SESMP	C	-		

STRATEGIC ENVIRONMENTAL ASSESSMENT PROCESS CHECKLIST					
Process Elements		**Responsibility**		**Initiated**	**Complete**
		Lead	**Support**		
7.2	Assign time-bound responsibility for prescribed actions developed from impact assessment	C	-		
7.3	Define plan for monitoring compliance with prescribed actions and effects of PPP on biophysical and socioeconomic environments	C	-		
7.4	Identify capacity building needs to support PPP's strong environmental and social performance and define capacity building measures.	C	-		
7.5	Estimate costs of SESMP implementation over life of PPP	C	-		
STEP 8: DRAFT SEA REPORT					
8.1	Assemble comprehensive Draft SEA Report	C	-		
8.2	Prepare accessible executive summary	C	-		
STEP 9: SEA REPORT REVIEW AND ADJUSTMENT					
9.1	Review Draft SEA Report and provide feedback	PA, SC	-		
9.2	Seek review from entities implicated in SESMP and confirm agreement with roles assigned	PA	-		
9.3	Disseminate Draft SEA report to stakeholders for review and comment	PA	-		
9.4	Produce Final SEA Report, reflecting comments on Draft SEA Report as appropriate	C	-		
9.5	Review Final SEA Report to confirm appropriate reflection of feedback	PA	-		
STEP 10: ADOPTION AND PUBLICATION					
10.1	Ensure that the SESMP is incorporated by reference in the official adoption decision for the PPP, and that the Final SEA Report is entered into the public record along with the PPP document	PA	-		
STEP 11: IMPLEMENTATION AND MONITORING					
11.1	Establish SESMP oversight body	OB	PA		
11.2	Adopt internal by-laws and policies	OB	-		
11.3	Adopt monitoring schedules and reporting formats	OB	-		
11.4	Adopt system for disclosing reports and soliciting comment	OB	-		
11.5	Establish fiduciary responsibilities	OB	-		
11.6	Develop and adopt an operating budget and disbursement schedule	OB	-		

Source: Consultant

V. SEA REPORTS CONTENT AND QUALITY CRITERIA

62. The following table (provides a guide for evaluating the completeness and quality of an SEA report. It is intended as a tool for the use to both SEA consultants and the proponent agencies and other entities charged with verifying and judging the outputs of the SEA study process.

Table 2: SEA Report Content and Quality Criteria

	SEA Report Section	Quality Criteria
	Executive Summary	▪ Succinctly outlines the context, rationale, process, findings and prescriptions and conclusions detailed in the report, in non-technical language accessible to decision-makers and stakeholders, including those without backgrounds in environmental and social sciences ▪ Is no longer than 10 percent the length of the main document ▪ Avoids copy-and-paste of material from the main document
1	Introduction	▪ Briefly explains the context and purpose of the SEA ▪ Identifies the subject PPP and indicates its underlying rationale ▪ Clearly outlines the methods or methodological approach used in the study, including information sources, analytical scope and consultative processes
2	Legal and Administrative Context	▪ Provides a concise overview of governmental entities and instruments of law and policy with direct relevance for the conduct of SEA, with a focus on those that directly justify and structure the SEA process ▪ Identifies other national PPPs with potential for intersection with the subject PPP ▪ Avoids lengthy descriptions of legal and policy instruments
3	Description of the Proposed PPP	▪ Provides the reader with a solid high-level understanding of what the PPP is and what it will do, as a basis for engaging with the impact analysis to come ▪ Clearly describes the objectives of the PPP ▪ Indicates how the PPP was formulated ▪ Identifies all significant component parts of the PPP, using maps and figures as appropriate to limit the length of textual descriptions ▪ Indicates how the PPP will be implemented, including institutional roles, schedules and financing
4	Baseline Context for the PPP	▪ Takes a broad view of environment, encompassing relevant biophysical, social, economic, cultural and policy dimensions ▪ Is concise and focused on characterizing only the attributes of the environment of clear relevance to the proposed PPP ▪ Illuminates trends over time wherever suitable ▪ Avoids providing excessive detail and data ▪ Provides up-to-date information, and acknowledges as appropriate if only older information is available ▪ Makes judicious use of maps, figures and data tables ▪ Is properly, though not excessively, referenced
5	Anticipated Impacts and Prescribed Mitigation	▪ Clearly identifies impacts and assesses the significance of each ▪ Presents evidence and rationale for determinations of significance ▪ Explains impact pathways for direct and indirect impacts in language accessible to the educated lay reader ▪ Thoroughly considers potential for broadly-scaled cumulative impacts ▪ Identifies and briefly describes at least one mitigation measure for each negative impact deemed significant ▪ Formulates mitigation as required actions rather than less enforceable recommendations, wherever possible ▪ Acknowledges limits of information when appropriate, and indicates what additional new information will be needed to properly inform decision-making regarding the subject PPP's acceptability
6	Analysis of Alternatives	▪ Clearly identifies and delineates plausible alternatives to the PPP for addressing the target policy problem, including the alternative of taking no action ▪ Takes into account the impacts that would be avoided or foregone due to the PPP's implementation ▪ Compares alternatives in relation to the same set of impact areas as the proposed PPP, while acknowledging other impacts specific to other alternatives

	SEA Report Section	Quality Criteria
7	Strategic Environmental and Social Management Plan	▪ Includes all mitigation proposals identified in the impact analysis, providing comprehensive coverage ▪ Prescribes mitigation measures in precise, unambiguous terms, indicating what must be done and who will do it ▪ Where needs for further study are indicated, provides clear direction for the scope and analytical aims of necessary studies ▪ Includes a monitoring plan encompassing both compliance monitoring and effects monitoring ▪ Identifies effects monitoring indicators that are practical and economical to measure (and ideally already measured for other purposes), enable clear attribution, and are within the technical and institutional means of the assigned measuring entities ▪ Defines a practical, cost-efficient and accountable institutional mechanism for ensuring thorough implementation of mitigation, monitoring and stakeholder communication ▪ Identifies capacity gaps that will foreseeably limit effective SESMP implementation, and defines feasible capacity-building measures to address them ▪ Provides a credible (if preliminary) estimate of incremental costs associated with implementation of mitigation and monitoring prescribed in the SESMP, and with the operation of the chosen institutional mechanism for SESMP implementation
8	Conclusions and Recommendations	▪ Succinctly sums up findings and prescribed actions in relation to key impact areas or themes ▪ Specifies key conclusions for each key impact area or theme, and notes any assumptions and data limitations that condition the solidity of the conclusions ▪ Includes recommendations regarding the interpretation and application of the report in decision-making
	Appendices	▪ Includes only items referred to in the document ▪ Includes only items that a significant proportion of the SEA Report's audience can reasonably be expected to want to read in order to strengthen their understanding, or confirm the validity, of assertions made in the main document

Source: Consultant

ADB TA-6916 BAN: Master Plan for National Highways Connectivity

Bhutan Highways Master Plan to 2040

Strategic Environmental Assessment Scoping Report

Version: Draft 26 May 2024

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

ABBREVIATIONS

ADB	Asian Development Bank
CMIP5	Coupled Model Intercomparison Project Phase 5
CMIP6	Coupled Model Intercomparison Project Phase 6
CNDP	Comprehensive National Development Plan 2030
DoST	Department of Surface Transport
EIA	Environmental Impact Assessment
GNHI	Gross National Happiness Index
HMP	Bhutan National Highways Connectivity Master Plan to 2040
DoCDD	Department of Culture and Dzongkha Development
DoFPS	Department of Forests and Park Services
HCV	Area or Site of High Conservation Value
MDPR	Minimum Daily Package Rate
MMPI	Moderate Multidimensional Poverty Index
MoIT	Ministry of Infrastructure and Transport
NTFP	Non-Timber Forest Product
PPP	Policy, Plan or Program
RGoB	Royal Government of Bhutan
SEA	Strategic Environmental Assessment
SESMP	Strategic Environmental and Social Management Plan
TA	ADB Technical Assistance

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1 INTRODUCTION

1. This report details the process and findings of an exercise carried out to define the substantive scope of the Strategic Environmental Assessment (SEA) for the Bhutan National Highways Connectivity Master Plan to 2040 (hereafter 'Highways Master Plan' or 'HMP'). The formulation of the Highways Master Plan and the preparation of a corresponding SEA are components of ADB TA-6916 BHU: Bhutan National Highways Connectivity Master Plan, being implemented in 2023–2024. The firm David Lupton and Associates, Ltd. (New Zealand), in association with APECS Consultancy (Bhutan) and Maxwell Stamp (Bangladesh), has been engaged to provide consulting services under the TA. The HMP and SEA are being developed concurrently, under the supervision of the Department of Surface Transport (DoST).

2. The scoping report begins by outlining the purpose, higher-order objectives and content of the HMP, as well as the process, data sources, and analytical techniques with which it is being developed. This is followed by an overview of the baseline context for the HMP, including the present state of the national highways network, as well as relevant biophysical, socioeconomic, cultural, and policy conditions and factors that may help to shape the HMP's formulation. Subsequently, the purpose and process of SEA are explained, including the linkages between the master planning process and the SEA study. Finally, the SEA scoping process is described and conclusions regarding the SEA study's scope are presented.

2 BHUTAN NATIONAL HIGHWAYS CONNECTIVITY MASTER PLAN TO 2040

2.1 Strategic Vision and Mission

3. A long-term vision for the road sector in Bhutan has been expressed through the Comprehensive National Development Plan for Bhutan 2030 (CNDP); the Road Sector Master Plan 2007–2027; the Road Act of Bhutan 2013; the Bhutan Transport 2040 Integrated Strategic Vision; the Road Classification and Network Information 2020; the Twelfth Five-Year Plan 2018–2023; and the forthcoming Thirteenth Five-Year Plan 2024–2029.[1] The CNDP emphasizes the importance of addressing rural–urban migration and seeking a more even balancing of development across regions, with targeted maximum travel times for the north–south corridors of 8 hours, and 16 hours for east–west corridors. The Twelfth Five-Year Plan aimed to (1) improve the national road network through consolidation and enhancement of the national highway grid and building new roads to fill significant missing links, such as those that would complete a second east–west highway in the southern part of the country; (2) improve national highways using environmentally friendly road construction and climate-ready technology; and (3) reduce travel time by means of bypass roads and tunnels. The Thirteenth Five-Year Plan, though not yet issued at the time of writing, is expected to largely carry forth these objectives.

4. The mission of the HMP is to identify feasible highway network improvements that support the aims articulated in the long-term vision for the road sector, and to provide a sound basis for prioritizing and planning investments to deliver on the strategic vision.

[1] (1) RGoB (Ministry of Works and Human Settlements). 2019. The Project for Formulation of Comprehensive Development Plan for Bhutan 2030. Thimphu.; (2) RGoB (Ministry of Works and Human Settlements). 2006. Road Sector Master Plan (2007–2027). Thimphu; (3) RGoB. 2013. The Road Act of Bhutan 2013. Thimphu; (4) ADB. 2013. Bhutan Transport 2040 Integrated Strategic Vision. Manila; (5) RGoB (Ministry of Works and Human Settlements). 2020. Road Classification and Network Information of Bhutan. Thimphu.; (6) RGoB. Twelfth Five-Year Plan (2018–2023). Thimphu.

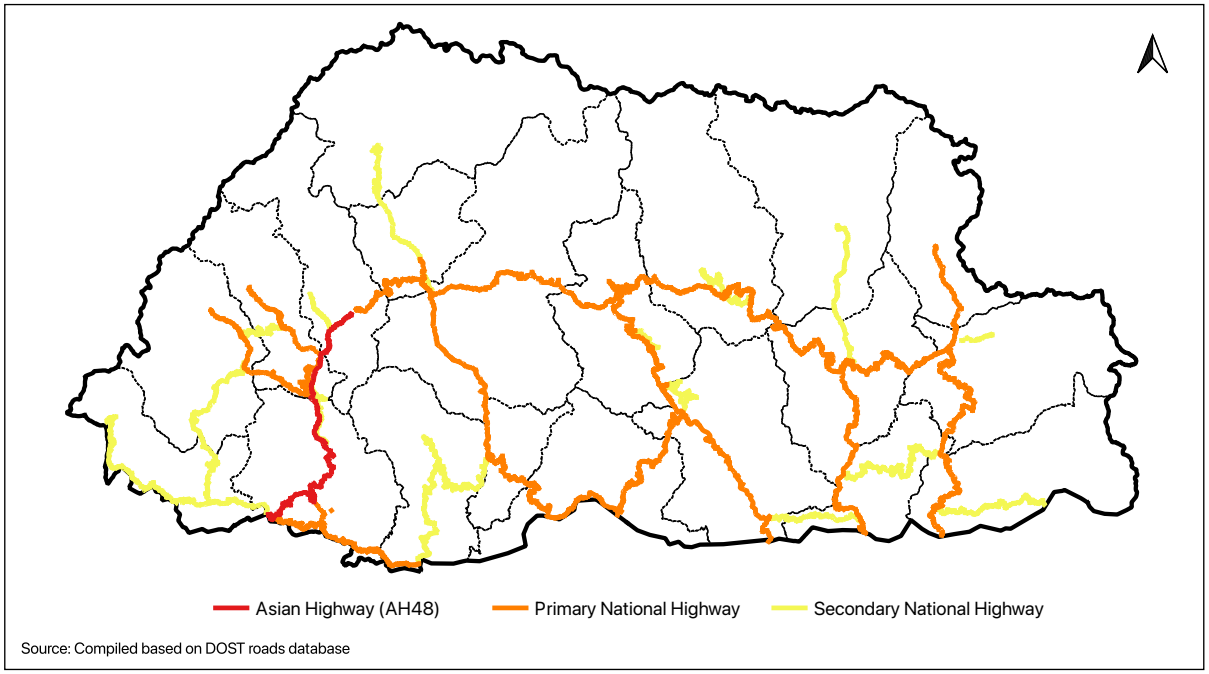


Figure 1: National Highways Network (2020)

2.2 Content of HMP

5. The HMP will identify necessary capital projects to configure the national highways network for optimal efficiency and utility by 2040, maximizing mobility benefits for the country's people and economy to the extent possible within financial and human resource limits. Capital works proposed under the HMP may include new highway segments to fill gaps in the present network, rehabilitation and upgrading, major slope stabilization works, bridge replacements, safety improvements, bypasses, viaducts and tunnels. The HMP will be supported by a companion 2040 Investment Plan to optimize the phasing and financing of proposed projects.

6. The HMP will be closely aligned with a separate 2040 Maintenance Plan. The Maintenance Plan will concern the major maintenance procedures and projects proposed to optimize the functionality and safety of the national highways network, including measures needed to adapt highway infrastructure to climate change. The Maintenance Plan will focus on preventive maintenance rather than major repair and reconstruction works (which will be within the remit of the HMP), and may include overlays, edge repair, pothole repair, correction of drainage problems, installation of minor slope protection works, maintenance of all slope protection works, and upkeep of drainage structures. The Maintenance Plan will take account of the maintenance needs of the future national highways network as proposed in the HMP.

2.3 Highways Master Plan Formulation Process

7. The HMP will be developed based on analysis of

(1) Spatial and condition information gathered on the existing national and secondary highways;

(2) Present road network use, drawing on both traditional traffic count data and anonymized cellular telephone movement data supplied by Bhutan Telecom;

(3) Socioeconomic conditions and trends shaping future travel demand, including demographic change, livelihoods and spatial and sector development plans;

(4) Long-term prospects for the development of non-road modes of transport, including rail, air, ropeways and rivers;

(5) Geophysical, ecological and physical cultural heritage constraints;

(6) Governmental investment priorities articulated in Five-Year Plans, prior roads-sector plans, and the current government's policy statements;

(7) Estimated construction and maintenance costs; and

(8) Governmental budgetary and human resource constraints.

8. Results of assessment in the areas listed above will be used as inputs in a comprehensive network modeling analysis, which will generate and evaluate the feasibility of various investment scenarios for the national highways network. Alternative investment scenarios will be evaluated for their efficacy in supporting the strategic vision and mission for the roads sector; their cost and cost-effectiveness; their feasibility in view of the institutional capacity of DoST and foreseeable financing options; and their alignment with Bhutan's climate change mitigation and adaptation commitments under the Paris Agreement.

3 BASELINE CONTEXT OF THE HIGHWAYS MASTER PLAN

3.1 Existing Road Network of Bhutan

9. Bhutan currently has about 18,000 km of roads, of which about 26% are sealed. The country's roads are assigned to seven road classes: Asian Highway, Primary National Highway, Secondary National Highway, Dzongkhag Road, Urban Road, Farm Road and Access Road. Farm roads are the most prolific, accounting for approximately 60% of total road length. National highways (including the Asian Highway) comprise 2,841 km. A summary of roads by class is shown in Table 1, and a map of the road network appears in Figure 2.

Table 1: Summary of Road Network of Bhutan

Classification	Total Length (km)	Sealed Length (km)	Jurisdiction
Asian Highway (AH)	149	149	DANTAK
Primary National Highway (PNH)	1,531	1,531	DoST, DANTAK
Secondary National Highway (SNH)	1,161	943	DoST, DANTAK
Dzongkhag Road (DR)	2,073	1,165	Dzongkhags
Urban Road (UR)	417	403	Thromdes
Farm Road (FR)	11,257	151	Dzongkhags
Access Road (AR)	1,677	456	Mixed
Total	**18,265**	**4,798**	

Source: DOST, TA Consultant

10. **Jurisdiction.** Responsibility for roads in Bhutan rests with various entities. The Asian Highway within Bhutan is maintained and operated by Project DANTAK, an entity of the Indian Ministry of Defense, while the primary and secondary national highways are variously maintained and operated by the DoST and DANTAK. Dzongkhag roads and farm roads are the responsibility of the individual dzongkhags within which they lie, and urban roads are under the jurisdiction of the relevant thromdes. Access roads mostly provide links between the broader road network and sites including hydroelectric installations, hospitals, schools and forest management areas, and are built, maintained and operated by their owners.

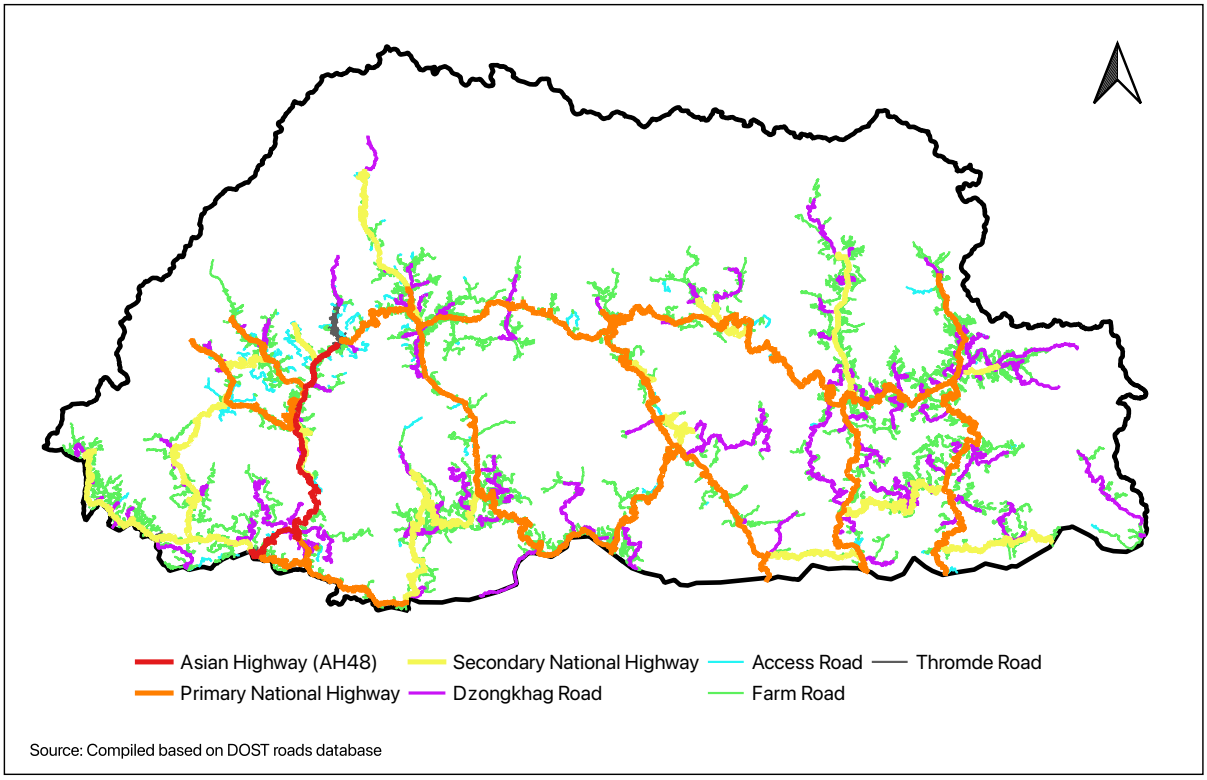


Figure 2: Road Network of Bhutan (2020)

11. **Design standards.** Minimum design standards for the four non-urban road classes are shown in Table 2. Only primary national highways are required to have at least two full lanes, although some secondary national highways also meet this requirement. The standards for primary national highways are applicable to the Asian Highway, although AH48 exceeds the standard in some locations. The design standards for access roads are the same as for farm roads, but many are built to a higher standard to serve their intended uses.

Table 2: Selected Design Standards for Roads in Bhutan

	Primary National Highways				Secondary National Highways				Dzongkhag Roads				Farm Roads			
Terrain classification[1]	L	R	M	S	L	R	M	S	L	R	M	S	L	R	M	S
Design speed (km/h)	60	50	40	30	50	40	30	20	40	30	20	15	30	25	15	10
Traffic volume (cvpd)[2]	>200				100-200				30–100				<30			
RoW (m)	30				30				18.3				12.2			
Carriageway width (m)	5.5–7.5				3.75–5.5				3.5				3.5			
Max vertical gradient	8º				8º				10º				10º			

[1] L = Level (0–10º); R = Rolling (10–25º); M = Mountainous (25–60º); Steep (>60º)
[2] Commercial vehicles per day

Source: Ministry of Works and Human Settlement. 2020. Road Classification and Network Information of Bhutan.

12. **Road condition.** The condition of Bhutan's roads varies widely. The Asian Highway and all primary national highways are sealed, but suffer from a high prevalence of slope failures and drainage-related subgrade and pavement damage. Tortuous alignments are the norm due to challenging topography, and this substantially constrains average vehicle speeds regardless of road condition. Fortunately, traffic volume is relatively light on most of Bhutan's roads, even the Asian Highway and primary national highways.

13. The secondary national highways are for the most part narrower and in worse condition than the primary national highways, although most are sealed. The country's dzongkhag roads are intermediate rural roads constructed to serve the seats and other large settlements of the sub-districts (gewogs) within each district (dzongkhag), linking the main dzongkhag towns to each other and to the highways network. Many of these roads are under-engineered and in poor condition; about half are sealed. Farm roads are mostly single-lane rural roads constructed to provide 'last-mile' access to isolated rural communities, and serve as feeders for dzongkhag roads and highways. These roads have typically been constructed without the benefit of significant engineering oversight. Less than 2% of the farm roads are sealed.

14. **Connectivity.** The map in Figure 2 illustrates that Bhutan's road network is quite low-density outside of the main highway corridors, with many substantial roadless gaps, and only one continuous primary national highway link in an east-west direction. Virtually no roads in Bhutan go straight from one point to another, instead following winding paths along complex topographical contours and through extensive switchback configurations. The practical implications are that it takes a long time to travel fairly modest distances, significant portions of the country have very limited road access, and there is little redundancy of highway corridors that could allow people and freight to go a different way when there is a road closure. For many long- and medium-distance trips between the east and west parts of the country, it is faster to cross into India to make use of the higher-speed highways there than it is to travel between the same two points exclusively on the Bhutanese road network.

15. **Road safety.** The low speed of traffic on Bhutan's mountain roads means that high-speed crashes are uncommon, but motorists and pedestrians face a host of safety risks. Prevalence of sharp curves and lack of passing lanes translates to frequent blind passing and other risky driver behaviors. Due to a lack of sidewalks and the widespread practice of free-range grazing, potential for surprise encounters with pedestrians and livestock at blind corners is substantial. These risks are multiplied in high mountain areas where thick fog is frequent. On some roads, the presence of large wildlife such as elephants and gaurs on the roadway can lead to dangerous confrontations. Guardrails are generally missing in many places where they are needed, and often of poor design where present. Pavement markings, reflective road-edge and centerline markers, and signage are rarely sufficient, and lacking in many locations. Vehicles that leave the road often have a long way to fall, almost invariably leading to serious injuries and deaths. Minor rockfalls onto the road are frequent in many locations, and slope failures ranging in scale from localized slips to catastrophic road-destroying slides and debris flows create hazards for drivers during the monsoon.

3.2 Vehicle Fleet

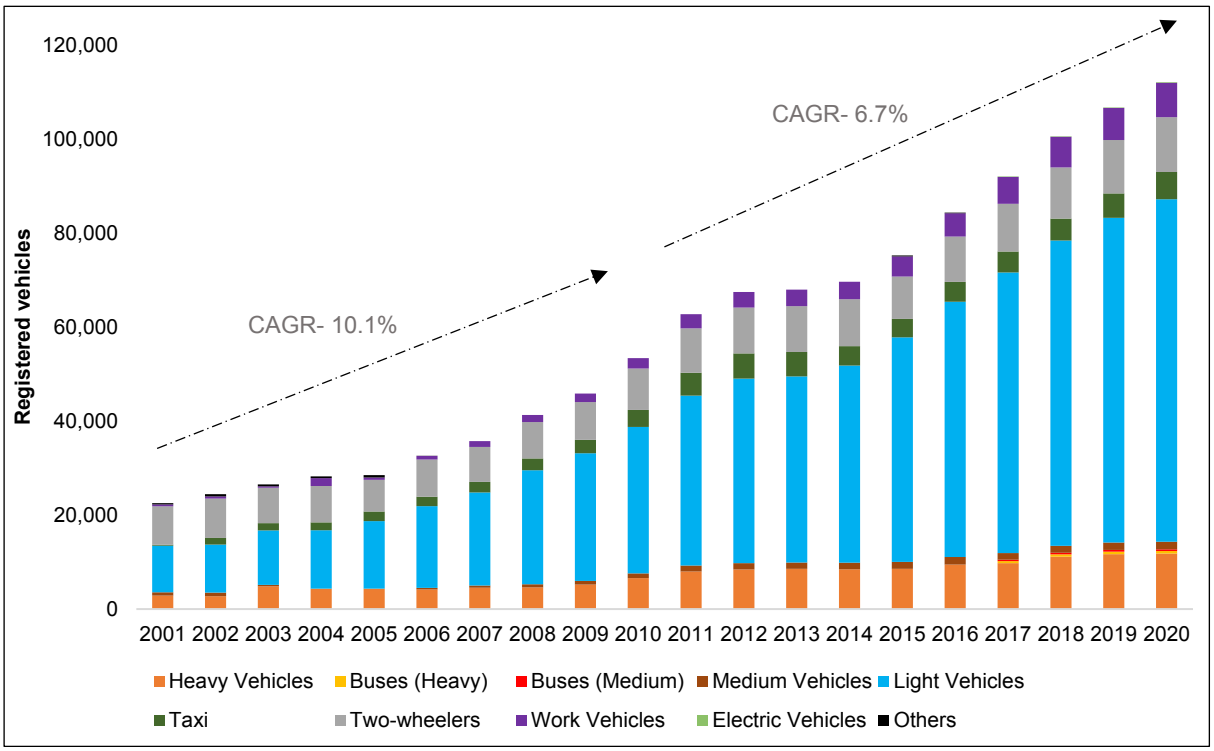
16. The number of motor vehicles registered for use on Bhutanese roads has undergone rapid growth over the last two decades, with most of the growth accounted for by light vehicles (see Figure 3). The ratio of vehicles to population in Bhutan was 150 vehicles per thousand people in 2021, which is below the global by-country mean of 315 (median 220), but well above the mean (105) and median (87) for the SAARC countries.[2] The transport sector accounted for 11.14% of the country's greenhouse gas emissions in 2015, and the total emissions from the sector are projected to double by 2050 under a business-as-usual scenario; this sharp growth would be led by 3.8-fold growth in emissions from light vehicles, a 3.6-fold increase from medium trucks, and a 3-fold increase from heavy trucks.[3]

17. Vehicle ownership in Bhutan has a strong regional skew, with 86% of vehicles registered to owners in the eight western dzongkhags. Approximately 45% of the vehicle fleet, across all

[2] World Population Review. 2024. Cars by Country 2024. https://worldpopulationreview.com/country-rankings/cars-by-country.

[3] Department of Environment and Climate Change. 2023. Bhutan's Long-Term Low Greenhouse Gas Emissions and Climate Resilient Development Strategy.

classes, is powered by diesel engines. Electric vehicle ownership is growing at a rapid annual rate (12.3%/yr from 2017–2020), but beginning from a very low baseline; as of 2021, electric vehicles accounted for just 0.1% of the total fleet.[4]



Source: Ministry of Information and Communications. 2021. Low Emission Development Strategy for Surface Transport 2021.

Figure 3: Growth in Vehicle Ownership 2001–2020

3.3 Non-Road Transport

18. Bhutan has one international/domestic airport in Paro, with flights to and from airports in India, Nepal, Bangladesh, Thailand and Singapore. There are domestic airports at Bumthang, Gelephu and Yongphula. The RGoB has taken preliminary steps towards expansion of the Gelephu airport, to enable it to serve long-haul air traffic. Development of airports is severely constrained by topography in almost all locations in Bhutan.

19. There are currently no railways in Bhutan, although proposals have been floated for various spur lines to connect industrial zones in the southern part of the country to the Indian rail network. Development of rail transport outside of the southern foothills area would require ambitious engineering due to steep topography and slope stability risks.

20. River transport in Bhutan is limited to local small craft capable of navigating swift currents and shallow channels. As almost all river segments in Bhutan are high-gradient, turbulent and given to strong seasonal fluctuations in flow, there is negligible potential for development of this mode. Ropeways are used as a temporary mode of transport for materials in some difficult-to-access locations in Bhutan, such as construction sites. Some interest has been expressed in exploring the potential for wider application of this mode.

[4] Ministry of Information and Communications. 2021. Low Emission Development Strategy for Surface Transport 2021.

3.4 Biophysical Environment

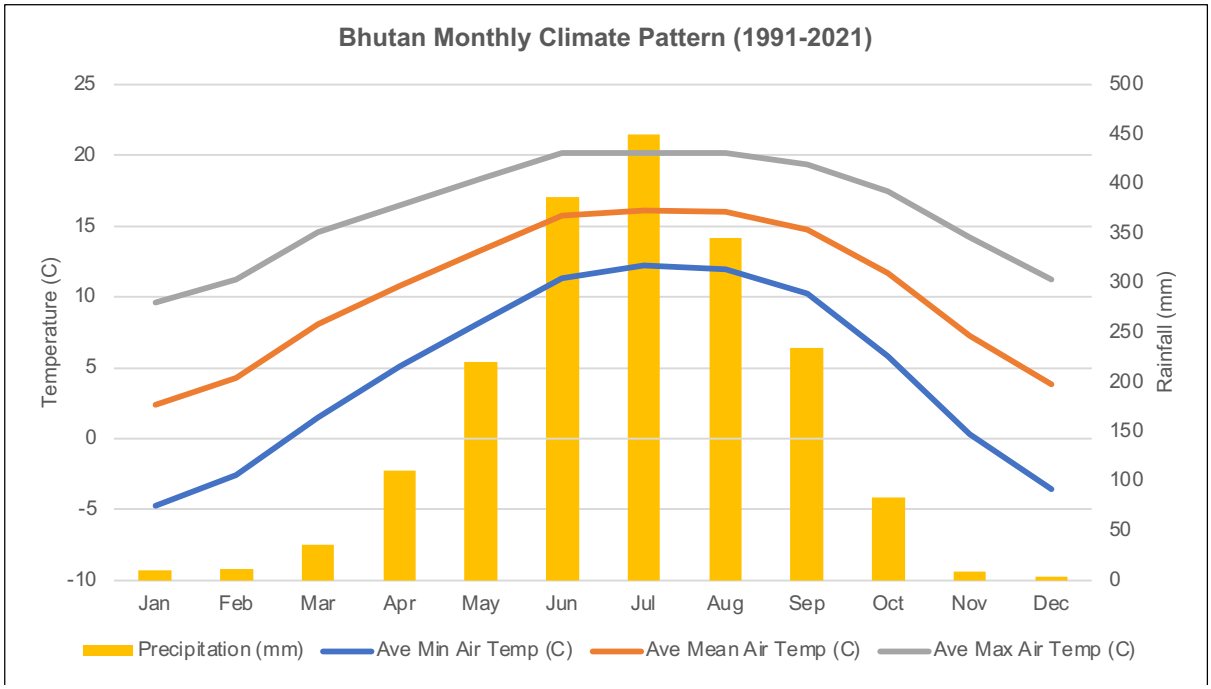
3.4.1 Geophysical Conditions

21. Bhutan is a difficult country in which to build and maintain roads. Nearly all of the national territory consists of steeply sloped mountainous terrain, and the underlying geology in many areas is characterized by inherently unstable uplifted soft sedimentary and sedimentary-metamorphic rock, especially in the southern half of the country. Landslides and debris flows are common even in areas undisturbed by human activity, and much more so where cross-slope cuts are made to permit road construction. With the exception of a few minor wetland areas, small alpine lakes, and those river segments that lie within a few kilometers of the southern border, most watercourses in the country run in steeply sided V-shaped valleys and gorges, leaving few feasible opportunities to place roads in river valleys.

22. Like all of the Himalayan Range, Bhutan is seismically active, and the historical and inferred records indicate occurrence of earthquakes up to Magnitude 7. Occasional earthquakes and more frequent lesser temblors contribute to the instability of steep slopes, and add to the challenge of maintaining road infrastructure.

3.4.2 Climate and Climate Change

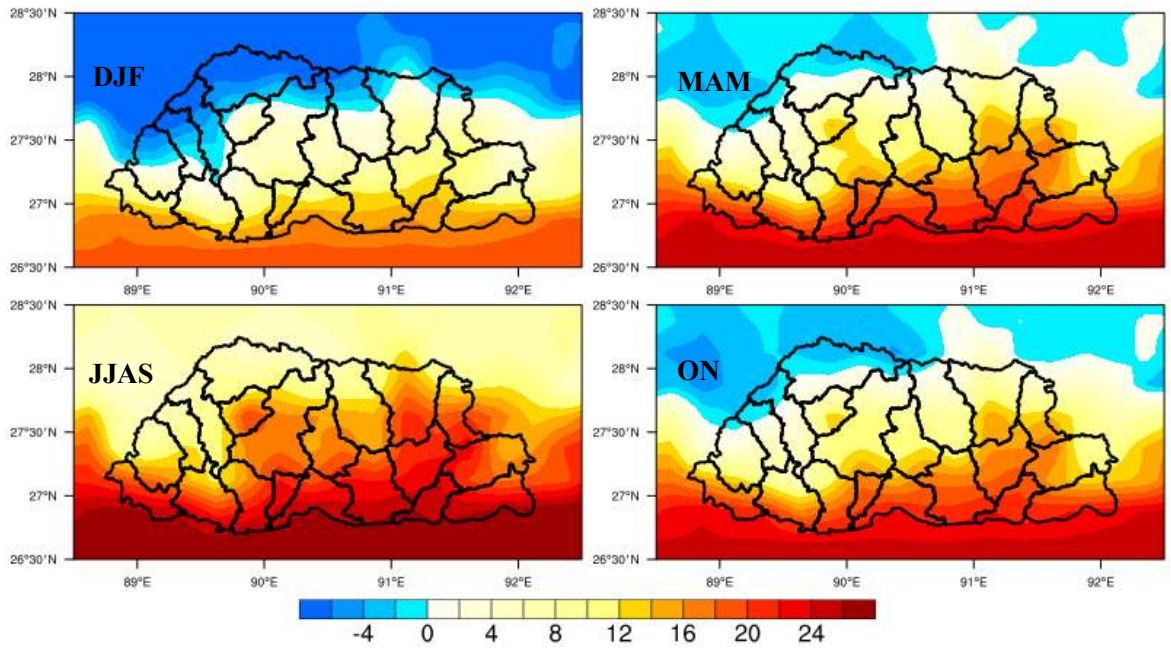
23. **Climate.** Bhutan sits at the convergence of the cold, dry Tibetan Plateau and the warm monsoonal Ganges-Brahmaputra Delta, and its climate shows characteristics and influences from both of these zones. The northern third of the country (the Higher Himalayan belt or zone) sits mostly above 3,000 masl, and is influenced by cold air descending off the adjacent Tibetan Plateau, particularly in the winter months of December to February. By contrast, Bhutan's narrow Southern Foothills belt, which lies mostly between about 100 and 1,500 masl and is less than 600 km from the Bay of Bengal, is warm during much of the year and clothed in tropical forest fed by monsoon rains that fall from June to September. An intermediate band of mid-elevation lands stretching nearly the full width of the country's midsection (the Inner Himalayan zone) experiences a generally mild climate that is a mix of temperate and subtropical climatic conditions. The country's complex topography allows these climatic zones to be stated only in general terms.



Source: World Bank Climate Change Knowledge Portal

Figure 4: Climatological Averages for Bhutan, 1991–2021

24. ***Temperature regime.*** Surface air temperature in Bhutan is strongly influenced by elevation, as well as the seasonal strengths of the southwest monsoon in the middle part of the calendar year and the Siberian winter high. Mean annual temperature (1991–2021) for the whole country is 9.3ºC, but average daily temperature ranges widely. Mean daily temperatures in summer reach as high as 25–26ºC in the far southern border zone, but remain below 10ºC along the northern border (see Figure 5). In winter, daily average temperatures are in the range of 12–14ºC in the far south, and dip below 6ºC in the far north.

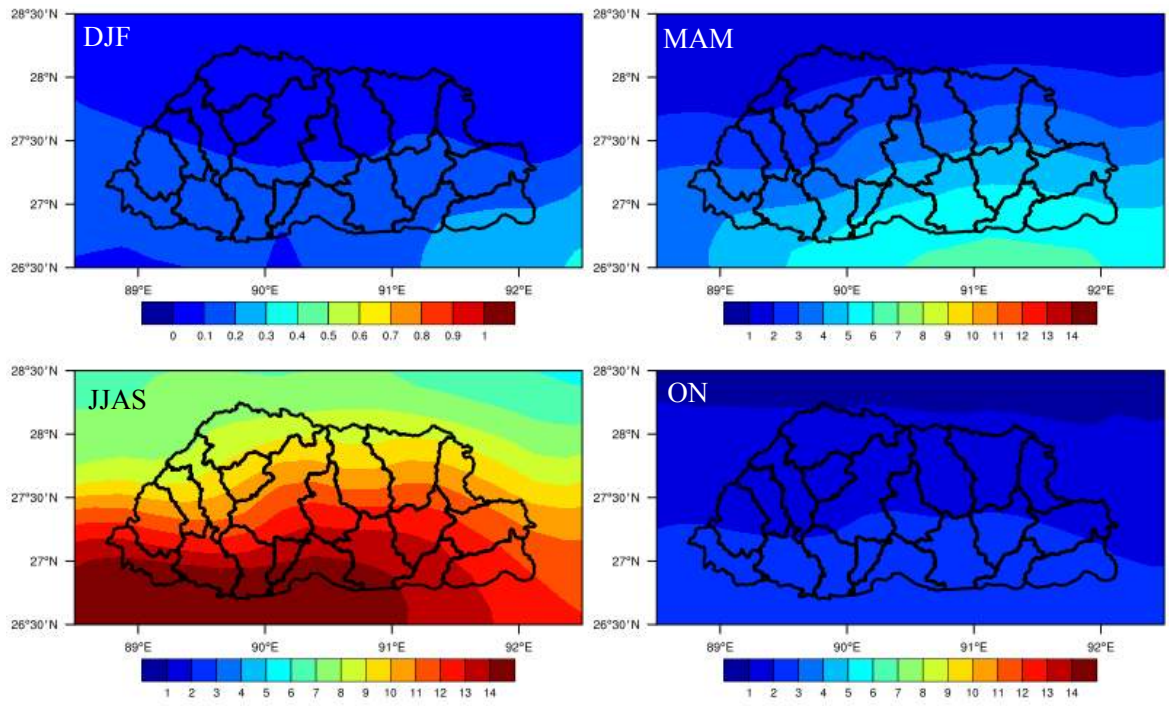


Source: National Center for Hydrology and Meteorology. 2019. Report on the Analysis of Historical Climate and Climate Change Projection for Bhutan.

Figure 5: Spatial Distribution of Mean Temperature (ºC) by Season (1975–2005)

25. ***Rainfall regime.*** Bhutan's rainfall patterns are driven by the southwest monsoon, which sends warm, moist air from the Indian Ocean sweeping across the Indian subcontinent. The southwestern part of the country is most heavily affected by the monsoon rains, but the monsoon is the wettest part of the year for all areas (see Figure 6). About 74% of the year's precipitation falls from May to August, while 92% arrives between April and September.

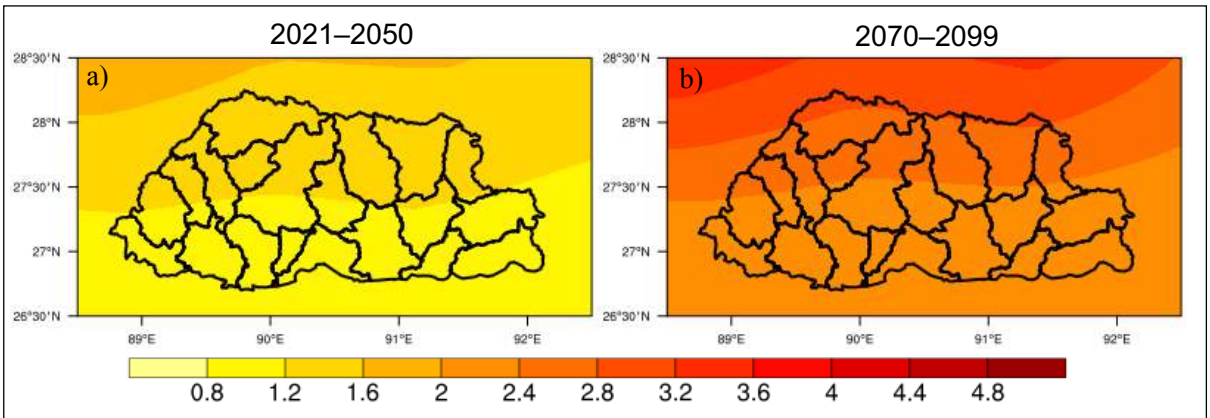
26. **Climate change.** Projection information presented in RGoB documents including the Third National Communication to the UNFCCC (2020) and the National Adaptation Plan for the Kingdom of Bhutan (2023) are based on the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset derived from five selected global climate models run under the Coupled Model Intercomparison Project Phase 5 (CMIP5), using the historical temperature and rainfall dataset compiled by the Climatic Research Unit (CRU), University of East Anglia to provide the historical baseline for comparison. The conclusions of the RGoB studies are summarized below, and supplemented with the TA Consultant's analysis of more recent projection (2015–2100) and historical baseline (1950–2014) data (0.25-degree multi-model ensemble median) generated under the Coupled Model Intercomparison Project Phase 6 (CMIP6). CMIP6 data are downscaled to the dzongkhag level. All projections are for the 'middle of the road' SSP2-4.5 radiative forcing scenario (denoted as RCP4.5 in the CMIP5 analysis).



Source: National Center for Hydrology and Meteorology. 2019. Report on the Analysis of Historical Climate and Climate Change Projection for Bhutan.

Figure 6: Spatial Distribution of Mean Annual Rainfall by Season (1975-2005)

27. ***Temperature.*** The CMIP5-based analysis projects that mean annual temperature will increase by about 2.0ºC – 3.0ºC by 2100, relative to the 1975–2005 baseline, with the largest increases to be experienced in the highest-elevation areas (see Figure 7). Temperature increases are expected to be somewhat more pronounced in the winter months than the summer months for all three of the broad altitudinally-defined climate zones (Higher Himalayas, Inner Himalayas, Southern Foothills).



Source: Adapted from National Center for Hydrology and Meteorology. 2019. Analysis of Historical Climate and Climate Projection for Bhutan.

Figure 7: Projected Change in Mean Annual Temperature (ºC) Relative to 1975-2005 Baseline (NEX-GDDP CMIP5, RCP4.5)

28. Data from the more recent CMIP6 model run indicate an overall rise in mean annual temperature of 2.7ºC for the country as a whole by 2100, and a very substantial increase in the occurrence of warm spells, with about 40% of days in the average year forming part of a warm spell towards the end of the century (see Table 3). The pattern of temperature increases being more dramatic in the high-elevation north of the country (as seen in Figure 7) is

confirmed by the CIMP6 data; the eight northern dzongkhags are collectively projected to see an increase of 2.8ºC (73.8% above baseline) by 2100, and the 12 southern dzongkhags an increase of 2.6ºC (19.3% above baseline).

Table 3: Temperature Projections to 2100, Bhutan

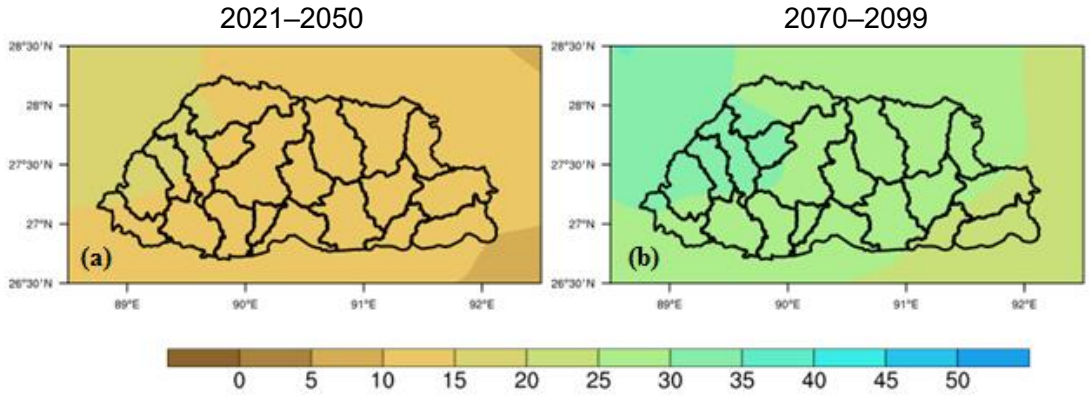
Temperature measure	Baseline 1950–2014[1]	2100 (SSP2-4.5)[1]	Change 2015– 2100
Mean annual temperature (ºC)	9.3	12.0	+2.7ºC
Mean annual maximum temperature (ºC)	13.7	16.3	+2.6ºC
Mean annual minimum temperature (ºC)	5.0	7.7	+2.7ºC
Warm spell duration index (WSDI)[1]	4.3	149.3	+145

[1]Baseline and projection data represent the CMIP6 0.25-degree multi-model ensemble median.
[2]The WSDI value represents the number of days in a sequence of at least six consecutive days during which the value of the daily maximum temperature is greater than the 90th percentile of daily maximum temperature calculated for a five-day window centered on each calendar day, using all data for the given calendar day-pentad.

Source: Compiled based on CMIP6 data available on the World Bank Climate Change Knowledge Portal

29. The projected temperature trends suggest reduced snow cover during winter at higher elevations, accelerating melting of glaciers and permafrost, extension of the growing season in some locations, heightened risk of forest fires in some locations, and increased vulnerability of forests and crops to cold-limited pests. The projected acceleration of glacial melting will increase the risk of glacial lake outburst floods (GLOFs), which may threaten life, property and infrastructure downstream in the major river catchments that have significant glaciers.

30. ***Rainfall.*** Per the RGoB's CMIP5-based analysis, rainfall increases are expected for all three of the Higher Himalayas, Inner Himalayas, and Southern Foothills zones. Increases are projected to accrue primarily in the monsoon and monsoon shoulder seasons. The highest percentage increases in rainfall are expected in the northwest (30-35% by 2100), and lowest (20–25%) in the southeast parts of the country (see Figure 8).



Source: Adapted from National Center for Hydrology and Meteorology. 2019. Analysis of Historical Climate and Climate Projection for Bhutan.

Figure 8: Projected Change in Mean Annual Rainfall (%) Relative to 1975–2005 Baseline (NEX-GDDP, CMIP5, RCP4.5)

31. Data from the more recent CMIP6 model run generally confirm the spatial distribution of the increase (i.e., strongest in the northwest, weakest in the southeast), but indicate significantly lower magnitude of change, with projected increase in mean annual rainfall averaging 9.8% across the five northwestern dzongkhags, and 9.0% across the three dzongkhags in the southeastern corner of the country. The intensity of rainfall is projected to strengthen to a greater degree than mean annual rainfall, which is consistent with the expectation that the additional increment of rain will accrue during the monsoon (see Table 4).

Table 4: Rainfall Projections to 2100, Bhutan

Rainfall measure	Baseline 1950–2014	2100 (SSP2-4.5)	% Change 2015–2100
Mean annual rainfall (mm)	3255.4	3556.0	+9.2
Average days with > 50 mm rain (days/yr)	6.3	9.0	+42.9
Average maximum 1-day rainfall (mm)	82.7	101.6	+22.9
Average maximum 5-day rainfall (mm)	241.1	294.8	+22.3
Note: Baseline and projection data represent the CMIP6 0.25-degree multi-model ensemble median			

Source: Compiled based on CMIP6 data available on the World Bank Climate Change Knowledge Portal

32. The rainfall trends suggested by the CMIP5-based and CMIP6-based analyses presented above are generally indicative of elevated risk of severe flooding events and increased incidence of landslides and debris flows due to increased slope saturation. Annual river discharges are expected to rise across all major basins as a result of the combination of increased glacial melting and heavier monsoon rainfall, and the timing and dynamism of discharges can also be expected to change compared to historical patterns. Bridges and river-proximate road segments may become more vulnerable to flood and scour risks as a result of evolving discharge patterns.

3.4.3 Water Resources

33. Bhutan has abundant surface water resources, due to high annual rainfall and the storage of large volumes of ice in glaciers distributed across the northern fringe of the country. The vast majority of the country's rivers and streams have exceptionally good water quality, thanks to extensive forest cover in watersheds and the relative paucity of large human settlements and polluting industries. Virtually all of Bhutan's rivers are high-energy, steep-gradient watercourses, and this translates to substantial hydropower potential. In addition to rivers and streams, Bhutan has many tarns and glacial lakes at high altitudes, and a modest number of wetland areas.

34. Although surface water resources are plentiful in aggregate, water availability is a significant concern outside the monsoon season in some locations where settlements and cropland are perched on tablelands and mountainsides high above the nearest river, making water delivery for domestic and agricultural use expensive and technically difficult. Although water storage has not been widely practiced, this is increasingly being explored for communities reliant solely on rainfall, ephemeral springs and intermittent streams and rivulets. Groundwater is infrequently exploited in Bhutan, except at natural springs. Little research has been undertaken on the distribution or dynamics of groundwater flows in Bhutan.[5]

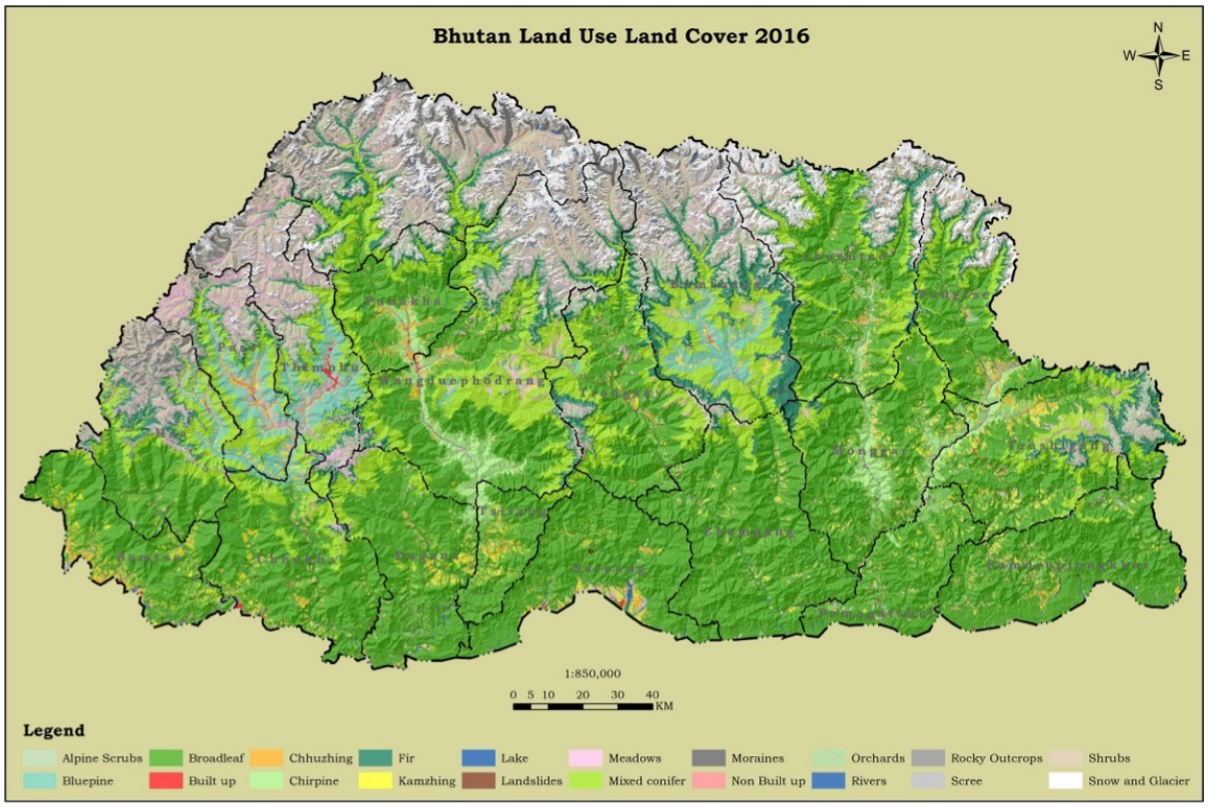
3.4.4 Land Cover and Land Use

35. Bhutan's constitution mandates the permanent maintenance of at least 60% of the national territory in a forested state, and as of 2021, land cover was classified as forest across 71.5% of the country. Forest cover in Bhutan showed a modest but consistent yearly increase over the 2000–2021 period, climbing from 65.5% in 2000; this contrasts with the global forest cover percentage, which showed a steady year-over-year downtrend from 32.0% in 2020 to 31.2% in 2021.[6] Well over half (64.9%) of Bhutan's forest area in 2016 was classified as broadleaf forest; this cover class predominates in the lower-altitude southern portions of the country. Mixed conifer forests accounted for 19.1% of total forest cover in 2016, followed by other coniferous classes: fir (8.5%), blue pine (3.7%) and chir pine (3.7%). Lands vegetated

[5] National Environment Commission. 2016. National Integrated Water Resources Management Plan 2016
[6] World Bank. World Development Indicators database, updated to 9/19/2023.

primarily by shrubs and thus not classified as forest accounted for 9.7% of the country in 2016.[7] The distribution of forest types can be seen in Figure 9.

36. A sizable portion of the northern reaches of the country is characterized by either alpine scrubs and meadows or areas of bare rock, moraine, scree, snow and ice where vegetation is sparse or non-existent. Such areas account for about 16% of the country's total area.



Source: Department of Forests and Park Services (Forest Resources Management Division). 2017. Land Use and Land Cover of Bhutan 2016 – Maps and Statistics.

Figure 9: Land Cover and Land Use, 2016

37. Just 2.75% of the national territory was cultivated land in 2016, of which about two thirds (64.6%) was rainfed (*kamzhing*), with most of the rest (30.2%) being irrigated and bench-terraced land (*chhuzhing*). Orchards made up 5.2% of the cultivated area. Cultivated land is concentrated along prominent rivers and road corridors. Built-up areas are very limited in Bhutan, covering just 0.19% of the country in 2016; this class includes all human-made impervious surfaces, including urban areas, roads, airports and buildings.

3.4.5 Biodiversity and Conservation Areas

38. Bhutan is blessed with rich biodiversity, due to its altitudinal range, highly varied topography, and position at the intersection of the Indo-Malayan and Paleo-Arctic biogeographical realms.[8] Low historical human population, physical constraints on settlement and extractive land use, a high proportion of land under state ownership, and foresightful government policy have combined to preserve the country's natural heritage to an impressive degree. The richness and healthy condition of Bhutan's natural heritage is a key element of the country's image on the international stage, and its attractiveness to tourists.

[7] Department of Forests and Park Services (Forest Resources Management Division). 2017. Land Use and Land Cover of Bhutan 2016 – Maps and Statistics. Thimphu.

[8] Dinerstein, E. et al. 2017. An Ecoregion-Based Approach to Protecting Half the Terrestrial Realm, BioScience 67(6): 534–545. https://doi.org/10.1093/biosci/bix014.

39. **Threatened wild species.** Some 11,248 wild species have been documented in Bhutan, among them 134 species considered by the IUCN to be in danger of serious population decline and eventual extinction. Globally threatened species in Bhutan include 21 species classified as critically endangered (CR), 43 endangered species (EN), and 70 considered vulnerable (VU).[9] Targeted national conservation plans have been developed for several high-profile species, including the Asian elephant, Tiger, White-bellied heron, Black-necked crane, Asiatic black bear, Red panda, Golden mahseer and Hornbills (several species). It is likely that some areas in Bhutan would be classified as critical habitat for certain species under the International Finance Corporation's Performance Standard 6 evaluation methodology; this applies to habitats found both in and outside of the protected areas system.

40. **Conservation areas.** The RGoB has developed a system of protected areas and biological corridors that now covers just over half of the country (see Figure 10). The protected areas represent various management classes, including national park, wildlife sanctuary and strict nature reserve. The protected areas and corridors are zoned, and significant portions are designated as buffer, transition and multiple-use zones, in which rural people are permitted to live and use natural resources. Management of the protected area system is supported by a multilateral financing arrangement called Bhutan for Life, which has made substantial investments in building protective management capacity and developing internal financing models based on ecotourism, sustainable extraction and payment for environmental services, and is set to culminate in a self-supporting protected area system and professional conservation corps capable of ensuring consistent and permanent protection.

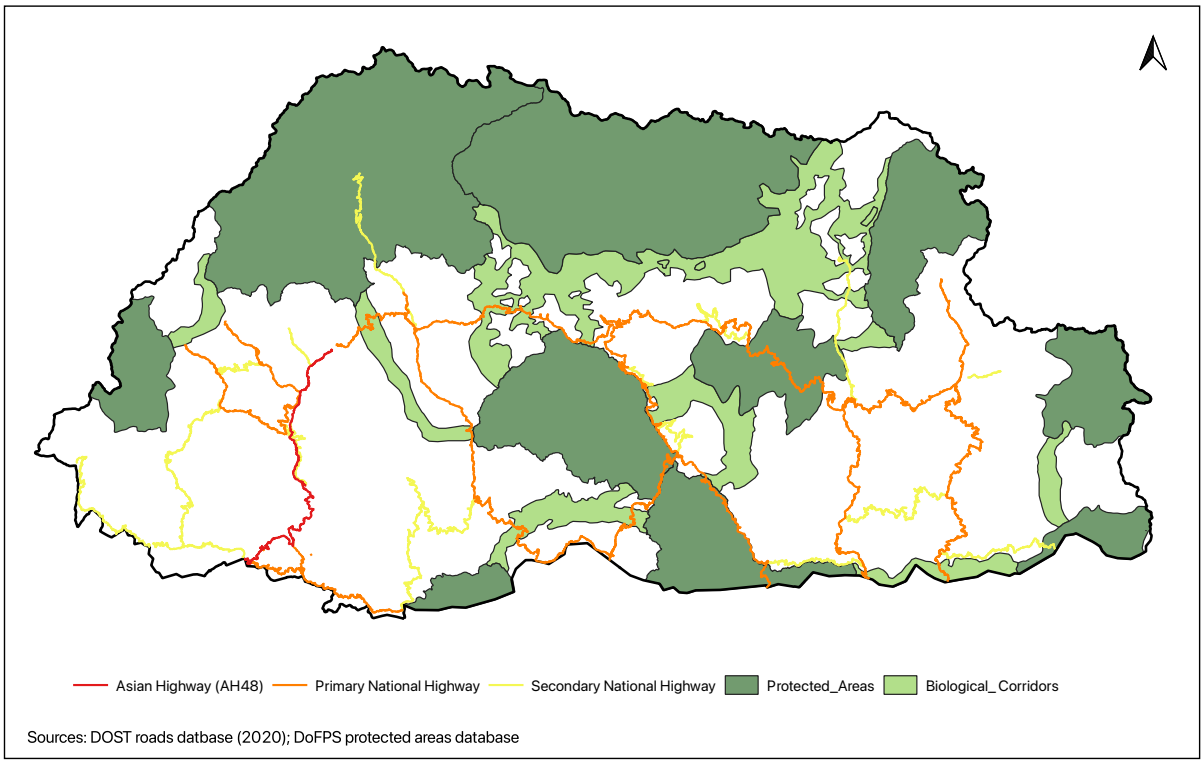


Figure 10: Bhutan's Protected Area System

41. In addition to statutory protected areas and corridors, a number of other areas have been internationally recognized as Key Biodiversity Areas and Ramsar Wetlands of International Importance, and these are targeted for special attention by Bhutan's conservation agencies. Several areas of high conservation value (HCVs) have also recently been identified

[9] Nepal, T.K. and Manita. 2021. An Updated Checklist of Globally Threatened Species in Bhutan as Listed in IUCN Red List of Threatened Species. Preprint, February 2021. DOI:10.20944/preprints202102.0124.v1.

outside of the protected area system, and these are similarly of interest for conservation management by the relevant agencies (see Figure 11). Some of these non-statutory conservation sites overlap in whole or in part with statutory protected areas and biological corridors shown in Figure 10. Numerous segments of the national highways network traverse or border statutory and non-statutory protected areas.

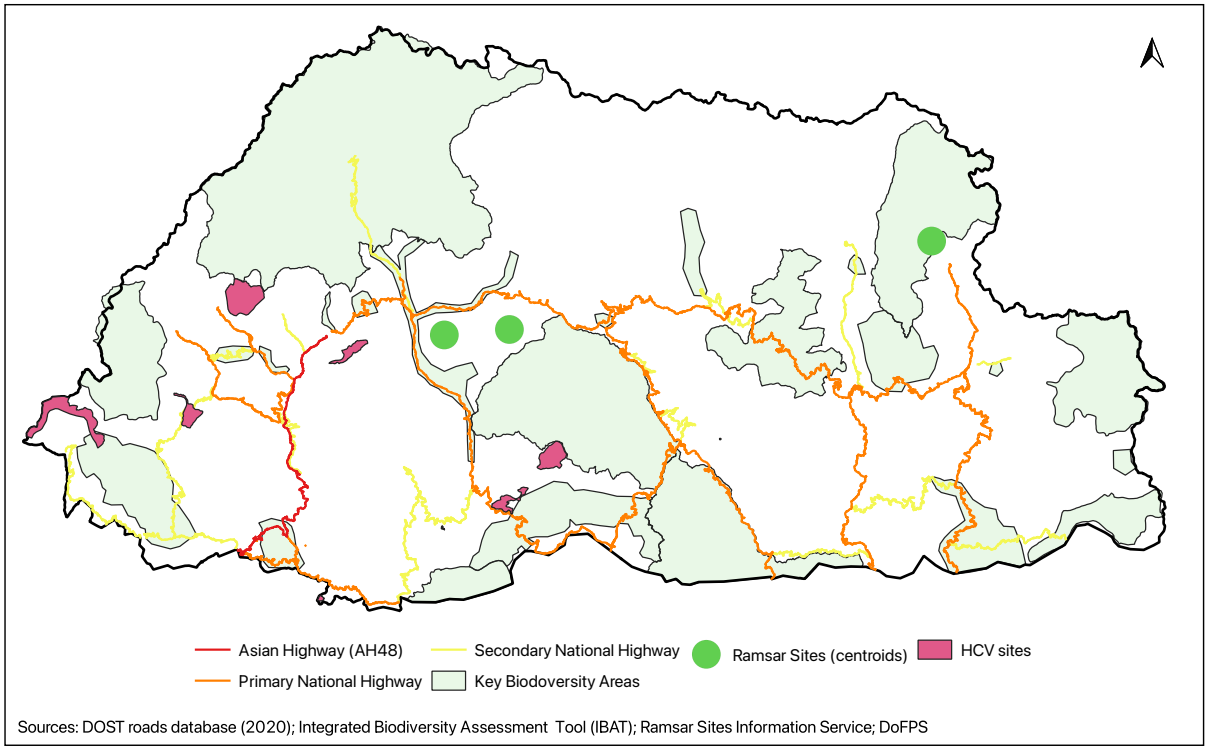


Figure 11: Key Biodiversity Areas, Ramsar Sites and HCVs

3.5 Socioeconomic Conditions

3.5.1 Demographics

42. Bhutan is a sparsely populated country, with projected 2022 population of 763,200 people and overall population density of 19.0/km^2. The five most populous and densely populated dzongkhags are all in the western half of the country. Only three towns (all in the west) had populations over 10,000 people as of the 2017 national census: Thimphu (114,551), Phuentsholing (27,658) and Tshongdue (11,448). These towns have good connectivity to the Asian Highway, the country's most advanced and reliable transport route.

43. The national population is experiencing modest growth, with projected average annual growth at +1.08% for the 2005–2022 period. Population growth appears to be slowing, as projected average annual growth for 2017–2022 is just +0.97%/yr, as compared to +1.13%/yr for 2005–2017. This trend may be attributable to a combination of low fertility (1.7 live births per woman in 2017) and increasing out-migration. Bhutan's population is young on average, with median age 26.9 years as of the 2017 national census. The sex ratio is strongly skewed towards males (110 males for every 100 females in 2017); attribution for high sex ratios such as this is often difficult to determine, but dependence on foreign workers (nearly all male) in sectors such as construction may play a role in the case of Bhutan.

44. Migration is a topic of considerable concern in Bhutan. Rural–urban migration is reflected in population data which show strong growth in major towns and even relatively small towns, as compared to the national average, and population decline in areas outside of towns (see Table 5). The proportion of the national population living in the country's 10 largest towns

rose from 21.6% in 2005 to 28.5% in 2017, and the proportion living in towns over 500 people rose from 52% in 2005 to 66.0% in 2017. An analysis conducted by the National Bureau of Statistics found that 38% of the national population was 'urban' in 2017, up from 31% in 2005.[10]

Table 5: Census Data Reflecting Rural–Urban Migration, 2005–2017

	Population 2005 Census	Population 2017 Census	Annual Average Growth 2005–2017
All of Bhutan	634,982	727,145	+1.12%/yr
In 10 largest towns	137,013	207,130	+3.44%/yr
In towns over 500 people[1]	330,456	479,735	+3.11%/yr
Not in towns over 500 people	304,526	247,410	-1.73%/yr
[1] Towns over 500 people in either 2005 or 2017, as classified based on national census data			

Source: Compiled based on data presented on www.citypopulation.de, which is in turn derived from census data published by the Bhutan National Bureau of Statistics

45. Rural–urban migration has been linked to a persistent and worsening labor shortage in Bhutan's agricultural sector, as well as growing problems in destination towns that are ill-prepared for rapid growth. However, it is also understood as an inevitable element of the country's transition from a primarily agrarian economy to one driven by manufacturing and services, which is in turn associated with gains in poverty reduction at the national level.[11]

46. International emigration, particularly of young people, is widely observed in Bhutan. Quantitative estimates of emigrant flows are difficult to generate through normal census-taking methods, and the available data are thought likely to underestimate emigration. Based on the 2017 national census, India is the most frequent destination, accepting about 39% of documented Bhutanese emigrants, followed by Australia (29%), the United States (10%), other Asian countries taken as a group (10%), and the Gulf States (8%). Emigrants to India have been mostly male, while women are more numerous emigrants to other countries, especially the Gulf States and the United States. Emigrants are mostly individuals seeking employment or education rather than entire households relocating. About half of recorded emigrants fall within the 20–29 age range.[12] Although commonly associated with beneficial remittances, emigration from Bhutan has also been linked to labor shortages in the countryside and conceptualized as a 'brain drain' with dire effects in the civil service especially.

3.5.2 Income and Employment

47. **Income.** As of December 2023, Bhutan is considered by the United Nations to have graduated from Least Developed Country status to the Developing Country category, based on rising per capita income; improvements in health, education and equity indicators; and reduced levels of economic and environmental vulnerability.[13] Bhutan's per capita GDP was USD 3,833 in 2022, and its per capita GNI was USD 3,634.[14] The 2022 Bhutan Living Standards Survey found that the incidence of monetary poverty was 12.4% nationally. Just 1% of surveyed households nationally self-reported as 'very poor' in 2022, while 13.2% self-reported as 'poor', 9.1% as 'not poor', and 76.2% as 'neither poor nor not poor'. Nearly 20% of rural households self-reported as 'very poor' or 'poor', compared to just 7.5% of urban households.[15]

[10] See National Statistics Bureau of Bhutan. 2018. Rural–Urban Migration and Urbanization in Bhutan.
[11] Ibid.
[12] Ibid.
[13] United Nations Department of Economic and Social Affairs. 2024. Least Developed Country Category: Bhutan Profile. https://www.un.org/development/desa/dpad/least-developed-country-category-bhutan.html.
[14] National Statistics Bureau. National Accounts Statistics 2023.
[15] National Statistics Bureau. Bhutan Livings Standards Survey 2022.

48. **Employment.** The leading source of employment in Bhutan in 2022 was the combined agriculture, forestry and fishing sector, which accounted for 43.5% of the employed workforce. Almost all people employed in this sector were self-employed or worked in family operations. Other major employment sectors were public administration and defense (10.6%), wholesale and retail trade (9.5%), manufacturing (6.8%), construction (6.4%) and education (5.7%). Just over 30,000 people worked in the civil service in 2022. About 140,000 approvals were granted to foreign workers in 2022–2023, 90% of which were for employment in the 'craft and related trades' which includes construction.[16] In 2022, 25% of employed people worked in the public sector (including the armed forces), 74.7% were employed in the private sector, and 0.4% worked for NGOs or CSOs.[17]

49. Women made up 52% of the working age population in 2022, but were significantly less likely than men to have paid employment (see Table 6). Overall unemployment was moderate in 2022, but youth unemployment (28.6%) was significantly elevated compared to other SAARC countries (average 17.4%) and the global average (14.2%).[18]

Table 6: Key Labor Market Indicators, 2022

Indicator	Male	Female	All
Working age population (15 and above)	233,437	251,529	484,965
Labor force participation rate (%)	73.4	53.5	63.1
Employment rate (%)	95.6	92.1	94.1
Unemployment rate (%)	4.4	7.9	5.9
Youth unemployment rate (%)	24.4	32.8	28.6

Source: National Statistics Bureau. Statistical Yearbook of Bhutan 2023.

3.5.3 Key Economic Sector Activity

50. **Agriculture, livestock and forestry.** Together, agriculture, livestock and forestry amounted to 14.7% of the national economy in 2022 (agriculture 6.8%, livestock 5.3%, forestry 2.6%).[19] Bhutan had an estimated 67,000 agricultural households in 2021.[20] Agricultural production is varied, and includes both tropical and temperate crops. The ten leading crops by tonnage in 2022 were irrigated rice, potatoes, maize, mandarin oranges, areca nut, chili, pumpkin/squash/gourd, ginger, cabbage and turnip.[21]

51. Livestock is widely held in Bhutan, with 53,974 households and 175 institutional entities across all 20 dzongkhags owning at least some livestock in 2021. The most frequently owned livestock are Jersey cross cattle (30,000 holders), poultry (22,000), Nublang/Thrabum cattle (20,000) and goats (10,000). The top five dzongkhags for milk production in 2021 were Trashigang, Samtse, Wangdue Phodrang, Sarpang and Tsirang. Chicken accounted for just under half of all meat produced in the country in 2021, with beef comprising about one quarter, and pork one fifth. Fish made up about 5% of total meat production; aquaculture is concentrated in the three foothills dzongkhags of Sarpang, Dagana and Tsirang.[22]

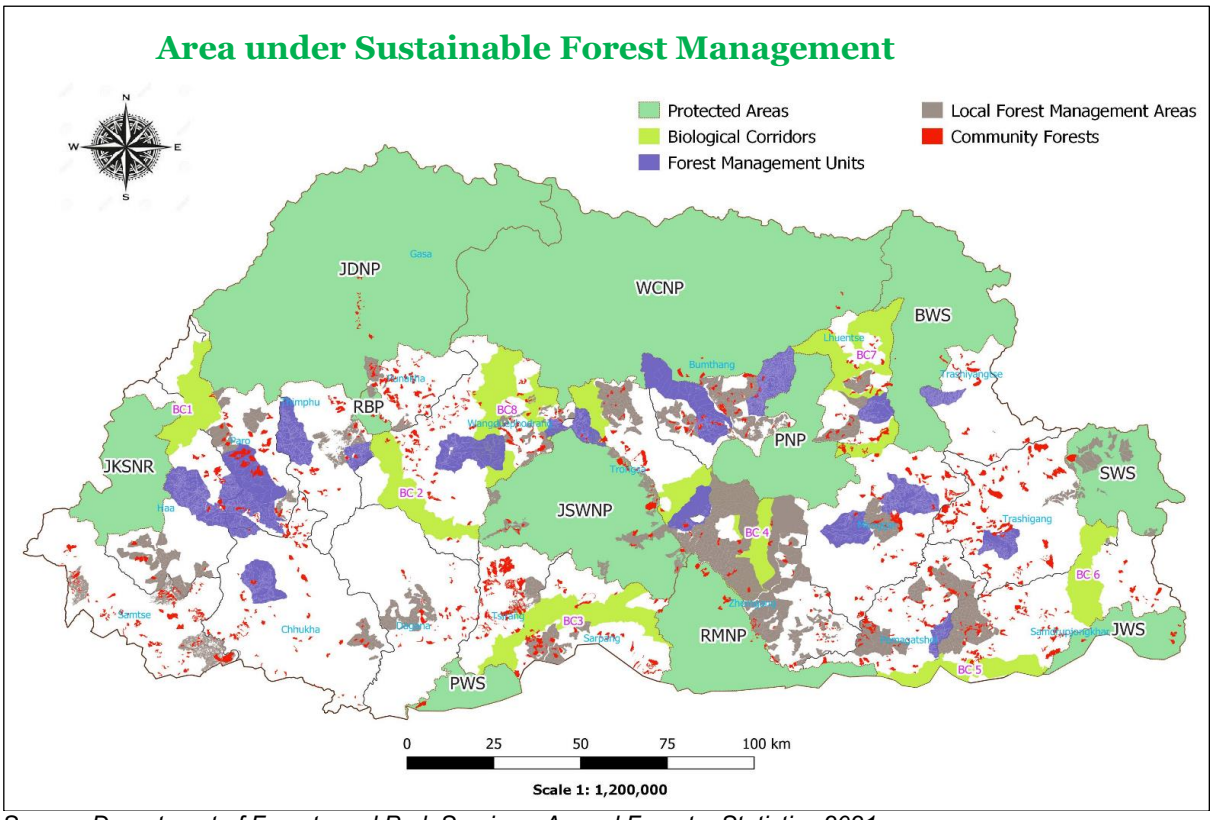
52. Most agricultural production serves local consumption, as access to domestic urban and export markets is constrained by high spoilage from long travel times, high transport costs, low by-producer volume and lack of inter-producer organization for consolidation and

[16] National Statistics Bureau. Statistical Yearbook of Bhutan 2023.
[17] National Statistics Bureau. 2022 Labour Force Survey Report.
[18] World Bank. 2024. Unemployment, youth total (% of total labor work force ages 15–24), modeled ILO estimate. https://data.worldbank.org/indicator/SL.UEM.1524.ZS
[19] national Statistics Bureau. National Accounts Statistics 2023.
[20] National Statistics Bureau. Agriculture Survey Report 2021.
[21] National Statistics Bureau. Statistical Yearbook of Bhutan 2023.
[22] National Statistics Bureau. Livestock Census 2021.

marketing.[23] The leading agricultural export in 2021 was whole cardamom; other exported goods included potatoes, oranges, ginger and betel nut. Livestock and livestock products do not figure among the country's major exports.[24]

53. Bhutan had approximately 2.7 million ha of forest land as of 2021, of which 22% was managed under officially designated extractive use regimes, which include Local Forest Management Areas (11%), Forest Management Units (7%) and Community Forests (4%).[25] Large areas of forest are managed as part of protected areas and biological corridors. Much of the country's forest area is difficult to access and manage for forestry purposes due to steep terrain and distance from roads.

54. The annual allowable cut from Forest Management Areas and Forest Management Units is apportioned to timber (67% in 2020) and firewood (33%), and to commercial uses (74% in 2020) and local people's uses (26%). A portion of the commercial harvest is undertaken by the government-owned Natural Resources Development Corporation. As of 2021, there were 856 Community Forests registered, involving 35,377 households; [26] it is not clear how many of these are functional and actively operating under an approved management plan. There is not a significant export market for wood or wood products.



Source: Department of Forests and Park Services. Annual Forestry Statistics 2021.

Figure 12: Areas Under Different Forest Management Regimes

55. Non-timber forest product (NTFP) royalties are collected on 42 different categories of plants, plant materials and fungi legally gathered in Bhutan's forests. The most valuable of these by far is the fungus *Ophiocordyceps sinensis*, which is prized in Chinese and Tibetan medicine, and is one of Bhutan's leading exports by value. Other NTFPs for which royalties

[23] Department of Agricultural Marketing and Cooperatives. 2021. Renewable Natural Resources Marketing Strategy.
[24] Ministry of External Affairs. Annual Trade Statistics 2021.
[25] Department of Forests and Park Services. Annual Forestry Statistics 2021.
[26] Department of Forests and Park Services. Annual Forestry Statistics 2021.

are paid include such materials as stones, boulders, gravel, sand, and soil. Royalties from plant and fungus materials approximately equaled royalties from stones, gravel, etc. in 2020.[27]

56. **Mining and manufacturing.** Mining activity in Bhutan is concentrated in the southern region, which had about 70% of all mining and quarrying establishments in 2017. Chukha and Samtse have notable concentrations of large and medium mineral-based industrial establishments, each with 21% of the national total of such entities.[28] Mining and mineral processing are mostly based around the limestones and other sedimentary-origin materials prevalent in the south, and produce such products as cement, gypsum, calcium carbide and ferrosilicon. Dolomite led total mineral extraction in 2022 with 37%, followed by limestone (34%), coal (11%), gypsum (10%) and iron ore (5%). Lesser amounts of marble, quartzite and boulders were also extracted. Mining and quarrying contributed about 1.8 of GDP in 2022.[29] Mineral commodities comprised eight of the top ten categories of goods exported to India in 2021, with a value of about USD 255 million, or about 81% of the total value of non-hydropower exports to that country. A similar proportion of the value of exports to Bangladesh was made up of mineral commodities.[30]

57. Manufacturing in Bhutan is dominated by the metals and non-metallic minerals sub-sectors, which together accounted for about three quarters of manufacturing activity in 2022. Food processing comprised about 14% of manufacturing.[31] Mineral-based industries made up 40% of all medium and large industrial establishments in 2023, while forest-based industries were more prevalent among cottage and small enterprises (see Table 7).[32] Manufacturing contributed 8.7% of GDP in 2022.

Table 7: Production and Manufacturing by Material Base and Enterprise Size, 2023

	Agro-based	Forest-based	Mineral-based	Other
Medium and large industries	25%	6%	40%	29%
Cottage and small industries	29%	42%	7%	23%
All industry sizes	28%	39%	9%	23%

Source: National Statistics Bureau. Statistical Yearbook 2023.

58. Since at least the Eleventh Five-Year Plan, proposals for expanding Bhutan's industrial capacity have focused on promoting industrial growth poles in the southern border areas, where significant industry already exists and access to external markets is convenient via the nearby Indian road and rail networks. The towns of Samtse, Pasakha, Phuentsholing, Jigmeling, Gelephu, Nganglam, Samdrupjongkhar, Motanga have been targeted for development or expansion of industrial estates and industrial parks.[33]

59. **Hydroelectricity.** The leading economic sector by value is hydropower, which contributed 13.4% of national GDP in 2022, taking account of construction and operation income in addition to electricity sales. Electricity exports to India amounted to about USD 393 million in 2021, which comprised 42% of all exports; approximately 70% of the country's total hydroelectricity production in 2022 was exported to India. Total installed hydroelectric capacity, encompassing six large plants and 22 lesser facilities, is 2,334 MW; over 99% of this figure is accounted for by the six large plants. Four additional large plants are under development, and will collectively add 2,938 MW to installed capacity. Total hydropower

[27] Department of Forests and Park Services. Annual Forestry Statistics 2021.
[28] National Statistics Bureau. National Accounts Statistics 2023.
[29] National Statistics Bureau. National Accounts Statistics 2023.
[30] Ministry of External Affairs. Annual Trade Statistics 2021.
[31] national Statistics Bureau. National Accounts Statistics 2023.
[32] National Statistics Bureau. Statistical Yearbook 2023.
[33] Ministry of Works and Human Settlements. 2019. The Project for Formation of Comprehensive Development Plan for Bhutan 2030, Final Report.

potential in Bhutan is estimated at 36,900 MW. Over 99% of households in Bhutan have electricity, and about 95% use it as the main source of energy for lighting and cooking.[34]

60. **Tourism.** Tourism is a significant generator of income, with foreign exchange earnings from the sector reaching USD 88.6 million in pre-COVID 2019, and is seen as having good potential to help diversify and grow economic activity. The RGoB favors a 'high value, low impact' tourism model. Direct government revenue from the Minimum Daily Package Rate (MDPR) levy on international tourists amounted to USD 23.4 million in 2019.[35] The hotels and restaurants sector, which is heavily dependent on flows of foreign tourists, contributed 1.2% to GDP in 2022, down from 2.6% in 2019, before the COVID pandemic. A total of 315,599 international tourists visited Bhutan in 2019, of which 78% were from South Asia, 11% from East Asia and the Pacific, 7% from Europe, 5% from the Americas, and less than 1% from Africa and the Middle East. By far the largest number of tourists from a single country were Indian, accounting for 73% of arrivals.

61. Spring and autumn are the most popular seasons to visit Bhutan, with 32% and 30% of arrivals. Most Indian tourists (86% in 2022) arrive via one of the land borders, while almost all (95% in 2022) of visitors from countries other than India arrive by air through Paro International Airport.[36] Table 8 shows the top five destination dzongkhags for tourists within Bhutan in 2019; the data suggest that the benefits from international tourism are not spread very evenly around the country, as about 90% of tourist arrivals and nights accrue to just these five dzongkhags, leaving just one tenth of tourist arrivals and nights for the other 15 dzongkhags combined.

Table 8: Destination Dzongkhags for International Tourists, 2019

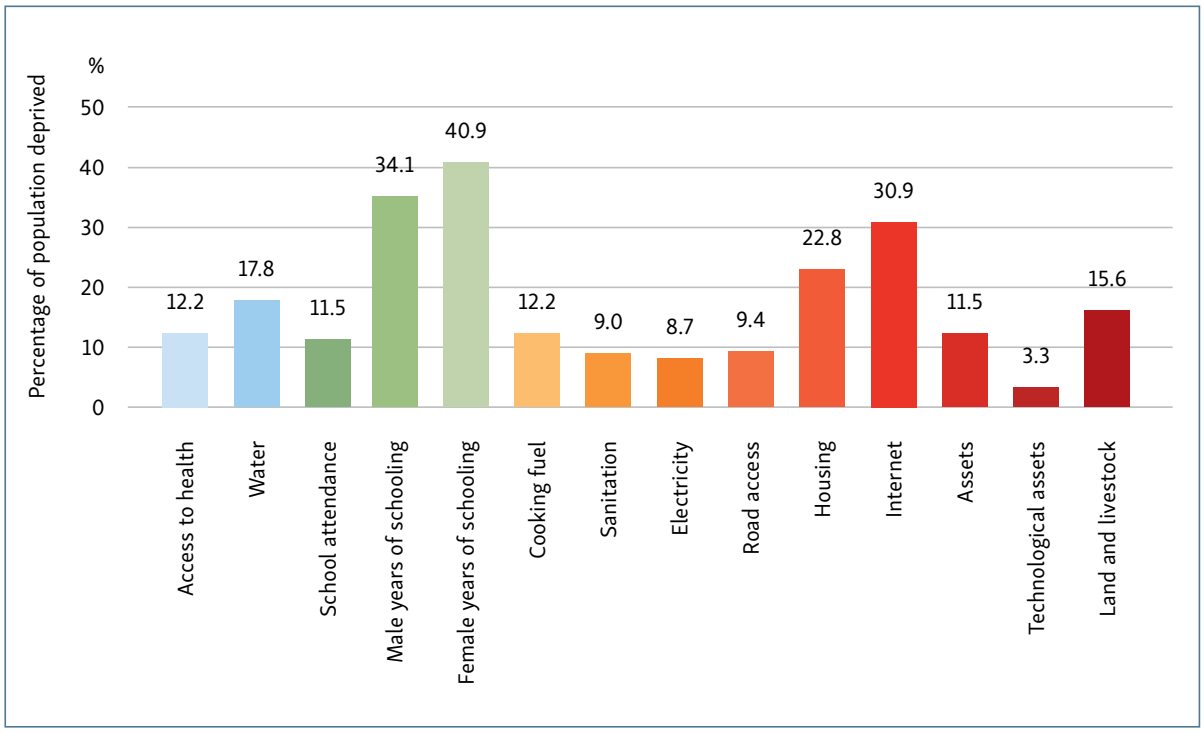
Tourist Arrivals (2019)*		Tourist Nights (2019)*	
Dzongkhag	**% of Total**	**Dzongkhag**	**% of total**
Paro	26	Paro	33
Thimphu	26	Thimphu	25
Punakha	24	Punakha	19
Wangdue Phodrang	9	Bumthang	7
Bumthang	5	Wangdue Phodrang	7
All others	10	All others	9
* Includes only international tourists who paid the MDPR (229,663 arrivals, 417,551 nights)			

Source: National Statistics Bureau. Statistical Yearbook of Bhutan 2023

3.5.4 Social Equity

62. **Poverty distribution.** The National Statistics Bureau uses a moderate multidimensional poverty index (MMPI) to assess well-being based on a suite of weighted indicators including health (access to health care services and clean water), education (school attendance and male and female years of schooling), and material living standards (cooking fuel, sanitation, electricity, road access, housing, internet, assets, technological assets, land and livestock).[37] Based on data from the 2022 Bhutan Living Standards Survey, 17.8% of the national population could be considered to be in a state of moderate multi-dimensional poverty, with a marked divide between urban (8.2%) and rural (23.9%) localities. Figure 13 shows the national findings (uncensored headcounts) across the indicators included in the MMPI, which indicate several areas in which particularly pronounced disparities exist; these include male and female educational attainment, internet access, housing, and access to clean water.

[34] National Statistics Bureau. Statistical Yearbook 2023.
[35] National Statistics Bureau. National Accounts Statistics 2023.
[36] National Statistics Bureau. Statistical Yearbook 2023.
[37] National Statistics Bureau and Oxford Poverty and Human Development Initiative. Multidimensional Poverty Index 2022.



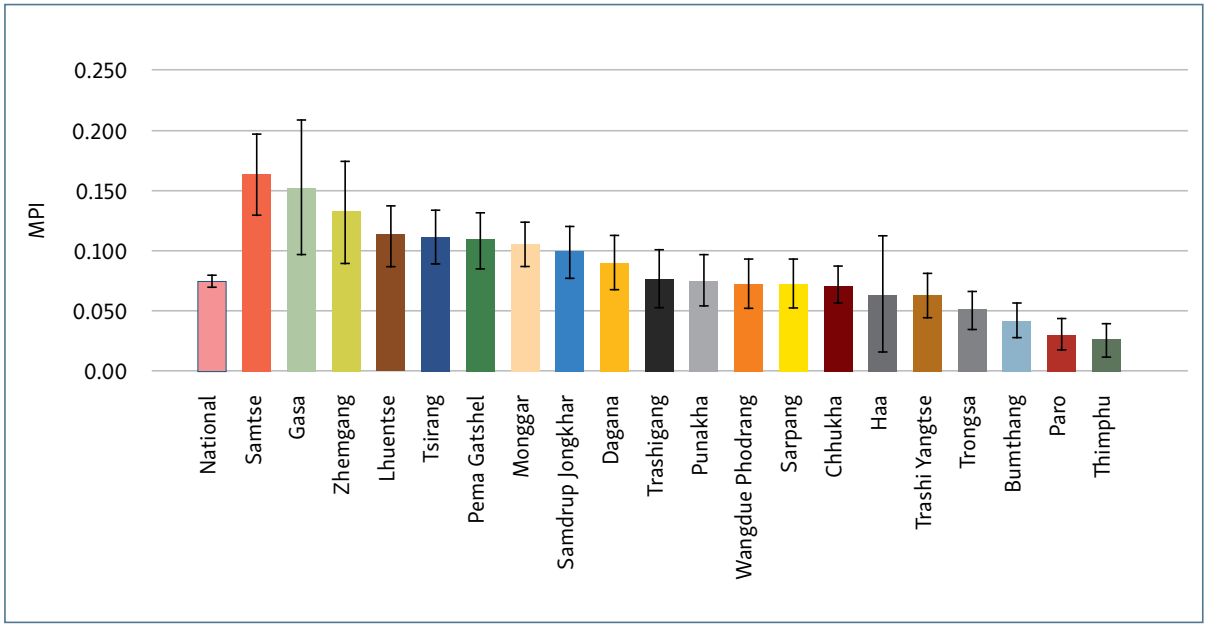
Source: National Statistics Bureau and Oxford Poverty and Human Development Initiative. Multidimensional Poverty Index 2022.

Figure 13: Findings of Bhutan Livings Standards Survey 2022

63. There are significant MMPI differences amongst the country's 20 dzongkhags (see Figure 14). Although it is not possible to definitively rank all dzongkhags due to overlapping standard deviations in the data, Samtse clearly has a greater incidence of moderate multidimensional poverty than 14 other dzongkhags (and roughly double the national average incidence), and Paro and Thimphu have a lower incidence than 14 other dzonkhags (and about half the national average). Samtse, Gasa, Zhemgang, Lhuentse, Tsirang, Pemagatshel and Mongar all have above-average incidence of MMPI, while Trongsa, Bumthang, Paro and Thimphu are all below the national average for MMPI incidence.

64. **Happiness distribution.** The RGoB's Centre for Bhutan and Gross National Happiness Studies uses a holistic index to periodically measure the well-being of the population and assess the country's progress towards greater happiness. The Gross National Happiness Index (GNHI) is based on sampled individuals' direct survey responses regarding 33 indicators that together represent the nine domains of Gross National Happiness (GNH), which are psychological well-being, health, education, time use, cultural diversity and resilience, good governance, community vitality ecological diversity and resilience, and living standards.[38] Respondents reporting a perception of sufficiency on at least 66% of indicators are classified as 'happy'. The aggregate GHNI is scored on a scale of 0 to 1, with 1 representing a perfect score. National surveys using the GNHI were conducted in 2010, 2015 and 2022, and the results (2010 GNHI = 0.743; 2015 GHNHI = 0.756; 2022 GNHI = 0.781) indicate steady progress at the national level.

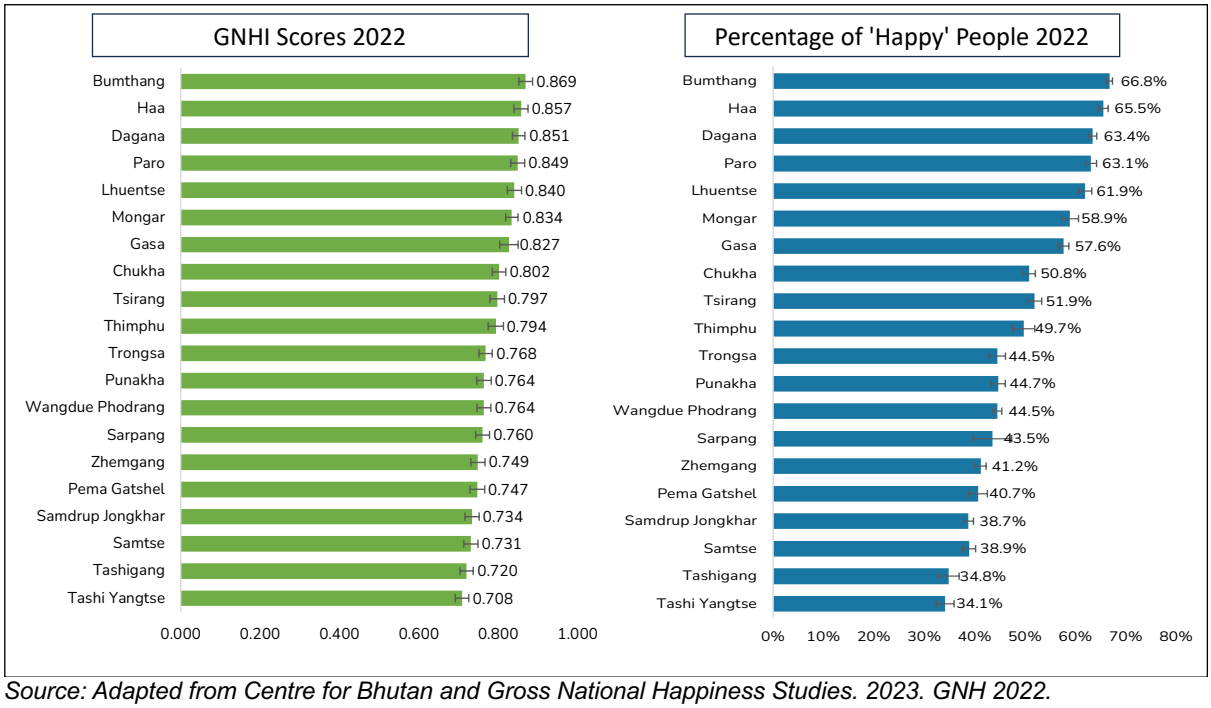
[38] Centre for Bhutan and Gross National Happiness Studies. 2023. GNH 2022.



Source: National Statistics Bureau and Oxford Poverty and Human Development Initiative. Multidimensional Poverty Index 2022

Figure 14: Moderate Multidimensional Poverty Index by Dzongkhag (2022)

65. Happiness as measured by the GHNI survey has not been evenly distributed. Figure 15 shows the 2022 survey results, broken down by GNHI scores and percentage of respondents with personal scores of 66% or higher, representing happiness. The rankings indicate that people in the least happy dzongkhag (Trashiyangtse) are about 81% as happy as their counterparts in the happiest dzongkhag (Bumthang). A more pronounced disparity is revealed by the presentation by percentage of happy people, which is about two-thirds in Bumthang, but just one third in Trashiyangtse.



Source: Adapted from Centre for Bhutan and Gross National Happiness Studies. 2023. GNH 2022.

Figure 15: Gross National Happiness Index and 'Happy' People by Dzongkhag, 2022

66. The 2022 survey also found differences between urban and rural areas; people living in urban centers were found to be happier (GNHI = 0.796) than rural people (GNHI = 0.771), but as a higher proportion of the country's population (59%) lives in rural areas, more happy people overall are found in rural areas than in urban areas.

3.6 Cultural Heritage

67. Bhutan has a wealth of tangible and intangible cultural heritage, and this is both a major element of national identity and a draw for domestic and international tourists. The Department of Culture and Dzongkha Development (DoCDD) has so far documented 9,633 features of varying significance; the most numerous of these are *choetens* and *lhakhangs* (see Table 9). The documented cultural heritage features are generally concentrated along the major rivers and highway corridors, as these are largely coincident with historically populated areas and early routes for trade, exploration and ethno-religious dissemination (see Figure 16).

Table 9: Documented Cultural Heritage Features in Bhutan

Feature	Number documented		Feature	Number documented
Choeten	5,018		Dzong	54
Lhakhang	1,926		Lake	46
Prayer wheel	1,218		Nagtshang	25
Nye	529		Traditional village	7
Dangrim	482		Waterfall	4
Spring	137		Not classified	3
Bridge	83		Ruins	1

Source: Department of Culture and Dzongkha Development database (March 2024)

68. The DoCDD is in the process of evaluating, registering and assigning formal site designations to features and groups of features, in line with the Cultural Heritage Bill, 2016. A total of 197 sites have been registered as of March 2024. Under the Bill, two designations have been defined: heritage buildings and cultural sites. The latter category is the broader of the two, and may be used to protect features and groups of features ranging from the locality scale up to landscape scale, and may include heritage buildings.

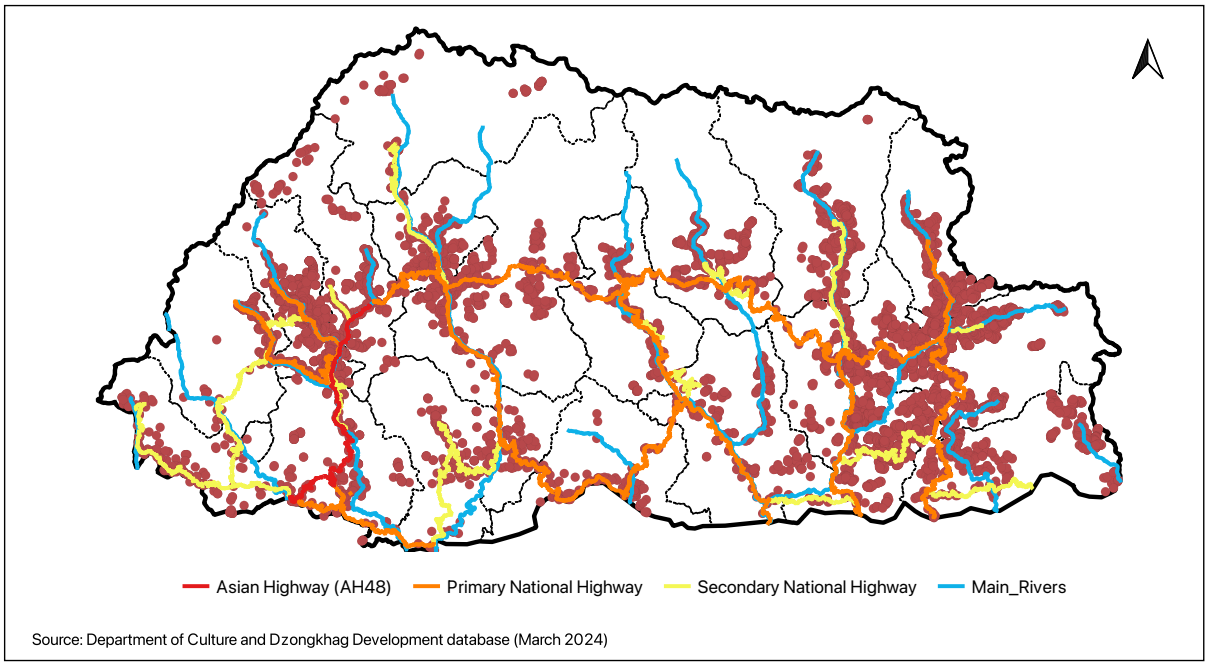


Figure 16: Distribution of Documented Cultural Heritage Features (all types)

69. Sites are assigned a significance based on the particular values represented and the relevance at local, national and regional scales; those assessed as having highest significance are prioritized for protective management. For these sites, management plans based on a zoned (core/buffer) approach are to be developed. Land use and development are to be strictly limited in core zones centered on particular high-value features, and subject to various context-specific restrictions and management measures within the surrounding buffer zones.

3.7 Policy Context

70. Part of the context for any policy, plan or program (PPP) is the constellation of other major policy instruments and initiatives with which it may intersect. It is not unusual for PPPs originating in different sectors to share similar or overlapping objectives, offering the opportunity for synergies. PPPs with roots in different sectors may also have objectives that are contradictory, which may frustrate implementation for one or both PPPs. It is therefore useful to take account of the current field of PPPs in Bhutan to support assessment of the risks and opportunities that may arise from implementation of the HMP. Table 10 lists 31 PPPs that have been identified and reviewed as part of the SEA scoping process, and classifies them according to their intersection with the HMP. This table is a simplified version of a more detailed review matrix, which is included in Appendix 1 for reference.

71. For most of the PPPs reviewed, the types of investments that may be part of the HMP can reasonably be expected to support the aims of the PPP. The SEA study should evaluate whether the HMP can feasibly be formulated to strengthen potential synergies in these cases. For nearly half of the PPPs reviewed, investments to be contemplated for the HMP are likely to frustrate the aims of the PPP, mainly because of impacts inherent to road development. This is mainly applicable to PPPs that seek to conserve biodiversity, natural habitat, prominent individual wildlife species, or physical cultural heritage. For some of these PPPs, some supportive effects (e.g., use of new and improved roads to enhance anti-poaching, ecotourism and cultural tourism) are also possible. The SEA study should assess the significance of road-derived threats to resources covered under the PPPs for which potential negative interactions with the HMP have been flagged, and develop measures to prevent or minimize such threats.

Table 10: Other PPPs and Their Potential Interaction with the Highways Master Plan

PPP	Potential Effect of HMP on PPP	
	Positive	Negative
Asiatic Black Bear Conservation Action Plan 2023-2033	Y	Y
Bhutan's Long-Term Low Greenhouse Gas Emission and Climate Resilient Development Strategy (2023)	Y	N
Bhutan National Urbanization Strategy (2008)	Y	N
Bhutan Transport Integrated Strategic Vision 2040	Y	N
Black-Necked Crane Conservation Action Plan For Bhutan 2021-2025	N	Y
Climate Change Policy of the Kingdom of Bhutan 2020	Y	Y
Comprehensive National Development Plan (2019)	Y	N
Conservation Action Plan for Hornbills of Bhutan 2023-2033	N	Y
Draft Cultural Heritage Bill of Bhutan (2016)	Y	Y
Disaster Risk Management Strategy (2016)	Y	N
Draft Tourism Policy of the Kingdom of Bhutan (2019)	Y	Y
Economic Development Policy (2016)	Y	N
Elephant Conservation Action Plan for Bhutan 2018-2028	N	Y
Food and Nutrition Security Policy of 2023	Y	N
Golden Mahseer Conservation Action Plan for Bhutan 2022-2032	N	N
Kingdom of Bhutan First National Adaptation Plan 2023	Y	N

PPP	Potential Effect of HMP on PPP	
	Positive	Negative
Low Emission Development Strategy (LEDS) – Surface Transport (2021)	Y	N
Mineral Development Policy (2017)	Y	N
National Action Plan to Combat Land Degradation (2014)	Y	N
National Biodiversity Strategies and Action Plan of Bhutan (2014)	N	Y
National Environment Strategy 2020-2030	Y	N
National Forest Policy (2009)	Y	Y
National Integrated Water Resources Plan (2016)	Y	Y
National Waste Management Strategy (2019)	N	N
Red Panda Conservation Action Plan for Bhutan 2018-2023	Y	Y
Renewable Natural Resource Marketing Strategy (2021)	Y	N
Renewable Natural Resources Strategy 2040 (2021)	Y	N
Road Sector Master Plan 2007–2027	Y	N
Thirteenth Five-Year Plan (pending 2024)	-	-
Tiger Action Plan for Bhutan 2018-2023	Y	Y
White-Bellied Heron Conservation Action Plan 2022-2031	Y	Y

4 SEA SCOPING

4.1 Rationale for SEA

72. In Bhutan, all PPPs with significant potential to affect the environment are required to undergo assessment to help ensure that their potential effects on the country's ecology and sustainable development prospects are understood and appropriately addressed prior to approval, as stipulated by the *Regulation on Strategic Environmental Assessment (2002)*. SEA enables critical foresight, through identification of foreseeable problems and opportunities to maximize benefits, that can inform the design of better national PPPs. Early 'upstream' consideration of the potential real-world effects of a PPP may pre-empt problems that could emerge when 'downstream' initiatives enabled by the PPP (e.g., individual road projects) are developed. In addition, SEA may support proactive measures to build synergies with other PPPs, which is typically difficult once implementation is already underway.

4.2 SEA Process

73. Strategic environmental assessment is ideally conducted in parallel with the formulation of the subject PPP. This enables dialogue, coordination and collaboration between the SEA team and PPP formulation team. In the present case, the SEA specialists and highway master planning specialists are part of the same consulting team, and the SEA specialists have been active participants from the earliest stages of setting up for the HMP formulation process. There are several windows of opportunity in the HMP formulation process at which inputs from the SEA work can be usefully made; these are highlighted in Figure 17.

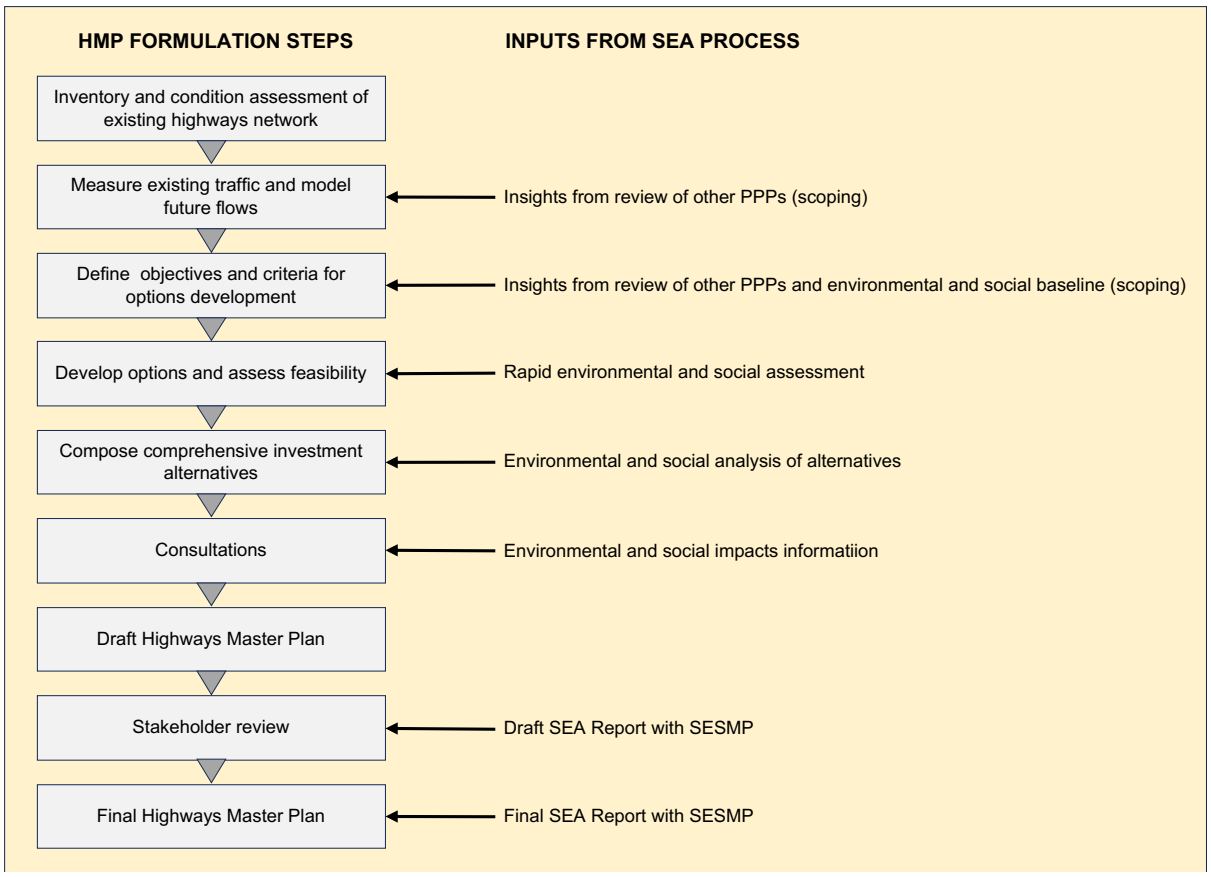


Figure 17: Inputs from SEA Work to HMP Formulation Process

74. **SEA process outputs.** The SEA process will culminate in the development and approval of an SEA Report identifying and explaining the positive and negative impacts that can be foreseen as a result of the implementation of the HMP, as well as feasible measures for avoiding, minimizing, compensating for, or enhancing the identified impacts. The SEA Report will include a Strategic Environmental and Social Management (SESMP), which will define and assign responsibility for implementation of impact management measures, as well as for monitoring to ensure that the prescribed impact management is carried out successfully.

75. **Timeline.** At the time of writing, acquisition of data on the road network and traffic, as well as environmental and social baseline information, has been underway for several months. Formulation of the HMP and accompanying 2040 Maintenance Plan and Investment Plan will proceed during May and June 2024, with the Draft HMP currently scheduled for the end of June 2024. The Draft SEA Report will follow approximately one month after the Draft HMP. Following a review period and the making of any necessary adjustments, the Final HMP and Final SEA Report will be produced by the end of October 2024.

4.3 Stakeholder Engagement

76. Two-way communication with the people and entities that may be affected by the implementation of a PPP is an essential element of the SEA process. Stakeholder engagement begins with scoping, and ongoing targeted consultations should normally be used to inform development of the draft PPP. Review and comment on the draft PPP is an important window for stakeholder engagement in all cases, and should be facilitated by thorough and thoughtful dissemination of the draft document. It is anticipated that the Draft HMP and Draft SEA will be presented at one or more workshops upon completion, and disseminated more widely through the web page set up for the SEA on the Ministry of Infrastructure and Transport (MoIT) website.

77. Stakeholder engagement should continue into the HMP implementation phase, as certain stakeholders typically are assigned ongoing roles and responsibilities for impact management and implementation monitoring under the SESMP. Reports from monitoring should be publicly shared with stakeholders to help ensure accountability. Stakeholder engagement will also be a required component of project-level EIA studies that will have to be conducted for each of the projects or groups of projects developed as part of the PPP's implementation.

78. **Stakeholder identification.** Some PPPs may have a fairly specific or narrow focus or apply to discrete and limited places or sub-sectors, and may thus have a relatively narrow range of potentially affected stakeholders. The HMP is not this kind of PPP, as improvements to the national highways system are likely to confer benefits and impose costs on practically everyone in the country to some extent, even if most will never realize it. In an SEA study for such a broad PPP, it is appropriate to focus engagement efforts on representative entities, such as government agencies and NGOs with a mandate to serve the public interest in particular realms relevant to the PPP, as well as local governments, whose purpose it is to serve the interests of their electorates. Table 11 presents the outcome of a basic stakeholder mapping exercise for the HMP, conducted at the scoping stage. The makeup of the group of stakeholder representatives invited to participate in an initial scoping workshop for the SEA (discussed in detail below) broadly reflected the categories identified.

79. It is important to note that the effects of a PPP on particular groups and entities will evolve as projects selected for implementation under a PPP are implemented. It is at this later stage that concrete impacts will become clear and present, and more fine-grained, context-specific stakeholder consultation is an essential component of project-level EIA studies.

Table 11: Stakeholder Identification Matrix

Stakeholder Category	Stakeholders and Stakeholder Groups
Central government agencies	• Agencies with definite or potential roles in HMP implementation • Agencies responsible for other PPPs whose success may be influenced by implementation of the HMP
Local representative governments	• All 20 dzongkhag administrations
Domestic non-governmental organizations	• NGOs and CSOs involved in other PPPs whose success may be influenced by implementation of the HMP • NGOs and CSOs with independent programs whose success may be influenced by implementation of the HMP
International non-governmental organizations	• NGOs involved in other PPPs whose success may be influenced by implementation of the HMP • NGOs with independent programs whose success may be influenced by implementation of the HMP
Multilateral institutions	• Multilaterals supporting active and upcoming projects and programs that may be influenced by implementation of the HMP
Domestic private sector interests	• National and local chambers of commerce • Industry groups and associations • Passenger and freight transport companies

4.4 Scoping

80. Scoping is a critical step in the SEA process, and an important window for direct involvement of stakeholders in the SEA study. The scoping process comprised several elements, including (1) collection and compilation of baseline information relating to the biophysical, socio-economic and cultural context in which the HMP will be implemented (a summary of which has been presented above); (2) identification and review of other PPPs whose goals and implementation may foreseeably interact with an implemented HMP (as

discussed above); (3) a scoping workshop involving a broad range of institutional stakeholders in the HMP; (4) additional targeted small-format meetings subsequent to the scoping workshop, for purposes of more in-depth discussion of particular matters with certain stakeholders; and (5) a field trip to help scope road-wildlife issues.

4.4.1 Scoping Workshop

81. The SEA Scoping Workshop was held on the morning of 14 February 2024, at Hotel Migmar in Thumphu. The workshop was hosted by Tenzin, DG-DoST and orchestrated by master of ceremonies Sonam Choden, DGD-DoST, and featured presentations by Janusz Sobieniak and Simeon Stairs, both representing the TA Consultants. Workshop participants learned about the highways master planning process and the parallel SEA process, and subsequently engaged in an extended discussion of the key themes that will animate the SEA study. The workshop agenda is included in Appendix 2.

82. Overall, 59 people (19% women, 81% men) representing 37 different stakeholder entities joined in the workshop; of these, 28 participants attended in person, and 31 joined remotely via a Zoom link. A wide range of entities were represented at the workshop, including government agencies, NGOs, multilateral entities and dzongkhag administrations. The full participant list from the SEA Scoping Workshop is provided in Appendix 3.

Figure 18: SEA Scoping Workshop In-Person Group

83. During the scoping workshop, the TA team gave an overview of the purpose and objectives of the TA and the highways master planning process and methods, followed by an introduction to SEA and the SEA process. The SEA specialists then presented a broad thematic survey of initial findings from desktop research to help structure discussion with the group, before leading a theme-by-theme discussion. In-person and online attendees were given a handout of the key theme slides and assigned the task of flagging items to raise for the structured discussion (the handout is shown in Appendix 4).

84. The theme-by-theme discussion yielded some useful insights that have enriched and shaped the overall findings of the scoping process. For example, an exchange around the potential impact of roads on recharge and flows of groundwater and springs, as well as the sometimes-conflictual interaction between road-building and irrigation systems, drew out groundwater and related watershed-scale interactions as important topics for consideration in the SEA. Also, a discussion about water quality, agriculture and biodiversity highlighted the potentially beneficial role of the proposed completion of the southern east-west highway in controlling the flow of illegal agricultural pesticides into the country, in addition to preventing cross-border poaching. Fresh insights were also gleaned from discussion of the expected enabling role of highway connectivity improvements on tourism, with concerns being raised about domestic wastes generated by tourism activity and the low level of readiness in the country to implement responsible waste management even for existing communities and tourism operations, let alone a wave of new tourism investments enabled by better highways.

85. At the end of the discussion, participants were asked to complete a basic ranking exercise of themes and topics using a five-point rating scale and additional write-in space (see handout sheet in Figure 19). In-person participants completed this on the paper handout provided, while remote attendees were asked to do the same from their own location and send a snapshot to a text number and email address provided for the purpose. Participants were encouraged to write in new themes and topics as they wished. The exercise was completed by 22 participants; their inputs were later tallied to lend further insight on the appropriate substantive scope of the SEA study.

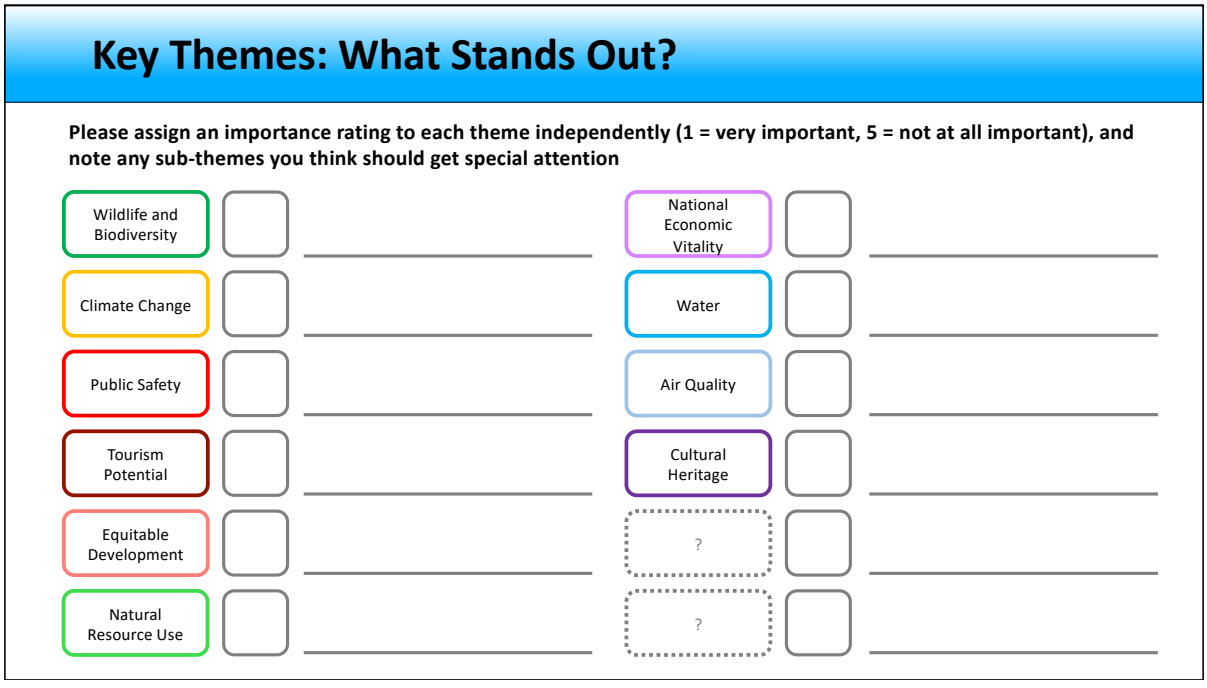


Figure 19: Theme Ranking Exercise Handout

86. The ranking exercise tally is shown in Table 12. Wildlife and biodiversity received the highest number of 'very important' rankings, with 19 out of 22 respondents ranking this theme as '1'. Climate change and national economic vitality also scored high. An interesting finding is that when the top two ranking categories ('1' and '2') are tallied together, social themes such as national economic vitality, equitable development and public safety show similar levels of importance to 'natural environment' themes such as wildlife and biodiversity, climate change, water and natural resource use. Overall, the ranking information supports the initial thematic framework developed and presented by the SEA specialists, while adding important nuance and a basis for modest reconfiguration and prioritization.

Table 12: Tally of Responses in Theme Importance Ranking by SEA Workshop Participants

	Importance Rankings				
	1 (very important)	**2**	**3**	**4**	**5 (not at all important)**
PRE-IDENTIFIED THEMES					
Wildlife and biodiversity	19	1	1	1	0
Climate change	15	4	1	1	0
Public safety	11	8	2	1	0
Tourism potential	4	11	5	1	0
Equitable development	12	6	1	0	3
Natural resource use	10	6	5	0	0
National economic vitality	15	3	1	0	1
Water	13	7	0	2	0
Air quality	7	7	3	3	2
Cultural heritage	5	9	5	2	0
ADDITIONAL PARTICIPANT-SUGGESTED THEMES					
Waste management	0	2	0	0	0
Health and education access	2	3	0	0	2
Border security	0	1	0	0	0
Settlement along highways	0	0	1	0	0
Land degradation	1	0	0	0	0

4.4.2 Targeted Small-Format Meetings

87. A meeting was held on 5 March 2024 at the Department of Culture and Dzongkhag Development (DoCDD) in Thimphu to discuss and scope the potential for the expansion and improvement of the national highway network to affect cultural heritage attributes, particularly tangible assets.[39] The SEA team was brought up to date on DoCDD's efforts to evaluate, categorize and map all physical cultural heritage sites and artifacts in the country, and DoCDD agreed to share shapefiles and other information to assist in assessment of risks. It was agreed that further dialogue would be appropriate and welcome as proposals for highway improvements emerge from the master planning process, as there is substantial potential for spatial overlap given the large number of known heritage sites and objects.

88. A second meeting was held on 7 March 2024 at the Department of Forests and Park Services (DoFPS) in Thimphu. The meeting was attended by representatives of the Nature Conservation Division, Forest Resources Management and Planning Division, and Forest Monitoring and Information Division.[40] The purpose of the meeting was to discuss and scope the significance of the numerous overlaps between the national highways network and lands important to biodiversity conservation and ecosystem services provision, including protected areas, biological corridors, productive forests and unprotected HCV sites. Some of the new road segments identified as priorities of the RGoB that will be considered for inclusion in the HMP would impinge on such areas, as could additional works such as widening, bypasses and other new alignments that may emerge from ongoing highway network analysis, and this is considered by the SEA team to be a high-priority concern. Discussion focused on the importance of avoiding impingement on the core areas of the protected areas, in order to minimize biodiversity impacts from habitat loss, habitat fragmentation and barrier effects. The use of wildlife crossing structures was also discussed. Besides these concerns, it was also

[39] DoCDD was represented by Mr. Yeshi Samdrup, Director, and Ms. Sangay Choden, Architect, both of the Heritage Sites and Archaeology Division.
[40] The full attendance list for the meeting is shown in Appendix 5.

acknowledged that the proposed new alignments and other network improvements may have some potential for positive impacts, in that they may enable ecotourism development in the protected areas as well as enhanced anti-poaching patrols, and also lend support to efforts to ramp up sustainable community-based forest resource use and marketing in Forest Management Units and Community Forests. The DoFPS agreed to provide shapefiles and other information to the SEA team to support proactive assessment and mitigation of the concerns discussed, and it was agreed that further dialogue would be useful and necessary as proposals for specific investments begin to emerge from the HMP formulation process.

4.4.3 Field Observation

89. The SEA team made a brief field trip to the Raidak–Lhamoizhingkha Road to enhance understanding of concerns regarding proposed second east-west highway links and to scope road-wildlife issues based in part on inspection of wildlife crossing structures previously installed along this road. Discussions with local DoFPS and DoST officers and field observation of the structures and their surroundings highlighted the public safety aspect of large wildlife on roads (i.e., dangerous confrontations with elephants and gaurs), and revealed innovations recently trialed by conservation officers to lessen such encounters. Various practical insights related to positioning, size, scour prevention and maintenance were also drawn from inspection of the large-mammal underpasses installed in the road.

5 CONCLUSIONS OF SCOPING

90. Drawing together insights from desktop compilation and review of baseline information, the scoping workshop and targeted small-format meetings, a framework has been developed to represent the scope of the SEA and guide the assessment work. In addition to defining the topics of priority interest, the framework identifies preliminary objectives that the SEA should consider and assess as the basis for practical influence on the HMP's formulation, or as guidance for the development of mitigation or enhancement measures to be specified in the SEA's SESMP. The scope framework, which lists the key themes in a rough order of priority (most important listed first) is presented in Table 13.

91. The framework laid out in Table 13 should be considered a changeable entity, in that it may well evolve as the HMP formulation proceeds, and the implications of planning decisions (including feasibility analysis) are weighed. Further consultation with stakeholders may also lead to the identification of new topics for investigation. The relative importance of the various potential impacts foreseen may also evolve as analysis proceeds.

Table 13: Summary of Substantive Scope of SEA

Key Resources/Receptors	Risks	Opportunities	Preliminary Objectives of HMP/SEA
WILDIIFE AND BIODIVERSITY			
• Protected areas and corridors • Key Biodiversity Areas • Ramsar sites • HCVs • Forested areas	• Fragmentation/barrier effects • Habitat loss • Human-wildlife conflict (large animals) • Wildlife mortality (small animals) • Enhanced exploitation pressure (poaching, illegal logging/mining, informal settlement, conversion to agriculture) • Proliferation of invasive species	• Amelioration of existing barrier effects • Amelioration of existing large fauna conflict • Facilitation of ecotourism as long-term support for biodiversity protection • Enhanced anti-poaching potential	• Avoid new alignments in protected area core zones • Make allowances for wildlife crossing structures in cost estimation and project-level EIA studies • Require preparation of critical habitat assessments and biodiversity action plans during project-level EIAs to determine appropriate biodiversity offsets to achieve net gain outcomes for biodiversity values • Take account of DoFPS ecotourism development priorities in evaluation of investment alternatives • Define formal means of collaboration between DoST and DoFPS regarding operation of new and upgraded roads through protected areas and biological corridors to enable optimal impact management
CLIMATE CHANGE AND DISASTER RESILIENCE			
• Public and private infrastructure • Forest resources • International commitments and standing	• Excessive contribution to national GHG emissions, threatening national targets and international commitments • Increased exposure and vulnerability to climate change-driven risks	• Reduce transport sector contribution to national GHG emissions and facilitate transition to low-carbon transport alternatives • Enhance climate change adaptation and resilience (physical infrastructure and network-level mobility)	• Prioritize investments that synergize with Surface Transport LEDS (e.g., charging stations, NMT lanes, freight hubs) • Make allowances for asphalt recycling in Maintenance Plan • Require project-level climate risk and adaptation assessment using latest projection data during detailed design • Make allowances in investment budget for enhanced slope protection, drainage capacity and bridge resilience to mitigate risks from increased and more intense rainfall, as well as GLOFs • Account for critical link redundancy in network planning

Key Resources/Receptors	Risks	Opportunities	Preliminary Objectives of HMP/SEA
WATER RESOURCES			
• Rivers intersecting and paralleling road corridors • Ecosystem services	• Degradation of water quality and aquatic ecology • Increased spill risks • Disruption of groundwater flows and watershed dynamics • Damage to irrigation infrastructure near roads	• Correction of existing erosion and scour problems • Correction of existing spill risk exposures • Correction of existing road-derived disruptions of groundwater flows and watershed dynamics • Potential synergies between road drainage and irrigation systems	• Make allowances in cost estimation and Investment Plan for correction of existing erosion and scour • Require spill risk assessment and mitigation in project-level EIA studies • Require assessment and mitigation of existing and potential disruptions to groundwater flows, watershed dynamics and irrigation systems in project-level EIA studies
PUBLIC SAFETY			
• Public safety • Traffic safety • Wildlife-vehicle interactions	• Geophysical safety risks for road users • Geophysical safety risks in uphill/downhill locations • Increased safety risk from higher traffic volume and speed • Increased potential for on-road conflict with large wildlife (elephants and gaurs)	• Correction of existing geohazard exposures • Safety improvements/correction of existing traffic safety problem areas	• Make allowances in cost estimation and Investment Plan for enhanced slope protection • Require site-specific assessment of physical risks to upslope/downslope communities in project-level EIAs • Make allowances in cost estimation and Investment Plan for installation of guardrails, pedestrian safety measures • Make allowances in Maintenance Plan for enhanced road markings • Make allowances for wildlife crossing structures in cost estimation, Investment Plan and project-level EIA studies
EQUITABLE DEVELOPMENT			
• Access to health and education and other public goods • Incidence of multidimensional poverty • Happiness • Rural-urban migration	• Existing disparities in MMPI and GNHI worsened by highway system investments that mainly serve already better-off and happier areas	• Leveraging of highway system improvements to help even out disparities in MMPI and GNHI reflected in national surveys	• Prioritize investments that serve dzongkhags with higher multidimensional poverty scores and lower Gross National Happiness Index scores • Require project-level EIA studies to stipulate gender equity measures in relation to hiring and working conditions

Key Resources/Receptors	Risks	Opportunities	Preliminary Objectives of HMP/SEA
NATIONAL ECONOMIC VITALITY			
• Economic resilience • Economic diversification • Economic opportunity • Balance of trade • Deficits and debt	• Increased debt if investments in highway infrastructure do not generate positive economic returns	• Leveraging of highway system improvements to support high-potential growth sectors (e.g., hydroelectricity, mining, manufacturing, tourism, services)	• Prioritize investments that enable sector growth opportunities prioritized by government
CULTURAL HERITAGE			
• Physical cultural heritage features in or nearby road corridors • Intangible culture	• Physical damage to heritage sites • Degradation of site amenity values • Displacement of traditional land and resource use from induced development	• Leveraging of highway system improvements to enable greater visitation and appreciation of heritage sites	• Screen proposed new alignments and widening to avoid potentially damaging overlap with cultural heritage features • Prioritize investments that could enhance tourist access to important heritage sites • Require consultation with DoCDD and site-specific heritage risk assessments during project-level EIA
NATURAL RESOURCE USE			
• Land use • Ecosystem services • Forestry, social forestry, NTFPs • Agriculture (traditional and market-oriented)	• Improved access for exploitation • Lower cost-to-market for unsustainably produced goods • Conversion of agricultural and forest land (induced urbanization)	• Lower cost-to-market for sustainably produced goods • Improve availability at reasonable price of agricultural inputs in more remote regions • Create potential for agricultural and forest product exports	• Avoid need for conversion of productive agricultural and forest land as much as possible during evaluation of potential new roads • Require site-specific assessment and mitigation of takings of productive agricultural and forest land in project-level EIA • Prioritize investments that will reduce travel time from agricultural centers to urban and export markets • Prioritize investments that will reduce travel time from Forest Management Units and Community Forests to urban and export markets • Require predictive land use dynamics assessment in project-level EIA studies to enable proactive mitigation of induced development in concert with dzongkhag administrations

Key Resources/Receptors	Risks	Opportunities	Preliminary Objectives of HMP/SEA
POLLUTION AND WASTE			
• Rivers • Airsheds • Environmental services • Human health and quality of life	• Improvements to highway network spur urban and industrial development in context of low preparedness for responsible waste management • Higher traffic volume enabled by highway network improvements lead to air quality impacts in roadside communities • Highway improvement and expansion works create solid waste, dust, noise and water pollution	• Correct existing road-related waste and pollution problems as part of new projects and Maintenance Plan	• Make allowances in cost estimation and Investment Plan for community bypasses where air quality impacts are foreseeable based on general traffic projections • Require location-specific assessment and mitigation of air quality impacts as part of project-level EIA studies • Require strong Environmental Management Plan (EMP) and Contractor Environmental Management Plans (CEMPs) in project-level EIAs

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APPENDICES

Appendix 1 – PPP Review Matrix

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
Asiatic Black Bear Conservation Action Plan 2023-2033	Department of Forests and Park Services	To maintain a viable and stable population of Asiatic black bears in Bhutan and ensure minimal conflict between humans and bears, by 2033, through efforts to prevent and manage human-bear conflict; prevent poaching and illegal trade of bear parts; mapping and monitoring of bear habitat; restoration of degraded habitat; and research on bear ecology and human-bear conflict.	The Action Plan identifies road construction as a driver of habitat loss and degradation, which points to the potential for new highway alignments to work at cross purposes to the Action Plan. Poaching and animal parts trafficking are also known threats to the bear in Bhutan, and enhanced anti-poaching patrols are advocated; there may be potential for some highway improvements to facilitate this, particularly in border areas where the present lack of roads is thought to allow trans-boundary incursion by poachers.
Bhutan National Urbanization Strategy (2008)	Ministry of Works and Human Settlement	To drive a proactive, managed transition to a more urbanized, regionally balanced and equitable national society, through promotion of regional growth centers in the eastern and central regions of the country, and by enhancing the role of gewog centers as service nodes for surrounding rural areas.	Although the National Urbanization Strategy is acknowledged to be high-level and preliminary, its main thrust is suggestive of the importance of enhanced highways connectivity as an enabler of both growth in selected regional growth centers and emergence of selected gewog centers as regional service centers for rural communities. The principal potential interaction between the HMP and the National Urbanization Strategy is one of positive synergy, which can be enhanced by highway investments that improve roads serving the identified priority towns.
Bhutan's Long-Term Low Greenhouse Gas Emissions and Climate Resilient Development Strategy (2023)	Department of Environment and Climate Change	To make Bhutan a dynamic, prosperous, resilient, inclusive and sustainable economy by 2050, with an emphasis on low carbon and climate resilient approaches to development, by (1) remaining carbon neutrality through targeted mitigation in key sectors and enhancement of sequestration potential of forests and other land uses; (2) prioritizing adaptation interventions to reduce climate-induced disasters and capitalize on opportunities provided by climate change; (3) improve climate and weather forecasting and build a body of knowledge based on local experience; (4) finance local mitigation and adaptation through global and regional climate financing instruments including both market and non-market approaches; and (5) continue Bhutan's	Surface sector is identified as a key sub-sector for intervention under the Long-Term Strategy (LTS), in relation to both mitigation and adaptation. Projected growth in overall vehicle emissions is acknowledged as a significant contributor to the foreseeable threat to carbon neutrality under a business-as-usual scenario, and the LTS mandates follows the LEDS – Surface Transport in mandating increased fuel efficiency, transition to low-emission (electric, hydrogen fuel cell and plug-in hybrid) vehicles, and wider use of shared mobility, public transport and non-motorized transport; there may be scope in the HMP to support some of these aims, e.g., by integrating charging stations (and perhaps also NMT lanes in some locations) in the infrastructure plan.

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		leadership in the global community of nations on climate change and sustainable development through rigorous engagement at regional and global levels.	With regards to adaptation in the surface transport sub-sector, the LTS prioritizes climate-proofing through redesign of transport infrastructure, beginning with critical stretches of national highways and urban roads, to mitigate increasing risk of flash flooding and glacier lake outburst floods (GLOFs). There is substantial scope to support this adaptation priority through investments in new infrastructure and maintenance improvements coming under the HMP.
Bhutan Transport Integrated Strategic Vision 2040	Royal Government of Bhutan	The comprehensive, high-level Vision concentrates on establishing the basic "building blocks" to enable Bhutan to achieve its desired 30-year transport vision, encompassing all modes of transport. The transport vision incorporates all existing transport related plans, policies, initiatives, and actions to create a long-term comprehensive strategy for the country. The Vision covers both the implementation of the physical infrastructure in the transport sector as well as the institutional and management functions associated with the delivery of transport services.	The Vision articulates six key strategies for the national highways: (1) widen the existing East-West Highway (and other key routes) to two lanes with alignment improvements to reduce travel times and enhance safety; (2) complete southern East-West Highway by upgrading existing routes and undertaking some new construction to connect new industrial growth centers; (3) construct new alignments (diversions) and tunnels and/or viaducts on key routes to reduce distances and allow increased speeds and/or driver comfort; (4) improve access routes between industrial centers and major border crossings, including the existing North-South Highway; (5) introduce improved engineering and construction technology to reduce overall life-cycle costs and provide better pavement quality; and (6) establish maintenance regime for all national highways and district roads to include pavement management systems and performance contracts. The HMP will be aligned with and support realization of the Vision.
Black-Necked Crane Conservation Action Plan For Bhutan 2021-2025	Department of Forests and Park Services and Royal Society	To maintain a viable wintering population of Black-necked cranes in Bhutan, living in a harmonious coexistence with local communities, through comprehensive habitat assessment, mapping and management; community-based livelihood programs linked to stewardship; interdisciplinary research; and stakeholder engagement.	Black-necked cranes winter in a small number of river valley and wetland sites in the northern half of Bhutan, some of which are in areas served by primary or secondary national highways. The principal road-related threats to Black-necked cranes identified in the Action Plan are land use change (growth of towns and settlements) and increasing disturbance by tourists. It is possible that improving highways may moderately exacerbate both threats in some contexts, bringing the HMP into potential

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
			conflict with the Action Plan's aims. The significance of this potential should be assessed.
Climate Change Policy of the Kingdom of Bhutan 2020	National Environment Commission	To promote a prosperous, resilient and carbon neutral Bhutan through provision of strategic guidance and support across sectors, and effective engagement with stakeholders.	Investments under the HMP may contribute to the carbon neutrality objective by improving road conditions and possibly adding shortcuts and bypasses, which could exert downward pressure on operating emissions; innovations in maintenance potentially proposed under the HMP may also help to reduce emissions. Improvements to the reliability and extent of the national highways system can be expected to enhance resilience, especially if adaptation measures are stipulated as standard requirements under the HMP. Expanding the highway network may in theory also facilitate continued growth in the national vehicle fleet, which could in turn threaten the country's carbon neutrality goal.
Comprehensive National Development Plan (2019)	Ministry of Works and Human Settlement	The Comprehensive National Development Plan (CNDP) is a structural plan covering numerous aspects of the spatial and economic organization of the country, and makes recommendations grouped under two categories: *stabilization factors* (measures to maintain and enhance valued attributes, such as the natural resource base, transport network, public services, disaster resilience) and *driving factors* (vehicles for pursuing new development opportunities, such as regional human resource hubs, agriculture and livestock promotion areas, forestry and non-wood forest product promotion areas, holistic tourism networks, industrial estates and agglomerations, water business promotion areas, and an 'all-electric society' basket of technologies.	The CNDP recognizes the importance of a stable arterial road network as an underpinning for much of the spatial and economic organization it recommends, including tourism development areas, industrial estates, economic corridors, and 'linked urban centers'. The plan adopts the target, also articulated in earlier road sector plans, of having east-west trips across the country's highway network require 16 hours or less, north-south trips 8 hours or less, and trips between adjacent dzongkhag centers 2 hours or less. This is proposed to be achieved by (1) geometric improvements to arterial roads, and (2) structural improvements including tunnels, bridges, bypasses and slope protection. The two key objectives for the arterial roads are an efficient and reliable transport system to help ensure economic development, and secure transportation throughout the year to ensure traffic safety. Completion of a second east-west highway in the southern part of the country is central to many of the plan's structural recommendations. The HMP can be expected to align with and support the road transport objectives stated in the CNDP.

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
Conservation Action Plan for Hornbills of Bhutan 2023-2033	Department of Forests and Park Services	To implement sustainable management of hornbill habitats and secure the conservation of hornbill populations in Bhutan in partnership with local communities, through habitat mapping; engaging local communities via education and integrated conservation-development programs; and research on ecology, habitat and threats.	Habitat fragmentation and habitat loss are the principal threats to hornbills identified in the Action Plan that have some association with road development. New alignments that may be proposed in the southern part of the country as part of the HMP may have some potential to conflict with the aims of the Action Plan.
Draft Cultural Heritage Bill of Bhutan (2016)	Department of Culture and Dzongkha Development	The purpose of the Cultural Heritage Bill is to sustain cultural heritage and the cultural landscape of Bhutan for present and future generations, primarily by establishing systems for documenting, protecting and managing culturally significant sites. Although the Bill has not yet been passed into law as of early 2024, the Department of Culture and Dzongkha Development anticipates that it will eventually, and has proceeded with documentation and protection activities, including mapping and classification of sites and development of a zoning-based management plan methodology.	There may be substantial scope for new alignments proposed under the HMP to conflict with physical cultural heritage protection objectives. The SEA must attempt to foresee and prevent problematic overlaps between new alignments and cultural sites. On the positive side, improved highways should enable better access to cultural heritage sites by domestic and foreign tourists, thereby creating potential to enhance appreciation of the country's cultural heritage.
Disaster Risk Management Strategy (2016)	Department of Disaster Management	To synthesize the policy drivers and progress being made in disaster risk management, emerging issues, challenges and lessons learned from the response to and management of recent disaster events, providing guidance to key ministries, departments and agencies in their disaster risk management planning, coordination and budgeting processes. The Strategy identifies four priority actions: (1) improving the understanding of disaster risks; (2) strengthening the risk governance system; (3) investing in disaster risk reduction for resilience; and (4) strengthening disaster management capabilities.	The Strategy makes little mention of roads and highways, but these may be assumed to fall under the category of 'critical infrastructure' which the Strategy emphasizes should be improved to make it more disaster resilient and functional during emergencies. All new critical infrastructure should be disaster resilient, and the 'build back better' principle should be applied to infrastructure being repaired, reconstructed or replaced following damage. Extreme events related to climate change, as well as seismicity, are identified as key threats to critical infrastructure. Improvements to the national highways have substantial scope to support disaster resilience, and investments proposed under the HMP should by default be designed to withstand earthquakes as appropriate to the risk level, and new construction, upgrades and maintenance activities proposed should be climate-ready.
Draft Tourism Policy of the Kingdom of Bhutan (2019)	Tourism Council of Bhutan	To promote high-value, low-volume tourism to foster sustainable, competitive and inclusive growth to enhance the industry's contribution to nation-building,	Improvement of highway connectivity has strong potential for enabling more tourist visits to more locations in the country, and for more of the year, and

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		through regulations and management planning at the site level to prevent unsustainable tourism from developing; positioning tourism in development policies and plans; developing governance frameworks and institutional frameworks; enabling investment; development of procedures, guidelines and standards to ensure tourism enterprises support the country's favored tourism model; branding, marketing and product positioning; assessing and addressing skills gaps; building necessary partnerships and collaborations; and ensuring that tourism is inclusive and integrated, and sensitive to the country's culture, society and interests of host communities.	thus there will be positive synergy between the HMP and the Tourism Policy. In some particular contexts, increased traffic volumes, as well as poorly planned new alignments, can degrade landscape and site-level aesthetic values important to tourism, and it will be important for the HMP to avoid creating unacceptable impacts in this regard.
Economic Development Policy (2016)	Royal Government of Bhutan	To facilitate and stimulate economic growth, with twin objectives of economic self-reliance and full employment, to be pursued through policy reforms organized around eight strategies: promoting the 'five jewels' (hydropower, tourism, cottage and small industries, mining and agriculture); diversifying the economic base; harnessing and adding value to natural resources in a sustainable manner; increasing and diversifying exports; promoting Bhutan as an organic brand; promoting industries that build the Brand Bhutan image; reducing dependency on fossil fuels; and promoting industries through a cluster effect and championing approach.	The Economic Development Policy notes explicitly the need to lower road transport distance and costs to support economic development, and indicates this shall be achieved through widening existing highways and building new highways, tunnels and bypasses. The HMP will thus have a positive synergy with the Economic Development Policy.
Elephant Conservation Action Plan for Bhutan 2018-2028	Department of Forests and Park Services	To maintain a viable population of elephants through improved habitat and reduced conflict with humans, through the meeting of eight objectives, including preventing habitat loss and improving habitat condition; reducing human-elephant conflict through science-based and community-based approaches; expanding ecological research; improved coordination between stakeholders, including trans-boundary partners; strengthening processional institutional capacity for elephant protection and habitat management; research and management interventions on emergent elephant diseases; preventing poaching and illegal trade of elephant	The Action Plan Identifies linear infrastructure as a leading threat to elephants (associated habitat loss and degradation, as well as interruption of migration routes), and specifically mentions the southern E-W Highway as a threat, noting that it would be in the main elephant habitat zone and would run perpendicular to elephant migration routes. Some new alignments to be considered under the HMP would be in areas that may qualify as critical habitat for Asian elephants. Invasive floral species are also noted as a significant modifier of elephant habitat, and proliferation of these is often facilitated by roads. There is significant potential for investments under the HMP to frustrate elephant conservation, and

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		parts; and improved management of captive elephants.	probably also significant scope for effective mitigation to be proactively built in from an early stage.
Food and Nutrition Security Policy of 2023	Ministry of Agriculture and Livestock	To strengthen Bhutan's food security by increasing domestic food production and processing through interventions aimed at rationalizing land use and sustainable production; augmenting the disaster and climate resilience of agriculture; agricultural research; enhancement of commercialization, value chains, processing and marketing logistics; promoting organic agriculture; adaptive use of agrobiodiversity; and interagency collaboration.	The principal relevance of roads to the Food and Nutrition Security Policy is that high transport costs and poor connectivity to domestic and export markets are recognized as constraints on expansion of agricultural production, leading to greater dependence on imported food. Improvement of the country's highway network should therefore logically lend some support to the aims of the Policy.
Golden Mahseer Conservation Action Plan for Bhutan 2022-2032	Department of Forests and Park Services	To conserve a viable population of Golden mahseer and sustain conservation benefits in the form of ecological services, through securing key habitats of the fish; increasing research and monitoring of populations, ecology and threats; promoting community-based high-end sport fishing enterprise linked to conservation; and education and outreach.	Golden mahseer is present in most of Bhutan's larger rivers up to about 1,000 masl, and water quality impacts from river-proximate highways development in select locations may have some potential to affect water quality. However, direct exposure of highways to rivers is quite low, except at a relatively small number of crossings. Investments under the HMP are unlikely to significantly affect the success of the Action Plan, although strong mitigation to protect water quality during construction should be stipulated as a matter of course for any new river-proximate alignments.
Kingdom of Bhutan First National Adaptation Plan 2023	Department of Environment and Climate Change	To protect the health, lives, livelihoods and happiness of the people of Bhutan from the diverse impacts of climate change by building adaptive capacity and enhancing resilience to reduce vulnerability and by integrating adaptation actions into the development planning process at all levels. Adaptation priorities are identified across seven sectors, including Water; Agriculture and Livestock; Forests and Biodiversity; Human Settlements & Climate Smart Cities; Health; Energy; and Climate Services and Disaster Risk Reduction.	The National Adaptation Plan identifies 'Construct climate resilient road infrastructure' as one of the priorities under the Human Settlements & Climate Smart Cities sector, recommending such actions as implementation of flood/landslide resilient infrastructure designed to accommodate expected precipitation increases, and exploring potential for tunnelling to bypass landslide prone areas. The cost estimates appended to the Plan indicate that constructing and maintaining climate resilient road infrastructure is expected to be by far the most expensive priority to implement, accounting for 93% of the USD 14 billion total cost estimate for the Plan. There is thus substantial scope for the HMP to support this aspect of the National Adaptation Plan, and development and maintenance investments

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
			proposed under the HMP should be planned and designed accordingly to maximize the synergy.
Low Emission Development Strategy (LEDS) – Surface Transport (2021)	Ministry of Information and Communication	To contribute to national efforts to reduce GHG emissions, ultimately helping the country to meet its carbon neutrality commitment under the Paris Agreement, through short-, medium- and long-term interventions promoting mass transit options, enhanced public transport, shared mobility, non-motorized transport, electric vehicles, phase-out of internal combustion vehicles, limitation of vehicle imports, and freight management.	The HMP may have some scope for facilitating the implementation of some of the measures foreseen under the LEDS, for example by making provision for supporting infrastructure like charging stations and non-motorized vehicle lanes, and articulating investments in highways with freight hub development plans.
Mineral Development Policy (2017)	Department of Geology and Mines	To maximize wealth creation in the Bhutanese economy through the supply of mineral resources and generation of employment in mining and mineral processing.	There is minor potential for intersection between the Mineral Development Policy and the HMP. The only mention of roads in the Policy are stipulations that mine leaseholders shall be responsible for sharing with the relevant authority the cost of maintenance of existing roads used for mine access, and for repair of damage caused to existing roads by mine operations, including hauling. This may be applicable to projection of maintenance costs for some road segments targeted for investment in the Maintenance Plan portion of the HMP. In general, it may be expected that improving the highway network may lower cost-to-market for mine outputs, and that new alignments may open up new mineral access opportunities, both of which may be seen as supporting the goals of the Policy.
National Action Plan to Combat Land Degradation (2014)	Department of Agriculture	The Action Plan was formulated as part of Bhutan's commitments under the United Nations Convention to Combat Desertification, and is a high-level, multi-sector attempt to prevent and mitigate land degradation and its impacts through systems and practices of sustainable land management, through achievement of five specific objectives: (1) conservation, rehabilitation and sustainable use of forest resources to maintain well-functioning forest landscapes and watersheds; (2) development and promotion of sustainable agricultural practices that enhance local livelihoods whilst maintaining the productivity and stability of agricultural lands; (3)	The main potential for interaction between the HMP and the Action Plan is considered under the third objective of the Action Plan. Construction of roads is identified as one of the factors contributing to land degradation in Bhutan, mostly in relation to improper construction practices, but also poor design decisions that exacerbate slope stability problems and lead to recurrent erosion and road failures that degrade water quality and road-proximate forests and agricultural areas (farm roads are singled out as the most problematic road class in these regards). Measures proposed to address road-related land degradation relate mostly to implementation of the

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		integration of environmental management measures in development activities that pose significant risks of land degradation; (4) strengthening of systemic and institutional capacity to combat land degradation and its impacts; and (5) information, advocacy and education to create increased policy ad public support for sustainable land management.	Environmentally Friendly Road Construction (EFRC) Guidelines developed and adopted by the Department of Roads. Accordingly, road investments proposed under the HMP should align with the EFRC guidelines as a matter of course, in order to maximize positive synergy between the HMP and the Action Plan.
National Biodiversity Strategies and Action Plan of Bhutan (2014)	National Biodiversity Center	To ensure that biodiversity is valued, conserved and sustainably used to provide essential ecosystem services for the economic, environmental and social well being of present and future generations, through achievement of targets in 20 substantive areas, including education and awareness-raising; establishment of a system for valuation of biodiversity and environmental services; removal of harmful incentives and enhancement of positive incentives; adoption by stakeholders of principles of sustainable production and consumption; mapping, documentation and monitoring of biodiversity resources; reduction of overall loss and fragmentation; institution of sustainable management practices on forest and agricultural land; reduction of pollution from agro-chemicals and other sources; rehabilitation of degraded landscapes; and enhancing the management effectiveness and financial stability of the protected area system.	Improving the national highway network will have some potential to drive biodiversity losses, and thus may run counter to the goals of the Action Plan if not effectively managed; in particular, increasing traffic volume and speed, as well as widening and development of new alignments, will tend to promote habitat fragmentation, which the Action Plan expressly aims to reduce.
National Environment Strategy 2020-2030	National Environment Commission	The purpose of the National Environment Strategy is to implement a unified cross-sector approach to regulate environmental impacts and promote the country's sustainable development. The Strategy specifies 31 strategic objectives, spread across four broad sectors: Land, Air, Water, and Life. The Strategy is a high-level document cross-referenced to existing laws and policies in relevant sectors.	Strategic Objective 4 of the National Environment Strategy is to promote environmentally friendly roads and infrastructure, by designing roads and bridges for climate resilience, reinforcing existing infrastructure for new climate realities, ensuring that new alignments do not impinge on ecologically sensitive areas and cultural heritage sites, and using a range of mitigation measures during construction and repair works to minimize impacts. This is the principal intersection with the HMP. The investments proposed under the HMP should align with Strategic Objective 4, and this should be assessed and promoted by the SEA.

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
National Forest Policy (2009)	Department of Forests and Park Services	To ensure that Bhutan's forests and biodiversity are managed sustainably to produce a wide range of social, economic and environmental goods and services for the equitable benefit of all citizens and the natural environment while still maintaining a minimum of 60% of the land under forest cover, thereby contributing to Gross National Happiness. Key policy objectives include managing forests and plantations for sustainable production; strengthening and managing a network of protected areas and biological corridors as well as management of other parts of the landscape for positive environmental outcomes; providing for effective watershed management; empowering communities to manage and benefit from forests in sustainable ways (social forestry); facilitate plantation development on private land; and support value-added processing and marketing of forest products.	The Forest Policy does not directly mention the role of roads in supporting development of a sustainable forest industry, but improved highway connectivity should be expected to lower transport costs for forest products, thereby supporting multiple aspects of the policy. The role of road access in enabling unsustainable extraction in new areas (most notably with new alignments and especially 'last mile' local roads is not acknowledged in the Forest Policy, but this is worthy of consideration in the SEA, particularly in the context of new highway alignments in previously less accessible areas.
National Integrated Water Resources Plan (2016)	Department of Water	The National Integrated Water Resources Plan is a high-level coordinative plan whose overall goal is to establish the framework and priorities for the implementation of integrated water resources management in Bhutan.	The Plan identifies roads as a source of suspended sediment, primarily in the context of landslides triggered by road cuts, especially on farm roads. Although the Plan does not include any proposed actions relating to road infrastructure, it does note that the Department of Roads has methods at its disposal to lessen slide and erosion risk, and by extension the potential for deleterious effects of road-derived sediment on water quality. To the extent that these tools are incorporated in investments proposed under the HMP, the HMP can support the goal of the Plan. In general, new roads proposed under the HMP should be designed so as to limit exposure to rivers, as river-proximity increases the risk of siltation and operation-phase contamination risks from roads, which would run counter to the aims of the Plan.
National Waste Management Strategy (2019)	Department of Environment and Climate Change	To promote and move towards a 'zero waste' status by 2030, by pursuing several objectives, including: inculcating a deeper sense of environmental responsibility by consuming less material; reduction of waste generation from goods and services; effective integrated management of waste to ensure maximum material recovery and minimize the	The HMP is unlikely to have any significant intersection with the National Waste Management Strategy, although waste generation is an acknowledged direct impact of road construction and maintenance activity, and increasing waste from certain sectors such as tourism and industry may be indirectly enabled by improvement of the highway

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		quantity of waste to be disposed; promoting participation of all stakeholders in waste management to achieve targets set for material recovery; improving waste management delivery; and ensuring proper treatment of all types of waste.	network. The SEA should nevertheless take account of the Strategy in development of the SESMP.
Red Panda Conservation Action Plan for Bhutan 2018-2023	Department of Forests and Park Services	To promote a viable population of Red pandas by strengthening panda conservation programs and restoring habitat through a landscape management approach. Five key objectives are to: restore and manage critical Red panda habitats within and outside protected areas; research on Red panda ecology; education to raise awareness of the Red panda and its significance; maintain zero poaching and trafficking of the species within Bhutan including trans-boundary activity; and transboundary collaboration to ensure functional landscapes at regional scale.	Red pandas are distributed mainly across the mid-latitude belt of Bhutan, so interactions with the highways system are most relevant in the more northerly portions of the network. As with other species conservation plans, the principal threat from roads is likely to be habitat fragmentation, while facilitation of anti-poaching patrols may be a positive effect of roads. Road mortality is not mentioned in the Action Plan as a significant threat to red pandas, and the generally low speed and volume of traffic on most of the country's highways may explain this.
Renewable Natural Resource Marketing Strategy (2021)	Department of Agricultural Marketing and Cooperatives	To support food security development, economic development, employment generation and policy decision making, through achievement of six objectives: (1) support RMR market development, trade facilitation and investment planning; (2) facilitate access to international and domestic markets; (3) promote clarity in the roles and responsibilities of agencies in RNR marketing; (4) promote ease of doing business in the RNR sector; (5) empower producers, buyers and traders with market information; and (6) enhance supply chain management.	The RNR Marketing Strategy clearly identifies the general of road transport in mountainous terrain and low reliability of roads especially during the main growing season as significant constraints on the successful development of both urban domestic and export marketing of agricultural produce. Road transport costs are high, travel times to market are long, leading to poor competitiveness at market, spoilage enroute, and low interest of consolidators. The Strategy proposes some non-road workarounds for this central problem, but clearly a faster and more reliable highway network would make a substantial difference to the feasibility of the proposed measures. The HMP is likely to lend substantial support to the Strategy's aims.
Renewable Natural Resources Strategy 2040 (2021)	Department of Agriculture, Department of Agricultural Marketing and Cooperatives, Department of Livestock, Department	To create enabling policy, technology, and value-chain to ensure sustainable environment and food security, through 11 strategies: (1) enhance production and quality of renewable natural resource (RNR) commodities; (2) enhance contribution of RNR sector to national economy; (3) accelerate agri-business development and expansion; (4) develop enabling policies for RNR sector; (5) strengthen	The RNR Strategy surprisingly makes very little mention of road transportation or transport costs as a possible constraint on the further development of the sector. In the analysis presented, loss of scarce agricultural land to infrastructure development is mentioned, though not quantified or assigned any significance, and roads are not specifically called out for this. Under Strategy 11, the importance of climate-

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
	of Forests and Park Services	research, innovation and dissemination; (6) institute efficient RNR service delivery; (7) enhance production efficiency of RNR commodities; (8) promote research and innovation; (9) diversify sustainable financing for RNR sector development; (10) mainstream sustainable management of natural resources; and (11) enhance and promote resilience to climate change impacts and low-emission development.	resilient roads is something to be favored, but no specific investments are suggested. Despite the lack of attention to roads, it is safe to assume that improving the highways network should help to lower transport costs for both input and produce, and the HMP will thus be inherently favorable for the RNR sector in that sense. There is substantial scope for the HMP to support the Strategy 4 recommendation for climate-resilient roads, and development and maintenance investments proposed under the HMP should be planned and designed to maximize this synergy.
Road Sector Master Plan 2007–2027	Department of Surface Transport	Developed to be implemented beginning under the 10th Five-Year Plan, the Road Sector Master Plan was intended as an initial screening of potential road projects at a level of detail appropriate to strategic planning. The Plan includes road network expansion, road realignment, tunneling, roads for inter-dzongkhag connectivity, and completion of the second east-west highway. As of 2024, a number of the projects proposed under the Plan have been completed or are underway.	The HMP will essentially continue and expand upon the work laid out in the Road Sector Master Plan.
Thirteenth Five-Year Plan (pending 2024)	Royal Government of Bhutan	At the time of writing, the 13th Five-Year Plan had been drafted, but remained under review by the incoming government elected in January 2024, and had yet to be publicly released. The published pre-election policy agenda of the victorious PDP suggests that the 13th Five-Year Plan will generally echo the highway-related measures mandated in previous Five-Year Plans and the Road Sector Master Plan 2007-2027, and focus on completion of the Southern East-West Highway, filling certain key gaps in the national highways network, improvement of inter-dzongkhag connectivity, and exploration of feasible travel time reductions through widening, tunneling and bypasses.	Formulation of the HMP will aim to align with the 13th Five-Year Plan's highways-related priorities.
Tiger Action Plan for Bhutan 2018-2023	Department of Forests and Park Services	To achieve and maintain a viable population of tigers and their prey, coexisting in harmony with humans in an interconnected landscape, increasing the tiger population in Bhutan by 20% by 2022 relative to the	In some contexts, roads have significant potential to support anti-poaching activity, so the HMP may have some positive synergy with the Action Plan. On the other hand, roads can lead to habitat fragmentation,

PPP	Responsible Entity	Key Aims	Potential for Interaction with HMP
		2015 baseline of 103 tigers. Four objectives are named: reduction of poaching by 90% though enhanced patrolling; habitat improvement and management through enrichment plantations, provision of salt licks and waterholes, and rehabilitation of grasslands and abandoned grazing land; enhanced prevention of human-tiger conflict through education, improved livelihood opportunities and fencing; and research on the ecology, movements and health of tigers.	with effects on both carnivores and their prey. At least some of the new alignments to be considered for inclusion in the HMP would be located in areas almost certain to qualify as critical habitat for tigers. Analysis of threats and opportunities for synergy is warranted.
White-Bellied Heron Conservation Action Plan 2022-2031	Department of Forests and Park Services and Royal Society for Protection of Nature	To achieve and maintain a viable population of the critically endangered White-bellied heron in the healthy riverine systems of Bhutan, through mapping and assessment of suitable habitat; research on ecology, biology, and behavior; habitat protection and restoration; mitigation of disturbance; monitoring and surveillance; community-based livelihood and stewardship programs; and captive breeding.	White-bellied herons are closely associated with rivers running through forest, and the known range of the species within Bhutan is limited to the lower reaches of certain large rivers. The highway network has limited exposure to such habitats, as roads are mostly built on mountain slopes even where they parallel rivers. Where new alignments or improved highways cross significant rivers, there is some potential for disturbance of White-bellied heron, especially during construction, but also as a result of increased human presence during operation. White-bellied herons are notoriously sensitive to disturbance, and may stop using habitat where disturbance (such as by vehicles, construction equipment, picnickers and passersby is frequent. This critically endangered bird's sensitivity should be considered in the SEA in relation to river-proximate road corridors, which are likely to qualify as critical habitat for the species.

Appendix 2 – SEA Scoping Workshop Agenda

TA-6916 BHU: Bhutan National Highways Connectivity Master Plan

Strategic Environmental Assessment Scoping Workshop
Wednesday, 14 March 2024

AGENDA

Begin–End	Topic	Presenter/Facilitator
9:00 am - 9:15 am	Arrival and Registration	
9:15 am – 9:20 am	Welcoming Remarks	DG, DoST
9:20 am – 9:25 am	Workshop Overview	Simeon Stairs/Karma Chogyel
9:25 am – 10:15am	Introduction of TA-6916 and Highways Master Plan	Janusz Sobieniak
10:15 am – 10:30 am	SEA Process and SEA Scoping	Simeon Stairs
10:30 am – 10:45 am	TEA BREAK	
10:45 am – 11:15 am	Initial Scoping (Findings)	Simeon Stairs
11:15 am – 12:30 pm	Structured Discussion of Initial Scoping Findings	Simeon Stairs/Karma Chogyel
12:30 pm - 12:40 pm	Summing Up and Next Steps	Simeon Stairs
12:40 pm – 12:45 pm	Concluding Remarks	Sonam Choden, DoST
12:45 pm – 1:30 pm	LUNCH	

Master of Ceremonies: Sonam Choden, Dy. EE, DoST

Appendix 3 SEA Scoping Workshop Attendance List

	Name	Position	Entity	On-site	Remote
1	Arun Rai	Principal Forestry Officer	Forest Monitoring and Information Division, DoFPS	x	
2	BB Rai		Dept. of Agriculture	x	
3	Cheki Wangchuk	Exectuive Engineer	Construction Division, DoST	x	
4	Choku Wangchuk	Sr. Dzongrab	Samtse Dzongkhag		x
5	Chosang Doma	Architect	Dept. of Culture and Dzongkha Development	x	
6	Dorji Duba	Dzongrab	Trashigang Dzongkhag		x
7	Jamyang Dorji	Chief Dzongkhag Engineer	Dagana Dzongkhag		x
8	Jamyang Zangpo	Sr. Hydrology/ Meteorology Officer	National Centre for Hydrology and Meteorology	x	
9	Jigme Dorji	Deputy Executive Engineer	Bridge Division, DoST	x	
10	Jigme Namgyel	Dasho Dzongda	Gasa Dzongkhag		x
11	Karchen Dorji	Dy. Environment Officer	Dept. of Industry, MoICE	x	
12	Karma Tenzin		WWF-Bhutan	x	
13	Kencho Wangdi	Assistant Engineer -II	Sarpang Dzongkhag		x
14	Kezang Wangdi	Engineer	Design & Geotech Division, DoST	x	
15	Kintu	Chief Dzongkhag Engineer	Tsirang Dzongkhag		x
16	Kinzang Namgay		Department of Water	x	
17	Kinzang Namgyel	Engineer	Construction Division, DoST	x	
18	Krishna Subba	Chief Program Officer	JICA Bhutan Office		x
19	Leela Devi Ghalley	Engineer	Maintenance Division, DoST	x	
20	Lekjay	Chief Dzongkhag Engineer	Chhukha Dzongkhag		x
21	Lotay Tenzin	Offtg. Chief Engineer	Mtc. Division, DoST	x	
22	Luv Kumar Chhetri	Chief Dzongkhag Engineer	Zhemgang Dzongkhag		x
23	Major Kencho Tshering	OC	Traffic Division, RBP		x
24	Nakchung	Chief Dzongkhag Engineer	Haa Dzongkhag		x
25	Namgay Tshering	Assistant Engineer I	Samtse Dzongkhag		x
26	Namgyel Wangdi	Sr. Program Officer	Bhutan Ecological Society		x
27	Nidup Tshering	Engineer	Regional Engineering Cluster		x
28	Nima Wangdi	Officiating DE	Trashiyangtse Dzongkhag		x
29	Nima Wangdi	Exectuive Engineer	Trashiyangtse Dzongkhag		x
30	Pema Zangmo	Engineer	Thimphu Dzongkhag		x
31	Phub Dem	Specialist/Advisor	Dept of Agricultural Marketing and Cooperatives		x

	Name	Position	Entity	On-site	Remote
32	Phub Rinzin	Dasho Dzongda	Wangdue Phodrang Dzongkhag		x
33	Pratik Bhattarai	Mining Engineer	MPCD, Dept. of Geology and Mines	x	
34	Rinchen Dorji	Engineer	Bridge Division, DoST	x	
35	Rinchen Lhazom	Offtg. DG	Department of Trade	x	
36	Rinchen Tshering		Paro Dzongkhag		x
37	Samten Norbu	Engineer	Samtse Dzongkhag		x
38	Sandeep Chhetri	Assistant Engineer	Dagana Dzongkhag		x
39	Sher Bdr. Gurung	Officiating DE	Lhuentse Dzongkhag		x
40	Sherab Lhamo		Construction Association of Bhutan	x	
41	Sherab Tenzin	Chief Dzongkhag Engineer	Mongar Dzobgkhag		x
42	Shri Kumar Gaurav	Assistant Executive Engineer	Project Dantak	x	
43	Singye Wangchuk		Dept of Environment and Climate Change, MoENR		x
44	Sonam	Dasho Dzongda	Tsirang Dzongkhag		x
45	Sonam Choden	Deputy Executive Engineer	DGD, Department of Surface Transport	x	
46	Sonam Rinzin	Project Technical Specialist	UNDP Bhutan	x	
47	Sonam Tobgay	Officiating Chief DE	Samdrup Jongkhar Dzongkhag		x
48	Sonam Wangmo		Transport & Railways Division, DoST	x	
49	Tashi Tenzin	Principal Engineer	Mtc. Division, DoST	x	
50	Tashi Tobgay	Dasho Dzongda	Dagana Dzongkhag		x
51	Tashi Tsheten	Engineer	Pemagatshel Dzongkhag		x
52	Tenzin	Director General	Department of Surface Transport	x	
53	Tenzin Dorji	Assistant Regional Transport Officer	BCTA, MoIT	x	
54	Tharchen	Chief Dzongkhag Engineer	Trongsa Dzongkhag		x
55	Tshering Choden	Research Officer	Bhutan Chamber of Commerce and Industry	x	
56	Tshering Pelden	Sr. Urban Planner	Dept. of Human Settlement, MoIT	x	
57	Tsheten Dorji		RSPN	x	
58	Tshewang Penjore	Offtg. CDE	Bumthang Dzongkhag		x
59	Tula Maya Adhikari		Dept of Infrastructure and Transport, MoIT	x	
				28	**31**

Appendix 4 – SEA Scoping Workshop Handout

TA-6916 BHU: Master Plan for National Highways Connectivity

Strategic Environmental Assessment Scoping Workshop

14 February 2024

HANDOUT FOR PARTICIPANTS

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

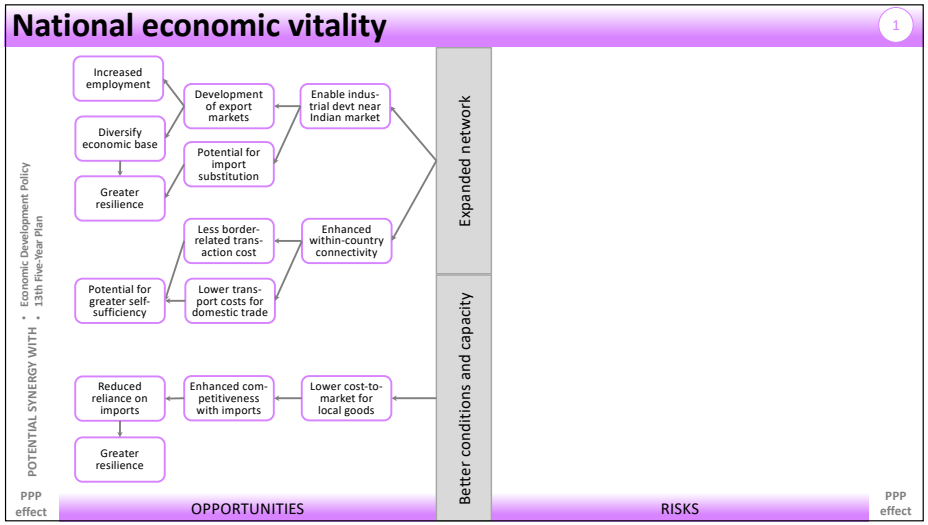
An Assignment for You

Make notes on your handouts as we go

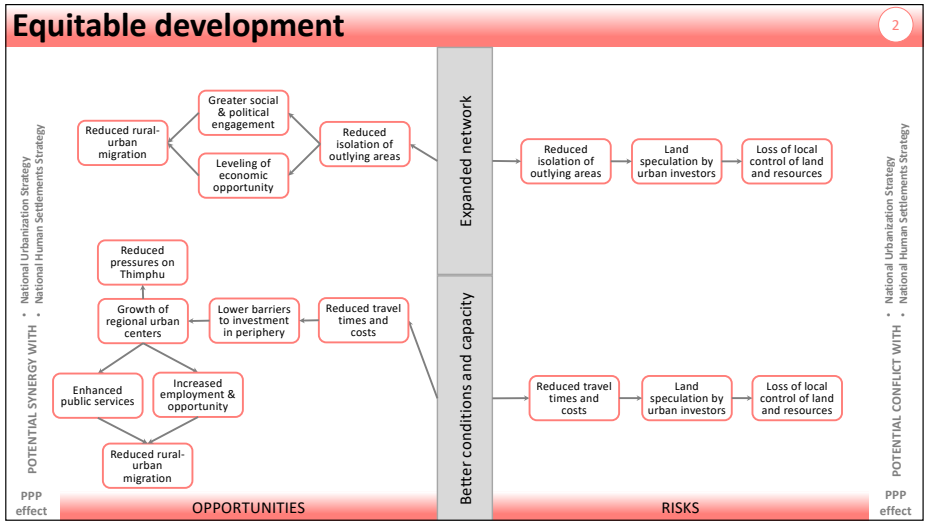
- Something important missing?
- Something you think deserves special attention?
- Something not particularly important in reality?
- Something not quite right?
- Something to suggest for further exploration?
- Something about which you have information to offer?

Flag it for discussion

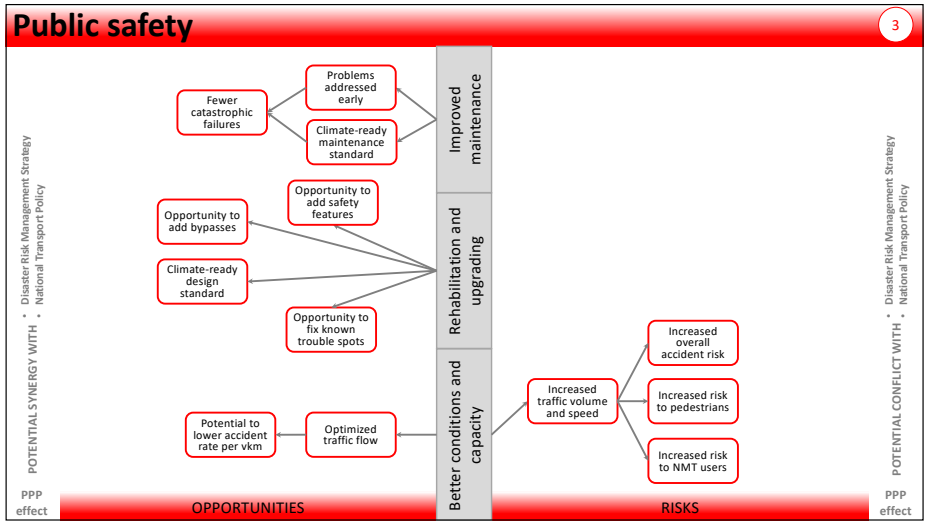
National economic vitality

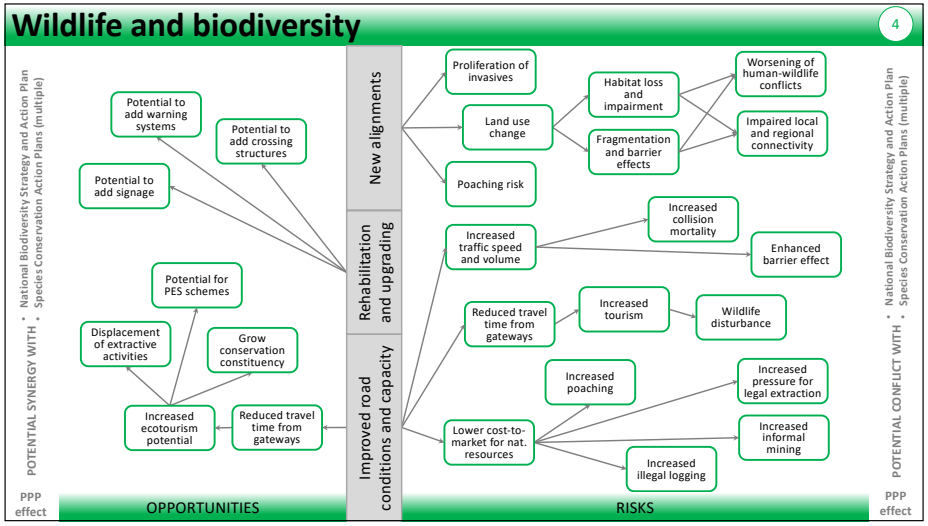


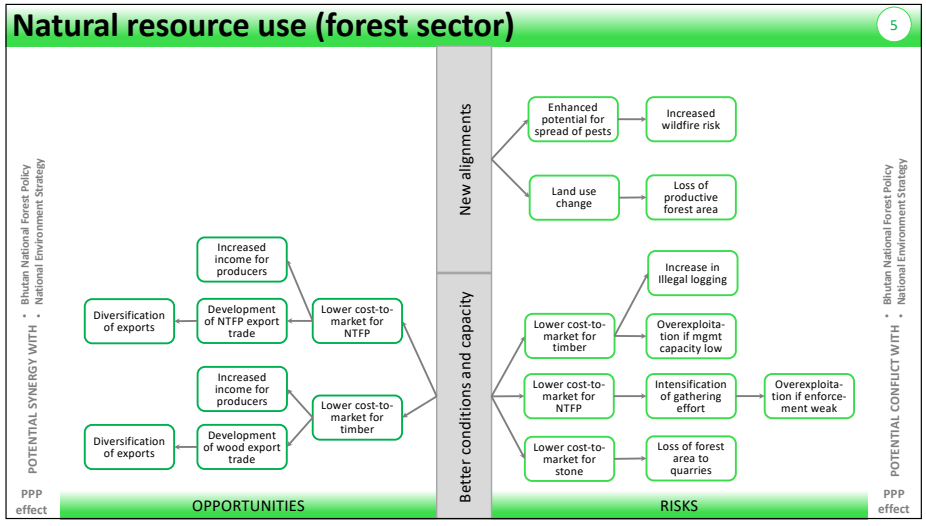
Equitable development

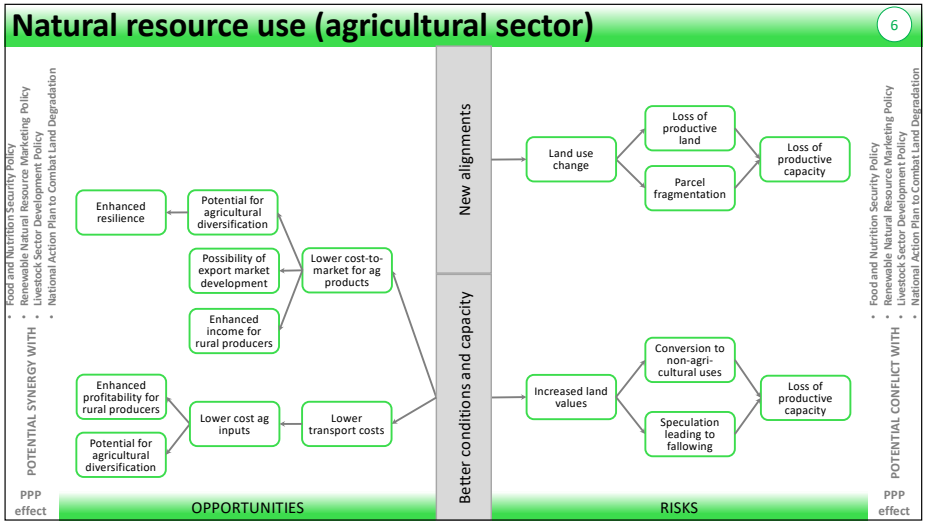


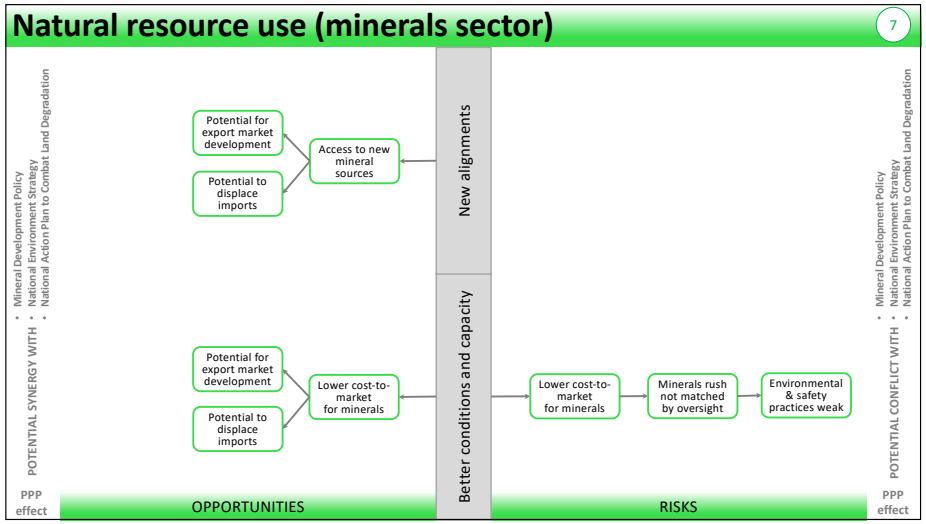
Public safety

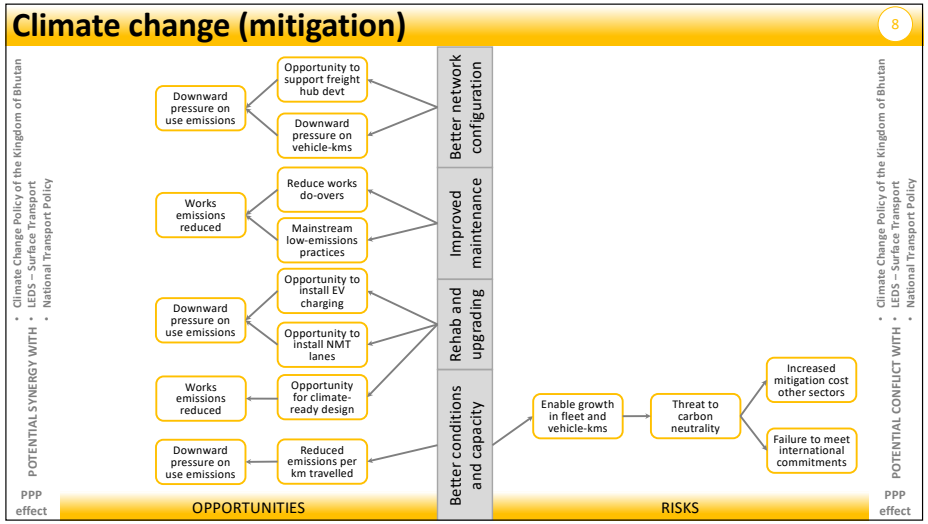


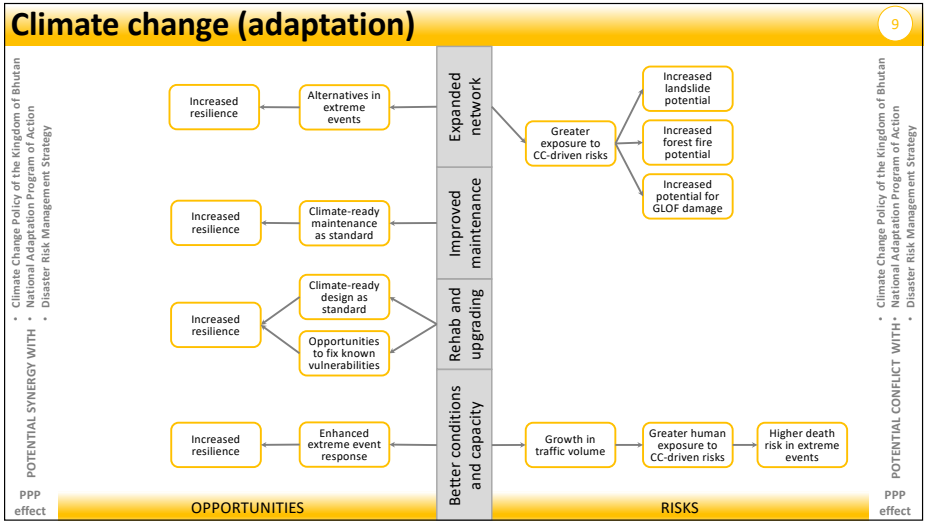

Wildlife and biodiversity
4
POTENTIAL SYNERGY WITH • National Biodiversity Strategy and Action Plan • Species Conservation Action Plans (multiple)
POTENTIAL CONFLICT WITH • National Biodiversity Strategy and Action Plan • Species Conservation Action Plans (multiple)
New alignments
Rehabilitation and upgrading
Improved road conditions and capacity
Potential to add warning systems
Potential to add crossing structures
Potential to add signage
Potential for PES schemes
Displacement of extractive activities
Grow conservation constituency
Increased ecotourism potential
Reduced travel time from gateways
Proliferation of invasives
Land use change
Poaching risk
Habitat loss and impairment
Fragmentation and barrier effects
Worsening of human-wildlife conflicts
Impaired local and regional connectivity
Increased traffic speed and volume
Increased collision mortality
Enhanced barrier effect
Reduced travel time from gateways
Increased tourism
Wildlife disturbance
Lower cost-to-market for nat. resources
Increased poaching
Increased pressure for legal extraction
Increased informal mining
Increased illegal logging
PPP effect
OPPORTUNITIES
RISKS
PPP effect

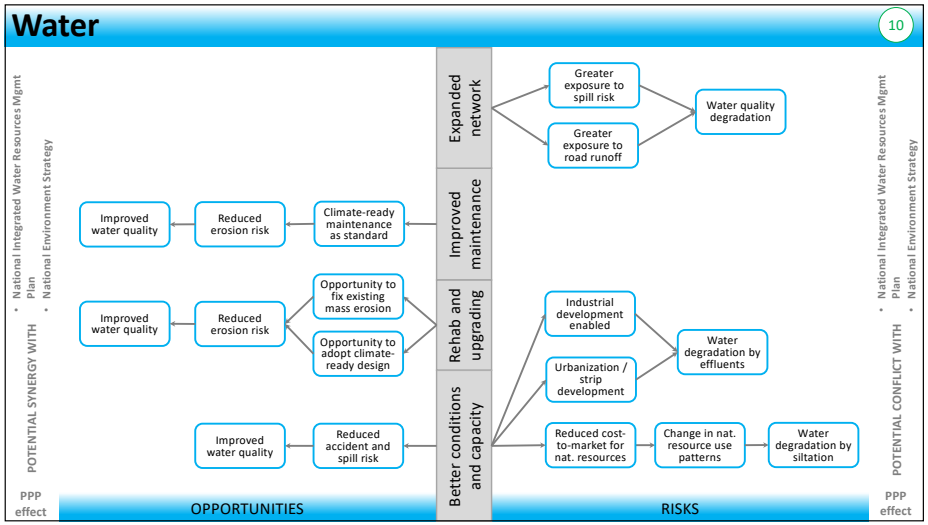

Natural resource use (forest sector)
5
POTENTIAL SYNERGY WITH • Bhutan National Forest Policy • National Environment Strategy
POTENTIAL CONFLICT WITH • Bhutan National Forest Policy • National Environment Strategy
New alignments
Better conditions and capacity
Increased income for producers
Diversification of exports
Development of NTFP export trade
Lower cost-to-market for NTFP
Increased income for producers
Diversification of exports
Development of wood export trade
Lower cost-to-market for timber
Enhanced potential for spread of pests
Increased wildfire risk
Land use change
Loss of productive forest area
Lower cost-to-market for timber
Increase in illegal logging
Overexploitation if mgmt capacity low
Lower cost-to-market for NTFP
Intensification of gathering effort
Overexploitation if enforcement weak
Lower cost-to-market for stone
Loss of forest area to quarries
PPP effect
OPPORTUNITIES
RISKS
PPP effect

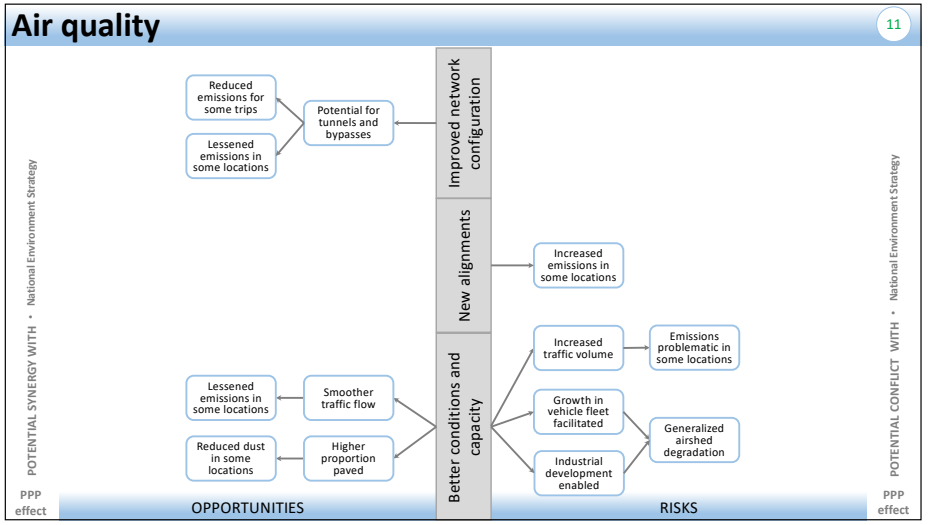

Natural resource use (agricultural sector)
6
POTENTIAL SYNERGY WITH • Food and Nutrition Security Policy • Renewable Natural Resource Marketing Policy • Livestock Sector Development Policy • National Action Plan to Combat Land Degradation
POTENTIAL CONFLICT WITH • Food and Nutrition Security Policy • Renewable Natural Resource Marketing Policy • Livestock Sector Development Policy • National Action Plan to Combat Land Degradation
New alignments
Better conditions and capacity
Enhanced resilience
Potential for agricultural diversification
Possibility of export market development
Enhanced income for rural producers
Lower cost-to-market for ag products
Enhanced profitability for rural producers
Potential for agricultural diversification
Lower cost ag inputs
Lower transport costs
Land use change
Loss of productive land
Parcel fragmentation
Loss of productive capacity
Increased land values
Conversion to non-agri-cultural uses
Speculation leading to fallowing
Loss of productive capacity
PPP effect
OPPORTUNITIES
RISKS
PPP effect

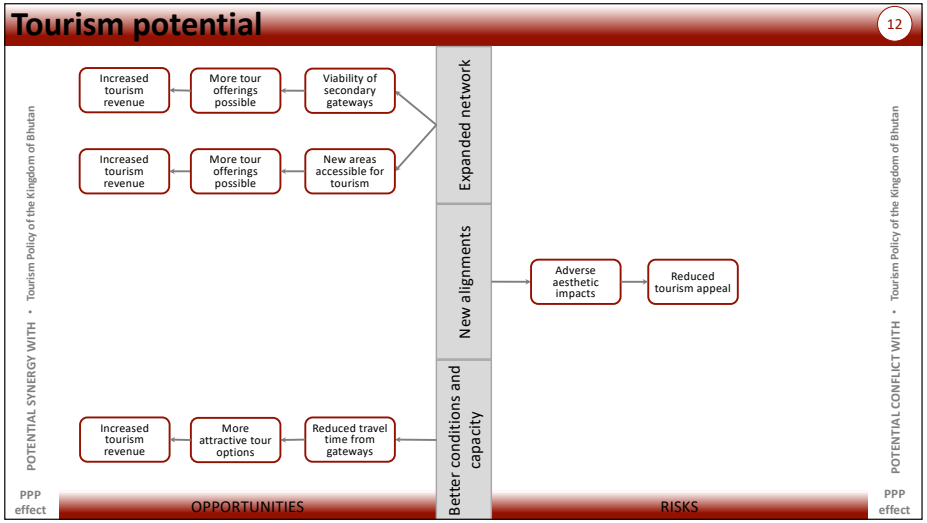

Natural resource use (minerals sector)
7
POTENTIAL SYNERGY WITH • Mineral Development Policy • National Environment Strategy • National Action Plan to Combat Land Degradation
POTENTIAL CONFLICT WITH • Mineral Development Policy • National Environment Strategy • National Action Plan to Combat Land Degradation
New alignments
Better conditions and capacity
Potential for export market development
Potential to displace imports
Access to new mineral sources
Potential for export market development
Potential to displace imports
Lower cost-to-market for minerals
Lower cost-to-market for minerals
Minerals rush not matched by oversight
Environmental & safety practices weak
PPP effect
OPPORTUNITIES
RISKS
PPP effect

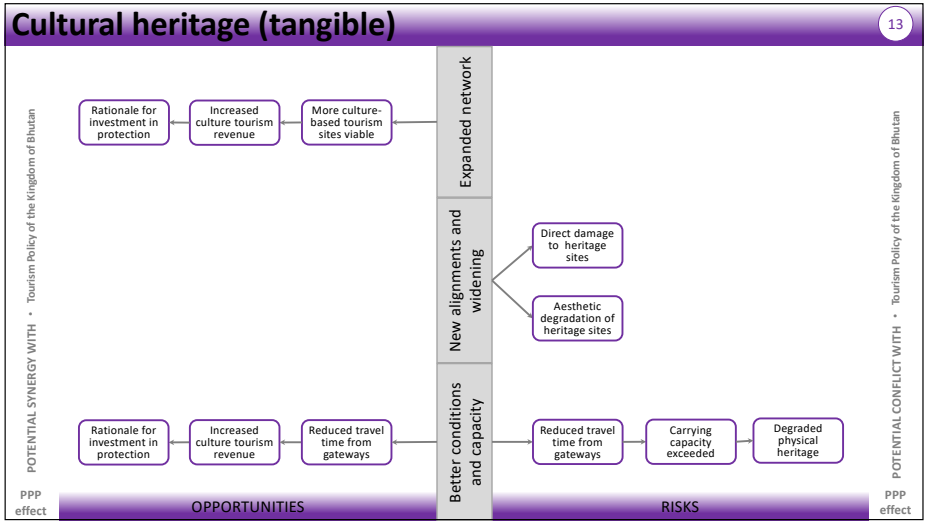

Climate change (mitigation)
8
POTENTIAL SYNERGY WITH
• Climate Change Policy of the Kingdom of Bhutan
• LEDS – Surface Transport
• National Transport Policy
Downward pressure on use emissions
Opportunity to support freight hub devt
Downward pressure on vehicle-kms
Works emissions reduced
Reduce works do-overs
Mainstream low-emissions practices
Downward pressure on use emissions
Opportunity to install EV charging
Opportunity to install NMT lanes
Works emissions reduced
Opportunity for climate-ready design
Downward pressure on use emissions
Reduced emissions per km travelled
Better network configuration
Improved maintenance
Rehab and upgrading
Better conditions and capacity
Enable growth in fleet and vehicle-kms
Threat to carbon neutrality
Increased mitigation cost other sectors
Failure to meet international commitments
POTENTIAL CONFLICT WITH
• Climate Change Policy of the Kingdom of Bhutan
• LEDS – Surface Transport
• National Transport Policy
PPP effect
OPPORTUNITIES
RISKS
PPP effect

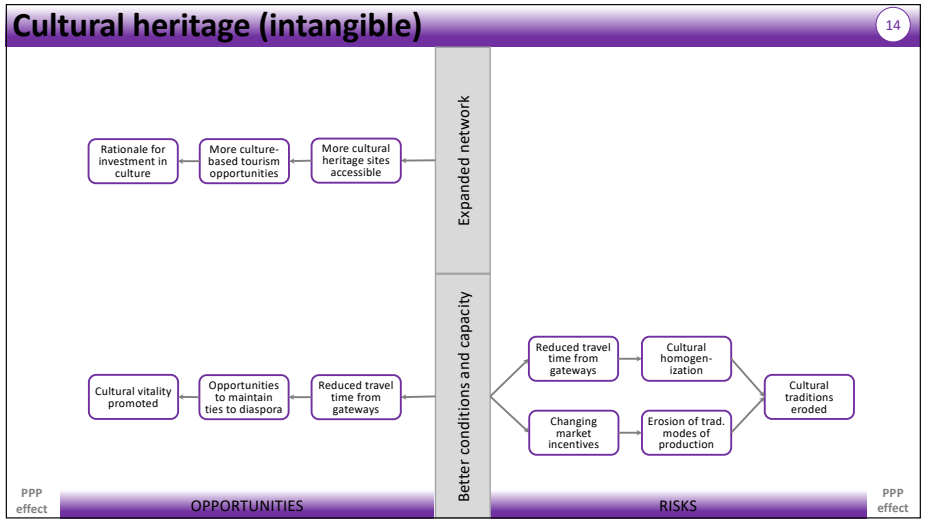

Climate change (adaptation)
9
POTENTIAL SYNERGY WITH
• Climate Change Policy of the Kingdom of Bhutan
• National Adaptation Program of Action
• Disaster Risk Management Strategy
Increased resilience
Alternatives in extreme events
Increased resilience
Climate-ready maintenance as standard
Increased resilience
Climate-ready design as standard
Opportunities to fix known vulnerabilities
Increased resilience
Enhanced extreme event response
Expanded network
Improved maintenance
Rehab and upgrading
Better conditions and capacity
Greater exposure to CC-driven risks
Increased landslide potential
Increased forest fire potential
Increased potential for GLOF damage
Growth in traffic volume
Greater human exposure to CC-driven risks
Higher death risk in extreme events
POTENTIAL CONFLICT WITH
• Climate Change Policy of the Kingdom of Bhutan
• National Adaptation Program of Action
• Disaster Risk Management Strategy
PPP effect
OPPORTUNITIES
RISKS
PPP effect

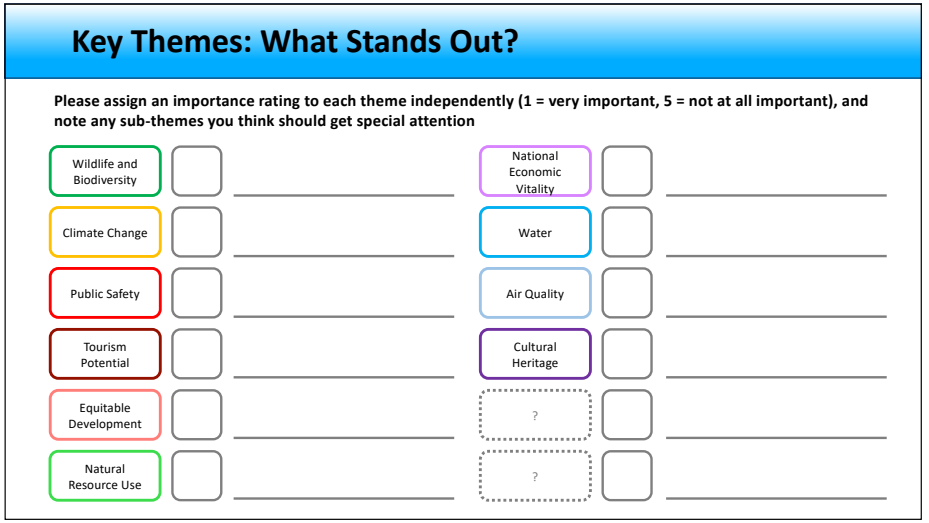

Water
10
POTENTIAL SYNERGY WITH
• National Integrated Water Resources Mgmt Plan
• National Environment Strategy
Improved water quality
Reduced erosion risk
Climate-ready maintenance as standard
Improved water quality
Reduced erosion risk
Opportunity to fix existing mass erosion
Opportunity to adopt climate-ready design
Improved water quality
Reduced accident and spill risk
Expanded network
Improved maintenance
Rehab and upgrading
Better conditions and capacity
Greater exposure to spill risk
Greater exposure to road runoff
Water quality degradation
Industrial development enabled
Urbanization / strip development
Water degradation by effluents
Reduced cost-to-market for nat. resources
Change in nat. resource use patterns
Water degradation by siltation
POTENTIAL CONFLICT WITH
• National Integrated Water Resources Mgmt Plan
• National Environment Strategy
PPP effect
OPPORTUNITIES
RISKS
PPP effect


Air quality
11
POTENTIAL SYNERGY WITH
• National Environment Strategy
Reduced emissions for some trips
Lessened emissions in some locations
Potential for tunnels and bypasses
Lessened emissions in some locations
Smoother traffic flow
Reduced dust in some locations
Higher proportion paved
Improved network configuration
New alignments
Better conditions and capacity
Increased emissions in some locations
Increased traffic volume
Emissions problematic in some locations
Growth in vehicle fleet facilitated
Generalized airshed degradation
Industrial development enabled
POTENTIAL CONFLICT WITH
• National Environment Strategy
PPP effect
OPPORTUNITIES
RISKS
PPP effect


Tourism potential
12
POTENTIAL SYNERGY WITH • Tourism Policy of the Kingdom of Bhutan
POTENTIAL CONFLICT WITH • Tourism Policy of the Kingdom of Bhutan
Increased tourism revenue
More tour offerings possible
Viability of secondary gateways
Increased tourism revenue
More tour offerings possible
New areas accessible for tourism
Increased tourism revenue
More attractive tour options
Reduced travel time from gateways
Expanded network
New alignments
Better conditions and capacity
Adverse aesthetic impacts
Reduced tourism appeal
PPP effect
OPPORTUNITIES
RISKS
PPP effect


Cultural heritage (tangible)
13
POTENTIAL SYNERGY WITH • Tourism Policy of the Kingdom of Bhutan
POTENTIAL CONFLICT WITH • Tourism Policy of the Kingdom of Bhutan
Rationale for investment in protection
Increased culture tourism revenue
More culture-based tourism sites viable
Rationale for investment in protection
Increased culture tourism revenue
Reduced travel time from gateways
Expanded network
New alignments and widening
Better conditions and capacity
Direct damage to heritage sites
Aesthetic degradation of heritage sites
Reduced travel time from gateways
Carrying capacity exceeded
Degraded physical heritage
PPP effect
OPPORTUNITIES
RISKS
PPP effect


Cultural heritage (intangible)
14
Rationale for investment in culture
More culture-based tourism opportunities
More cultural heritage sites accessible
Cultural vitality promoted
Opportunities to maintain ties to diaspora
Reduced travel time from gateways
Expanded network
Better conditions and capacity
Reduced travel time from gateways
Cultural homogen-ization
Changing market incentives
Erosion of trad. modes of production
Cultural traditions eroded
PPP effect
OPPORTUNITIES
RISKS
PPP effect


Key Themes: What Stands Out?
Please assign an importance rating to each theme independently (1 = very important, 5 = not at all important), and note any sub-themes you think should get special attention
Wildlife and Biodiversity
Climate Change
Public Safety
Tourism Potential
Equitable Development
Natural Resource Use
National Economic Vitality
Water
Air Quality
Cultural Heritage
?
?

Appendix 5 – Attendance List for Meeting at DoFPS

S.No	Name	Designation	Division under DoFPS	Email address
1	Sonam Wangdi	CFO	NCD	sonamwangdi@moenr.gov.bt
2	Kesang Droelkar Tshering	Principal Forestry Officer	FRPMD	kdtshering@moenr.gov.bt
3	Kinley Dem	CFO	FMID	kinleydem@moenr.gov.bt
4	Kencho Dukpa	Principal Forestry Officer	FRPMD	kenchodukpa@moenr.gov.bt
5	Lhab Tshering	Dy.CFO	FRPMD	lhabt@moenr.gov.bt
6	Karma Chorten Dhendup		FRPMD	karmachortendendup@gmail.com
7	Tashi Norbu Waiba		FRPMD	tashinorbuwaiba@moenr.gov.bt
8	Simeon Stairs	Consultant	DLA	simeon.stairs@gmail.com
9	Karma Chogyel	National counterpart	APECS	chogyelk@yahoo.com

1

Workshop objectives

Provide updated information

- Formulation of the Highways Master Plan
- Environmental and social analysis (SEA study)

Seek insights and feedback

- To feed into project evaluations and plan formulation
- To help enrich analysis of risks and opportunities
- To inform development of SEA study outputs

2

Outline

- Overview of TA-6916 and Highways Master Plan
- Objectives and scope of SEA Study
- Key SEA themes identified from SEA scoping process
- TEA BREAK
- Presentation and Discussion of Environmental and Social Analysis to Date
- Summing Up and Next Steps
- LUNCH

3

TA-6916 BHU: Master Plan for National Highways Connectivity

ADB

National Highways Master Plan

Presentation to SEA Workshop
14 October 2024

DLA MAXWELL STAMP LTD APECS

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

4

Overview of TA-6916 BHU

- Objective of TA-6916 BHU Technical Assistance
- TA activities
- Road surveys and maintenance operations
- Road network analysis
- Road network development candidates
- Progress in preparing the Development Plan for 2040
- Immediate Steps and Issues

5

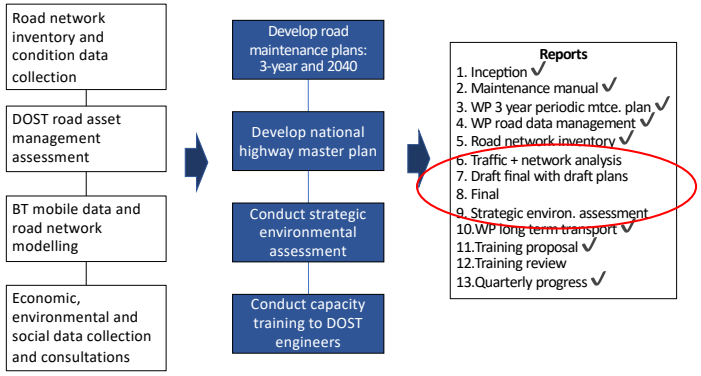
Objectives

The technical assistance (TA) will support Bhutan in:

1. Development of a National Highway master plan to 2040.
2. Development of a road maintenance plan to 2040 and an immediate periodic maintenance plan for three years.
3. Capacity building of DOST on transport planning and road asset management.

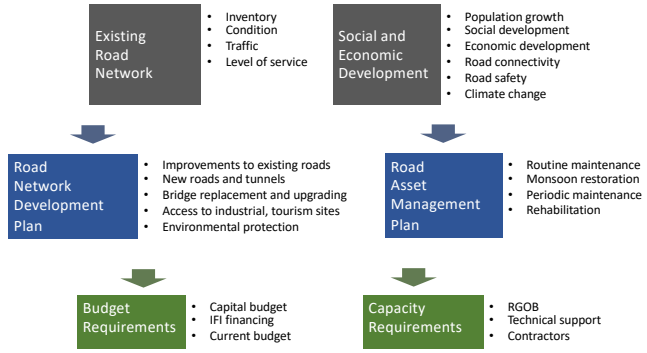
6

TA Activities



7

Preparing the 2040 Road Master Plan



8

Bhutan Road Network At a Glance

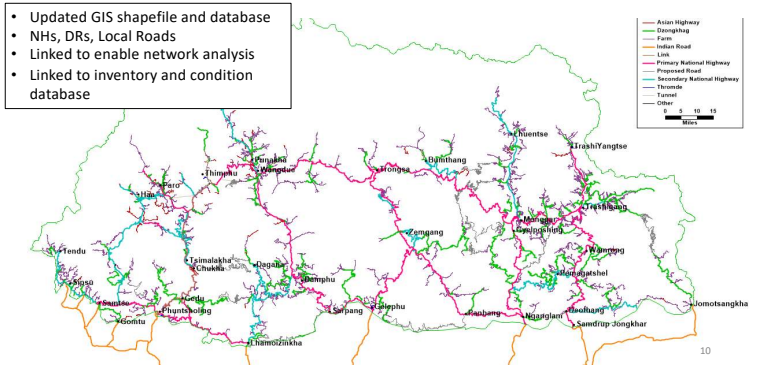
- MOIT
- DOST
- DANTAK
- Local Governments
- BCTA
- Traffic Police

Classification	Design-ation	Total Length km	Sealed km	Jurisdiction
Asian Highway	AH	141	141	DANTAK
Primary National Highway	PNH	1,646	1,646	DOST, DANTAK
Secondary National Highway	SNH	1,112	1,020	DOST, DANTAK
Dzongkhag Road	DR	1,948	1,732	DOST
Urban Road	UR	417	403	Thromdes
Farm Road	FR	11,257	151	Dzongkhags
Access Road	AR	1,677	456	Mixed
Total		**18,198**	**5,549**	

9

Current Road Network

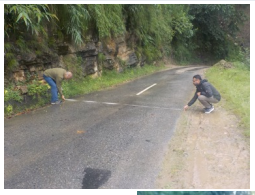
- Updated GIS shapefile and database
- NHs, DRs, Local Roads
- Linked to enable network analysis
- Linked to inventory and condition database



10

Dzongkhag Road Surveys

- 215 roads, 1948 km
- Start-end points
- Connection to NH network
- Road track and length
- Road inventory
  - Pavement
  - Roughness
  - Drainage
  - Bridges
  - Protective works
  - Road furniture



11

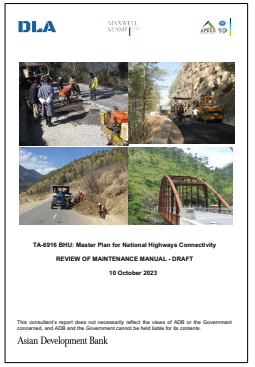
Road Maintenance

Maintenance Plans

- 3 year periodic maintenance plan
- 2040 maintenance plan

Highway Development and Management (HDM-4)

- Maintenance strategic planning and programming
- Project economic evaluation
- 2 licences and training to DOST staff


DLA

TA-6916 BHU: Master Plan for National Highways Connectivity

REVIEW OF MAINTENANCE MANUAL - DRAFT

10 October 2023

This consultant's report does not necessarily reflect the views of ADB or the Government concerned, and ADB and the Government cannot be held liable for its contents.

Asian Development Bank

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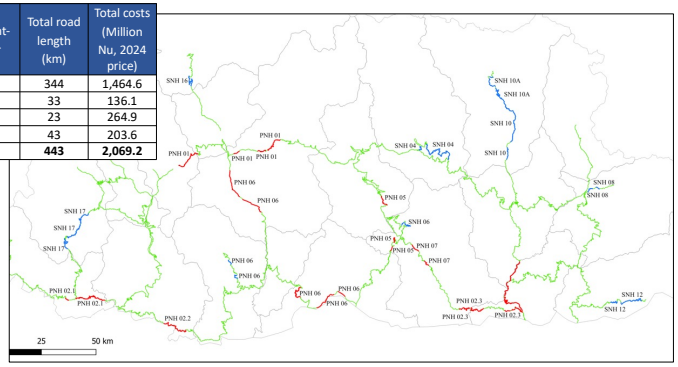
3 Year Periodic Maintenance Plan

Implement-ation Year	Total road length (km)	Total costs (Million Nu, 2024 price)
1-2026	344	1,464.6
2-2027	33	136.1
3-2028	23	264.9
4-2029	43	203.6
Total	**443**	**2,069.2**



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2040 Maintenance Plan

Data Collection
- Detailed inventory and condition survey at sample locations
- Traffic surveys
- Axle load surveys

Strategic Analysis of Network Requirements
- HDM-4 model of network and traffic
- Unconstrained budget requirements
- Constrained budget plan

Include 2040 Network Plan
- Additional road links
- Improved road links
- Additional slope protection and road furniture

2040 Maintenance Plan
- Performance targets
- Annual budget requirement
- Periodic maintenance protocol

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Road Network Traffic Modelling

Bhutan Telecom:
- Mobile phone data to identify origins-destinations of person trips

TransCAD road network model:
- GIS-based road network analysis
- Traffic assignment and what-if analysis of network improvements (new links, bypasses, tunnels, increased capacity)

Other transport modes:
- Proposed waterways, ropeways and railway connections

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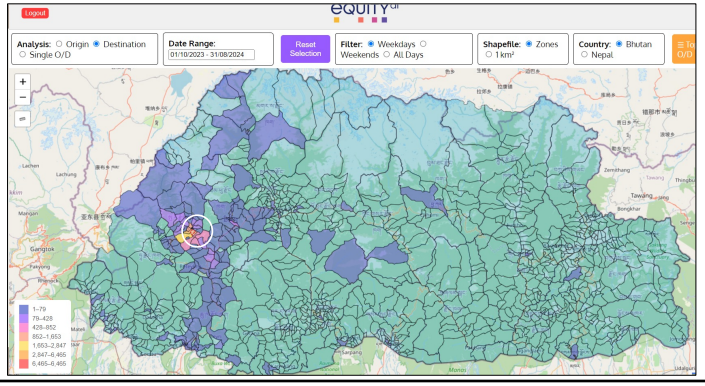
Example: Trip Destinations from Dungar Namkar Chiwog



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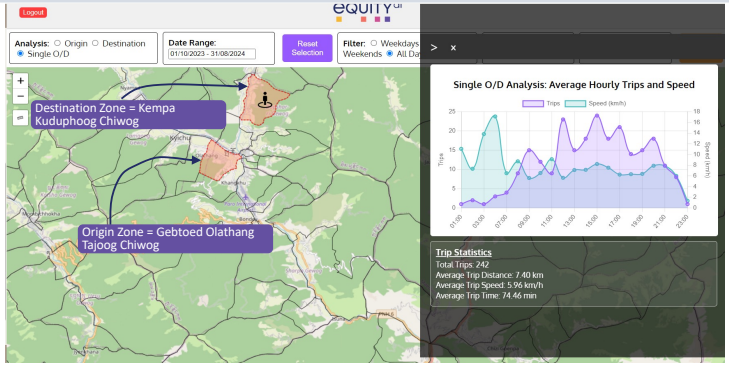
Example: Analysis of Trips Between O-D Pairs



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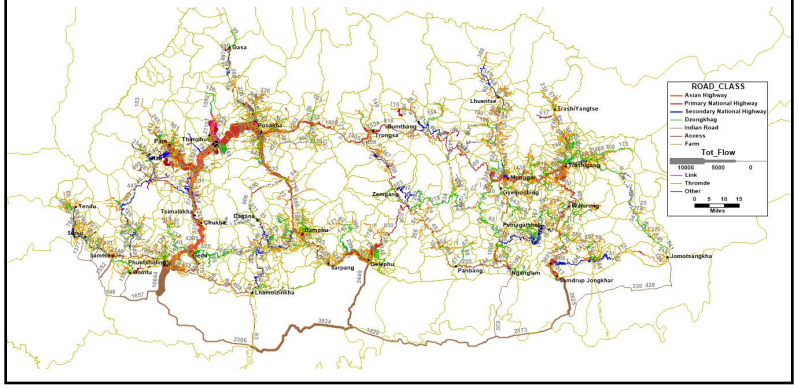
Person Trip Assignment to NH and DR Network



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Development Categories for 2040 Plan

1.Existing Roads	1.1 Road widening 1.2 Road safety measures 1.3 Climate change adaptation
2. Network Development	2.1 PNH missing links 2.2 Additional new roads 2.3 Bypasses and tunnels
3. Bridges	3.1 Replacement & upgrading
4. Access to Industrial Sites	4.1 Dry ports, SARs, rail heads

→ 5. Environmental Requirements: 5.1 Impact minimization; 5.2 Biodiversity offsets; 5.3 Facilities for EVs

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Road Widening Requirements

Road Group	Length km	Note
PNH <5.5m	127	PNHs 02,05,06
SNH <3.5m	29	Various
SNH 3.5-5.5m	459	Assess need to widen

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Road Safety Requirements

Infrastructure:
- Guard rails
- Improving sharp curves and sight lines
- Uniform signs
- Pavement markings , delineation, rumble strips
- Improving major intersections
- Blackspots
- School zones

Institutional:
- Road safety council
- Road crash database
- Crash investigation training
- Road safety audit SOP
- Schools training



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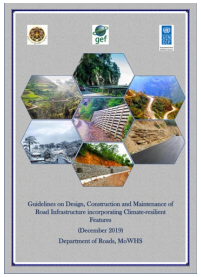
Climate Change Adaptation

Infrastructure:
- Slope failure protection
- Updated drainage specifications
- Restoration maintenance

Institutional:
- Adaptation strategy
- Vulnerability assessment system
- Slope monitoring system
- Climate financing initiatives

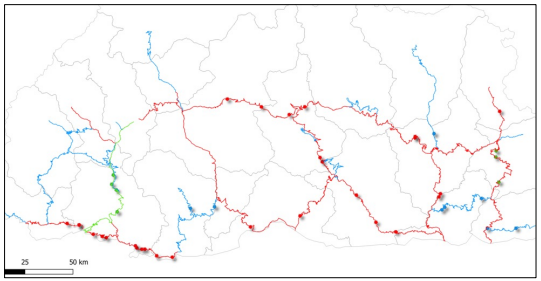




22

High Risk Slope Failure Locations

Infrastructure
- Protection works at 44 locations: Nu. 8811 million
- Provisional sums for climate resilience measures in all new road and bridge construction



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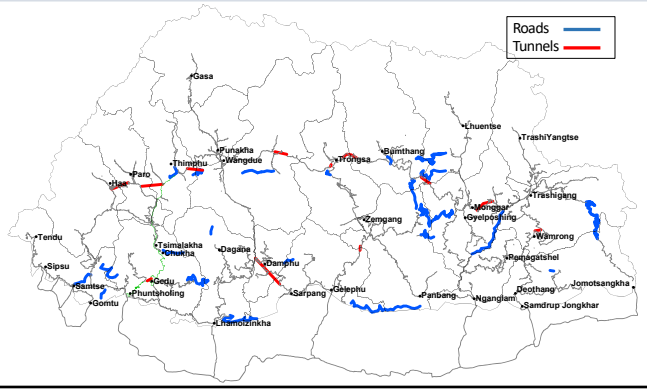
Proposed Development Projects



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PNH Missing Links

Project No.	Road No.	Road Name	Length km
2.1.1	PNH-02	Lhamoizingkha-Sarpang	103.8
2.1.2	PNH-02	Taraythang-Panbang	78.5
Total PNH-02 missing links			**182.3**

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Other Proposed Roads

SN	New Construction and Upgrading of Existing Roads	New	Upgrade	Total km
1	Daga Dzong - Tsimakoti	134	14	148
2	Khomshar - Wama	41	19	60
3	Lauri - Merak	118	5	123
4	Chamgang (Halela) - Nahi	42	13	55
5	Shingkhar (Zhemgang) - Gyazamchu	54	9	63
6	Tindobaney (Dunglegang, Tsirang) - Phedi (Dovan, Sarpang)	28	16	44
7	Gatena (Chukha) - Dorona (Dagana)	37	34	71
8	Khotokha-Phubjikha	0	31	31
9	Denchukha (Samtse) - Chimuna (Chukha)	24	18	42
10	Shingkhar (Zhemgang) - Thidangbi / Lingmethang (Mongar)	107	11	118
11	Yungichu Hydropower (Lhuentse) - Shingkhar (Ura, Bumthang)	77	24	101
12	Sarjung-Yarphu (Samdrup Jongkhar)	13	12	25
13	Yabala-Dhamdum	22	0	21.9
14	Gomtu-Pagli-Tading	0	27	0
15	Gyazamchu-Autsho highway	91	23	114
16	Sherichu-Gongrizomsa	62	0	62
	Total New Roads	**850**	**256**	**1102**

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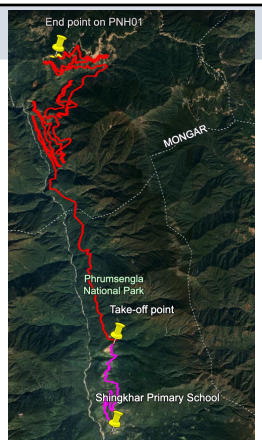
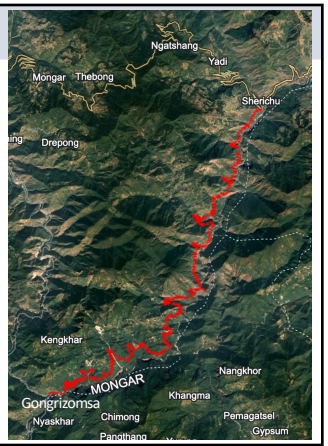
Example New Roads

R5 Shingkhar (Zhemgang) – Gyazamchu on PNH01
New section
54 km

R16 Sherichu on PNH01 - Gongrizomsa
62 km





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Bypasses and Tunnels

SN	Road No.	Type	Project Name	Length km	Existing length km	Travel distance reduced km
B1	PNH01	Bypass	Tangsibji-Refee	31.4	38.7	7.3
B2	SNH04, PNH01	Bypass	Chamkhar-Gektongzam	10.2	13.3	3.1
B3	PNH06, SNH11	Bypass	Kamichu-Tseza-Daga Dzong	68	124	56
T1	PNH05	Tunnel	Tama-Samkhara	2.4	7.75	5.4
T2	AH48	Tunnel	Gedu-Ganglakha	2.8	11.1	8.3
T3	PNH03	Tunnel	Wamrong- Khaling	3.3	7.3	4
T4	PNH01	Tunnel	Sengor-Gayzamchu	6	19.15	13.2
T5	PNH01	Tunnel	Nobding-Chendebji (Sephu)	6.6	15.3	8.7
T6	PNH01	Tunnel	Dorji Goenpa-Gyetsha	8	17.34	9.3
T7	SNH13	Tunnel	Paro-Haa	10	47.5	37.5
T8	PNH01	Tunnel	Kilikhar-Nigala	10.7	27.2	16.5
T9	AH48, PNH04	Tunnel	Thimphu (Khasadrapchu) - Paro (Shaba) : [12 km tunnel + 300 m viaduct + 500 m new road]	12	42.76	10.9
T10	PNH06	Tunnel	Sunkosh-Sarpang	20.3	62.5	42.2
T11	PNH01	Tunnel and Road	Yesipang-Nahi	29.2	52.2	23

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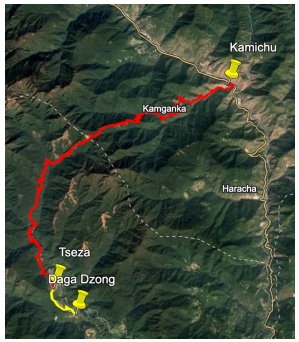
Example Bypass Projects

B1 Kamichu – Daga Dzong 68 km, reducing distance 54 km



B2 Chamkhar-Gektongzam 10.2 km, reducing distance 3.1 km

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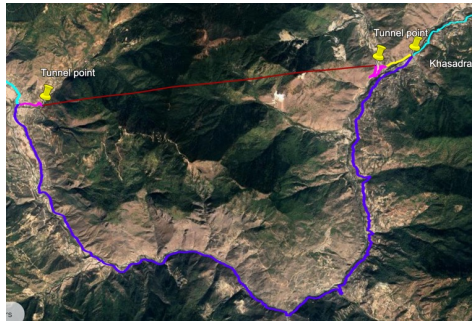
Example Tunnel Projects

T1 Gedu-Ganglakha Tunnel AH48
Length 2.8 km, shortening distance 8.3 km

T9 Khasadrapchu-Shaba AH48-PNH04
Length 12 km, shortening distance 11 km



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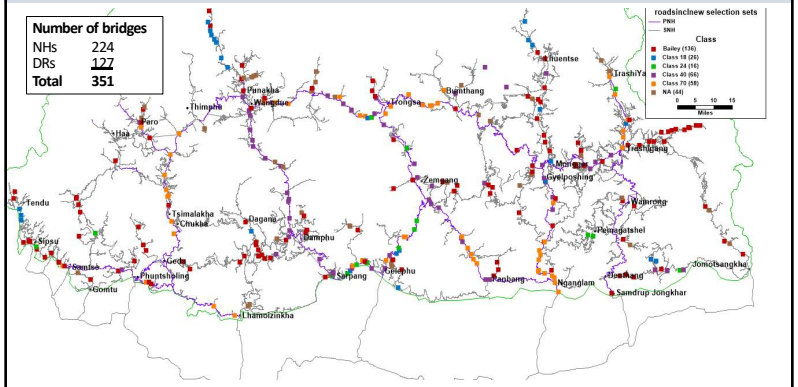
Bridges

Number of bridges	
NHs	224
DRs	127
Total	351



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Bridges: Replacement and Upgrading

SN	Road Name	Road ID	Bridge Name	Existing Bridge Type	Existing Bridge Span (m)	Year construct-ed	Proposed bridge span (m)
1	Thimphu-Tashigang PNH	PNH-01	Pakhadrang Bridge	RCC Slab	19	1982	35
2	Thimphu-Tashigang PNH	PNH-01	Tashiling Bridge	RCC Slab	15		15
3	Thimphu-Tashigang PNH	PNH-01	Gektong Zam	DDR Baily	32	2003	35
4	Samtse-Dewathang PNH	PNH-02	Singeychu Bridge	TSR Baily	44	2009	55
5	Trongsa-Gelephu PNH	PNH-05	Chapleychu Bridge	RCC Slab	20	1993	25
6	Trongsa-Gelephu PNH	PNH-05	Golipong Bridge	RCC Slab	15.4	1993	20
7	Trongsa-Gelephu PNH	PNH-05	Kami chu Zam	RCC slab	20	2011	20
8	Tingtibi-Panbang PNH	PNH-07	Adhigangchu Bridge	RCC slab	15.5	1992	16
9	Tingtibi-Panbang PNH	PNH-07	Chendigangchu bridge	RCC Slab	15.50		16
10	Gongrizomsa Bridge	PNH-08	Gongrizomsa Bridge	Truss	57.9	2024	58

DOST 13th and 14th FYPs:
- 39 bridges

Replacement:
- New bridges to replace existing bridges in bad condition
- Based on BMS data

Upgrading:
- New bridges to increase load limit to 70t or to provide 2 lanes where required

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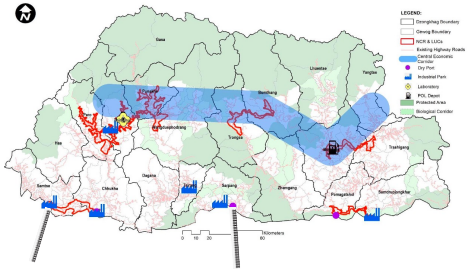
Access to Industrial Sites

13TH FIVE YEAR PLAN: Trade and Industries (Economic)



Activity
1. Trade related infrastructure
1. Develop **Pasakha** Dry Port 2. Develop **Gelephu** Dry Port 3. Develop **Nganglam** Dry Port 4. Develop **Samtse** Dry Port 5. Develop Petroleum, Oil and Lubricant (POL) Depot for Eastern region (**Garmani**) 6. Construct metrology laboratory-**Thimphu**
2. Industry related infrastructure
1. Develop Industrial Parks (**Damdum, Bjimina, Jigmeling, Motanga, Passakha**) 2. Maintain existing Industrial Parks (Damdum, Bjimina, Motanga, Passakha, Changchey). 3. Develop new Industrial Park in Norbugang (Samtse) (shifting of JIP) 4. Setup Leachate treatment plant in Pasakha Industrial Estate 5. Establish craft market

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Example: Samtse Industrial Site and Dry Port

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Other Transport Modes

Railways	• Extension of Indian Railways into planned dry ports at Samtse and Gelephu • No other railways within Bhutan feasible within 2040 plan period
Air Transport	• Road access provided to four existing airports • No additional road requirements identified
Ropeways	• Presently used for construction and logging activities
Inland Waterways	• No effect on road network identified
Non-Motorized Transport	• Roads replacing animal transport in remote locations e.g. Dewathang-Nganglam, Gasa-Laya • Road requirements for bicycles will affect Thromde Roads

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Biodiversity Impacts Mitigation

Significant biodiversity impacts anticipated

- Most of country has high biodiversity values
- Associated mitigation costs may be substantial for some projects
- Provisional mitigation costs will be reflected in cost estimation

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Electric Vehicle Facilities

Current EV population:

- 581 vehicles vs. 89,500 ICE light vehicles in 2023

Future EV population:

- Grow to 20,000-50,000 vehicles

Road infrastructure requirements:

- Charging station space on NHs

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Estimated Costs

Cost estimates include:

- Construction of works
- Climate change adaption measures in scope and design
- Engineering services
- Social and environmental assessments and monitoring
- Construction supervision
- 8%-20%

Budget issues:

- Costs of all projects will exceed RGOB financial capacity
- IFI financial assistance will be needed
- Policy on prioritization of:
  - Maintenance of existing network (including DRs)
  - Improvements to existing NH network
  - Expansion of NH network

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Next Steps

Complete Project Identification
- Scope of works
- Cost estimates

Network modelling
- Traffic forecasts
- Traffic assignment
- Levels of service

Economic Analysis
- Road user benefits
- HDM-4 analysis
- Economic indicators
- Priorities

2040 Development Plan
- Projects
- Cost estimates
- Priorities

Strategic Environmental Assessment

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Thank You – Questions?

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TA-6916 BHU: Master Plan for National Highways Connectivity

Thank You

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

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Purpose, objectives and scope of SEA study

Purpose

- Narrow sense: Meet mandate under national law
- Wider sense: Foresee risks and opportunities posed by Highways Master Plan and begin addressing them early, in dialogue with economic aims

Objectives

- Identify significant risks and opportunities
- Get input from range of stakeholders
- Influence formulation of Highways Master Plan
- Develop Strategic Environmental and Social Management Plan (SESMP)

Scope

- SEA Study: Risks and opportunities important to stakeholders
- SESMP: Measures implementable within the road sector and beyond

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Key themes identified from SEA scoping process

1. Wildlife and biodiversity
2. Climate change and disaster resilience
3. Water resources
4. Public safety
5. Equitable development
6. National economic vitality
7. Cultural heritage
8. Natural resource use
9. Pollution and waste

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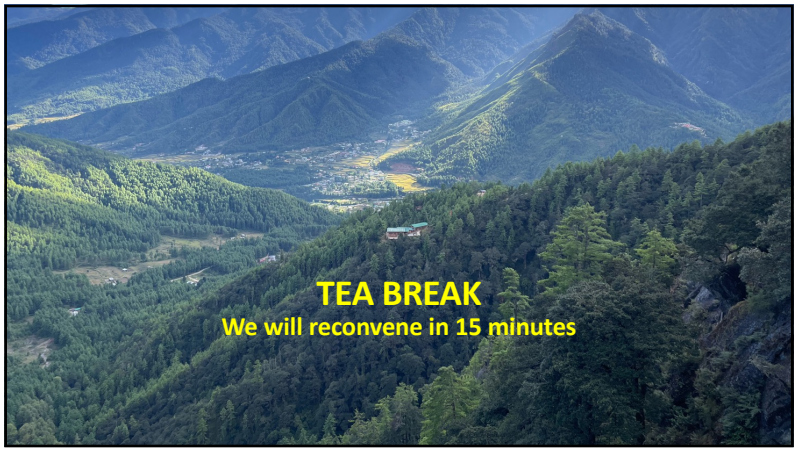

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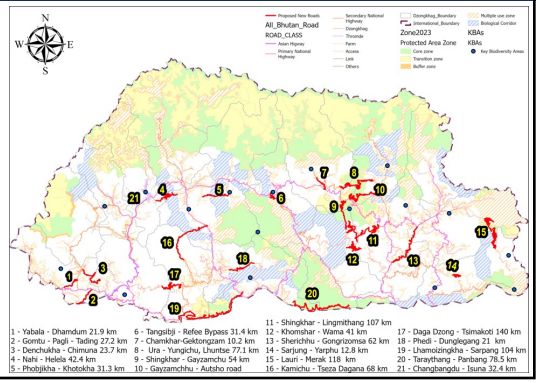
1. Wildlife and biodiversity

Proposed new roads



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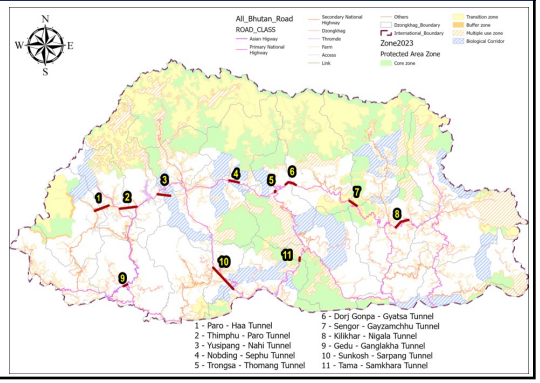
Wildlife and biodiversity

Proposed tunnels



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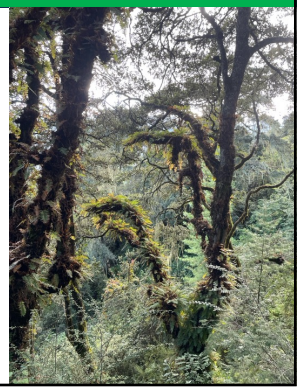
Conservation Areas Traversed by Proposed Projects

Protected Areas (PAs)
Jigme Singye Wangchuck NP
Phibsoo Wildlife Sanctuary
Phrumsengla National Park
Royal Manas National Park
Sakteng Wildlife Sanctuary

Biological Corridors (BCs)
Biological Corridor 3
Biological Corridor 4
Biological Corridor 7
Biological Corridor 8

Key Biodiversity Areas (KBAs)
Samtse KBA
Kamji KBA
Chele La KBA
Paro Wetlands KBA
Phipsoo Wildlife Sanctuary KBA
Ada Lake/Puna Tsangche KBA
Sarpang-Gelephu Foothills KBA
Jigme Singye Wangchuck NP KBA
Thrumsing La NP KBA
Royal Manas NP KBA
Kori La KBA
Sakteng KBA



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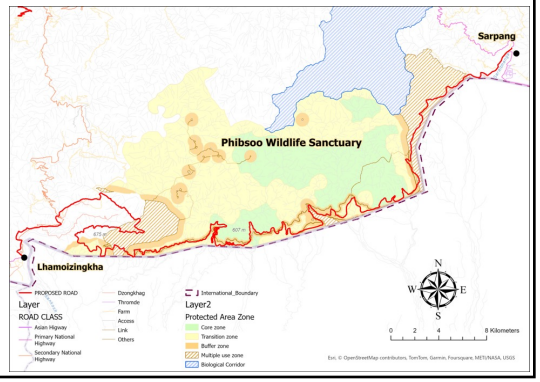
Phibsoo Wildlife Sanctuary

Lhamoizhingkha to Sarpang Link



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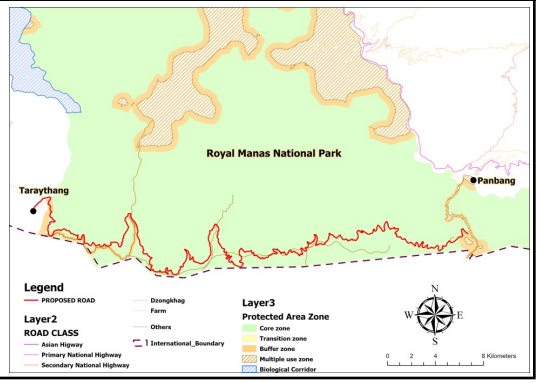
Royal Manas National Park

Tareythang – Panbang Link



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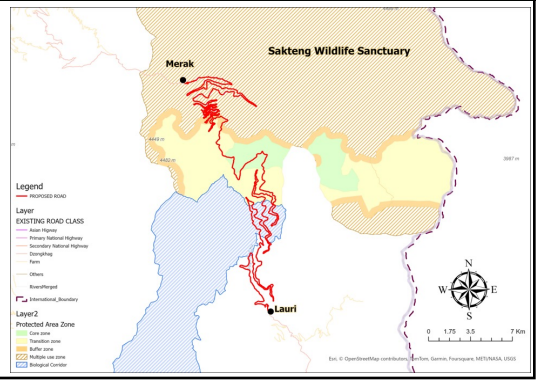
Sakteng Wildlife Sanctuary

Lauri – Merak Link



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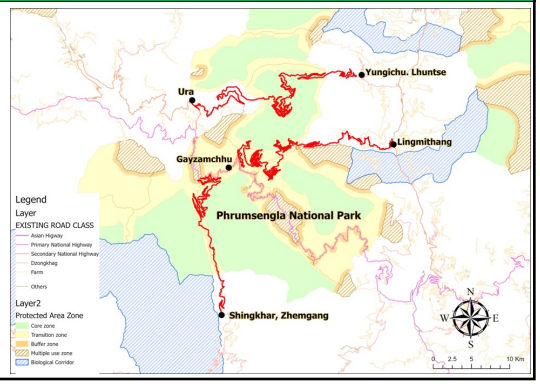
Phrumsengla National Park

Ura – Yungichu Link

Shingkhar – Linmithang Link

Gyazamchhu – Autsho Link



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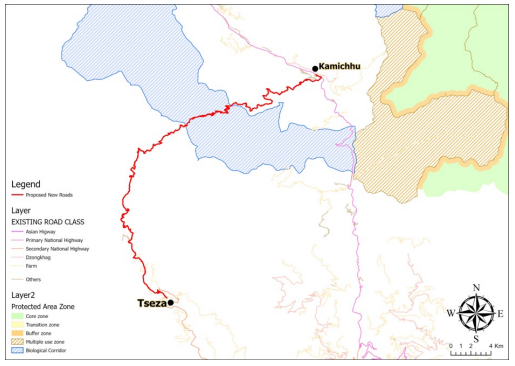
Biological Corridor 3

Kamichhu - Tseza Link



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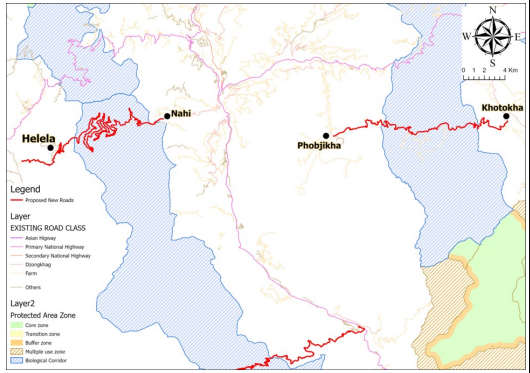
Biological Corridor 3 and Biological Corridor 8

Nahi – Helela Link

Phobjikha – Khotokha Link



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Foreseeable biodiversity risks (new roads)

Impact	Manifestation
Vehicle-wildlife conflict	▪ Direct wildlife injury and mortality ▪ Indirect effects of frequent on-road confrontations (large mammals)
Direct habitat loss	▪ Permanent removal of habitat in highway RoW
Habitat fragmentation	▪ Physical barrier effect ▪ Psychological barrier effect ▪ Formation of edge habitat ▪ Constrained local and long-range migration ▪ Genetic isolation of sub-populations
Behavioral effects and stress	▪ Altered foraging, movement, and reproduction patterns ▪ Declining condition of individuals
Enhanced natural resource exploitation	▪ Poaching ▪ Illegal logging ▪ Unregulated non-timber forest product extraction
Spread of invasive species	▪ Decline of native species ▪ Ecological change
Land use change	▪ Informal settlement ▪ Conversion to agricultural, residential, commercial uses ▪ Emergence of tracks and feeder roads, driving more change

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Summary of direct habitat loss (new roads)

Projected direct habitat loss*		**ha**	**km²**
Protected areas (national parks, wildlife sanctuaries)	Core	523	5.23
	Buffer	195	1.95
	Transition	215	2.15
Biological corridors		253	2.5
Unprotected areas (presently unsettled)		2,532	25.3
Total area of unmodified and lightly modified habitat lost		**3,718**	**37.2**

*** These numbers will change**

- Some proposed projects may drop out of the Development Plan for economic viability reasons
- The numbers are based on preliminary alignments, and will change during design, when alternative alignments will be considered

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Potential biodiversity-related opportunities

Support anti-poaching activities

- Mainly in southern border area (PNH-02 links)
- Highways may enhance surveillance capabilities
- Don't really need a highway for this (lesser park roads sufficient)

Support ecotourism development

- Earn revenue for conservation
- Enhance value of conservation to national economy
- Strengthen public support for conservation
- Don't really need a highway for this (lesser park roads sufficient)

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Options for managing risks to biodiversity

Mitigation Hierarchy	Applicable measures for roads	Scope for Application to Proposed Projects
FIRST PRIORITY: AVOIDANCE	▪ Adopt 'no project' alternative	▪ Existing roads provide alternatives for some proposed new roads (e.g., PNH-02 links)
NEXT BEST: MINIMIZATION	▪ Ecologically-informed alignment design to avoid most sensitive habitat areas ▪ Enhance permeability of road corridor to wildlife ▪ Narrow road formation to eliminate canopy gap, reducing some fragmentation effects ▪ Traffic control and driver education	▪ Ecologically-informed alignment design prescribed ▪ Wildlife crossing structures of different types proposed for evaluation during design ▪ Canopy gap elimination not feasible everywhere ▪ Traffic control and driver education by DoFPS proposed for roads in PAs and BCs
LAST RESORT: COMPENSATION	▪ Direct habitat loss is a residual biodiversity impact ▪ Per IFC PS6, residual biodiversity impacts must be offset to achieve 'no net loss' (natural habitat) or 'net gain' (critical habitat)	▪ Financing institutions generally require EIA of projects to conform to IFC PS6 procedures ▪ Most proposed projects will have some natural habitat loss ▪ Critical habitat loss anticipated for some proposed projects

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Avoidance – 'No project' alternative

Factors in initial project evaluation (still underway)

- Traffic projections
- Availability of alternative routes
- Construction and maintenance costs
- Biodiversity mitigation and offset costs
- Economic linkages
- Socio-economic benefits

Feasibility studies and EIA

- Standard requirement to consider 'no-project' alternative

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Minimization – Road design

Alignment selection/refinement

- Avoid impingement on areas with highest biodiversity values
- Enabled by detailed ecological studies in design stage
- SESMP will prescribe this for design stage EIA

Reduce canopy gap

- No canopy gap = much smaller fragmentation effect
- Minimize width of road structure, do not clear full 30-m RoW
- Suited to roads with low projected traffic volume and low design speed
- Difficult to achieve in hilly terrain and coniferous forest
- SESMP will prescribe feasibility evaluation during design

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Minimization – Wildlife crossing structures

Crossing structure types that may be suitable

- Large animal underpasses
- Ridgeline overpasses
- Culverts adapted for passage by small species
- Dry pipe culverts for small species
- Aerial crossing structures for canopy species

Needs assessment

- Ecological studies at design stage to determine need, structure types in context
- Traffic volume important factor
- Preliminary assumptions made to support cost estimation

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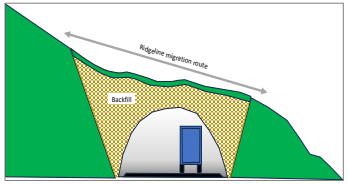
Wildlife crossing structures

Elephant underpass at stream crossing (Southern Bhutan)



Ridgeline migration route overpass installed in box cut

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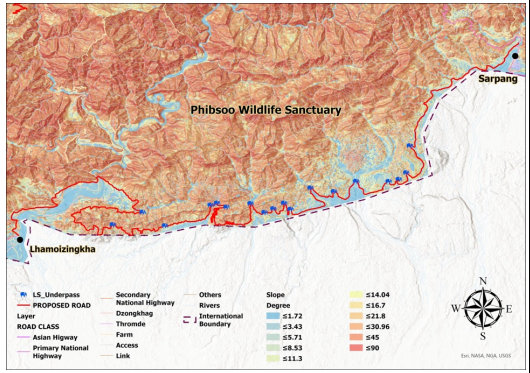
Wildlife crossing structures

Initial scoping of probable large mammal movement routes in PWS, based on topographical analysis



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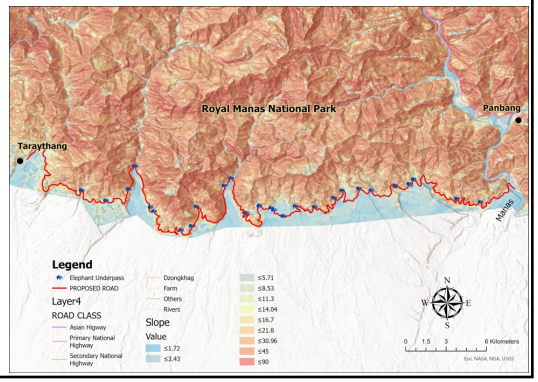
Wildlife crossing structures

Initial scoping of probable large mammal movement routes in RMNP, based on topographical analysis



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Wildlife crossing structures

Modified culvert designs with benches enabling passage by non-swimming animals

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Wildlife crossing structures





Dry culverts for small animal passage

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Wildlife crossing structures


Aerial overpass for canopy species (e.g., Golden Langur)

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Minimization – Traffic control and driver education

Facilities

- At entry/exit points of protected areas and biological corridors
- Gate, checkpoint booth, education center, staff accommodations
- Would enable DoFPS to control traffic
  - Enforce low speed limits and maximum transit time
  - Provide education and alerts to drivers
  - Night closures
  - Base for poaching and wildlife trafficking prevention

Proposed institutional arrangement

- Road co-management agreement (DoST, DoFPS, BCTA)
- DoST responsible for road upkeep, DoFPS for traffic control
- Facilities paid for under road project, DoFPS responsible for operation

FOR DISCUSSION

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Compensation for Residual Biodiversity Impacts

IFC – Performance Standard 6

- Best practice standard for assessment of biodiversity risks
- ADB, WB require adherence to PS6 procedures
- Natural habitat: 'no net loss' of biodiversity values
- Critical habitat: 'net gain' of biodiversity values

Natural habitat

- Mostly native species and processes mostly intact
- Most of Bhutan forest area is natural habitat

Critical habitat

- Habitat important to survival of certain classes of species, processes and ecosystem types
- Some areas affected by proposed projects likely to qualify as critical habitat for certain endangered species
- Tiger, Asian elephant, White-bellied heron, Golden langur

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Compensation (Biodiversity offsets)

Types of offset

- Restoration offset
- Protection offset
- Creation offset
- Payment for lost environmental services

Key challenges in offset design

- Availability of analogous habitat for offset
- Determining appropriate multiplier as safety factor
- Defining effectiveness and verification measures
- Arrangements for long-term management and monitoring
- Fiduciary responsibility

Cost of offsets

- Very difficult to estimate before design
- Will be lower if minimization is aggressive
- Developing assumptions for project cost estimation

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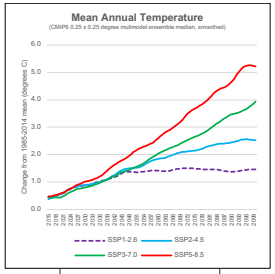
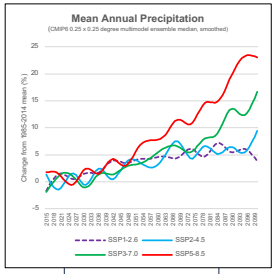
2. Climate change and disaster resilience



2040-2059: + 1.5-2.0°C

2080-2099: + 2.4-4.7°C

Projected climate anomalies for Bhutan to 2100



2040-2059: + 3-5%

2080-2099: + 6-20%

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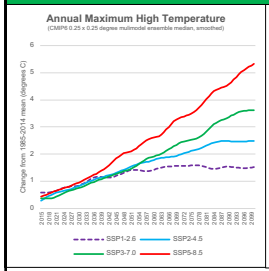
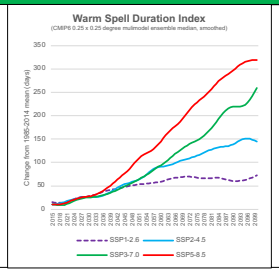
Temperature anomalies to 2100



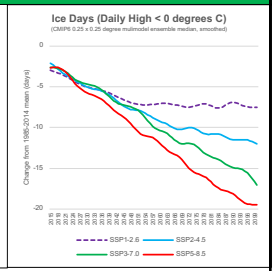
2040-2059: + 1.5-2.1°C

2080-2099: + 2.4-4.6°C



2040-2059: + 64-98 days/yr

2080-2099: + 140-253 days/yr



2040-2059: - 8-10 days/yr

2080-2099: + -11-18 days/yr

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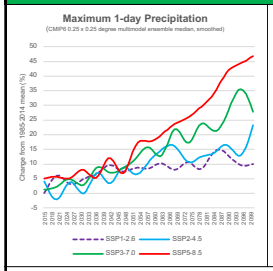
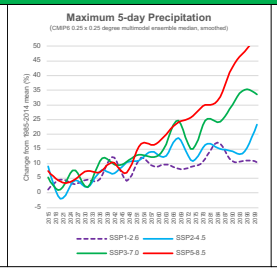
Precipitation anomalies to 2100



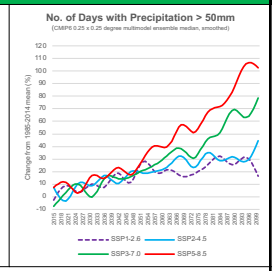
2040-2059: + 7-13%

2080-2099: + 15-40%



2040-2059: + 11-12%

2080-2099: + 16-41%



2040-2059: + 18-25%

2080-2099: + 31-87%

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Implications of climate change for road network

- Higher incidence of slope instability
  - More slides in more locations
  - Larger slides
- More frequent overload of drainage
- More frequent washouts
  - More flash floods
  - Higher peak river discharge
- Changing river dynamics
  - Increased scour
  - Scour and aggradation in new places
- More frequent debris flows and rockfall linked to forest fires
- Higher GLOF and LDOF risk
- Less snow, ice and freeze-thaw in some locations

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Climate change and disaster resilience

Resilience (small picture)

- Adaptation measures in Development Plan
  - Landslide mitigation works (~40 slope failures targeted)
  - Upgraded drainage specifications to be standard
- Enhanced maintenance under Maintenance Plan should strengthen resilience
- SESMP will prescribe project-level climate risk and adaptation assessment during design

Resilience (big picture)

- Significant need for investment to expand DoST's capacity for adaptation
- Budgets for maintenance and slope stabilization works will need to grow over time
- Whole-of-agency adaptation strategy
- External financing for resiliency planning and adaptation works
- SESMP will recommend capacity development in parallel with network expansion

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3. Water resources

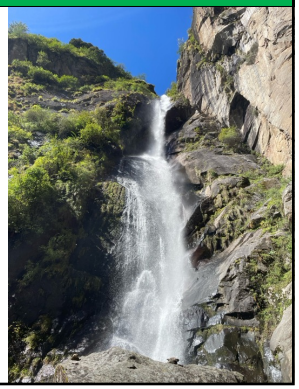
Risks to water resources (construction)

- Bridge sites (~40 bridges under evaluation)
- Springs and groundwater flows
- Irrigation systems
- SESMP will prescribe attention to these in project-level EIA studies

Risks to water resources (operation)

- Spill risk (hazardous materials)
- SESMP will prescribe development of plan and capacity for spill response
- Collaboration/sharing of responsibilities between DoST, DECC and DoW suggested

FOR DISCUSSION



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Roads, water resources and climate change

Opportunity for cross-sectoral collaboration

- Complementary adaptation interests
  - Road sector: moderate runoff, remove water from vulnerable slopes
  - Water sector: get water to where it is needed, store water
  - Agriculture sector: secure irrigation supply, reduce flood and erosion risks
- External financing for climate change adaptation
  - Substantial amounts being made available (much as grants)
  - Favorable to link infrastructure investments to social and environmental resilience
  - Cross-sectoral collaboration can support the linkage
  - Potential for DoST/DOW/DOA adaptation initiative

FOR DISCUSSION

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4. Public safety

Safety impacts of Highways Master Plan

- New highways to be equipped with best practice safety features
- Widening of some existing highways will improve safety
- Landslide mitigation works (~40 slopes targeted) will reduce risks to public
- Maintenance improvements on all national highways will enhance safety
- SESMP will prescribe pedestrian safety assessment during design (settled areas)

Bigger picture

- Safety on the national highways would be enabled by institutional growth
  - Strengthening road accidents data collection and management
  - Creation of Road Safety Council
  - Road safety audit SOP
  - Schools training
- SESMP will recommend implementation in parallel with network expansion

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5. Equitable development

Anticipated equity benefits of highway access

- 34 rural gewogs traversed by proposed projects*
- Collective population of affected gewogs: 245,000*
- Seeking gewog-level data for further analysis

Typical benefits of new highway access: Road Network Project II (2009-2012)

- National highways and feeder roads
- Before-and-after social assessments done

Social Impacts	Pre Road construction (%)		Post Road construction (%)	
	Yes	No	Yes	No
Access to electricity	100		100	
Access to market	48	52	91	9
Opening of new shops	16	84	92	8
Employment Opportunity	4	96	65	35
Rural-urban migration	18	82	66	34
Good telecommunication network	49	51	100	0
Degradation of the environment, landslides and pollution	6	94	35	65

* Numbers will change as project evaluation proceeds

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Equitable development

RNP II qualitative impacts summary

Pre-construction	Post-construction
• People were living mostly in thatch huts without CGI sheets as roofing which were not even considered semi-permanent houses. • Very few business activities such as marketing oranges. • No community milk processing Unit. • Marketing of agricultural produce was cumbersome, carrying oranges on horses and backload traveling sometimes days and again battle with high wage rate. • People had no choice but to walk with difficulty to reach the health centers or hospitals. • People faced several challenges while availing the facilities due to inadequate road connectivity resulting in (i) shortage of medicines (ii) carrying patients on human back which was often not desirable (iii) long time to reach health centers which would sometimes result in deaths of patients and (iv) limited time to refer serious cases to referral hospitals. • Education: Children traveling for hours and risks due to wild animal attacks. • Difficulty in walking and crossing rivers, particularly during monsoon season. • Limited communication facilities. • Compensation for the lost assets was an issue.	• Many permanent structures were observed. • Employment opportunities for youth. • People started growing more cash crops such as potatoes, oranges and gingers resulting in easy transportation of agricultural produce to market. • Several milk processing units have been established resulting in easy transportation of processed goods such as milk, butter, cheese and hardened cheese to nearby markets and to other dzongkhags. • Easy transportation of agricultural goods to nearby markets. • Reduced travel time. • Ease of Import and export of any goods. Establishment of shops near the road. • Increase in people's income levels. • Reduction of travel time in accessing health care services. • Reduced travel time to schools. Increased in number of school enrolment. • Communication facilities like telephone and mobile have been established. • Overall lifestyle improved. • Land value at the roadside will increase.
The new roads have made a significant contribution to economic growth in remote villages, mainly by promoting welfare and reducing poverty by providing access to health, education, markets and improvement in households' income.	

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6. National economic vitality

Economic benefits of proposed network expansion

- Economic evaluation of projects forthcoming

Opportunities and risks (in general)

- Opportunity: Network improvement and expansion should enable industrial development
  - Enhanced access to existing and planned industrial nodes
  - Industrial parks
  - Mines
  - Dry ports
  - Railheads
  - Tourism nodes
- Risk: Budgetary risk from projects with low economic viability
  - Long-term maintenance liability
  - Climate change context important

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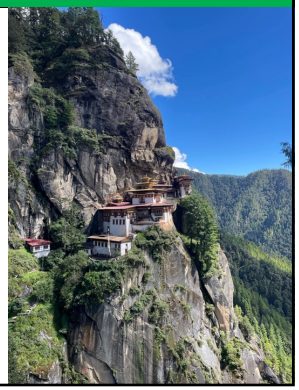
7. Cultural heritage

Improved access to cultural heritage sites

- Access to sites across country uneven now
- Shortened travel time to more distant sites from population centers and international airport
- Some proposed projects will enhance access to areas rich in cultural sites

Anticipated SESMP prescriptions

- Requirement for DoCDD involvement during project design
  - Contribution of cultural heritage criteria to multi-criteria analysis in feasibility study
  - Avoid impingement, visual impairment and other deleterious impacts on sites and their buffer zones
  - Maximize cultural site access through alignment adjustment where applicable and feasible



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8. Natural resource use

Opportunities

- Several proposed projects traverse community forests and forest management units
- Network improvements likely to shorten travel times to market for agricultural areas
- Enhanced livelihoods in forest and agricultural sectors can be expected

Risks

- Access likely to enable unsustainable extraction of natural resources if regulation weak
- Particular concern is recent move to export raw logs to India from road-proximate land
  - Does DoFPS have sufficient capacity to prevent high-grading?
  - Does DoFPS have sufficient capacity to control illegal logging?
  - Is there a plan to capture local benefits through local processing?
  - SESMP could recommend development of capacity and policy parallel to highway network improvement

FOR DISCUSSION

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9. Pollution and waste

Air pollution

- Not significant general concern due to low traffic volumes, coming EV transition
- Locality-level concerns will be addressed in project-level EIA process
- Construction dust a significant concern, but this is addressed in project-level EIA process

Water pollution

- Wastewater treatment rudimentary across country
- Highway network expansion will exacerbate existing problem by enabling development
- SESMP could recommend policy review and plan development in parallel to network improvement

Solid waste

- Solid waste management systems generally weak
- Highway network expansion will exacerbate existing problem by enabling development
- SESMP could recommend policy review and plan development in parallel to network improvement

FOR DISCUSSION

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Wrap-up and next steps

- Thank you for your participation and feedback!
- Further feedback, questions, comments?
- Key points of discussion noted

Next steps

- Complete SEA study in parallel with Highways Master Plan (one step behind)
- Draft SEA Report (opportunity for comment/feedback)
- Final SEA Report

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Thank you for participating!!

To access today's slides and forthcoming Draft and Final SEA reports, visit the SEA web page

https//:moit.gov.bt

(under 'News and Events')

To ask questions or raise concerns regarding the Highways Master Plan or the SEA study, please email us

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SEA Consultation Workshop (14 October 2024) – List of Participants

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25	Namgyel Wangdi		BES		x
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	Name	Position	Entity	Onsite	Remote
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48	Yusaku Okazaki	JICA Volunteer	DoST, MoIT	x	
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Meet SEA Consultation Workshop (TA-6916 BHU)

Date 14-10-24

Venue: Thimphu Deluxe

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Date 14-10-24

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TA-6916 BHU: Bhutan National Highways Connectivity Master Plan

Technical Brief: Climate Change Assumptions for Master Planning

Version: 12 July 2024

1. Overview and Disclaimer

1. This brief aims to provide climate-related guidance to the development of a highways master plan (HMP) for Bhutan, based on up-to-date climate change projections from global climate models. The brief presents projections for eight climate indicators relevant to the design and maintenance of road and bridge infrastructure for the 2040–2100 period, referencing climate change scenarios defined by the Intergovernmental Panel on Climate Change (IPCC). Risks to infrastructure and possible resilience approaches are indicated.

2. The data and climate risk management implications presented in this brief are applicable to high-level master planning only. The contents of the brief should not be taken to substitute for more detailed analysis of climate risks to specific proposed infrastructure investments, which should be undertaken at the feasibility and detailed design stages using the most up-to-date downscaled projections and information on local conditions available at that time.

2. Climate Change Scenarios

3. The Coupled Model Intercomparison Project (CMIP) overseen by the World Climate Research Programme defines standards to facilitate comparability across the work of multiple independent modeling groups. These include the use of illustrative climate scenarios selected for priority analysis by the IPCC. The latest iteration of the scenarios, adopted for the IPCC's Sixth Assessment (AR6) and for the sixth phase of the CMIP (CMIP6), use the nomenclature Shared Socioeconomic Pathway (SSP), and build upon the earlier Representative Concentration Pathway (RCP) framework. The SSP scenarios encompass both a radiative forcing level (the increment in watts/m^2 by 2100 relative to the preindustrial 1750 baseline, indicated by the numbers following the dash in the scenario names), and a narrative characterization of the route taken collectively by human societies to end up at that level, accounting for mitigation policies, population trends, inequality, socioeconomic development, energy use, technological innovation and environmental conditions, as well as future emissions and concentrations of gases and aerosols and changes in land use and land cover.[1] The five core illustrative scenarios are outlined in Table 1.

Table 1: Summary of Core Illustrative Climate Scenarios Selected by IPCC

SSP	Socioeconomic Narrative[1]	Global CO_2 emissions milestones[2]	Global mean surface air temperature change by 2081–2100[3]
SSP1-1.9 SSP1-2.6	**Sustainability –** The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and	**SSP1-1.9** Peak: ~ 2025 Halved: ~ 2035 Net zero: ~ 2060	**SSP1-1.9** +1.0–1.8°C
		SSP1-2.6 Peak: ~ 2025 Halved: ~ 2040 Net zero: ~ 2080	**SSP1-2.6** +1.3–2.4°C

[1] Great Lakes Integrated Sciences and Assessments (GLISA). 2021. A Practitioner's Guide to Climate Model Scenarios.

SSP	Socioeconomic Narrative[1]	Global CO_2 emissions milestones[2]	Global mean surface air temperature change by 2081–2100[3]
	within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.		
SSP2-4.5	**Middle of the Road –** The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.	Peak: ~ 2030 Halved: ~ 2080 Net zero: after 2100	+2.1–3.5°C
SSP3-7.0	**Regional Rivalry –** A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.	Peak: after 2100 Halved: after 2100 Net zero: after 2100	+2.8–4.6°C
SSP5-8.5	**Fossil-Fueled Development –** This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.	Peak: after 2100 Halved: after 2100 Net zero: after 2100	+3.3–5.7°C

[1] As stated by Riahi et al. 2017 (citation below)
[2] Other greenhouse gases and aerosols will follow somewhat different trajectories; however, CO_2 is by far the largest contributor to warming.
[3] 'Very likely' range for 2080–2100, relative to 1850–1900 baseline. Changes relative to 1995-2014 baseline are about 0.85°C smaller, owing to increases that accrued during the 20th Century.

Source: Derived from (1) Intergovernmental Panel on Climate Change. 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.; (2) Riahi et al. 2017. The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change 42:153–168.

4. Few in the climate modeling community are willing to assign probabilities to the illustrative climate scenarios. However, the two SSP1 scenarios are rarely referenced in infrastructure resiliency planning. These scenarios are more or less consistent with the Paris Agreement goal of limiting global mean surface air temperature rise to no more than 2.0°C above pre-industrial levels by 2100, and are widely acknowledged to be optimistic, as their radiative forcing reference levels have already been exceeded and can only be attained through sharp declines in net emissions.[2] Despite the steady movement of climate change into mainstream political discourse at all levels and substantial progress in initiating the necessary energy transition, the SSP1 scenarios are an insufficiently conservative basis for resiliency planning, which is an inherently precautionary activity.

5. With respect to the higher end of the suite of scenarios, SSP5-8.5 is considered by the IPCC to have a relatively low probability of being realized, given recent investments and long-term projections in the energy sector, although it is acknowledged that major events such as pandemics and multi-regional war could emerge to counteract the positive trends underway.[3] In the context of infrastructure resiliency planning, projection data linked to the SSP5-8.5 scenario are often used as a 'most conservative' benchmark or taken to imply a prudent 'safety factor', without necessarily being considered 'realistic'.

6. Rather than picking a single 'most probable' scenario to guide infrastructure resiliency planning, it is common to reference projection data for a 'low' and 'high' scenario, and situate analysis and decision-making within a comparative space between them. This can mean using their respective projections as end-points in a 'plausible range'; perhaps leaning towards one end or the other on a case-by-case basis depending on the sensitivity of particular infrastructure to a given climate risk, or the risk tolerance of the infrastructure's owner and users. Weighing of different scenarios' projections for particular climate parameters may also enter directly into cost-benefit and life cycle analysis of resiliency investments, particularly when the difference between projections is large and adaptation options are expensive. This brief uses the range defined by SSP2-4.5 and SSP5-8.5, which is sufficiently indicative for high-level master planning.

3. Projection Data

7. Projection data were sourced from the World Bank's Climate Change Knowledge Portal (CCKP), which presents a series of data packages aggregating the results of 30 global climate modeling groups participating in the CMIP6.[4] The datasets used in the present analysis represent the median values reported across the ensemble of 30 modeling efforts (the multi-model ensemble median), for both a historical baseline period (1985–2014) and projection period (2015–2100) for each of three SSP experiments (SSP2-4.5, SSP3-7.0 and SSP5-8.5). The multi-model ensemble median is generally considered an acceptable basis for interpretation of projections, unless the analyst has reason to consider a particular model or set of models more strongly representative of local conditions.

8. Modeling outputs produced under CMIP6 were bias-corrected and downscaled by CCKP to a common 0.25 x 0.25-degree grid, and spatially disaggregated at national and sub-national scales. For Bhutan, the 0.25 x 0.25-degree grid yields individual cells of approximately 27.75 x 24.75 km; the national territory is covered by 38 complete cells and parts of 40 others.

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[2] Radiative forcing was calculated by the National Oceanic and Atmospheric Administration (NOAA) as 3.398 W/m^2 in 2022. See NOAA. 2023. The NOAA Annual Greenhouse Gas Index (AGGI), Updated Spring 2023. gml.noaa.gov/aggi/html.

[3] Intergovernmental Panel on Climate Change. 2021. Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. doi:10.1017/9781009157896.

[4] For a detailed explanation of the methods and standards used to generate the data packages, see World Bank Group. 2024. Metadata – Climate Change Knowledge Portal (CCKP), which is available for download at https://climateknowledgeportal.worldbank.org/.

In the CCKP datasets for Bhutan, the sub-national data disaggregation is to the dzongkhag level. The CCKP data packages present historical and future projections for several dozen climate indicators derived from daily projection data for temperature and precipitation. The climate indicators referenced in the present analysis, selected for their particular relevance to road transport infrastructure, are identified in Table 2.

Table 2: Climate Indicators Referenced

Indicator Name	Code	Description	Unit
Precipitation	pr	Aggregated accumulated precipitation.	mm
Average Largest 1-Day Precipitation	rx1day	The highest average precipitation amount in a 1-day period during each month in the data period.	mm
Average Largest 5-Day Cumulative Precipitation	rx5day	The average highest precipitation amount over a consecutive 5-day period during each month in the data period.	mm
Number of Days With Precipitation >= 50 mm	r50mm	The number of very heavy precipitation days during the aggregation period. A very heavy precipitation day is defined as any day in which the daily accumulated precipitation is greater than or equal to 50 mm.	days
Average Surface Air Temperature	tas	Average temperature over the aggregation period.	°C
Maximum of Daily Maximum Surface Air Temperature	txx	The single-day maximum value of the daily maximum temperatures over the aggregated data period.	°C
Warm Spell Duration Index	wsdi	The number of days in a sequence of at least six consecutive days during which the value of the daily maximum temperature is greater than the 90th percentile of daily maximum temperature calculated for a five-day window centered on each calendar day, using all data for the given calendar day-pentad from the data period for a reference climate.	days
Number of Ice Days (Tmax < 0°C)	id	The average aggregated number of days where the daily maximum temperature is < 0°C in the data period.	days

Source: World Bank Group. 2024. Metadata – Climate Change Knowledge Portal (CCKP).

4. Uncertainty and Bias

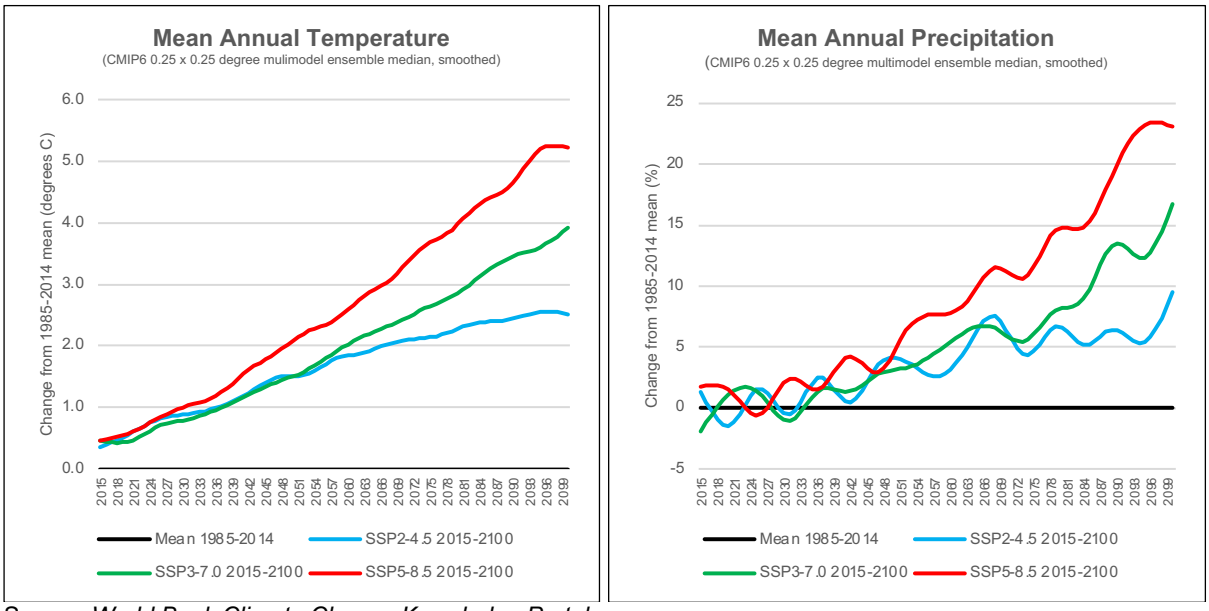
9. **Uncertainty.** The current crop of global climate models participating in CMIP6 are the most useful source of guidance available, but the earth-atmosphere system is complex and climate modeling does still remain an experimental endeavor. Variance across model outputs is high despite the use of common protocols. Indeed, the respective differences between the median and the 10th and 90th percentile projections for the multi-model ensemble are in some cases larger than the differences between the median projection values for different SSP scenarios. High uncertainty requires humility in interpretation of modeled data, and calls for a conservative approach to their application to infrastructure planning. The use of ranges in the present analysis is a recognition of modelling uncertainty.

10. **Bias.** One means of assessing the significance of biases in climate model outputs in relation to a particular place is to compare the model ensemble's reconstruction of historical climate to data from local weather stations. A strong fit between the reconstructed and empirical historical climate trends may justify confidence in the ensemble's projections for the future. Bhutan has 40 weather stations, but the historical record is short, and the station network is weakly representative of the country topographically and spatially; this limits the value of such a 'fit' assessment. However, tentative comparison of dzongkhag-level multi-model ensemble reconstructions against data from selected weather stations suggests that the ensemble median may substantially overestimate precipitation, while moderately underestimating surface air temperature. Given these suspected biases, the presentation of projection data below sticks to comparisons between the reconstructed baseline median and

modeled future median (i.e., analysis of the direction and magnitude of anomalies), and does not reference the absolute values generated by the models for any of the indicators.

5. Climate Change Projections

11. Figure 1 shows projected change in surface air temperature and precipitation under three climate change scenarios (SSP2-4.5, SSP3-7.0 and SSP5-8.5) for the 2015–2100 period, aggregated at the national level. Both mean annual temperature and mean annual precipitation are projected to rise substantially, with the most significant change taking off from the 2040s onward. The upward trend is expected to be more consistent for temperature than for precipitation. Divergences between the scenario trajectories for both precipitation and temperature become more pronounced in the latter half of the projection period.



Source: World Bank Climate Change Knowledge Portal

Figure 1: Projected Temperature and Precipitation Changes for Bhutan, 2015-2100

12. Table 3 breaks down the projections for selected indicators of temperature and precipitation across three time slices covering the second half of the present century, during which all infrastructure proposed under the HMP will be operational. While asphalt pavements are typically replaced on a short cycle and can be iteratively redesigned to reflect changing weather patterns, the design life of other highway infrastructure components would generally exceed 50 years, making all three time slices relevant. As can be seen in Table 3, projections for all indicators move progressively away from the baseline over time, with the 2080–2099 time slice showing the largest anomalies across all three scenarios.

Table 3: Projected Change in Climate Indicators Across Scenarios and Time Periods, Bhutan

Climate Scenario/Indicator	Projected Change Relative to 1985–2014 Baseline[1]		
	2040–2059	2060–2079	2080–2099
SSP2-4.5			
Precipitation (annual)	+2.7%	+5.6%	+6.1%
Precipitation (monsoon)	+3.4%	+4.0%	+5.8%
Average Largest 1-Day Precipitation	+7.4%	+13.6%	+14.9%
Average Largest 5-Day Cumulative Precipitation	+10.6%	+14.4%	+15.5%
Number of Days With Precipitation > 50 mm	+17.5%	+27.8%	+31.1%
Average Surface Air Temperature	+1.5°C	+2.0°C	+2.4°C
Maximum of Daily Maximum Temperature	+1.5°C	+2.0°C	+2.4°C

Climate Scenario/Indicator	Projected Change Relative to 1985–2014 Baseline[1]		
	2040–2059	2060–2079	2080–2099
Warm Spell Duration Index	+63.6 days	105.4 days	+139.7 days
Number of Ice Days	-7.8 days	-10.1 days	-11.3 days
SSP3-7.0			
Precipitation (annual)	+3.0%	+6.3%	+11.7%
Precipitation (monsoon)	+4.6%	+6.8%	+14.0%
Average Largest 1-Day Precipitation	+10.8%	+18.4%	+27.9%
Average Largest 5-Day Cumulative Precipitation	+11.5%	+19.2%	+26.6%
Number of Days With Precipitation > 50 mm	+19.1%	+35.7%	+61.2%
Average Surface Air Temperature	+1.5°C	+2.4°C	+3.4%
Maximum of Daily Maximum Temperature	+1.5°C	+2.3°C	+3.3°C
Warm Spell Duration Index	+61.4 days	+129.3 days	+211.6 days
Number of Ice Days	-8.1 days	-11.8 days	-14.8 days
SSP5-8.5			
Precipitation (annual)	+5.2%	+10.9%	+19.2%
Precipitation (monsoon)	+5.7%	+11.3%	+20.5%
Average Largest 1-Day Precipitation	+13.1%	+24.0%	+39.7%
Average Largest 5-Day Cumulative Precipitation	+12.3%	+24.1%	+40.7%
Number of Days With Precipitation > 50 mm	+27.4%	+52.1%	+87.4%
Average Surface Air Temperature	+2.0°C	+3.2°C	+4.7°C
Maximum of Daily Maximum Temperature	+2.1°C	+3.2°C	+4.6°C
Warm Spell Duration Index	+98.2 days	+197.4 days	+253.0 days
Number of Ice Days	-9.8 days	-14.2 days	-18.2 days

[1]All baseline and projection data represent the CMIP6 0.25-degree multi-model ensemble median. The baseline is the calculated mean of 1985–2014 projection values. Values given for each time slice are the mean of the values reported for the 20 years within the slice.

Source: Derived from data packages available through the World Bank Climate Change Knowledge Portal

6. Implications for Highway Infrastructure and Master Planning

13. Table 4 presents a high-level characterization of the anticipated risks to highway infrastructure in Bhutan, based on the projection data shown in Table 3, and draws out the implications of the risk trends identified for highways master planning in relation to both the Development Plan and Maintenance Plan components. Anomaly ranges specified in Table 4 are for the 2080–2099 time slice, as this period has the highest anomaly values.

Table 4: Summary of Climate Risks to Highways and Implications for Master Planning

Risk Origin	Risk Characterization	Implications for Highways Master Planning[1]
RISKS LINKED TO CHANGES IN TEMPERATURE REGIME		
Hotter days and longer warm spells (general) (tas +2.4–4.7°C) (txx +2.4–4.6°C) (wsdi +140–253 days)	• Enhanced pavement deterioration • Bridge deck expansion exceeds design tolerance, leading to structural damage	• Periodic adjustment of pavement design specifications may be required to maintain desired performance levels despite rising temperatures (MP) • Retrofitting of some bridges may be necessary (DP) • New bridges should be designed with expansion tolerances for higher maximum temperatures (DP)
Hotter days and longer warm spells (more frequent forest fires) (tas +2.4–4.7°C)	• Higher erosion-associated slope failure risk in years following upslope and downslope fires due to reduced vegetative cover	• Anticipate higher maintenance costs for fire-associated slope failure response and repair (MP)

Risk Origin	Risk Characterization	Implications for Highways Master Planning[1]
(txx +2.4–4.6°C) (wsdi +140–253 days)	• Higher peak runoff discharges in years following fires in above-road catchment areas due to reduced absorption and infiltration	• Anticipate higher maintenance costs for drain upkeep and repair (MP)
Higher temperatures at high altitude (permafrost melting)	• Negligible risk to national highways, as all are below 4,000 masl (lower limit of permafrost in Bhutan)	• n/a
Higher temperatures at high altitude (increased glacial meltwater)	• Bridges and associated protective structures on rivers with significant upstream glacial area (Pa Chhu, Mo Chhu, Pho Chuu, Punatsangchhu, Mangde Chhu, Chamkhar Chhu, Kuri Chhu, Manas Chhu) may be subject to increased scour • Bridges and approaches on rivers with significant upstream glacial area may become more vulnerable to flood damage • Risk to national highways (road segments) is overall quite low in Bhutan due to limited river proximity	• Highway bridges on main stem of rivers with significant upstream glacial area may require more robust design and protection (DP)
Higher temperatures at high altitude (increased risk of glacial lake outburst floods)	• Highway bridges over main stems of Mo Chhu, Pho Chuu, Punatsangchhu, Mangde Chhu, Chamkhar Chhu, Kuri Chhu, Manas Chhu may have increased exposure to GLOF risk due to possible glacial lake expansion in their catchments, but RGoB monitoring and proactive mitigation efforts at high-risk lakes substantially reduce the risk	• Highway bridges on main stem of relevant rivers may require more robust design and protection (DP)
Fewer freezing days (id -11 to -18 days)	• Pavement and sub-grade deterioration linked to freeze-thaw and de-icing is likely to decline in significance at the network level over time as more of the national highway system becomes frost-free year round	• Maintenance cost savings may be anticipated in higher-altitude portions of the highways network (MP)
RISKS LINKED TO CHANGES IN PRECIPITATION		
Higher overall precipitation (pr annual +6–19%) (pr monsoon +6–21%)	• Slopes above and below roads may become more prone to failure due to higher average and peak soil saturation, causing more frequent major and minor road damage • Bridges and associated protective structures may be subject to increased scour due to higher mean and peak flows in rivers • Bridges and approaches may become more vulnerable to flood damage due to higher mean and peak flows in rivers (risk to other highway segments is overall quite low in Bhutan due to limited river proximity)	• Some existing highway segments may require retrofitting and expansion of slope protection measures (DP) • New and widened highway segments will require more robust slope protection measures than typically used in Bhutan, and in more locations (DP) • More frequent inspection and cleanout of pre-existing drainage structures may be required (MP) • New highway bridges will likely require more robust design and scour protection (DP) • Some pre-existing highway bridges may require retrofitting and strengthening of scour protection (DP) • Realignments may be warranted in some locations where existing instability problems are likely to worsen (DP) • Development of alternative routes (redundancy) may be warranted in critical corridors (DP)

Risk Origin	Risk Characterization	Implications for Highways Master Planning[1]
Higher rainfall intensity (rx1day +15–40%) (rx5day +16–41%) (r50mm +31–87%)	• Drainage structures may overflow more frequently, leading to increased incidence of pavement and subgrade damage, erosion and slope failure • Slopes above and below roads may fail more often and with greater severity due to more frequent incidence of high soil saturation, causing more frequent major and minor road damage • Bridges may be more vulnerable to washout and scour due to higher peak discharge in rivers	• Culverts, lateral drains and other drainage structures will have to be designed to accommodate significantly higher peak flow (DP) • Many pre-existing drainage structures may require retrofitting (DP) • More frequent inspection, cleanout and repair of all drainage structures will be required (MP) • Some existing highway segments may require retrofitting and expansion of slope protection measures (DP) • New and widened highway segments will require more robust slope protection measures than typically used in Bhutan, and in more locations (DP) • Slope protection measures will require more frequent inspection, preventive maintenance and repair (MP) • Bridge design criteria may have to become more conservative (DP) • More frequent inspection and correction of scour protection will be required (MP) • Realignments may be warranted in some locations where existing instability problems are likely to worsen (DP) • Development of alternative routes (redundancy) may be warranted in critical corridors (DP)

[1] (DP) = relevant to Development Plan; (MP) = relevant to Maintenance Plan

TA-6916 BHU: Master Plan for National Highways Connectivity

Climate Change Adaptation in Road Asset Management

10 October 2024

Thimphu, Bhutan

David Lupton & Associates Limited (New Zealand) in association with APECS (Bhutan) and MSL (Bangladesh)

1

Outline

- Some key terms and concepts
- Climate change projections for Bhutan
- Discussion: What do the projections mean for road infrastructure?
- What is adaptation and what are we adapting?

TEA BREAK

- Adapting RAM: Planning
- Adapting RAM: Design
- Adapting RAM: Construction
- Adapting RAM: Maintenance
- Bringing it all together: Adaptation Strategy

LUNCH

2

Weather and climate

Weather

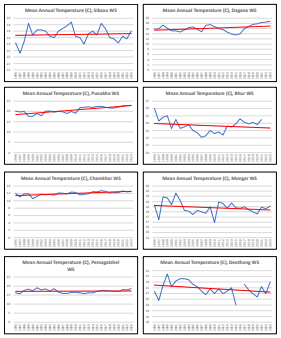
- Short-term conditions of the atmosphere
- Changes in weather highly perceptible to people

Climate

- Average weather conditions over a long period of time
- Seasonal variation highly perceptible to people
- Change in long-term averages perceptible but subject to bias

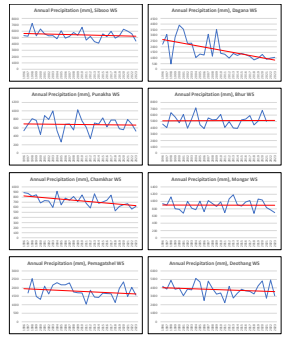
3

Natural variability (spatial and temporal)



Temperature

Selected Bhutan Class A Weather Stations, 1996-2023



Precipitation

4

Climate change and climate extremes

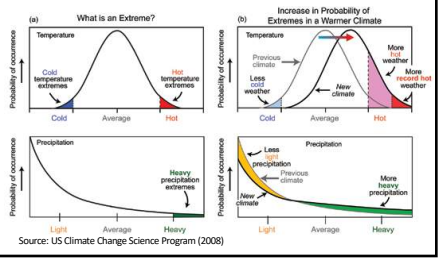
Slow-moving change

- Shift in mean conditions over several decades or longer

Shock events

- Extreme conditions that test limits of human and natural systems

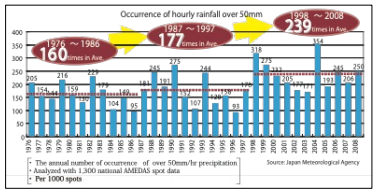
Slow-moving change makes some types of shock events more likely, more frequent, and more extreme

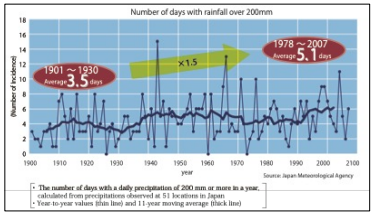


Source: US Climate Change Science Program (2008)

5

Climate change and climate extremes





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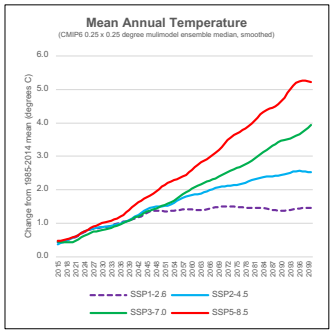
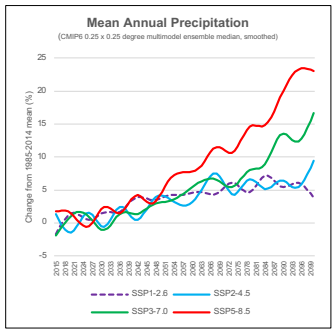
Climate change in Bhutan: Anomalies to 2100





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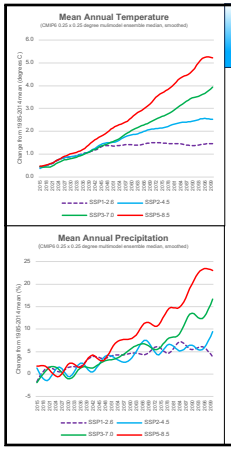


Climate change scenarios

Shared Socio-Economic Pathways (SSPs)

- Build upon earlier Representative Concentration Pathways (RCPs)
- Selected by Intergovernmental Panel on Climate Change to represent the spectrum of scenarios developed

SSP1 - 2.6
SSP2 - 4.5
SSP3 - 7.0
SSP5 - 8.5

Radiative forcing levels

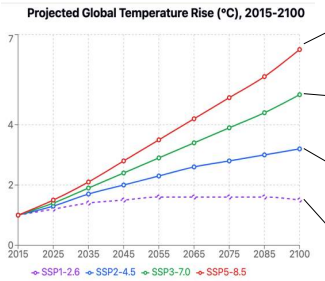
- Increment in watts/m^2 by 2100 relative to the preindustrial 1750 baseline
- Determined by atmospheric concentrations of carbon dioxide and other greenhouse gases (GHG)

Scenarios explaining how we get to each forcing level

- Each a combination of demographic, political, social, economic, technological, land use and policy factors

8

Climate change scenarios



SSP5-8.5: 'Fossil-Fueled Development'
- What happens if GHG reduction efforts not pursued
- Becomes less likely as world invests in GHG reduction
- Useful as 'upper end' benchmark in resiliency planning

SSP3-7.0: 'Regional Rivalry'
- What happens if world powers spend more effort on competing for dominance than cooperating towards GHG reduction for benefit of all

SSP2-4.5: 'Middle of the Road'
- More or less the status quo
- Substantial investment in GHG reduction, but not as aggressive as is needed

SSP1-2.6: 'Sustainability'
- In line with Paris Agreement goals
- Widely viewed as optimistic
- Not conservative assumption for resiliency planning

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Data source for projections

Coupled Model Intercomparison Project, Phase 6 (CMIP6)
- Coordinated global climate modeling by ~30 separate modeling groups
- Modeling experiments conducted from ~2017-2020
- Data presented are the median values from the modeling experiments (multi-model ensemble median)

World Bank Climate Change Knowledge Portal (CCKP)
- https://climateknowledgeportal.worldbank.org/
- Provides CMIP6 data processed into many climate variables
- Downscaled to country and sub-national levels
- Easily accessible and easy to use in MS Excel
- Free

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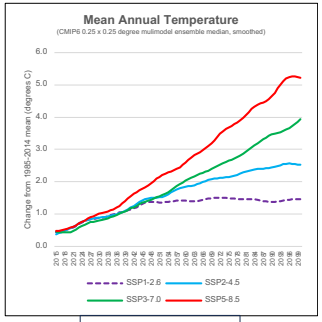
Uncertainty

CMIP6 data packages as good as it gets, but…
- Earth-atmosphere system complex
- Global climate modeling experimental
- Scenarios inherently speculative
- Downscaling introduces bias
- Calibration to real world difficult (weak historical weather data, topographical diversity)

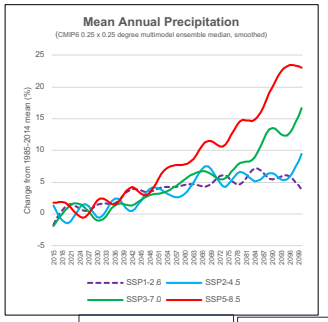
Takeaways
- Have to be cautious and humble in interpretation
- Take projections as broad indicators, not precise predictions
- Work with ranges, not point values

11

Projected anomalies to 2100 for Bhutan



2040-2059: + 1.5-2.0°C
2080-2099: + 2.4-4.7°C

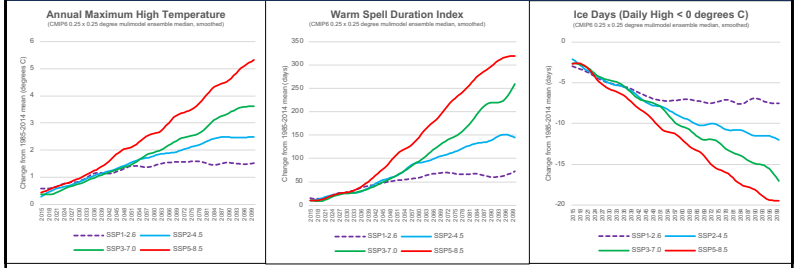


2040-2059: + 3-5%
2080-2099: + 6-20%

Monsoon months anomalies in same range

12

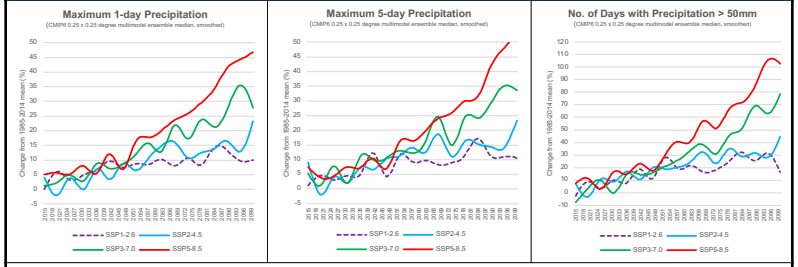
Projected temperature anomalies to 2100 for Bhutan



2040-2059: + 1.5-2.1°C 2080-2099: + 2.4-4.6°C	2040-2059: + 64-98 days/yr 2080-2099: + 140-253 days/yr	2040-2059: - 8-10 days/yr 2080-2099: + -11-18 days/yr

13

Projected precipitation anomalies to 2100 for Bhutan



2040-2059: + 7-13% 2080-2099: + 15-40%	2040-2059: + 11-12% 2080-2099: + 16-41%	2040-2059: + 18-25% 2080-2099: + 31-87%

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Handout: Climate risk

HAZARDS
What hazards are likely, and what are their potential effects?

EXPOSURE
What people, assets and economic activities are within reach of the hazards' effects?

VULNERABILITY
What characteristics of people, buildings, infrastructure and economic activities increase the likelihood that the hazards' effects will cause significant harm?

RISK

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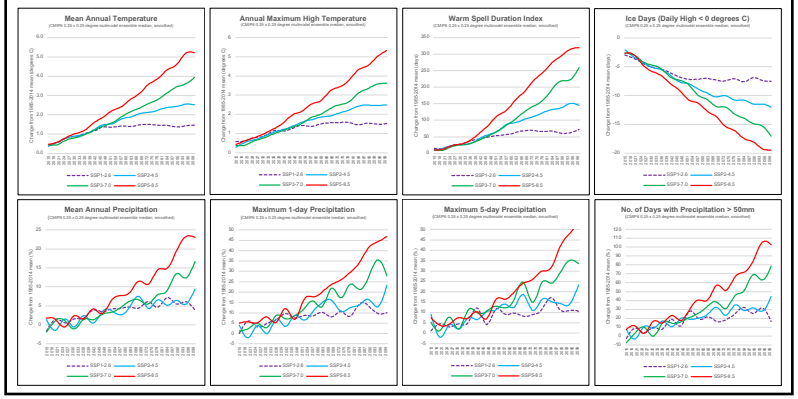
Handout: Projected climate anomalies to 2100 for Bhutan



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Vulnerability, resilience and adaptation

Vulnerability
- The state of being susceptible to harm due to external challenges

Resilience
- The capacity to withstand or to recover quickly from difficult circumstances

Adaptation
- The process of change by which an organization or system becomes better suited to meeting new challenges posed by changed circumstances (i.e., becomes less vulnerable and more resilient)

How can road asset management adapt to climate change in order to enhance the resilience of the road network?

17

Adaptation as risk management

Two main avenues for action
- Mitigate risk factors
- Increase capacity for understanding and addressing identified risks

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TEA BREAK
(reconvene in 15 minutes)

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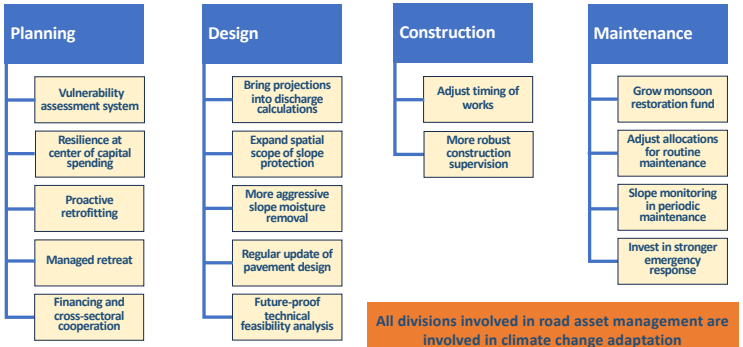
Adapting RAM for climate change: Whole-of-agency approach



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Adapting RAM: Planning

Planning
- Vulnerability assessment system
- Resilience at center of capital spending
- Proactive retrofitting
- Managed retreat
- Financing and cross-sectoral cooperation

Climate change challenge
- Changing context for road network planning
- Established planning methods will still be valid, but may benefit from supplementation with additional approaches and thinking

Adaptation
- Add adaptation tools and concepts to planning toolkit

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Climate change vulnerability assessment systems

Planning
- Vulnerability assessment system
- Resilience at center of capital spending
- Proactive retrofitting
- Managed retreat
- Financing and cross-sectoral cooperation

Rationale
- Figure out where the climate resilience weak points are
- Enable prioritization of proactive fixes

Key elements of vulnerability assessment systems
- Bring together climate projections, information on assets and their use, and engineering knowledge and judgement
- Enable **systematic** and **consistent** evaluation of vulnerabilities to inform prioritization of adaptation investments

Examples of vulnerability assessment approaches
- FHWA Vulnerability Assessment and Adaptation Framework (US)
- ROADAPT (EU)
- Public Infrastructure Engineering Vulnerability Committee (PIEVC) Protocol (Canada)

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Climate change vulnerability assessment systems

Generic process reflected in three systems mentioned

- Identify asset(s) of interest
- Gather location-appropriate climate projection information
- Gather asset information
- Consider asset vulnerability based on:
  1. Relevant climate hazard(s)
  2. Probability of consequences for asset
  3. Severity of consequences if probable
  4. Criticality of asset(s)
- Assign a score to be used in decision-making
- Formulate adaptation proposals

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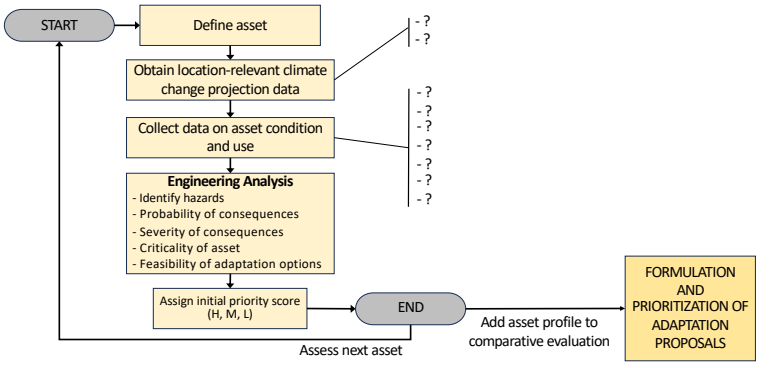
How might a DoST vulnerability assessment system look?



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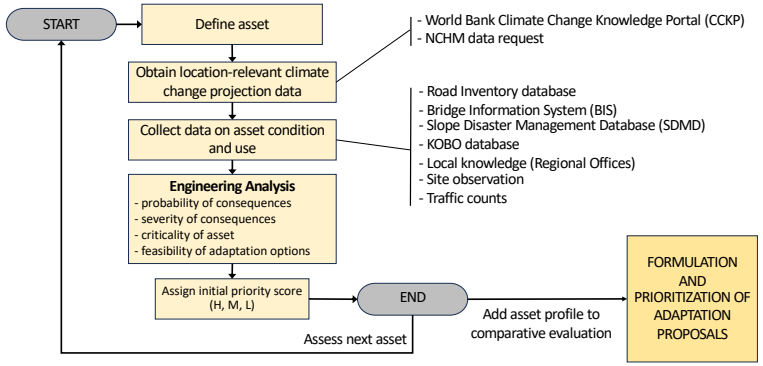
How might a DoST vulnerability assessment system look?



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Centering resilience in capital spending

Planning
- Vulnerability assessment system
- Resilience at center of capital spending
- Proactive retrofitting
- Managed retreat
- Financing and cross-sectoral cooperation

Climate change challenge

- Large backlog of known problem spots affecting resilience
- All will get worse due to climate changes projected
- Maintenance budget will balloon, **OR** quality, connectivity and safety will decline

Adaptation to consider

- Slow down on network expansion?
- Fix what is broken before building more?

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Proactive retrofitting

Planning
- Vulnerability assessment system
- Resilience at center of capital spending
- Proactive retrofitting
- Managed retreat
- Financing and cross-sectoral cooperation

Rationale

- Get ahead of projected climate changes
- 'Catch up' existing roads to resilience standard of newer ones

Prerequisite analysis

- Vulnerability assessment
- Identify asset classes and retrofit objectives
- Identify screening and inclusion criteria
- Formulate retrofit actions

Likely candidate: road drainage systems

- Address known overflow and blockage locations
- Provide supplemental drainage capacity (e.g., additional cross drainage) **and/or**
- Replace undersized structures

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Managed retreat

Planning
- Vulnerability assessment system
- Resilience at center of capital spending
- Proactive retrofitting
- Managed retreat
- Financing and cross-sectoral cooperation

Climate change challenge

- Maintenance costs will increasingly outweigh benefits for some roads

Adaptation option

- Cut losses on excessively vulnerable infrastructure
- Free up resources spent on non-critical infrastructure for critical infrastructure
- Low end: realign high-cost segments
- High end: abandon asset and relocate affected communities

Prerequisite analysis

- Past and future maintenance cost analysis
- Criticality assessment
- Analysis of social consequences for communities

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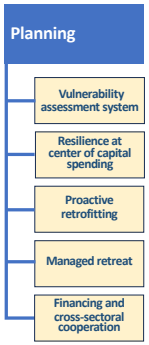
Financing and cross-sectoral cooperation



Climate change challenge

- Adaptation needs may outstrip national budget capacity

Adaptation option

- Seek outside financing for adaptation initiatives
- E.G.: Global Climate Fund, Adaptation Fund, Global Environment Facility, bilateral programs (many are grants)
- ADB USD 100 billion for CC initiatives through 2030 (~40% adaptation so far)
- Useful to position within cross-sectoral context

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Cross-sectoral cooperation in seeking adaptation funding

Rationale for cross-sectoral cooperation

- Some adaptation financiers (e.g., AF, GCF, GEF) may prefer not to fund straight infrastructure
- Resilience can mean many things, good roads can be linked to most
- Need to show linkage to social and environmental resilience
- E.G.: current GEF project 'Enhancing Sustainability and Climate Resilience of Forest and Agricultural Landscape and Community Livelihoods' (agricultural resilience supported by road resilience)
- Nature-based solutions current hot theme
- Requires work and creativity

30

Ideas for cross-sector adaptation proposals

Watershed management to moderate runoff?

- Involvement of road + water + power + forest + agriculture sectors

Marginalized communities secure access program?

- Involvement of road + social development sectors

Groundwater recharge zone protection?

- Involvement of road + agricultural + forest + environment + power sectors

Disaster risk reduction program?

- Involvement of road + disaster management + social development sectors

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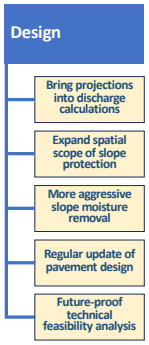
Adapting RAM: Design



Climate change challenges

- Mean runoff ⇧
- Peak runoff ⇧
- Slope saturation potential ⇧
- River discharge ⇧
- Scour risk ⇧
- Channel dynamism ⇧

32

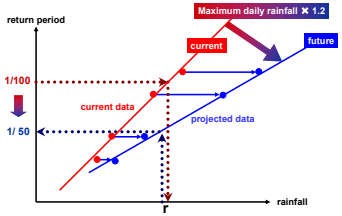
Design discharge/bridge clearance/scour protection

Design

- Bring projections into discharge calculations
- Expand spatial scope of slope protection
- More aggressive slope moisture removal
- Regular update of pavement design
- Future-proof technical feasibility analysis

Climate change challenge

- Climate is dynamic, design standards are less so
- Have to adapt hydrological analysis and design discharge calculations to reflect future climate, not historical



Source: Japan Ministry of Lands, Infrastructure, Transport and Tourism

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Difficulties of adapting hydrological/hydraulic analysis

Approach	Challenges
1. Adjust input assumptions (precipitation, evapotranspiration) in hydrological analysis	• Lack of solid baseline weather and streamflow data makes it difficult to adjust for projected change
2. Change design guidelines to specify precautionary higher ARI event assumptions	• Low confidence in validity of longer return period event magnitude due to short and patchy empirical weather and streamflow data • Risk of overbuilt and expensive infrastructure
3. Find better data and model peak events	• May be time consuming to acquire data • User learning curve
4. What else can be done? FOR DISCUSSION	

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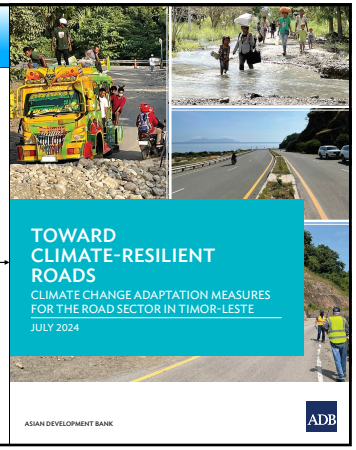
Case example (Timor Leste)

Modeling future design rainfall taking account of climate change

- Historical satellite precipitation used as stand-in for ground-level weather data
- Adjustment ratio for climate change derived from CMIP6 projections
- Future 10-yr return rainfall predicted for culvert locations
- Culvert design to 10-yr return capacity using rational method

see Section 2.2
(in Adaptation Resource Library)



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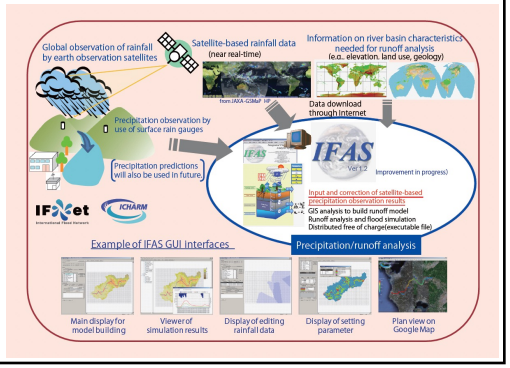
Tool for modeling runoff

Integrated Flood Analysis System (IFAS)

- Developed in Japan, distributed by International Centre for Water Hazard and Risk Management (ICHARM)
- Designed for use in developing country contexts where hydrological data are weak or non-existent
- Models runoff for catchments based on satellite precipitation data (and ground-level data when available)
- Intended for real-time applications, but can also provide estimates useful for design work
- Free to download and use
- Satellite rainfall data available free from JAXA, NASA and other sources



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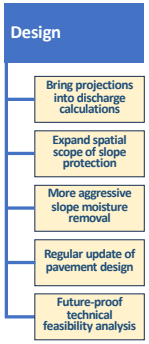
Scope of slope protection



Climate change challenge

- More slopes will become unstable
- Some slopes will be unstable over a larger area

Implications

- Slope protection will occupy greater proportion of design work
- Slope protection design expertise more and more important
- Per-km capital costs ⇧

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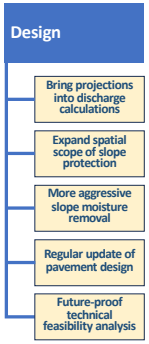
Slope moisture management



Climate change challenge

- Saturation potential higher = more need to remove moisture

Adaptations

- More catch drains in more locations
- More weeping capacity in concrete walls
- More use of gabion walls for enhanced moisture removal capacity
- More bioengineering with species selected for high water demand

Implications

- Per-km capital costs ⇧

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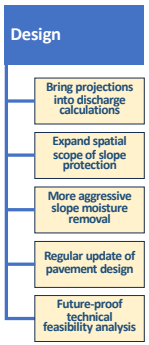
Iterative pavement redesign



Climate change challenge

- Higher maximum temperatures and more frequent warm spells affect asphalt pavement performance
- Rutting and shoving

Adaptation

- Adjust pavement design as temperature increases (assess parameters with each renewal cycle)
- Use angular aggregate in asphalt in hotter lowland areas

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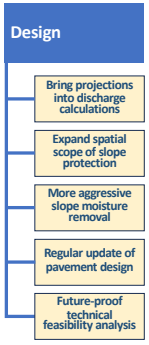
Future-proofing technical feasibility analysis



Foreseeable impact

- More locations will become more infeasible for roads
- Projects with borderline technical feasibility now will be increasingly untenable in the future

Adaptation

- Need to center future maintenance cost, public safety and environmental quality in feasibility analysis
- Don't build anything that doesn't have really robust technical feasibility

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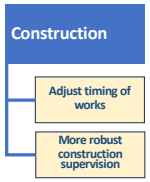
Adapting RAM: Construction



Climate change relevance to construction

- Timing of monsoon may become more erratic
- Resilience measures to be implemented by contractors will become more critical

Construction-related adaptation

- May be necessary to adjust work periods to avoid rainy season
- More robust construction supervision needed
  - Ensure contractors implement all slope protection properly
  - Ensure contractors meet responsibility for proper establishment of vegetation in bioengineering through end of defects period
  - Ensure contractors properly address seepages encountered during works

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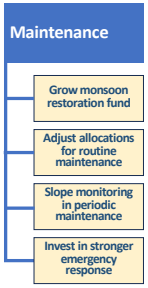
Adapting RAM: Maintenance



Key challenges due to climate change

- Many slopes more unstable than now
- New areas of instability likely to emerge
- Debris flows and rockfalls more common
- More bridge and culvert washouts
- Scour and river dynamism more intense

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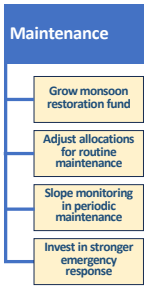
Monsoon restoration fund



Foreseeable impacts

- Landslide response needs ⇧
- Proactive slope protection will help, but scale of problem massive
- More equipment on stand-by in more locations
- More materials stockpiles in more locations
- Greater capacity for rapid needs assessment
- More extreme events, more often = More frequent fund depletion

- **Monsoon fund will have to grow (esp. after 2050)**

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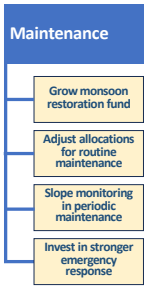
Routine maintenance



Foreseeable impacts

- Drainage cleanout needs ⇧
- Minor slip clearance needs ⇧
- Pothole and crack repair needs ⇧⇩
- De-icing and snow removal needs ⇩

- **Routine maintenance budget ⇧ on balance**

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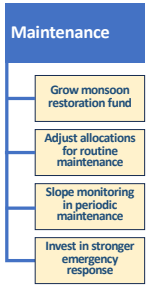
Periodic maintenance: Slope protection



Foreseeable need

- More instability = more proactive slope protection needed
- More slope protection measures = more inspection and upkeep
- More bioengineering = more vegetation inspection and maintenance
- Periodic maintenance budget ⇧

Adaptation: Slope protection monitoring program

- Systematic, consistent effort to identify and correct emerging failures in off-road slope protection
- Focus on installed catch drains, walls and bioengineering
- Expansion of periodic maintenance activity

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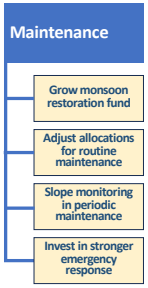
Emergency response



Foreseeable impact

- Investment in resilient infrastructure will help, but increase in major incidents should be expected
- Emergency response needs ⇧
- Capacity and budget for managing road closures, traffic redirection, public communication ⇧

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Bringing it all together: Adaptation strategy

Climate change adaptation challenge

- Adaptation requires whole-of-agency approach
- Some means of organizing and coordinating actions needed

Adaptation Strategy

- Many road agencies around the world have developed overall climate change adaptation strategies or plans
- Typically linked to or consistent with national adaptation plans
- Types of things discussed today could be collected and prioritized under an overall DOST adaptation strategy
- Preparation of strategy would be good candidate for external adaptation financing (grant)

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Guide to Resource Library

- On the USB drive (for you to keep)
- Collection of useful guidance materials and tools related to adaptation of road asset management to climate change
- Divided into thematic directories
- For reference, further reading, discussion with your colleagues
- Today's presentation also on the drive

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Thank you for participating!

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Evaluations

Please take a few minutes to complete an evaluation.
Lunch will be served shortly.

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