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INFRASTRUCTURE ASSESSMENT IN SNOW LEOPARD HABITAT OF NEPAL

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FOREWORD

With Nepal transitioning into its new federal structure, greater emphasis has been placed on infrastructural development by the Government to achieve its ambitious target of becoming a middle-income country by 2030. However, such development, while critical for any nation's economic prosperity, is globally recognized as a challenge to wildlife conservation. These challenges are even greater for a country like Nepal – with its aspiration for development and responsibility to preserve its rich natural heritage.

In the context of increasing infrastructural development in Nepal, and potential growth of large infrastructures in the future, WWF commissioned a rapid assessment of infrastructure in the Himalayan region; a global priority landscape for snow leopards. The overall objective of the assessment was to explore, identify and assess the impacts of current as well as planned future infrastructures on snow leopard habitats of Nepal.

Snow leopards are a flagship species of the high mountain ecosystems. Their survival ensures well-being of the entire ecosystems they inhabit. Any development initiatives that ensures minimal damage to snow leopards and their habitats contributes therefore to securing long-term benefits of the entire ecosystem.

This report is an outcome of the assessment of existing and planned infrastructures in the Himalayan range of Nepal and wouldn't have been possible without the support of WWF UK. Contribution to this report includes 'An Infrastructure Assessment in Snow Leopard Habitat of Nepal's Himalayas', executed under WWF's Guarding the God's Pet in the Himalayas.

We hope this assessment serves as an important guide for taking forward Nepal's agenda of sustainable green infrastructure for the benefit of people, nature and wildlife, and the nation at large.

Dr. Ghana S. Gurung
Country Representative, WWF Nepal
Snow Leopard Champion, WWF Network

ACRONYMS

AHP	Analytical Hierarchical Process
CR	Consistency Ratio
CHAL	Chitwan Annapurna Landscape
DDC	District Development Committee
DMG	Department of Mines and Geology
DR	District Road
DoR	Department of Roads
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GSLEP	Global Snow Leopard and Ecosystem Protection Program
GoN	Government of Nepal
HW	Highway
IEE	Initial Enviromental Examination
LDC	Least Developed Countries
MAPs	Medicinal and Aromatic Plants
MCDM	Multi-Criteria Decision Making
MoFE	Ministry of Forests and Environment
MoPE	Ministry of Population and Environment
MW	Mega Watt
SEA	Strategic Environmental Assessment
SRN	Strategic Roads Network
TR	Track
UNDP	United Nation Development Program
USD	United States Dollar
USAID	United States Agency for International Development
VAR	Village and Agriculture Road
YAE	Youth Alliance for Environment
WWF	World Wildlife Fund Inc.

EXECUTIVE SUMMARY

With Nepal having stepped into the federal structure, development of infrastructure seems more viable as the nation's capital expenditure is expected to be better exploited to drive the infrastructure trends towards prosperity. Infrastructural development is instrumental to the country's economic development, however only proper planning and execution of developmental projects can yield positive results in conserving the natural environment. Snow leopards; global priority species are found in high mountain ecosystems and their survival ensures well-being of the entire ecosystems they inhabit. Any development initiatives that ensures minimal damage to snow leopards and their habitats, therefore, contributes to securing long-term benefits of the entire ecosystem.

Rapid infrastructure assessment was conducted with an objective of exploring, identifying and assessing the impacts of current as well as planned infrastructures on snow leopard habitats of Nepal. Thus, this report is an outcome of that assessment carried out in Nepal's Himalayas in mid-2016. Current and planned projects focusing on road, hydropower and airport were the focal point of this assessment. Settlement buildup, mines and trail development were also considered as possible sources bearing an impact on the snow leopard habitat. Efforts were made to evaluate their impact, both qualitatively and quantitatively, and recommend priority actions for prevention and/or mitigation of negative impacts. During the assessment, multi-criteria decision-making tools incorporating analytic hierarchy process technique was used in impact assessment of conservation and development projects. This publication also consolidates necessary information that could serves as a starting point for research to help plan and implement infrastructure projects, with minimal impacts on biodiversity, especially in the snow leopard conservation landscape within Nepal.

The evaluation shows that among the six-infrastructure themes that this assessment focused on, roads seem to have the highest amount of impact on the snow leopard habitat. Experts' ranking ranged from 61% for road to 12.4% for settlement. Impact due to high density road infrastructure on snow leopard habitat ranges from 5,725 sq. km. to 17,775 sq. km.. Prediction maps show an area (greater than 90 percentile) measuring between 525 sq. km. and 625 sq. km. as high impact zone in snow leopard habitat, affected by infrastructural development. The study concluded that the current cumulative effect of infrastructural development on snow leopard habitat is low. However, future impact scenario shows an increase of 50% impact area, most of which within or traversing through the core snow leopard habitats. Therefore, it is likely that snow leopard habitats would be subjected to a high degree of fragmentation and human disturbances in the future.

There is common understanding among us on the need to ensure environment sustainability in the face of infrastructure development, for the long-term well-being of both nature and people. National policies should reflect this knowledge and ensure minimal negative consequences of developmental activities. Improvement in quality of impact assessment, identification of potential risks and solutions during planning, incorporation of mitigation measures during construction, regular monitoring and corrective measures during operation as highlighted in environmental impact assessment reports, can greatly ensure sustainable development. Meanwhile, since, most transboundary roads in the country lies within the protected areas of Nepal, regular coordination between development and conservation stakeholders is a must to promote ssustainable green infrastructures.

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1.0 BACKGROUND

1.1 Snow leopards in Nepal

Nepal is one of the 12 extant range countries of the snow leopard, *Panthera uncia, (*Fig. 1). It hosts snow leopard habitat spread across approximately 30,000 sq. km. in the high Himalayan region, stretching from Taplejung district in the east to Darchula in the far-west. With an estimated national population of 300-400 individuals, equivalent to around 6.8% of the global estimates, Nepal is an important stronghold for the species.

To conserve the species and high-mountain ecosystems, the global community united its efforts under the Global Snow Leopard and Ecosystem Protection Program (GSLEP). Along with the range country governments, other governments and non-government partners, local communities and private partners, and the GSLEP facilitates a global holistic approach to snow leopard conservation.

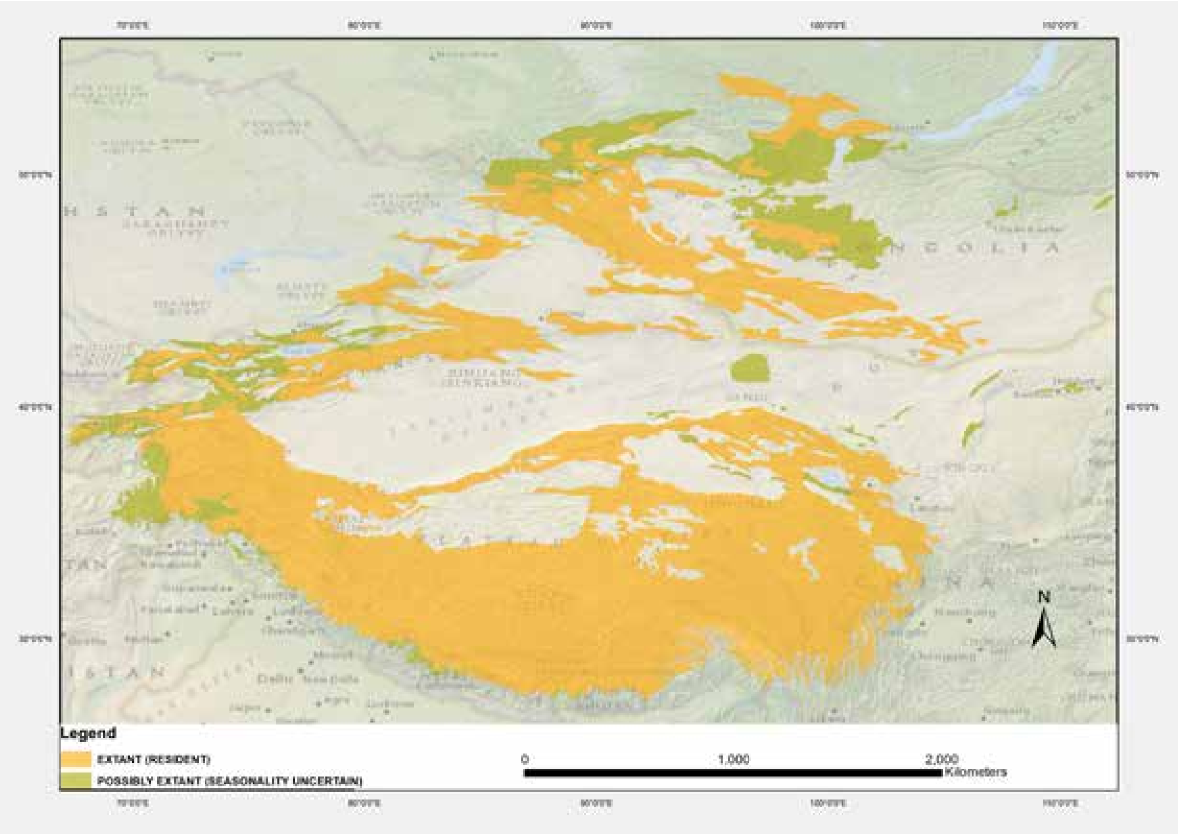


Figure 1: Global distribution of snow leopard in its historical range (yellow color indicates "extent distribution", violet color suggests "possible extent", and the rest indicates probable extent) (source: www.redlist.org)

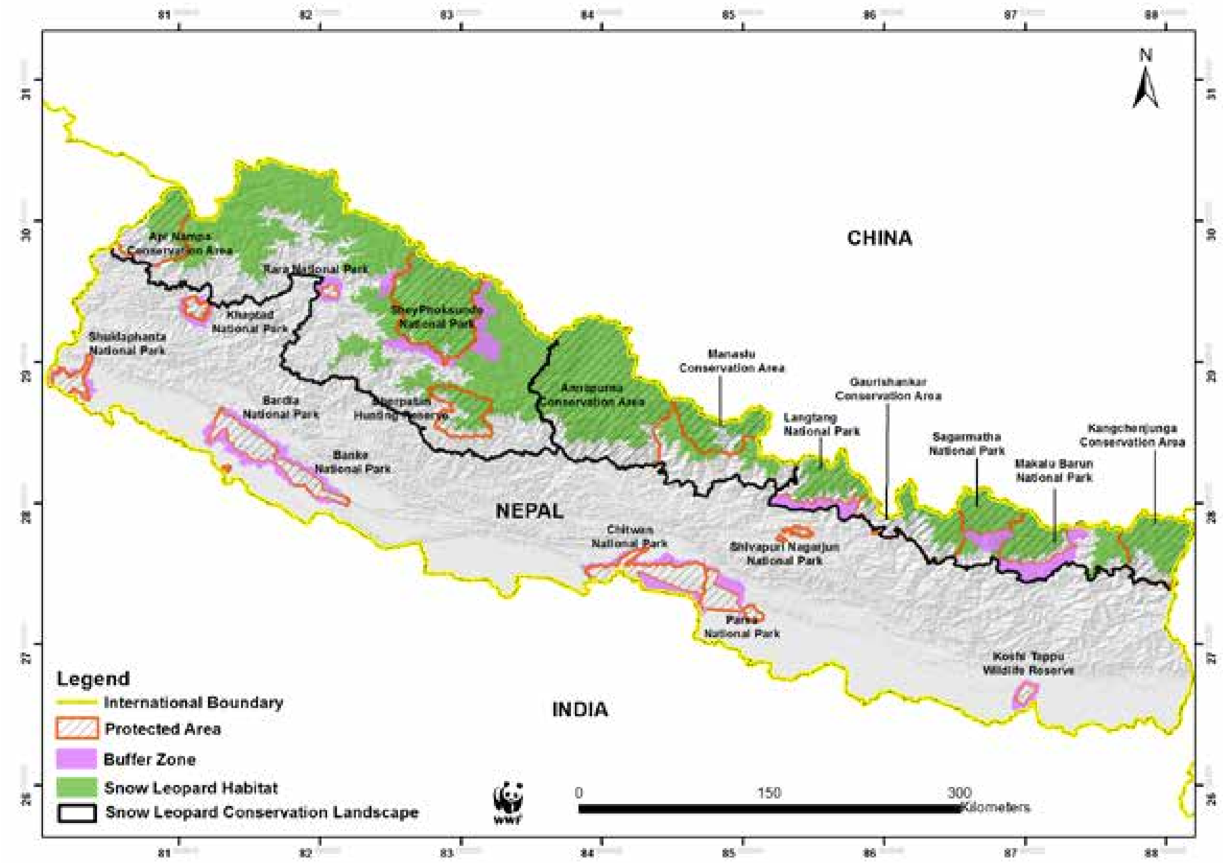


Figure 2: Protected Areas of Nepal showing PAs in Snow Leopard Conservation Landscape

In 2013, the unified global efforts culminated in the adoption of the Bishkek Declaration by the snow leopard range countries. Among others, this Declaration recognized and mandated joint efforts to secure at least 23 priority snow leopard conservation landscapes. Three of these landscapes (Western, Central and Eastern Snow Leopard Conservation Landscape) lies in the Himalayan region of Nepal (Fig. 2). The eastern snow leopard conservation landscape comprises of Kangchenjunga Conservation Area, Makalu-Barun National Park, Sagarmatha National Park, Gaurishankar Conservation Area, and Langtang National Park. The central snow leopard conservation landscape covers Manaslu Conservation Area and Annapurna Conservation Area. Towards the west from Kali Gandaki gorge, the western snow leopard conservation landscape covers Dolpa, Mugu, Humla, Darchula districts including Shey Phoksundo National Park, Rara National Park and Api-Nampa Conservation Area, and Dhorpatan Hunting Reserve.

As in other range countries, snow leopards in Nepal face a multitude of threats. Direct threats to the species include retaliatory killings, prey base decline, poaching and illegal wildlife trade. However, relatively fewer research has meant limited information on the magnitude of these threats as well as the status of the species itself. While efforts are being made to fill in these gaps, the conservation community is also working towards anticipating potential impacts to address indirect threats such as climate change and infrastructure development which can compound the risks for the species.

1.2 Snow leopards - an opportunity towards sustainable infrastructure development in Nepal

Holding the epithet – the ghost of the mountains, owing plausibly to its elusive nature and perfect camouflage, snow leopards are an indicator of the health of high mountain ecosystem. These ecosystems also provide other environmental services to people, most importantly as water towers on which depends survival of hundreds of millions of human lives.

Snow leopards lead solitary lives, with coverage of individual territories seemingly varying in different areas. Telemetry studies carried out in the 1970s in western snow leopard conservation landscape indicated territorial spread of about 30 sq. km. (Jackson and Ahlborn 1989), while recent satellite telemetry studies in eastern snow leopard conservation landscape indicated use of over 1,000 sq. km. by an adult male (unpublished data).

They mark their territories with scrapes, urine sprays, scats and pugmarks, to communicate remotely with other individuals. These marks are also used by researchers in understanding snow leopard ecology.

Although seemingly barren, these habitats are rich in natural treasures. Other than snow leopards, these landscapes host co-predators such as the Himalayan wolf, Tibetan fox, golden jackal and prey species such as blue sheep, Himalayan tahr, Himalayan argali, Himalayan serow, goral, musk deer, small mammals like marmot, pika and birds including the country's national bird, Danfe (*Lophophorus impejanus*) among a wide variety of wildlife. These Himalayan regions are also known for their productivity of Medicinal and Aromatic Plants (MAPs), most notably the '*Yarsagumba*' (*Cordyceps sinesis*, Caterpillar fungus).

Snow leopards are flagship of the high mountain ecosystems. Their survival ensures well-being of the entire ecosystems they inhabit. Any development initiatives that ensures minimal damage to snow leopards and their habitats, contributes therefore to securing long-term benefits of the entire ecosystem.

1.3 Infrastructure Development in Nepal

Infrastructure development, while critical for nation's economic prosperity, is globally recognized as a challenge to wildlife conservation. These challenges are even greater for a country like Nepal – with its aspiration for development and responsibility to preserve its rich natural heritage.

Nepal is among the Least Developed Countries (LDC), with its GDP worth 24.47 billion USD in 2017, representing just 0.03% of the global economy. More than 20% of the country's population currently live below poverty line. The Government has set itself a goal to graduate the nation from its LDC status by 2022 and transition to a middle-income country by 2030[1]. Accordingly, Nepal strives for higher growth rates, and has increased public spending on infrastructure development.

Infrastructures that may impact snow leopards and their habitat in Nepal include predominantly the linear infrastructures. To tap into obvious economic opportunities, improving connectivity with the northern neighbor is crucial for the country. Since 1970s, there has been a rapid increase in road connectivity in Nepal. Statistics of Local Road Network (SLRN) published by Department of Local Infrastructure Development and Agriculture roads (DoLIDAR) in 2016 points out that the total national road network spans over 57,632 km today, as against 2500 km less than five decades ago. The GoN has reportedly allocated 816 billion rupees for five years to improve land connectivity within the country. Apart from enhancing East-West connectivity, significant improvements are expected in the North-South connectivity traversing through snow leopard habitats in Nepal Himalayas. In November 2015, the governments of Nepal and China signed an agreement to study feasibility of opening seven new trade routes. Anticipating better economic benefits, road construction along these trade routes will most likely see positive response by local communities, as in the case of Olangchungola, Eastern Nepal. Likewise, there are plans to create a trans-Himalayan railway line providing overland trade route via Nepal, into India. Although political negotiations are ongoing regarding North-South Railway line, the final modality of the construction of the line has not yet been finalized despite few field visits and pre-feasibility studies from both counterparts.

These linear infrastructures will help fit Nepal into another of China's massive projects 'One Belt One Road (OBOR)'. The project has been touted as an opportunity for Nepal, provided it can match up to the infrastructure needs. There is increasing advocacy for this, especially considering Nepal being a potential gateway for China to south Asia.

1 Economic Review, Transportation Sector profile, Investment Board Nepal, March 2017

These routes will traverse critical snow leopard habitat and the subsequent human colonization of habitats alongside the road networks may cause severe fragmentation, affecting dispersal and genetic exchange between populations which is critical for long-term viability of any species. Improved access to remote snow leopard habitats also presents plausible challenge of increasing activities of poachers and illicit wildlife traders.

Other than linear infrastructures, hydropower and transmission lines, mines and tourism development may impact snow leopard conservation, albeit to a smaller degree if not planned well.

In a drive for such growth, often, long-term ecosystem services offered by nature are irresponsibly compromised. With changing climate scenarios, negative impacts of these infrastructure on wildlife conservation as well as long-term welfare of local communities may be more severely jeopardized. Considering federal restructuring and potential opportunities, the northern region which harbors the snow leopard is likely to see greater impacts of this drive.

These development measures are necessary to meet the country's aspirations. However, these must be done in ways that minimize negative impact on nature, for long-term benefits to local communities. Being informed on existing infrastructures as well as discovering and identifying planned infrastructures will be a crucial step to ensure minimal disturbances to the snow leopard habitat. This will also help Nepal in adhering to its global conservation commitments, and to find green sustainable solutions that allow development with minimal negative impacts.

1.4 Large Infrastructure Assessment in snow leopard habitat of Nepal's Himalayas

With this context of increasing infrastructure development in Nepal, and potential growth of large infrastructures in the future ahead, WWF commissioned a study for infrastructure assessment in the northern Himalayan regions; a global priority landscape for snow leopards. The overall objective of the assessment was to explore, identify and assess the impacts of current as well as planned future infrastructures on snow leopard habitats of Nepal.

This report is an outcome of an assessment of existing and planned infrastructures in the Nepali Himalayas, carried out in mid-2016. Efforts were also made to assess their impacts, qualitatively and quantitatively, and recommend priority actions for prevention and/or mitigation of negative impacts.

Contributions to this report include 'an infrastructure assessment in snow leopard habitat in Nepal Himalayas', executed under WWF's Guarding the God's Pet in the Himalayas, by the Youth Alliance for Environment (YAE) in 2016-17. This publication comprises the base line information on existing, and planned infrastructure in the Nepal's Himalayas, gathered by this team. The findings of impacts of the infrastructure by YAE team, was fine-scaled, and additional information was updated based on latest literature, and consultations with global experts within WWF Network.

In addition, efforts have been made to further enrich the publication to address certain limitations to facilitate better Environment Impact Assessment (EIA) of infrastructures in the snow leopard landscape. This publication therefore includes information and maps on snow leopard habitat of Nepal, for use by EIA professionals. The publication also tries to capture global literature including positions of WWF global practices, guidelines, and case studies, for policy makers, planners and implementers of large infrastructures, to ensure long-term benefits to communities and nature. This publication tries to consolidate the information available to provide a starting point for necessary research to help plan and implement infrastructure projects, with minimal impacts on biodiversity, especially in the snow leopard conservation landscape within Nepal. All the information has been consolidated and presented in Annex 2 and 3.

2.0 DESIGN

2.1 Geographical Context

Snow leopards are distributed throughout Nepal's Himalayas and are recorded at an altitudinal range between 3,000 and 5,400 meters above sea level; range considered as a potential elevation zone of snow leopard. Assessment covers a total of 32 districts (Annex 3, Fig. 3).

The area covers four national parks (1. Shey Phoksundo National Park, 2- Langtang National Park, 3- Sagarmatha National Park, 4—Makalu Barun National Park) and five conservation areas (1-Api Nampa Conservation Area, 2-Annapurna Conservation Area, 3- Manaslu Conservation Area, 4- Gaurishanker Conservation Area, 5-Kanchanjunga Conservation Area) (Figure 2).

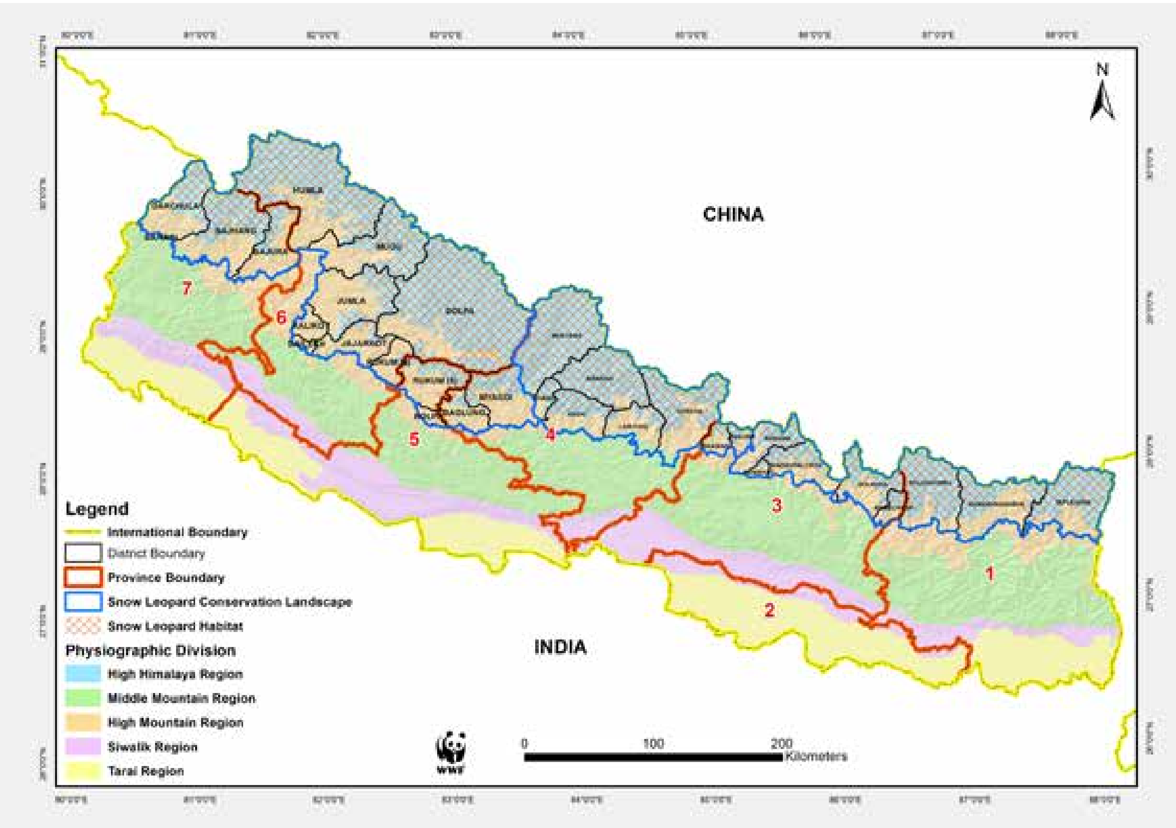


Figure 3: Study Area along the Snow Leopard Conservation Landscape

2.2 Conceptual Framework of Impact Assessment

This work involved an assessment of existing and proposed large infrastructure in the snow leopard landscape (as identified under GLSLEP) in Nepal. A multi-pronged strategy was used to generate data and their analyses. The tentative outline of conceptual framework is provided in Fig. 4.

Anthropogenic disturbances including impact of large infrastructure on wildlife habitat is a complex problem that has been difficult to quantify. Strategic assessment using expert opinion reduces underlying biases and uncertainties in impact prediction as it collectively addresses diverse opinion into a consensus. Data from government documents (action plans, policies and strategies), public opinion and discussion (newspaper reports) and remote sensing were primary source of information and used in the analysis (Table 1).

Table 1: Methods of data collection

Data Source	Method	Expected data
Literature Review		
Academic publication	Search publications in 'Web of Science', Scopus, Google Scholar, Pub Med using different search strings	Scientific information on snow leopard ecology, impact of human disturbances on snow leopard
EIA Report	Collection and review of EIA reports submitted to Ministry of Population and Environment	Data on (a) impact scoping, (b) impact assessment, (c) prioritization and (d) mitigation measures pertinent to snow leopard habitat
Government Report (periodic plans, strategies, programs)	Collection and review of Nepal's development strategies (3-5 year development plans, sectoral development strategies for road, tourism, agriculture, urban development etc.)	Data on existing, proposed and potential development programs in snow leopard habitat range of Nepal (Data sources: National Planning Commission of Nepal, Ministry of Urban Development, Ministry of Agriculture, Ministry of Transport, Ministry of Tourism)
Reports by (a) development aid agencies, (b) bilateral agencies and (d) intergovernmental organizations	Collection and review of policy documents published by international organization	Data on existing, proposed and potential development programs in snow leopard habitat range of Nepal (Data sources: Asian Development Bank, World Development Bank, UNDP etc.)
Annual Progress Report by District Development Committee	Collection and review of local development programs in snow leopard habitat districts.	Data on existing, proposed and potential development programs in snow leopard habitat range of Nepal (data sources: Districts covering northern frontiers of Nepal -Taplejung to Darchula)
Newspaper survey	Collection and review of development programs that are discussed in public forum and yet to be endorsed by government agencies	Data on potential development programs in snow leopard habitat range of Nepal (data source: Kantipur Daily)

Geospatial Data	Collection, check and review of geospatial data available in public repositories	Geospatial data obtained from remote sensing and maps provide information on spatial distribution of development projects
Key informant discussion		
Members of Parliament	Informal meeting with Members of Parliament (snow leopard habitat district)	- Data on existing, proposed and potential development programs in snow leopard habitat range of Nepal - Collect spatial information of projects and their social and economic impact
Expert consultation	Online consultation with experts using predefined questionnaire (development expert, conservation biologist etc.)	- Identify key development programs and prioritize them based on risks
Field visit	Observation and consultation with local community	- Obtain insight on pattern and trend of development projects.

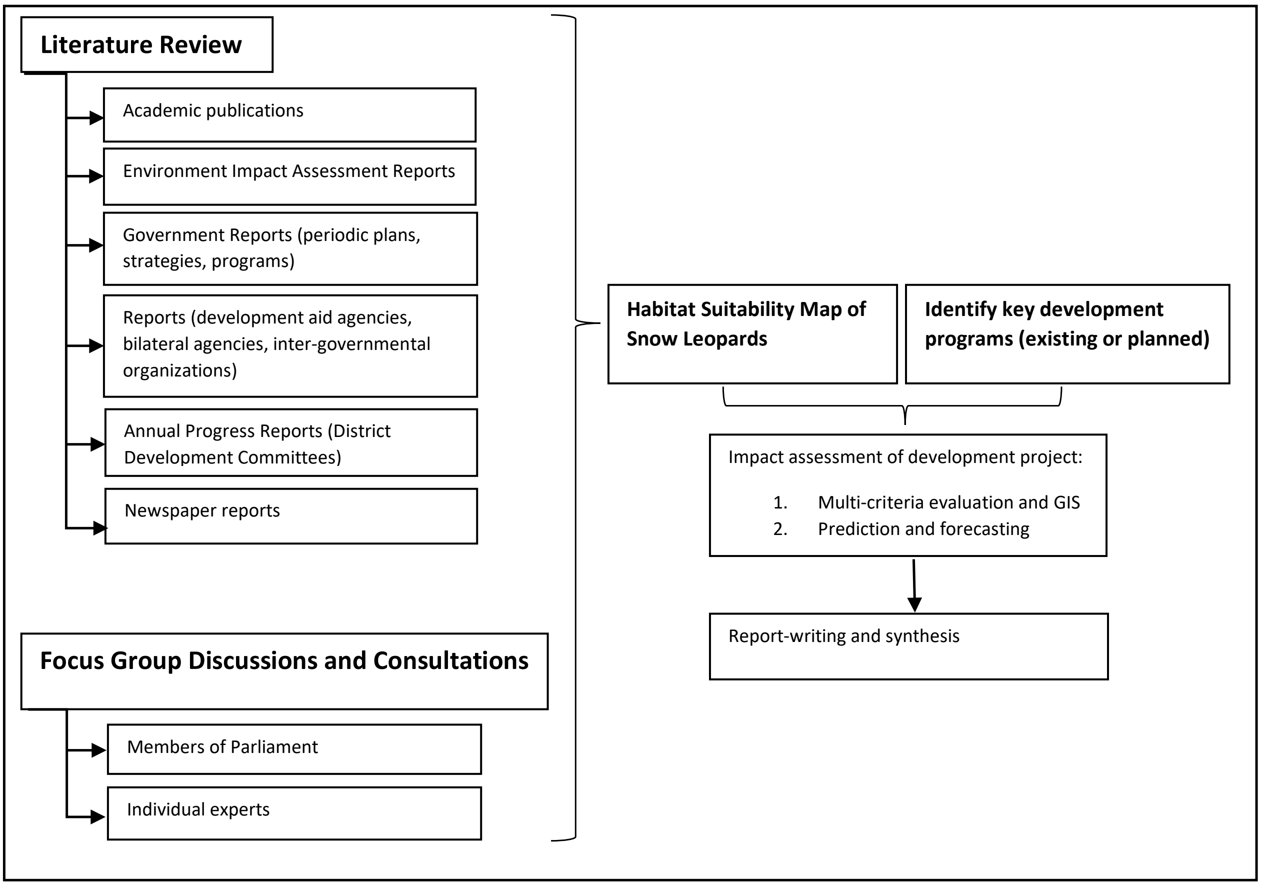


Figure 4: Conceptual Framework

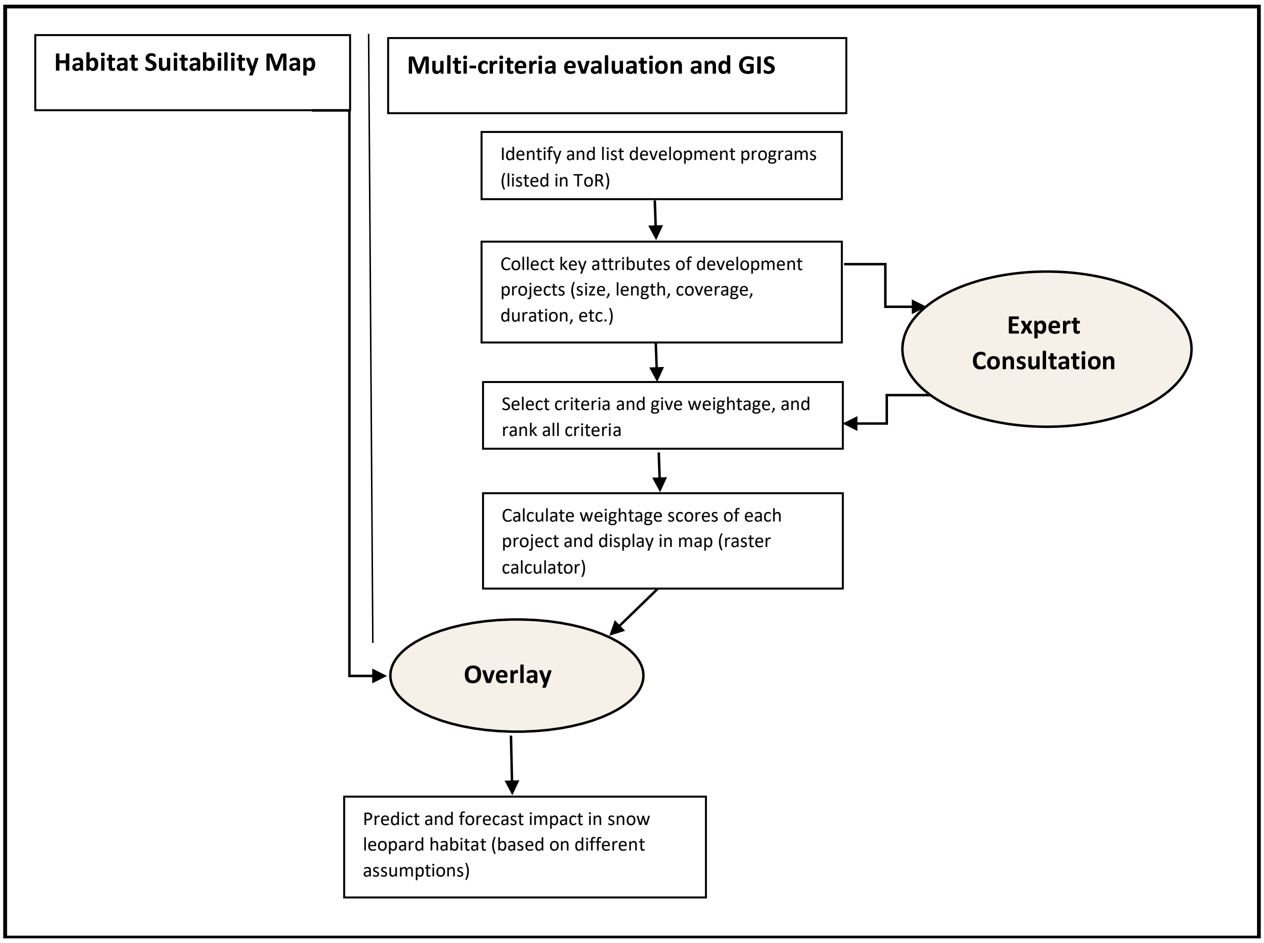


Figure 5: Details of Multi-Criteria Decision Making Approach

First, an exhaustive search of data (e.g., current and proposed large infrastructure projects) was carried out by using literature review and expert consultation (see Data section for details each method). Each project was categorized into four themes: (a) Road, (b) Tourism (trail and airport), (c) Hydropower, and (d) Mines. Based on it, experts (EIA experts, conservation biologists, researchers, conservation practitioners) were asked to rank each category on the basis of Analytical Hierarchical Process (AHP) in Multi-Criteria Decision Making (MCDM) approach (Fig. 5).

2.3 Data

2.3.1 Literature Review

Extensive review of academic research articles, government policies, government development plans (national and district levels) and news magazine was carried out to collect data on development projects in the snow leopard habitat range area and behavioral ecology of snow leopard.

Research Articles

An extensive review of scientific literature published up to 2016 was carried out to get information about ecological aspects of the snow leopards in the Himalayas. First, research articles in the Scopus database (www.scopus.com) were searched using following search strings: "snow leopard" OR “Panthera uncia" AND Nepal OR Himalayas . This search resulted in 584 papers. Second, article metadata was carefully checked to identify their relevance to this study.

Government Policy and EIA Report

Policy implies a course of action adopted or pursued by a government and can remain unwritten, properly documented and endorsed. Variety of following policy documents were collected. Based on the following criteria, 13 sectoral policies were reviewed:

- Relevant government documents and instruments
- Government documents which profess or would reasonably be interpreted to describe, set out or establish government policy on any topic or issue
- Any Bill for legislation on any issue or topic
- Any government document which establishes a Budget, or defines a government intention, authority or obligation to raise, commit or expend funds
- Any government accession to, involvement in, or endorsement of, any international agreement
- Any other documented component of government activity likely to have a significant effect on the environment.

EIA reports (Annex 4) of development projects applicable to the snow leopard habitat were obtained from the then Ministry of Population and Environment (now Ministry of Forest and Environment). Access to IEE/EIA/SEA reports were limited, thus the only basis for documentation and analysis of information for planned future infrastructure location/alignment information was holding consultations with the key stakeholders.

Development Programs at Local Level

Other than national level development programs, annual fiscal plan of districts covering snow leopard range were collected to get insight into local level infrastructure development program.

Newspaper Survey

Newspapers serve as a major source of information as they frequently report news on development issues. Reports on development issues, from 1 Jan, 2016 to 31 December, 2016 published in Kantipur National Daily (one of the most widely read Nepali language newspapers) was systematically scanned for information on development projects being planned or implemented.

2.3.2 Consultation Meetings

A few members of parliament representing snow leopard ranging districts, senior government staff at Ministry of Forests and Environment, Ministry of Energy, Ministry of Agriculture and Cooperatives, Ministry of Transport were consulted, to collect data on infrastructure projects, and verify the data collected throughout data collection cycle.

2.3.3 Habitat Model of Snow leopard

Habitat model of snow leopards in Nepal was prepared by WWF Nepal and was used as a baseline map for analysis.

2.3.4 Geospatial Data

Land-use map of study area was obtained from global land cover maps available on (http://glc30.tianditu.com). The map is available in 30 m resolution and includes classes such as forest area, cultivated land, grassland, shrub land, wetland, water bodies, artificial surfaces, bare land, permanent snow, and ice.

Maps of road, settlement, track, paths and building were obtained from open street map (http://download.geofabrik.deasia.html, downloaded on May 24, 2017) (Haklay and Weber, 2008; Map, 2014). The map is publicly available for download and has sufficiently high quality for large scale analysis (Haklay, 2010). Spatial locations of hydropower of Nepal along with ancillary information such as capacity and license status were obtained from Department of Energy (http://www.doed.gov.np downloaded on May 13, 2017). GIS thematic layer of hydropower project was created in ArcGIS. The mine data were obtained from Departments of Mines (http://gis.dmgnepal.gov.np/dmg/). Airport location data were obtained from Wiki page (https://en.wikipedia.org/wiki/List_of_airports_in_Nepal).

2.4 Data Analysis

2.4.1 Preparation of Thematic Maps

Thematic maps representing road, tourism (trail and airport), mines and hydropower were generated using geospatial data in ArcGIS. Road map was classified into four categories: (a) highway [HW], (b) district road [DR], (c) village and agriculture road [VAR], (c) track [TR]. Road density (km/km^2) map was prepared using line density function in ArcGIS within a search radius of 6.7 km. Anecdotal information on future new road networks connecting Nepal - China border was identified through various sources (e.g., newsmagazine, government reports and policy documents) and cross verified with concerned stakeholders.

Maps of current road network and new road network were combined to develop a map of potential road network of Nepal. GIS shape file of road density was created using line density function in ArcGIS with a search radius of 6.7 km. Footway, footpath and trail in mountain regions are important tourism infrastructure. A track density shape file was created using map of footway, footpath and trail using onscreen digitization approach within a search radius of 6.7 km using same line density function in ArcGIS. Data on mines did not include precise spatial (global positioning system-GPS) location or administrative address in a consistent manner. Therefore, district boundary was used as an approximate boundary of mine location.

Building locations were available in polygon feature in map. Polygon was converted into a point feature map by creating random points with an inhibition distance of 25 m. This is because mountain regions generally have a very dense settlement. A building density shape file was created by using point density feature in ArcGIS with a search radius of 6.7 km. Future settlement density shape file was created in the following manner:

First, random maps were developed along proposed road with an inhibition distance of 25 m and maximum spatial distance of 50 m that are situated in less than 450 m from steep land surfaces. This is because human settlements are mostly concentrated along roads, and therefore settlements appear to be ribbon like along the highways.

Second, new building distribution polygon was combined with that of existing ones and a building density map was created using point density function with a search radius of 6.7 km.

Density shape file of existing hydropower stations was developed by using point density feature in ArcGIS. Here, basic assumption was that the size of the hydropower has a proportionate environment impact. Therefore, capacity of hydropower (in MW) was assigned as the weight of hydropower in developing a density map. The future hydropower distribution map included both hydropower stations that are under production and projects with generation licenses[2]. But, detailed data about the status of projects of some of the hydropower under various stages of construction was lacking.

GIS shape files featuring the airports in Nepal as point features was developed within a search radius 5 km. This is because airports cause noise pollution which deters approaching snow leopard in their range. New proposals to expand the existing airport in the snow leopard habitat was not identified, and no future map was developed for this theme.

2.4.2 Multi-Criteria Evaluation

MCDM is an effective tool for impact assessment because it allows diverse structure, auditability, transparency and gives rigor to decisions. Saaty's Analytical Hierarchical Process (AHP) is a widely used MCDM technique in impact assessment of conservation and development projects (Saaty 1980). AHP is a useful tool to deal with complex decision problems when quantitative ratings are unavailable. AHP provides a consistent way of comparing two attributes based on relative importance of criteria (Saaty 1980). APH includes following stages (see the Box below for problem context):

- Identify the decision problem—The decision problem must be investigated in the topmost level of a hierarchy that is broken down into a number of levels
- Ascertain that the problem can be solved by AHP—AHP is only suitable for the decision problem that can be turned into a hierarchical decision model
- Structure the decision problem—A hierarchy structure formed for the decision problem consists of several levels
- Determine the experts—AHP relies on expert judgment and therefore, only experts who are responsible for making the decision are eligible to rate it
- Collect data from the expert—AHP determines the relative priorities of different criteria in every level of the hierarchy by employing a pairwise comparison. During the process, each expert is required to make judgments on the relative importance in relation to the element at the higher level with reference to a 9-point scale
- Calculate the priority weights of each criterion—Each decomposed level with respect to a higher level forms a matrix. The pairwise comparison data are summarized in the absolute priority weights based on Saaty's eigenvector procedure, and
- Measure the consistency ratio (C.R.)—This is done to ascertain that the experts are consistent in rating the relative importance of the criteria. AHP does not demand perfect consistency but a judgment is only considered acceptable when C.R. < or = 0.10. If the C.R. value is not less than 0.1, the ratings are considered inconsistent and require rework on it.

2 With an assumption that all hydropower plants with generation license will be completed in the near future.

2.4.3 Quantification of Model and Scenario Prediction

The current and potential (future) impact maps were developed using thematic layers of road, trail, hydropower, settlement, mines, and, airport. The density maps of all thematic layers were prepared and each density maps was converted into a percentage scale (i.e., each pixel was divided by largest pixel value and multiplied by 100) to minimize scale induced biases in the model. The existing and future impact maps resulting from infrastructure development in snow leopard habitat were computed as weighted linear combination of layers in the GIS environment with the help of QGIS software as:

Impact map=$\sum_i^n W_i \times T_i$, where W_i is weight of thematic layer i and T_i is thematic layer i.

Problem: Strategic Assessment of Infrastructure Development in Snow Leopard Habitat in Nepal

Context

Nepal is one of the 12 range countries of the endangered snow leopard (*Panthera uncia*). It is considered as an indicator species of the health of the Himalayas that provides crucial ecosystem, services to people residing in these areas and beyond. However, snow leopards in Nepal face a multitude of threats. Major direct threats include retaliatory killings, decrease in prey base, illegal wildlife trade and unplanned infrastructure development.

Assessment Options

This assessment focuses on the extent, if any, of infrastructure development (existing and proposed) and its effect on snow leopard habitat in Nepal. Here, expert opinion were gathered based on following assessment options:

- Road
- Hydropower
- Tourism: track
- Tourism: airport
- Mines
- Building

Assessment Method

The first step in assessment is to make a pair wise comparison between each criterion.

Value	*Degree of impact/intensity of importance*	*Definition*
1	Equal importance	Two criteria/sub-criteria contribute equally to the level immediately above
3	Moderate importance	Judgment slightly favors one criterion/ sub-criterion over another
5	Strong importance	Judgment strongly favors one criterion/sub-criterion over another
7	Very strong importance	One criterion/sub-criterion is favored very strongly over another
9	Absolute/extreme importance	There is evidence affirming that one criterion/ sub-criterion is favored over another
	(2, 4, 6, 8) Immediate values	Absolute judgment cannot be given and a compromise is required above scale values

3.0 INFRASTRUCTURES IN NEPAL'S HIMALAYAS - BASELINE REPORT

Compared against lower plains of Nepal and middle hill ranges, the northern Himalayan frontier has seen fewer infrastructure development. Extreme terrain and low demography have been the general limiting factors to development across this high Himalayan belt.

Over recent decades, however, there is a growing interest in tapping various potentials by accessing this region. Strategically, for Nepal, improving connectivity with China, via market centers of Tibet, can help boost trade and thereby economy. The country's policies therefore are aligned to prioritizing this north-south connectivity. With the new federal governance system, the power is being devolved to the grassroots, making way for greater local control over development. Additionally, there appears to be a strong surge of road construction by stakeholders. Improving access will bring about more development opportunities, and challenges. As a result, expansion of tourism and trade centers, mining, hydropower generation may see a surge.

This section outlines the current baseline of existing and planned linear and non-linear infrastructures in the Himalayan region.

3.1. Linear Infrastructures

3.1.1 Road construction in Nepal

History of Road development in Nepal[3]:

The history of Road construction in Nepal does not date back long. In 1924, the first motorable road was constructed in Kathmandu valley. By 1950, the total road length of the country was only 376 km. The first transboundary road, linking Kathmandu with the southern border was opened for traffic in 1956. The Government of China constructed the Kathmandu-Kodari road in 1966. By the same time, the GoN initiated the construction of East-West (Mahendra) highway ranging of 1028 km with the support of bilateral and multilateral agencies.

The National highways together with the feeder roads constitute the Strategic Road Network (SRN) of the country. The district roads together with village roads constitute the District Road Network. At present the SRN consists of 15 National highways and 51 feeder roads totaling to 12,473.94 km.

The principal agencies involved in planning stages of road projects are Ministry of Physical planning and Transportation (MoPIT), National Planning Commission (NPC) and Department of Local Infrastructure Development and Agricultural Roads (DoLIDAR - now renamed as Department of Local Infrastructure DoLI). However, after

3 Extracted from website: https://www.slideshare.net/pnbastola/history-of-road

federalism, as the powers have been disseminated to local governments, local and state governments will have the authority to develop plans and policies which could mainly include infrastructure development to meet the public demand.

Various road networks through East-west and North – South (NS) territory crosses through critical wildlife habitat of Nepal. The concerns raised here are of NS roads which might have direct and indirect impacts on snow leopard habitat.

These NS routes will traverse through critical snow leopard habitat and the subsequent human colonization of habitats alongside the road networks could cause severe fragmentation, affecting dispersal and genetic exchange between populations critical for long-term viability of any species. The improved access to the remote snow leopard habitats also has the potential to attract poachers and illicit wildlife traders.

Current Status

The road network in Nepal is depicted in Fig. 8, which includes all types of land-based transportations including highways, feeder roads, district roads, village roads, footway, path, and trails. There is an extensive network of road in the lowland Nepal. The middle mountain range, especially central Nepal also has an extensive network of road. Accordingly, a high proportion of highways are in the lowland followed by middle mountain region in Nepal.

Linear Infrastructures – Classification as per Road Standard 2070

Administrative Classification

As per the Nepal Road Standard, 2070, administrative classification of roads is intended to assign national importance and the level of government responsible for overall management and methods of financing. According to this classification roads are classified into:

(i) National Highways

National highways are main roads connecting East-West and North-South of the nation. These serve directly the greater portion of the longer distance travel, provide consistently higher level of service in terms of travel speeds, and bear the inter-community mobility. These roads are the main arterial routes passing through the length and breadth of the country as a whole. They are designated by letter ‘H’ followed by a two-digit number.

(ii) Feeder Roads

Feeder roads are important roads of localized nature. These serve the community's wide interest and connect district headquarters, major economic and tourism centers to National Highways or other feeder roads. They are designated by letter ‘F’ followed by 3-digit number.

(iii) District Roads

District roads are important roads within a district that serves as areas of production and markets and connect with each other or with the main highways.

(iv) Urban Roads

Urban roads are the roads within the urban municipalities.

In Nepal, the overall management of National Highways and Feeder Roads comes within the responsibility of the Department of Roads (DOR). These roads are collectively called Strategic Roads Network (SRN). District Roads and Urban Roads are managed by Department of Local Infrastructure Development and Agricultural Roads (DOLIDAR) and are collectively called Local Roads Network (LRN).

Table 2: Roads in Nepal

Type of Roads	Country (km)	Snow Leopard Habitat (km)
National highways & Feeder Roads	12,473.94	0.00
Urban Roads	368.39	0.00
District Roads	25,728.19	94.51
Village Roads	31,903.87	289.35
Total	70,474.40	498.01

(Source: Strategic Local Road Network 2016)

Of the total 70,474.40 km roads in Nepal (Table 2), total strategic roads which comprise of national highways and feeder roads, equivalent to 17.7% of the total roads. Currently, roads in the snow leopard habitat contribute to less than 1% of the overall road network of Nepal. Subsequently, there is a high tendency of road construction than that of national average.

Several roads of various priorities are being constructed throughout the northern borders of the country. In far-west Nepal, road connects Nepal-China border and construction of new road track (129 km) in Byas, Limi and many village development committees of Humla district (Fig. 7 Block A) is now complete. A total of 28 km track has been completed towards the north of Mugu. Additionally, plans are underway to connect Chinese border here (Fig.7 Block B). Among the northern borders, the largest network of road constructed is in Kaligandaki Corridor (Mustang district), including the way to Chame of Manang district. The track passes through Lete, Kunjo, Tukuche and Kagbeni. In Manang, the track passes through Khangsar, Pisang and Chame (Fig. 7 Block C). These areas include approximately 321 km of track road. Plans are underway to expand the road network to every

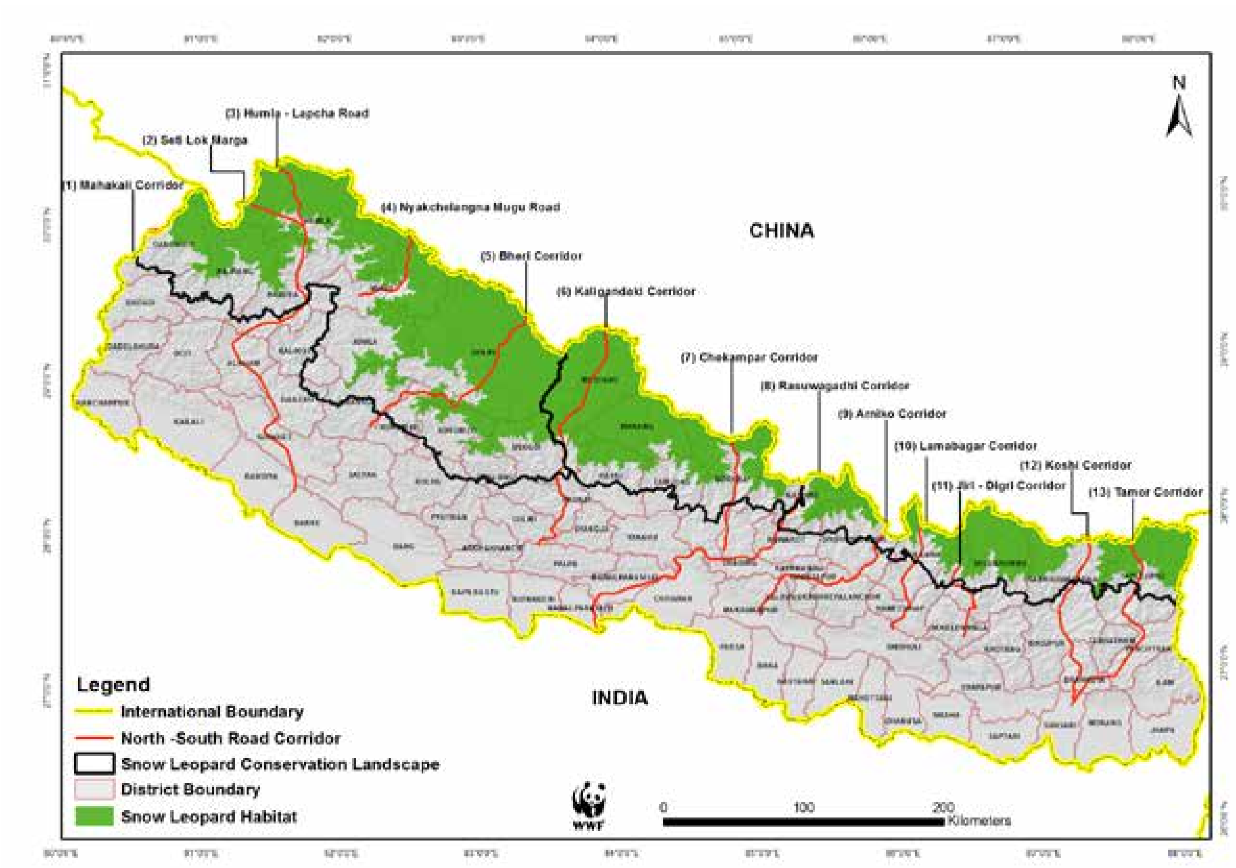


Figure 6: Classification of road network in Nepal

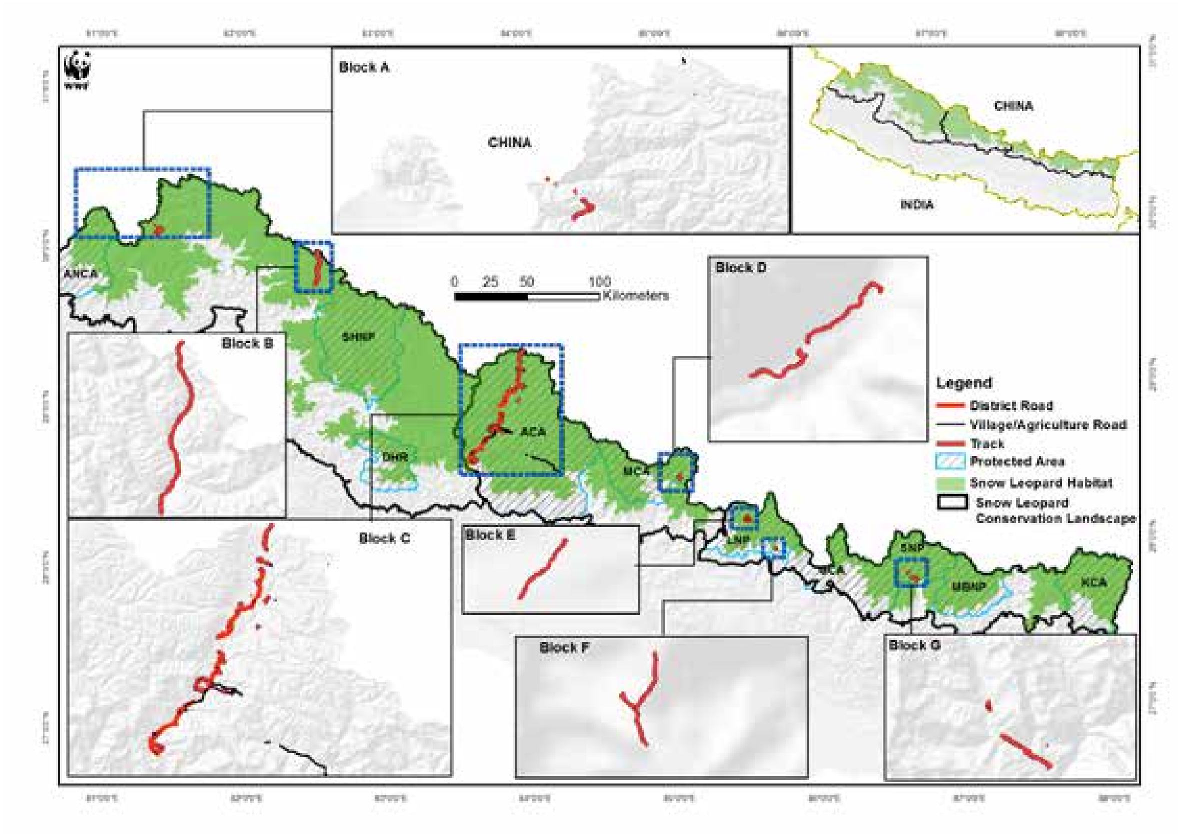


Figure 7: Existing road networks in snow leopard habitat

village in Mustang district. In completely isolated region of Gorkha district, the construction of a track of 4.1 km has been completed and is being expanded towards Chinese border from Chakampar (Fig.7 Block D). Likewise, tracks of road in snow leopard habitat in Rasuwa and Sindhupalchowk are being constructed (Fig. 7 Block E). In the Everest region, a total of 12 km road has been completed (Fig. 7 Block F).

All these road networks constitute a part of Government of Nepal's strategy to connect adjoining market centers of Tibet by road with the aim of boosting trade and local economy. Nepal's policy documents prioritizing NS connectivity although specific details (road standard, project completion period) are not systematically accessible. There are two major drivers for such road expansion. First, there is a strong public demand to expand road network along the northern boundary. Second, there is a growing consensus among Nepal's policy makers that NS connectivity is vital for Nepal's economic growth, especially to benefit from fast growing economies of India and China. Furthermore, there is a strong surge of road construction tendency driven by various actors such as community members at local level, district development committee at district level and, central government at national level. Our systematic review of news magazine and government plans suggest, that at least 13 NS corridors are either being planned for construction or are already under construction or being considered (Fig. 8).

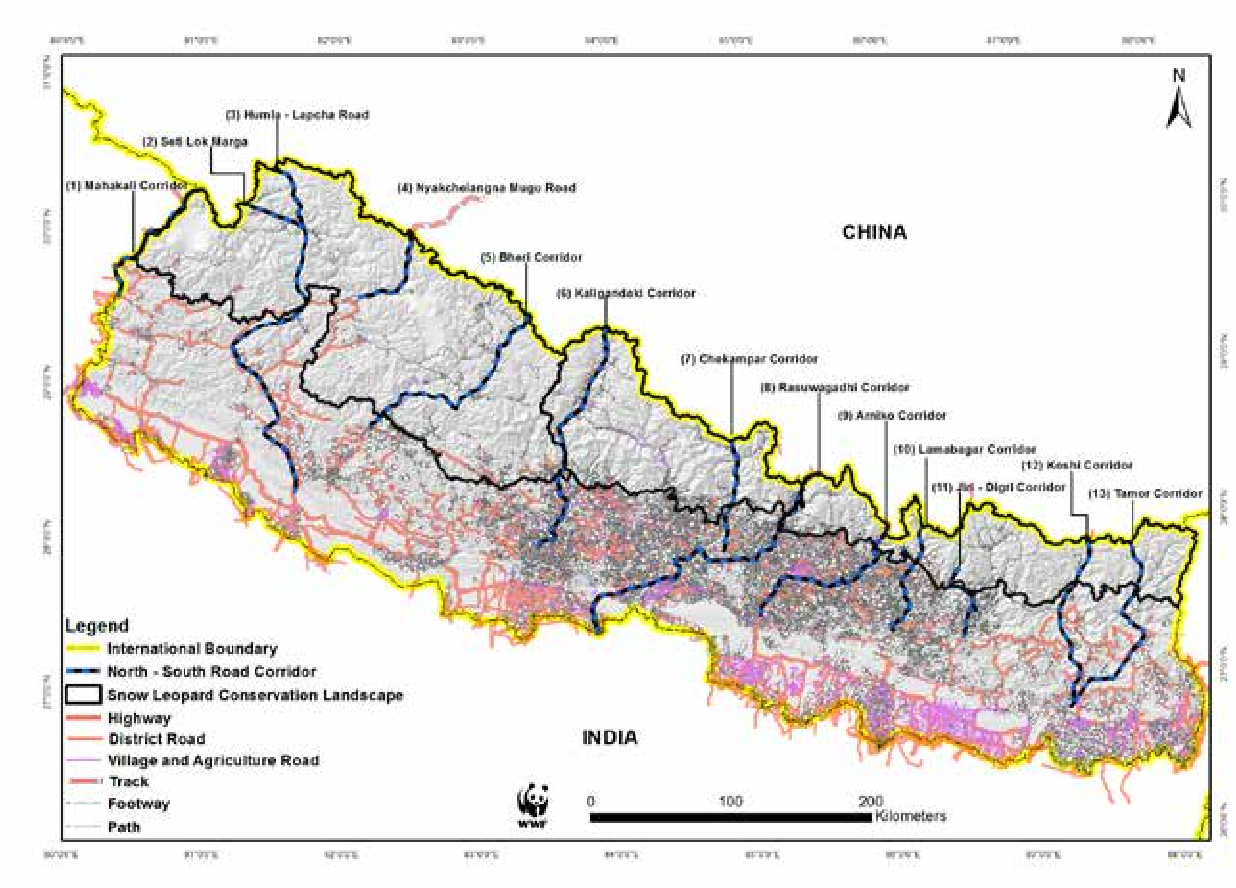


Figure 8: Existing and potential road network in Nepal

Table 3: North-South corridors (under construction: c & proposed: p)

SN	Name	Path	Length (km)
1	Mahakali Corridor (p)	Bramadev-Jhulaghat-Darchula-Tinkar	415
2	Seti Lok Marga (p)	Tikapur-Lodi-Chinapur-Taklakot	298
3	Humla-Lapcha Road (p)	Humla-Simikot-Limi-Lapcha	105
4	Nyakchelangna Mugu Road (p)	Mugu -Nyakchelagna	85
5	Bheri Corridor (p)	Jajarkot-Dunai-Marim-TinjeDho	190
6	Kaligandaki Corridor (c)	Gaidakot-Ridi-Rudrabani-Purtighat-Baglung-Beni-Jomsom-Korala	435
7	Chekampar Corridor (p)	Nalyang-Bhanjang-Chekampar-Chuchet-Sirdibas-Gumda	120

8	Rashuwagadhi Corridor (c)	Thori-Bhandara-Malekhu-Galchi-Trishuli-Betrawati-Syaprubeshi-Rasuwagadhi	188
9	Arniko Highway (p)	Maitighar,Kathmandu-Dhulikhel-Dolalghat--Barhabise-Kodari	113
10	Lamabagar Corridor (p)	Bhittamod-Dhalkebar-Sindhuli-Manthali-Dolakha-Lamabagar—Lapcha	186
11	Jiri-Digri Corridor (p)	Jiri-Salleri-Digri	88
12	Koshi Corridor (p)	Bitatnagar(Rani)-Itahari-Dhankuta-Leguwaghat-Khandbari-Kimanthanka	310
13	Tamor Corridor (p)	Dhankuta -Mulghat-Lumbughat-Taplejung (Majitar) Dhovan- Olangchungola	265

Mahakali Corridor is a 420 km-long road that goes along Mahakali River. This road links Province number 7 with China. Likewise, Seti Lok Marga is a 298 km-long highway that begins from Tikapur (Kailali district), passes through Lodi and Chainpur and ends in Taklakot, near the China border. Construction of 44 km-long track has been completed including the 3 km asphalt-topped and 30 km gravel-surfaced roads. The Humla-Lapcha road is 105 km stretch that starts from Humla, passes through Limi and ends in Lapcha along the Nepal-China border. Nearly 80% of track of this corridor has been completed. Mugu-Nyakchelagna is 85 km-long road that aims to connect Mugu to the Nepal-China border. Only 13 km track of the road has been constructed. Bheri Corridor connects Jajarkot with Tinje Dho, near Nepal-India border. The road passes through Dunai and Marim. Dunai is the district headquarter of Dolpa district and is expected to be connected to the rest of country by end of this year. More than 87% of track opening of Jajarkot - Dunai (117 km) has been completed. Dunai -Tinje Dho is a 70 km long, but only 8 km track was opened in 2015.

Kaligandaki Corridor begins from Gaidakot and passes through Ridi, Rudrabani, Purtighat, Baglung, Beni, Jomsom and ends in Korala near the Nepal-China border. This corridor is one of the most prioritized NS corridors for trade with China. The Government of Nepal has recently established an army barrack, an armed police barrack and designed a space for custom and immigration office including a dry port near the Nepal-China border. Rapid expansion of road from Jomsom to surrounding villages, and likewise in Upper Mustang has also been ongoing. Likewise, the construction work of the two-lane road of 78 km stretch from Beni to Jomsom is also in rapid progress. Likewise, the gravelling of 110 km Jomsom-Korala Road is under construction. Chekampar Corridor is approximately 120 km long and passes through Nalyang Bhanjang, Chekampar, Chuchet, Sirdibas, and ends in Gumda. Nearly 12 km of this track has been opened.

Rasuwagadhi Corridor is one of the two currently operational NS corridors. There are plans to upgrade this corridor to serve as an international highway for rapid transit between India and China through Nepal. These 188 km-long corridors start in Thori, near the Nepal-India border and passes through Bhandara, Malekhu, Galchi, Trisuli, Betrabati, Syafrubeshi and ends in Rasuwagadhi. The Thori-Malekhu section of the road is about 86 km long and about 42 km of this proposed route lies in Chitwan National Park. However, this section of Thori-Bhandara (42km) is doubted for construction as it bisects the core forest area of the national park. Additionally, Galchi-Trishuli-Betrabati-Mailung is being expanded into a double-lane road, and the section of Mailung-Syafrubeshi is being newly-excavated under the leadership of Nepal Army.

Additionally, media reports suggest the construction of Sigatse-Kerung Railway connection, scheduled to be ready in three years' time. Further details on the project are unavailable in public domain.

Arniko Highway Corridor is 144 km long and connects Kathmandu with Kodari. It passes through Kathmandu, Dhulikhel, Dolalghat, Barhabise and Kodari.

Lamabagar Corridor passes through Bhittamod, Dhalkebar, Sindhuli, Manthali, Dolakha, Lamabagar and Lapcha. This proposed road measures 186 km in length. From Bhittamod to Ramechhap is an existing road which needs upgrading of Charikot-Lamabagar road from Bhimeshwor. Jiri-Salleri-Digri is an 88 km long road, and 55 km of the track has been opened.

The Koshi Corridor connects Rani Custom Office in Biratnagar near the Nepal-India border with Kimanthanka near the Nepal-China border. This corridor is 310 km long and passes through Itahari, Dhankuta, Laguwaghat, Khandbari and Kimanthanka. Khandbari-Kimanthanka section is 162 km long of which construction of about 80 km has been completed.

Tamor Corridor is a 265 km long road that connects Dhankuta with Olangchung Gola and passes through Mulghat, Lumbughat, Taplejung (Majhitar) and Dhovan. A total of 123 km section of 265 km of corridor needs new excavation and only 51 km track has been opened so far.

3.2. Non-Linear Infrastructures

3.2.1 Hydropower

The trajectory of hydropower development started with the commissioning of 500 KW Pharping Power Plant in 1911 followed by 900 KW hydropower plant at Sundarijal in 1934. Prior to 1960, the hydropower projects were constructed through grant aid and since 1970, bilateral and multilateral funds started getting available for hydropower development. But from 1990s, hydropower development took a new direction with the entry of private sector in the arena.

Nepal is estimated to have 'economically-feasible' hydropower potential of around 42,000 MW. But, an estimate of only 70% (Source: NEA Annual Report 2017/18) of the country's population have access to electricity, making this a plausible limiting factor to national economic growth. Considering the electricity as one of the key drivers for rapid economic growth of the nation, GoN has set hydropower as a most potential and priority source of energy. Nepal Electricity Authority (NEA) is a primary responsible institution for planning, construction and operations for electricity supply in the country. Currently, there are also other several independent power producers who generate electricity under the power purchase agreement with NEA and sell the power to NEA.

National Water Plan 2005 has targeted to generate 4,000 MW by 2027, however, later in 2009, GoN came up with the plan of development of 25,000 MW by 2030. Based on the accelerated growth scenario analysis, National Energy Strategy of Nepal 2013 considered the power requirement of 12,053 MW by 2030. Understanding the demand of energy, it is important to develop hydropower projects including other sources of energy. But it is also equally important to understand their threats and implications starting from the planning stage that will be necessary to ensure that the seemingly good projects have minimal negative impacts.

Current Status

Due to high topographic variations, extreme altitudinal gradient and vast network of river system fed by spring and snow, Nepal's hydropower potential is very high. Currently, 74 hydropower plants of size above 1 MW are in operation in Nepal, with a combined installed capacity of 1003.34 MW. Besides, there are also 15 hydro plants of size below 1 MW with combined installed capacity of 11.24 MW, making a total installed capacity of 1016.08 MW from hydropower (Source: DoED, 25 February 2019).

Additional 1,039 hydropower projects with a combined capacity of 36,211 MW have been considered for development. This includes 227 hydropower projects (7,459 MW) requested by developers for survey, 305 hydropower projects (7,022 MW) granted for survey, and 262 hydropower projects (7,181 MW) granted license for construction. Government of Nepal has reserved 241 hydropower projects (14,537.2 MW) (Table 4).

Photo 1. An operating micro hydro at Tsarang, Upper Mustang.
©WWF Nepal

Table 4: Hydro-power Projects in Nepal

Type of Project	Number	Average (MW)
Applications for Survey License (MW)		
< 1	66	0.83
1 ¾ 25	122	7.95
25¾ 100	25	57.18
> 100	14	357.50
GON Reserved Projects	241	60.32
Survey License Issued		
< 1	171	0.72
1 ¾ 25	93	8.67
25¾ 100	24	52.62
> 100	17	284.19
Generation Licenses	262	27.41
Operating Projects	60	14.91

Fortunately, none of the existing operational 60 hydropower projects are in the country's snow leopard habitat (Fig. 9). However, in the near future, as per the current plan, at least 37 hydropower stations with a combined capacity of 3,246 MW (average 83 MW, range 0.81-916 MW), may fall in this region (Table 5). Of these, ten hydropower plants (1,087 MW) have been granted generation license.

Photo 2. Existing highway track at Tsarang, Upper Mustang. ©WWF Nepal

Table 5: Hydropower projects in the snow leopard habitat in Nepal

Type of Project	Number	Total (MW)	Average (MW)	Range
Applications for Survey License (MW) [range]				
< 1	2	0.366	0.183	0.183¾0.183
1 ¾ 25	3	50.59	16.86	1.43¾24.63
25¾ 100	5	325	65	50¾90
> 100	1	396	396	396¾396
GON Reserved Projects	12	1309	109	2¾916
Survey License Issued				
< 1	2	1.19	0.59	0.2¾0.99
1 ¾ 25	1	8.2	8.2	8.2¾8.2
25¾ 100	1	62	62	62¾62
> 100	0	0	0	
Generation Licenses	10	1087	27.41	2.4¾400
Operating Projects	0	0	0	

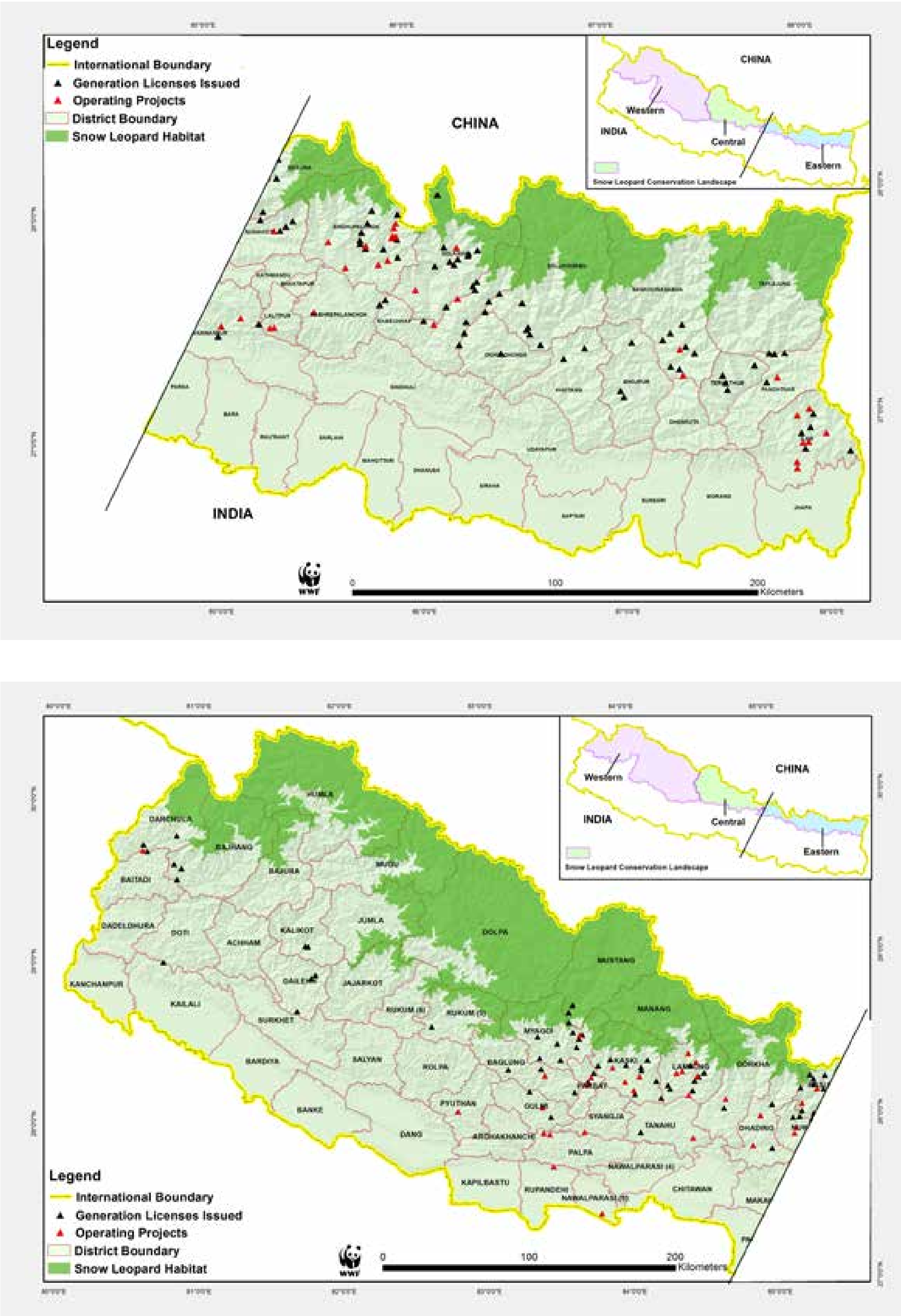


Figure 9: Hydropower stations in Nepal

4.0 TOURISM AND ITS IMPACT ON BIODIVERSITY

4.1 Airports and Trails

Mountain tourism provides unique recreational opportunity that includes trekking, climbing expeditions, cultural tours, river-rafting and bird gazing, but this poses a growing environmental concern (Saffrey, 2000; Tonderayi, 2000). Studies have shown that mountain tourism has adverse effects on natural areas (Stevens, 2003; Buntaine et al., 2006). In Nepal, there has been an unprecedented tourism growth in the past 30 years. The impact of tourism development on forest resources and alpine biodiversity (Stevens, 2003), as well as its impact in terms of air pollution and noise (Shah et al., 1997) have been well documented. Trail use is one of the fastest growing recreational activities and is having widespread impact on the ecosystem (Lynn and Brown, 2003).

Other than road network (defined earlier), access to promote tourism in these remote Himalayan areas of Nepal are facilitated by flight connections. Globally, air freight has seen preferential growth as it is the easiest and fastest means of transportation; a reason that has been instrumental for expansion of tourism industry in high altitude regions. Among the major impacts of airports are noise pollution, increase of human traffic and associated outcomes (e.g., solid waste).

Nepal is a tourism-dependent economy. With diverse geographic features spanning at an altitude of less than 100 m in the southern plains to over 8000 m along the northern Himalayas, Nepal hosts countless natural attractions. Moreover, a multitude of socio-cultural and religious attractions enrich the experience of visitors from around the globe.

In 2017, the country saw around 950,000 visitors, generating approximately 0.66 billion USD in revenue. National Parks and Wildlife Reserves accounted for more than 64% of the total visitors. Trekking and mountaineering contributed to around 8% (more than 75,000 individuals) of total the visitors. These included 5,745 trekkers in Manaslu, 6,632 in Mustang, 13,398 in Humla, 924 and 425 respectively in lower and upper Dolpa, and 1,008 in Kangchenjunga (Ministry of Culture, Tourism and Civil Aviation, 2017). Except for Dolpa, trekking in all other regions reported to have increased as compared to the 2016 statistics.

These figures underscore the overall values of nature-based tourism for the country's economy. With large swathes of the mountain landscapes still unexplored, the opportunity for growth of tourism in Nepal Himalayas is obvious.

Trail Development

In Nepal, a total of 3,905 km trail is documented in the snow leopard habitat, which is nearly 9.74% of the total trails in the country (40,079 km). Trekking

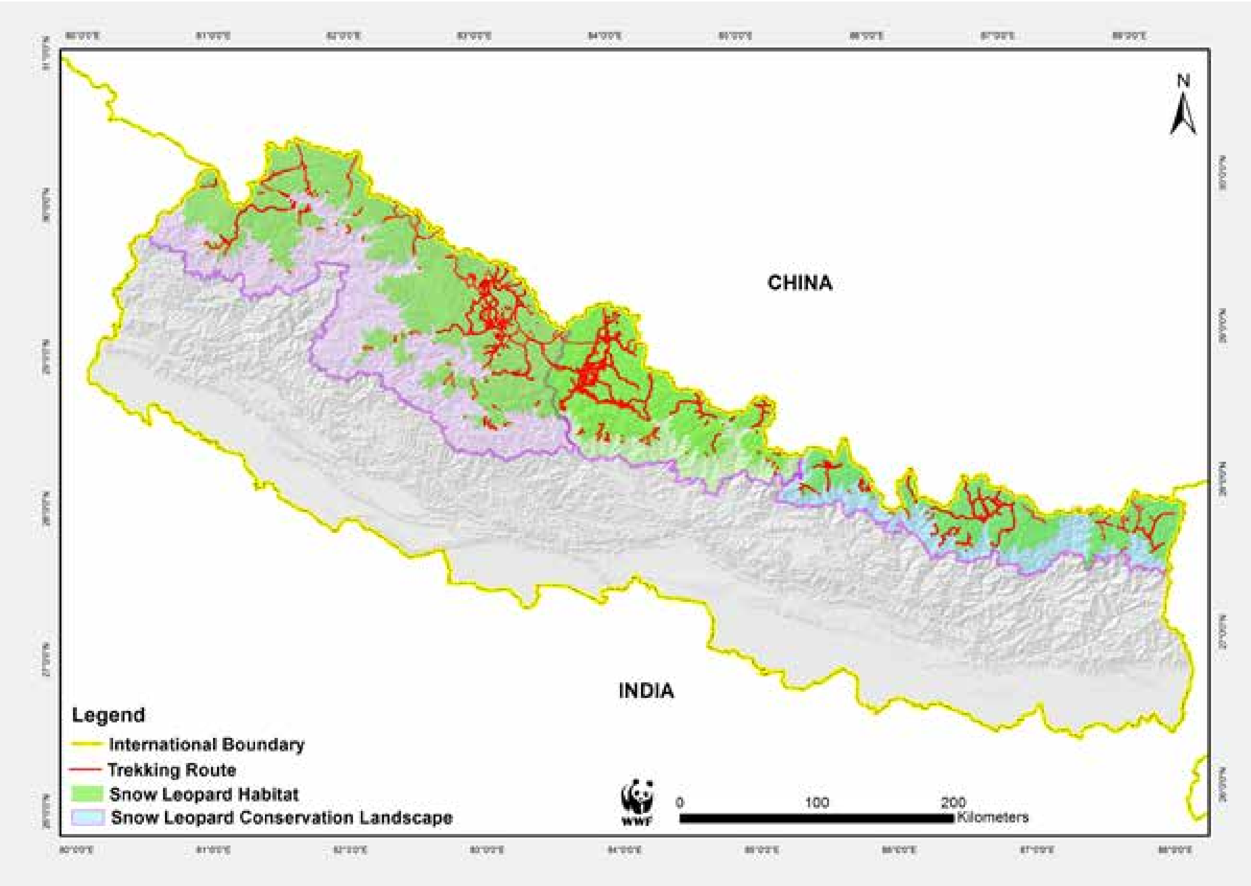


Figure 10: Trails in Snow Leopard Conservation Landscape

tourism has been steeply increasing with a growing popularity among domestic and international tourists. It is also being widely acknowledged as a way to support local economic developments due to service provision, job opportunities and, direct foreign revenue (Fig. 10).

In the far west region, Maansarovar trekking brings thousands of pilgrimages from India and Nepal every year. In western Himalayan region, a large network of trekking routes exists, mainly Shey Phoksundo National Park. The trails cover Phoksundo, Dho, Tinje and Saldang. The largest network of trekking routes in Nepal Himalayas is found in Mustang and Manang districts. Upper Gorkha is also famous for trekking, especially in Tsum Valley and surrounding areas. The Langtang trekking in Langtang National Park (Rasuwa district) has a moderate network of trekking routes but experiences a large influx of tourists here. Similarly, Everest region (peripheral areas of Namche and Khumjung) is famous for trekking among foreign and domestic tourists. In the eastern Himalaya of Nepal, Kangchenjunga Conservation Area is a favored trekking site. Areas north of Lelep and adjacent to Olangchung Gola also have a high-density of trekking paths.

Airport Development

The country's Civil Aviation Report – 2017, lists 49 airports in Nepal. Of these, 20 are currently non-operational. The 29 operational airports include one 'international airport', four 'hub airports', seven 'high-traffic regular domestic airports', ten 'regular domestic airports' and seven 'non-scheduled/chartered domestic airports'. The report outlines seven additional airports under construction.

The existing operational airports that provide immediate access to snow leopard habitats of the country include – Tumlingtar (high-traffic regular domestic) airport providing access to Makalu Barun National Park; (regular domestic) airports of Simikot, Juphal, Jumla, Jomsom, Rara and Tenzin Hillary (Lukla airport) providing connections to Humla, Dolpa, Jumla, Mustang, Mugu, Solukhumbu districts; and, a non-scheduled/chartered airport at Taplejung, connecting Kangchenjunga

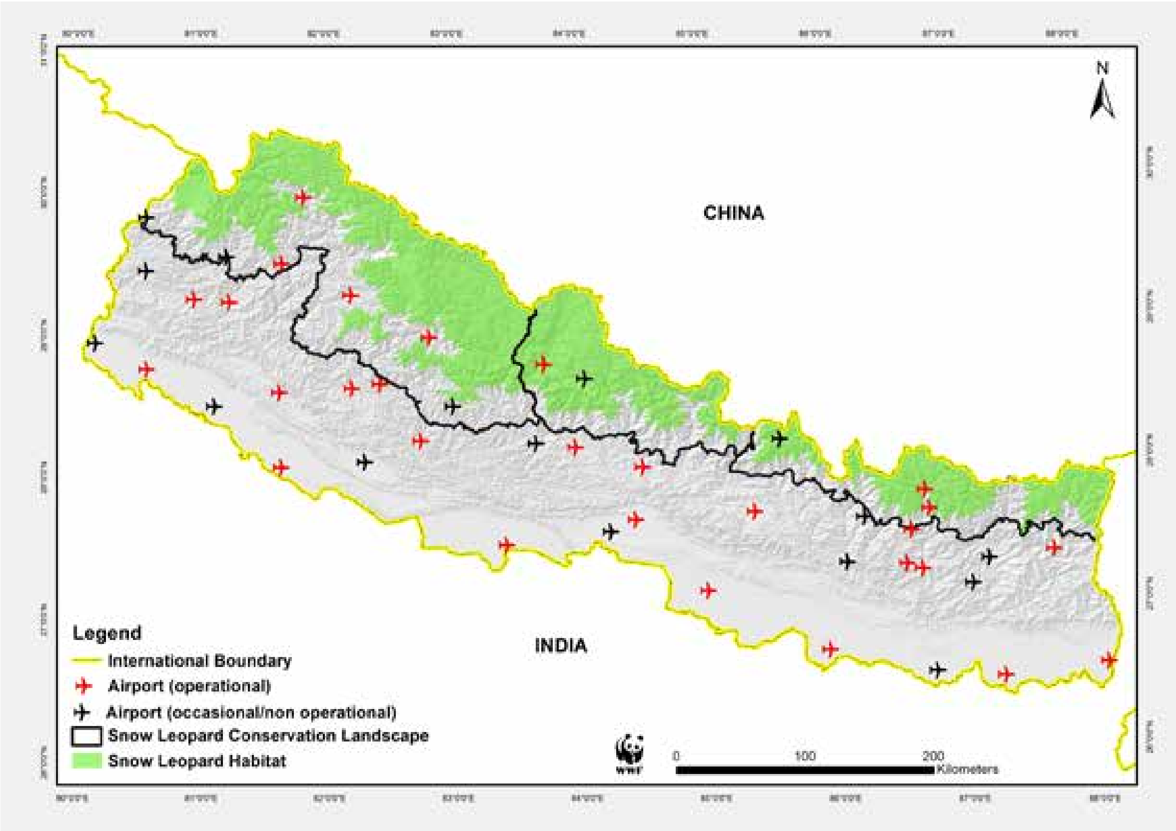


Figure 11: Airports in Nepal

Conservation Area. Fortunately, none of the even planned domestic airports fall in the snow leopard habitat of Nepal (Fig. 11).

4.2 Mines

Experts recognize potential values of mining industry as enhancing Nepal's growth. However, mining has also been globally known to have disastrous impacts on nature and local communities. In a geologically unstable region like Nepal, mining can have more disastrous consequences, and extreme caution must be exercised in sanctioning and carrying out mining in these areas.

Current Status

Nepal's Himalayas is a potential source of mineral deposits but remains relatively unexplored. Most mining sites in the country are located in the mid-mountains and the Mahabharat Range. However, some areas in the high Himalayas have been deemed highly promising for precious and semiprecious stones like ruby, sapphire and emerald, and metallic minerals like lead, zinc, uranium, gold, silver among others. The Tibetan Tethys Zone is prospective for limestone, gypsum, brine water (salt), radioactive minerals and natural gas. Preliminary exploration efforts suggest that salt and petrol reserves exist in Muktinath, and uranium has been reportedly detected in Lomanthang (Photo 3).

The extent of mining in snow leopard habitat within Nepal is currently low. Data suggests that a total of 174 mining sites of 20 minerals varieties have been identified in the districts falling in Nepal's snow leopard habitat. These spread over 447 sq. km. covering 17 districts (Annex 5 and 6, Fig. 12), but specific sites within these districts are not defined.

The most common items include limestone, tourmaline and quartzite. Dhading, Jajarkot and Nuwakot are topmost in terms of the number of identified mining

Photo 3. Hills containing potential uranium deposits identified on the outskirt of Lomanthang, Upper Mustang. ©WWF Nepal

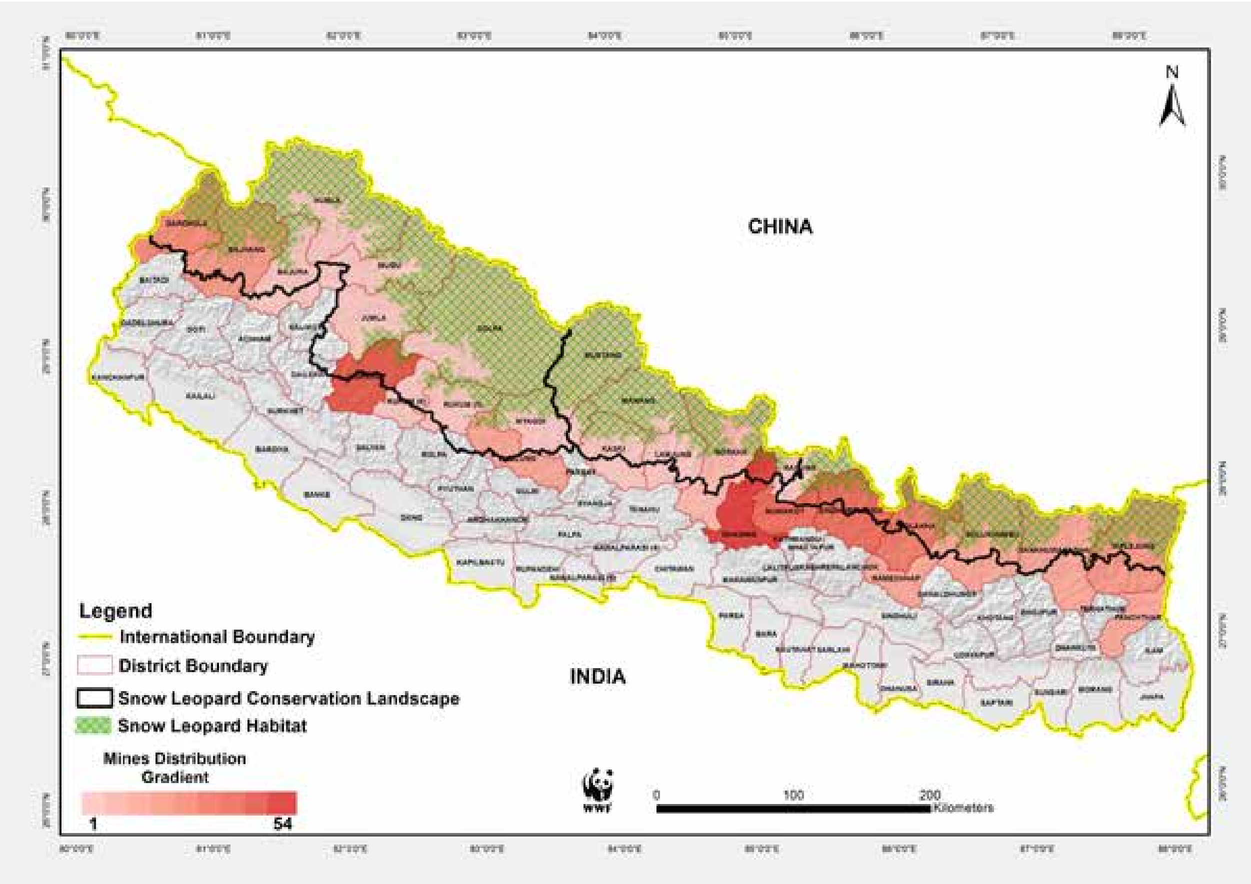


Figure 12: Location of mines in Snow Leopard Conservation Landscape

sites (31%) and area (35%). Subsequently, high altitude districts such as Dolakha, Humla, Manang, Mustang, Myagdi, Lamjung, Rukum and Kaski have few or no mine sites under exploration.

Among the plausible reasons for limited mining activities in Nepal's Himalayas is difficult terrain, and general inaccessibility. However, with expanding road networks, especially in view of the national priority for NS linkages, access to these sites could rapidly improve. Combined with the country's drive for economic development and the decentralized federal governance mechanism, mining may see an unprecedented growth in the country in the future.

5.0 RESULTS AND DISCUSSION

5.1 MODELLING APPROACH FOR IMPACT ASSESSMENT

Determining the ecological impact of infrastructure development on snow leopard habitats requires a method for translating spatially explicit data on development scenarios. MCDM with AHP method was used to prioritize and rank large infrastructure projects based on their anticipated potential impacts on snow leopard habitat. Models (given below) provide a finalized hierarchical decision model for deriving impact assessment. The consistency ratios of two models were 0.089 and 0.086 respectively. Both were within minimum thresholds as suggested by Satty (<0.10).

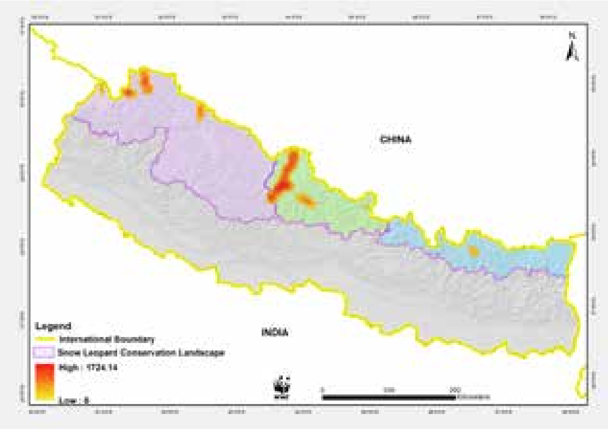
The first model included all geospatial layers (road, hydropower, trails, airport, mines, and settlement). The expert team emphasized on road (0.39), followed by mines (0.21), trail (0.14), settlement (0.11), airport (0.07), and hydropower (0.04) respectively (Table 6). Two maps were developed that incorporates existing impact and future prediction - existing impact map and future impact map. In doing so, data related to mines were not incorporated in the models as excavations of mines are not carried out on a large scale in snow leopard habitats. Similarly, future airport map was not included either as the airports planned for construction, do not fall in the high altitudes. Existing airport map was used to forecast the future airport density map with the assumption that there would be no additional airports constructed in the high altitude in the near future.

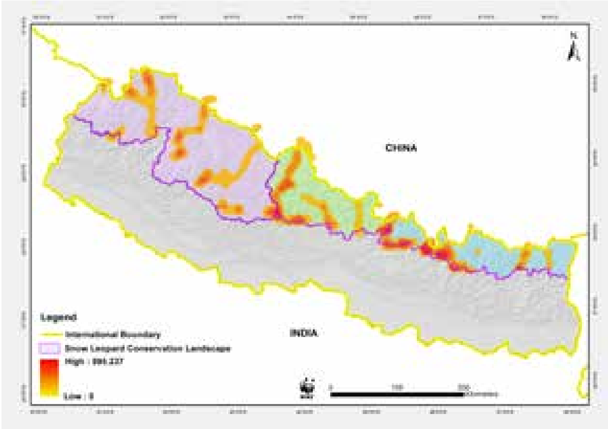
Table 6: Comparison matrix of thematic layers.

Variables	Road	Hydr	Tral	Mine	Sett	Airp	Weight	Evet
ROAD		0.35	0.606	0.441	0.375	0.206	0.397	6.924
HYDR			0.028	0.044	0.062	0.034	0.046	6.285
TRAL				0.110	0.125	0.344	0.145	6.502
MINE					0.25	0.206	0.217	6.442
SETT						0.137	0.115	6.455
AIRP							0.076	6.041

(HYDR-Hydropower, TRAL-Trail, MINE-Mines, SETT-Settlement, AIRP-Airport, EVET- Eigenvector)

Mines and airport maps have not been included in the second model as none of the mines are being exploited and/or under plans of being exploited in the near future (as per the information collated during this study), and airports are disproportionately located in the lower altitudes. In the second model, the expert groups have ranked road (0.61) at the top for potential impact on snow leopard habitats. Other infrastructure category included hydropower (0.16), settlement (0.12) and trail (0.109) (Table 7).


CHINA
INDIA
Legend
International Boundary
Snow Leopard Conservation Landscape
High : 1724.14
Low : 0


CHINA
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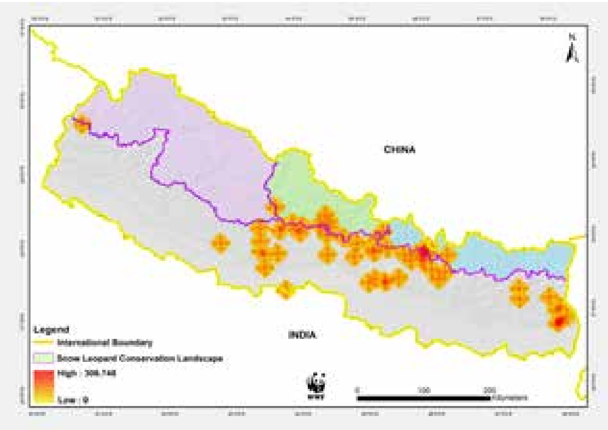
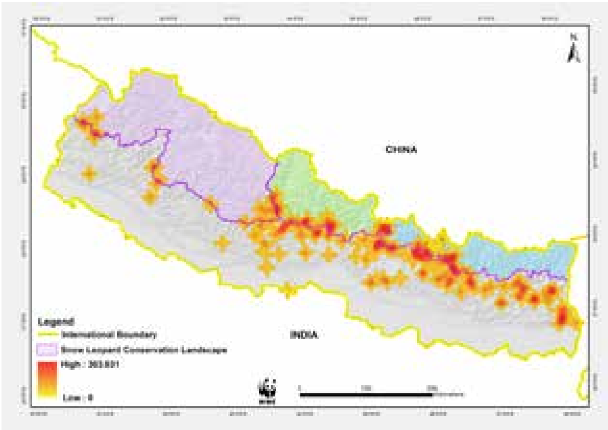
International Boundary
Snow Leopard Conservation Landscape
Low : 0


CHINA
INDIA
Legend
International Boundary
Snow Leopard Conservation Landscape
Low : 0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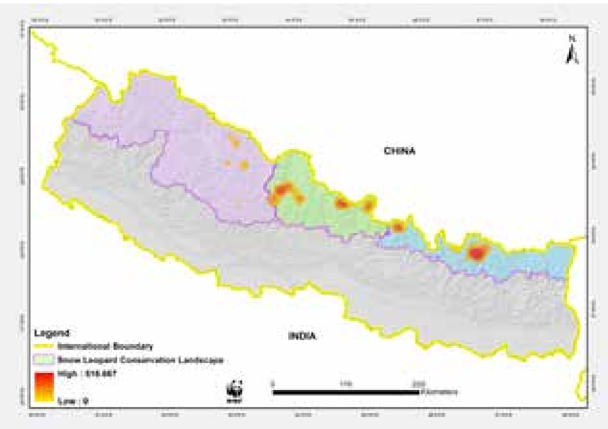
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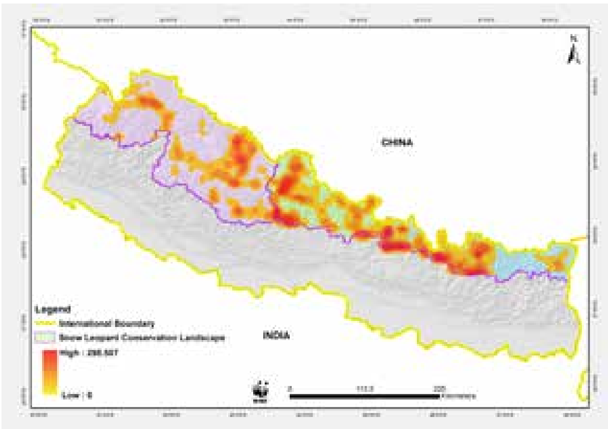
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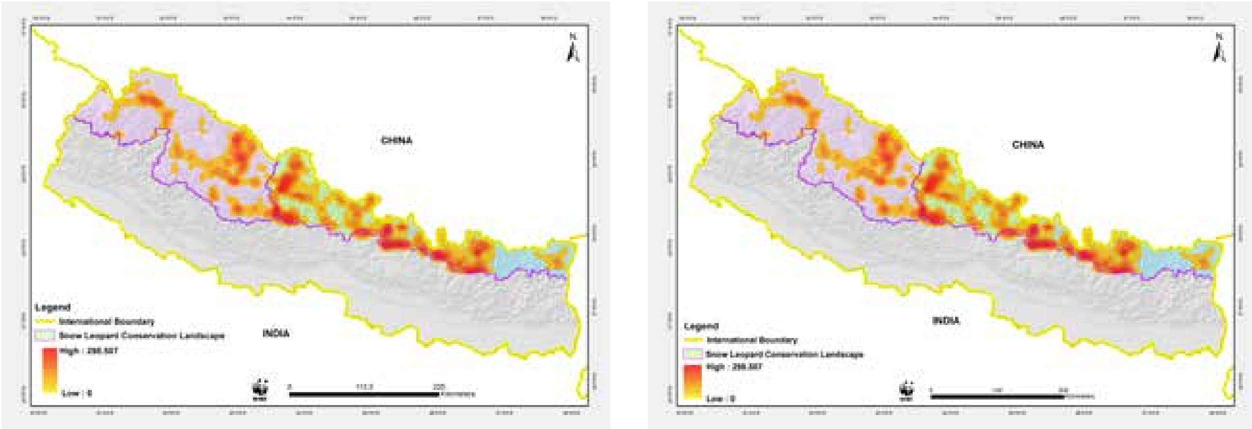

Figure 13: Current and future density map of infrastructures (a. road, b. hydropower, c. settlement and d. trail)

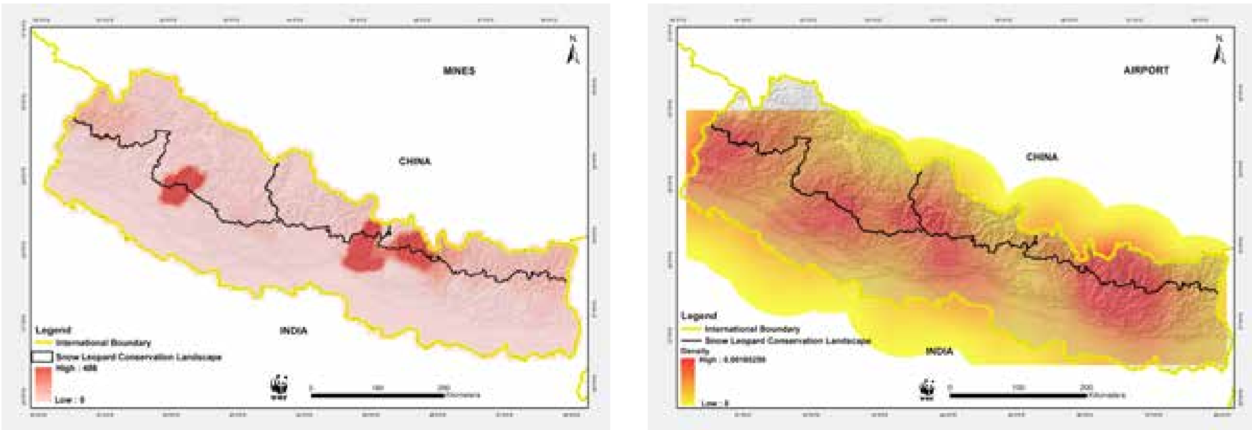

Figure 14: Density map of mines and airports

Table 7: Comparison matrix of thematic layers

Variables	ROAD	HYDR	TRAIL	SETT	Weight	EVET
ROAD		0.777	0.636	0.428	0.614	4.574
HYDR			0.181	0.285	0.166	4.146
TRAIL				0.142	0.094	4.124
SETT					0.124	4.086

(HYDR-Hydropower, SETT-Settlement, EVET- Eigenvector)

5.2 Impact of Large Infrastructures Development on Snow leopard Habitat

Impacts of infrastructure development was evaluated on the snow leopard habitat, and impact maps for road, hydropower, trail and settlement were developed using the second model[4]. Impact of mines was however avoided in the absence of specific spatial information. The airport map suggested that they did not overlap the habitat within the snow leopard range. The thematic layers were converted to impact maps using multiplicative approach (i.e. density maps were multiplied by experts' ranks). Experts' ranking ranged from 61% for road to 12.4% for settlement. Thus, maximum impacted area could be those from high density road infrastructures. Each thematic layer was rescaled to make a consistent impact map. Impact categories were classified as follows: >0 and <25-low impact, 25-50- moderate impact, 50-75 - high impact, >75 -very high impact.

5.3 Scenario Plan with Respect to Under Construction and Planned Linear Infrastructures with Their Potential Threats to Snow leopard Conservation

Road

Roads are the only linear infrastructures that have been identified within the snow leopard habitat. All transportation projects that are under construction and/ or operational are considered existing transportation infrastructure (here under referred to as "current"). Additionally, planned linear infrastructures are referred to as "future" transportation.

Roads are among large and ever expanding infrastructural development sector. According to the model, road sector has impacted approximately 5,725 sq. km. area of snow leopard habitat (Fig. 15). The impacted area by road is

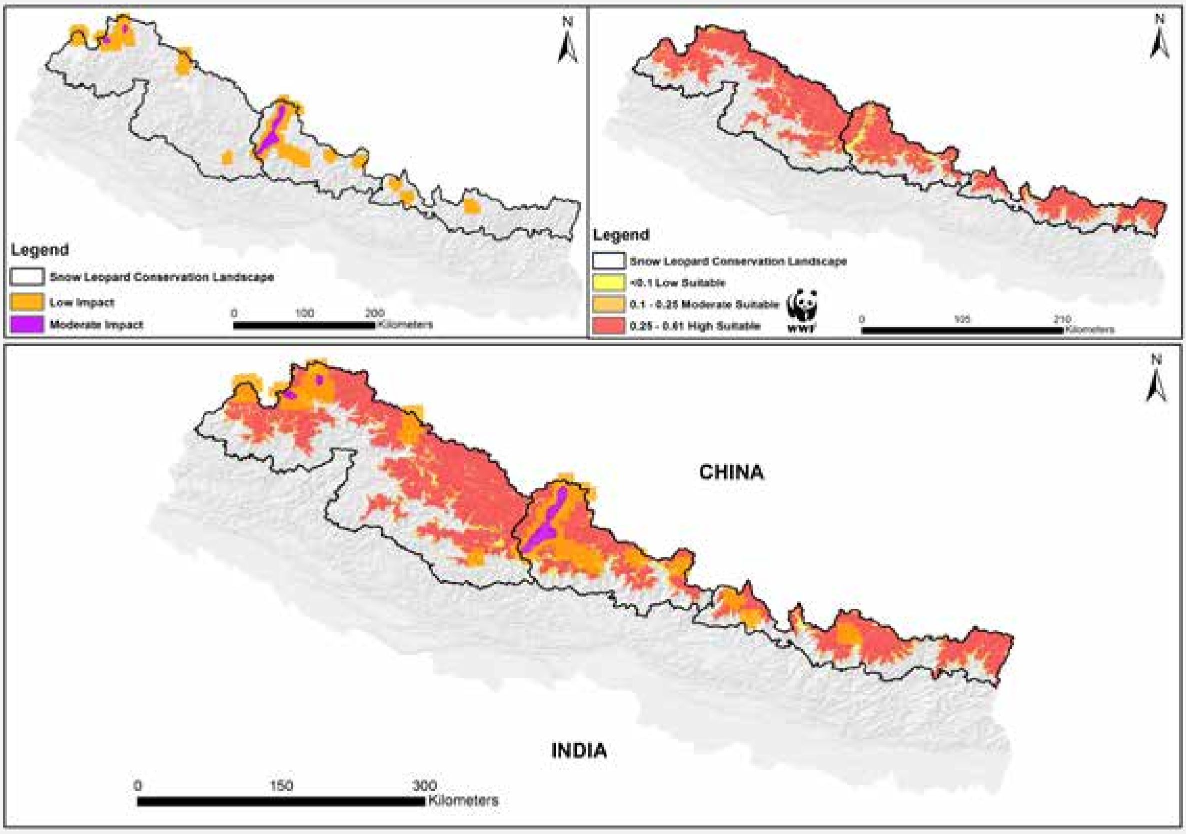

Figure 15: Current impact of road in snow leopard habitat. (Top left: Existing impact of road; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

4 Areas beyond snow leopard habitats are shown in the impact map to give an insight into development programs in adjoining snow leopard habitats. Please note, that actual impacted area in snow leopard habitat is trivial.

projected to increase by three-fold (17,775 sq. km.) upon the completion of infrastructure development projects (Fig. 16). The model suggests that existing road project has had a low impact in 70% of impacted area, where as 29% area had a moderate impact. According to the model, there would be a rapid increase of high impact areas in snow leopard habitat. This includes low impact zone (13, 875 sq. km.), moderate impact zone (3,125 sq. km.), high impact zone (600 sq. km.) and, very high impact zone (175 sq. km.). The future scenario suggested that there would be moderate impact in Lamabagar, Limi, Mugu, and Byas in western snow leopard landscape, and low impacts in Olangchung Gola, and Chhekampar in eastern snow leopard landscape.

Hydropower

Hydropower is another important driver of habitat fragmentation and disturbances and impacts snow leopard habitats. According to the model, a total of 275 sq. km. is currently impacted by hydropower projects. All hydropower developments are situated along the periphery of snow leopard habitat. The model predicts low impact in the snow leopard habitat (Fig. 17). The model predicts that there would be a five-fold increase in the impact zone (Fig. 18), in which nearly half of the impact zone would be moderately affected (50% low impact and 50% moderate impact).

Trail

Trail is an important infrastructure for tourism development. The model shows that a total of 15,300 sq. km. area (43% of total habitat) is under human influence (Fig. 19), and this is projected to increase by 1.2 times in the future; in 15 years period (Fig. 20). The models suggests that all the areas resulting from trails are poorly impacted and will remain the same in the future.

Human settlements in mountain areas are scattered throughout region. The model suggests that nearly 42% (15,000 sq. km.) of snow leopard habitat is impacted by human settlement (Fig. 21), and is projected to increase by 1.2 times (19,211 sq. km.) in the future (Fig. 22). Human settlements would have low impact in the snow leopard habitat

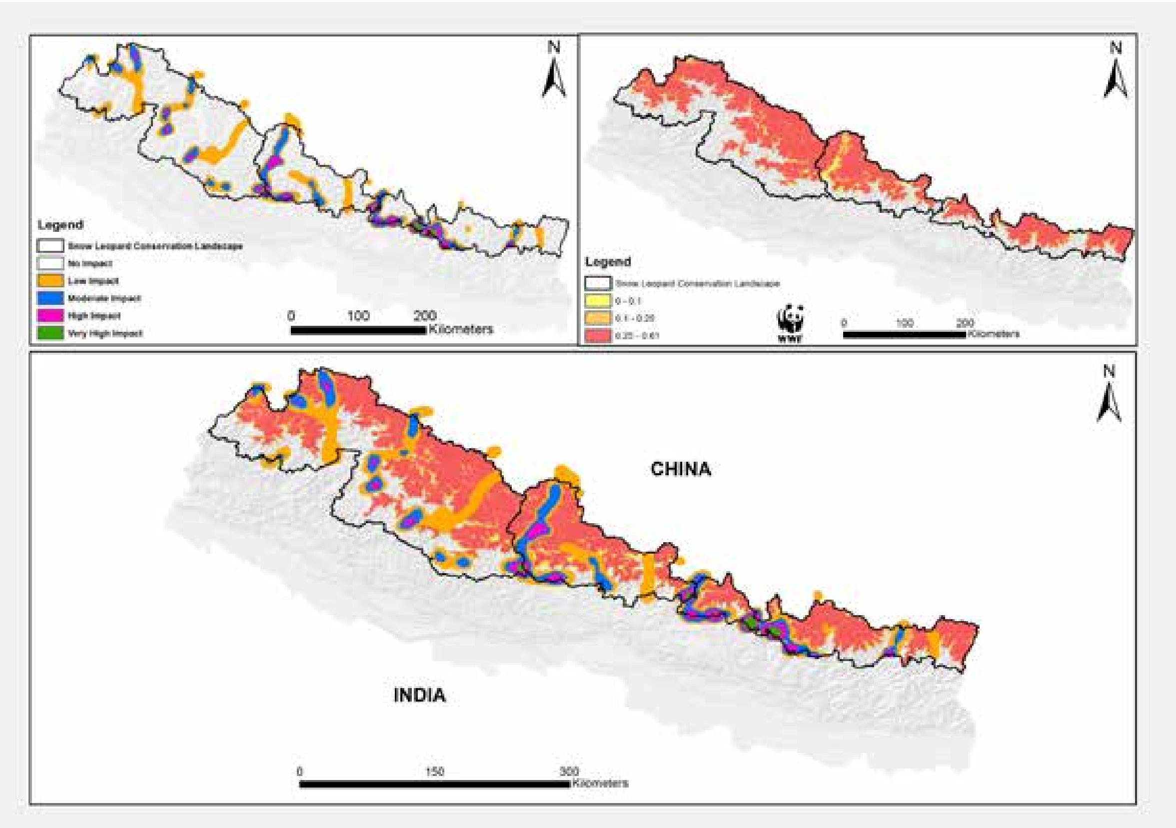

Figure 16: Future impact of road in snow leopard habitat (Top left: impacts resulting from roads; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map)

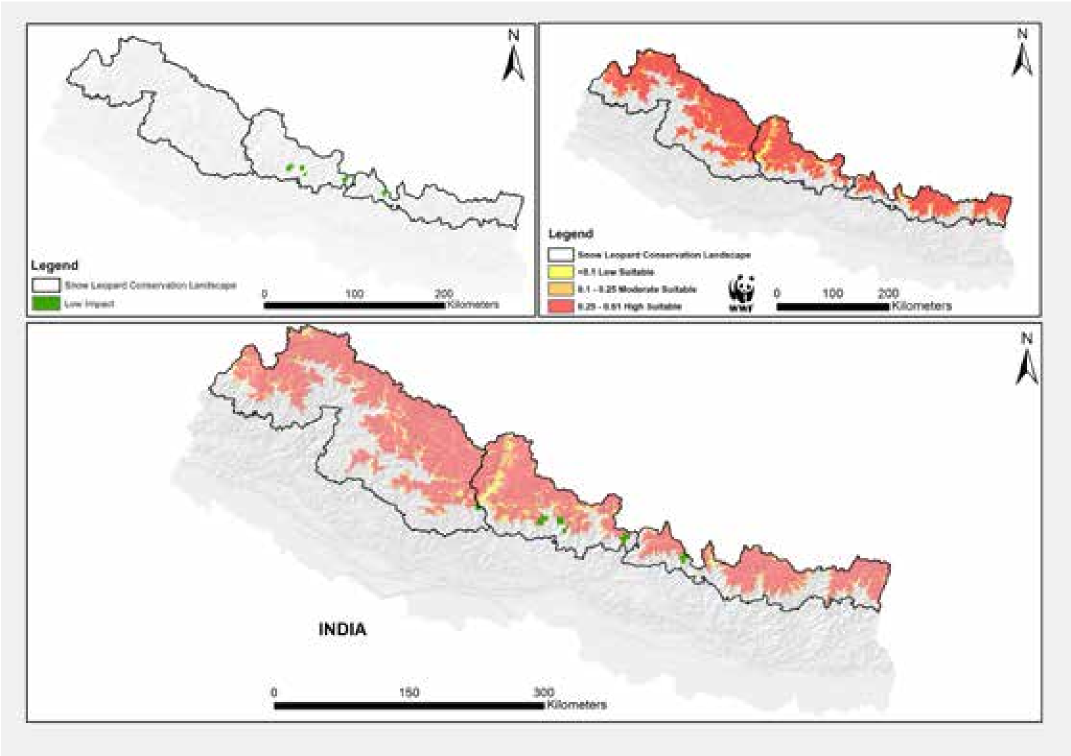

Figure 17: Current impact of hydropower in snow leopard habitat. (Top left: Existing impact of hydropower; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

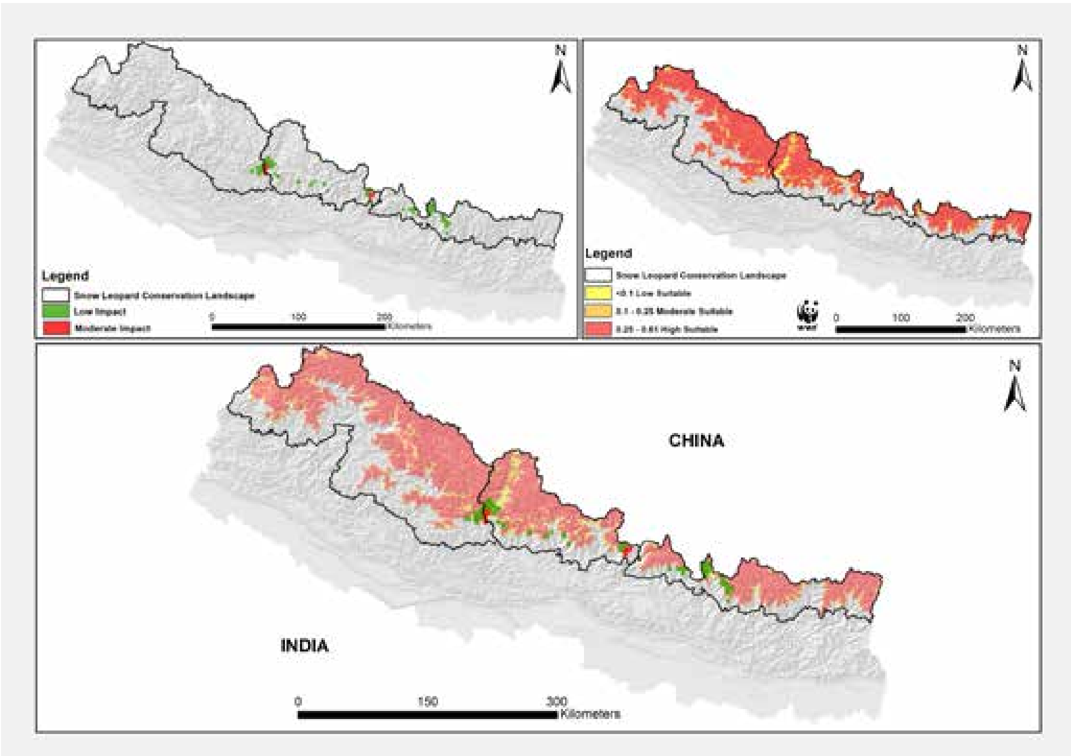

Figure 18: Future impact of hydropower in snow leopard habitat. (Top left: Future impact of hydropower; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

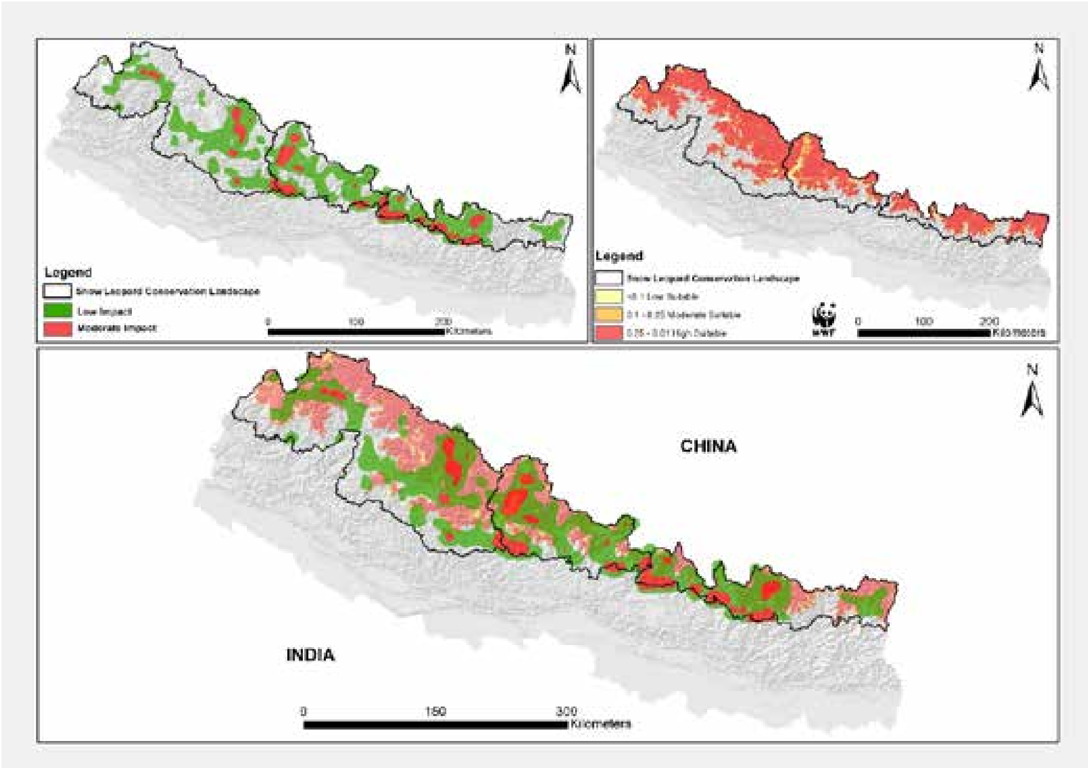

Figure 19: Current impact of trail in snow leopard habitat. (Top left: Future impact of trail; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

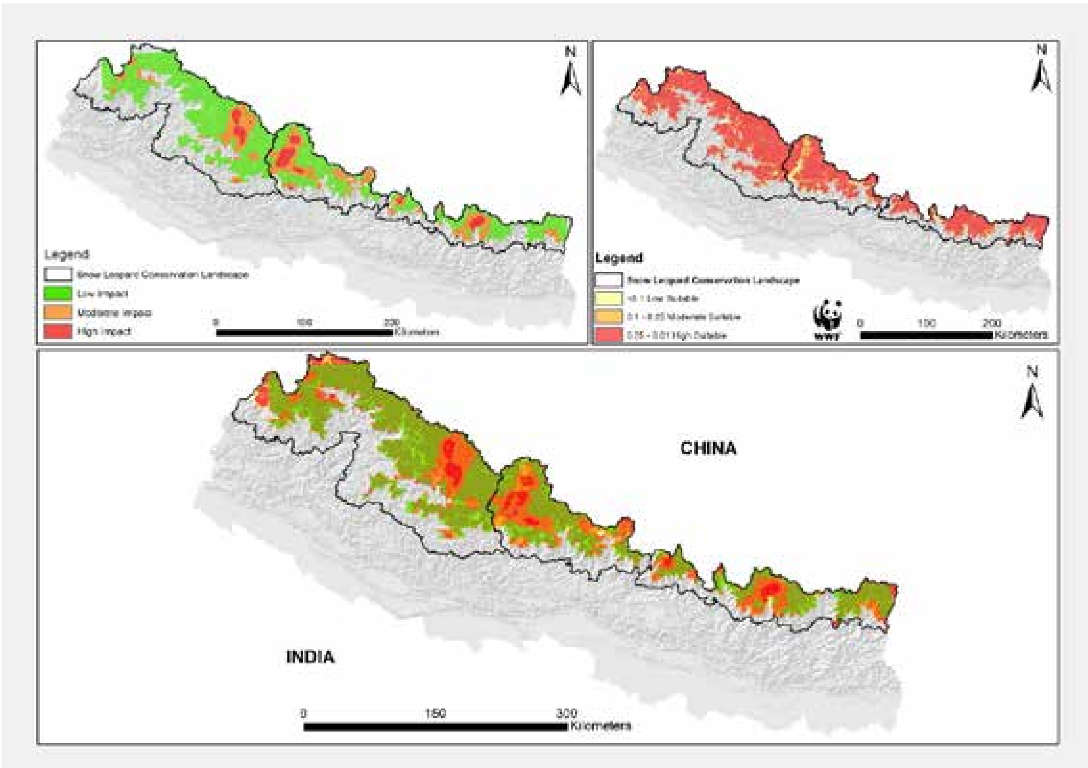

Figure 20: Future impact of trail in snow leopard habitat. (Top left: Future impact of trail; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

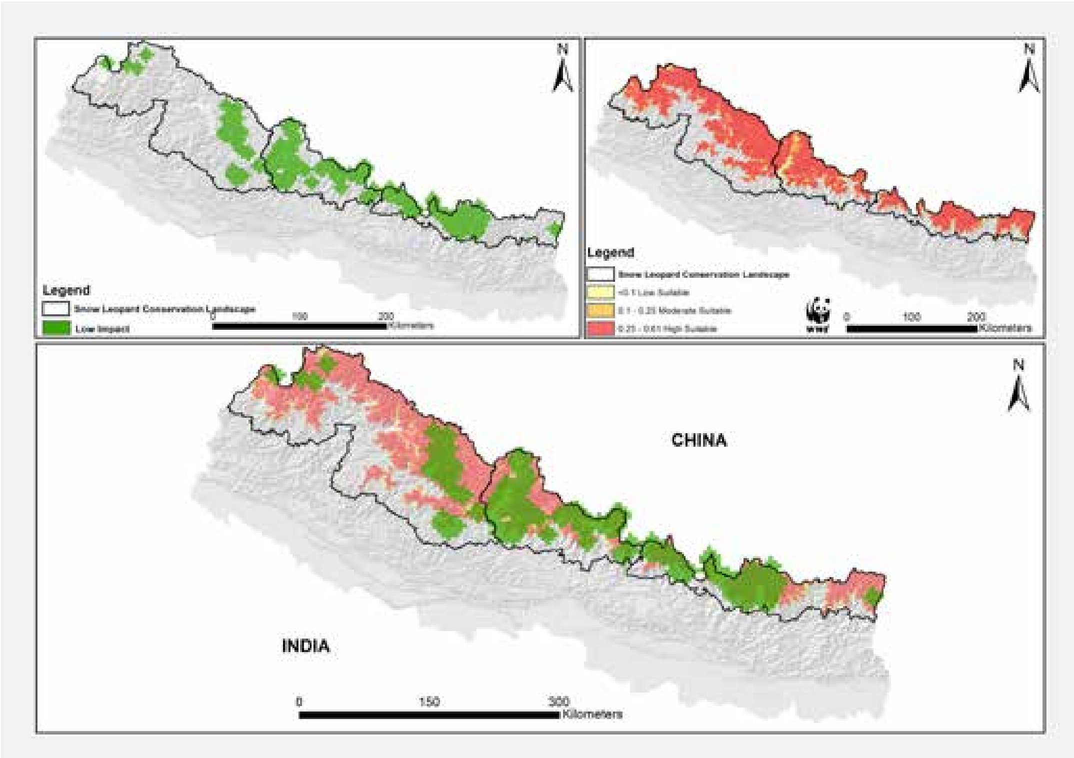

Figure 21: Current impact of settlement in snow leopard habitat. (Top left: current impact of settlement; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

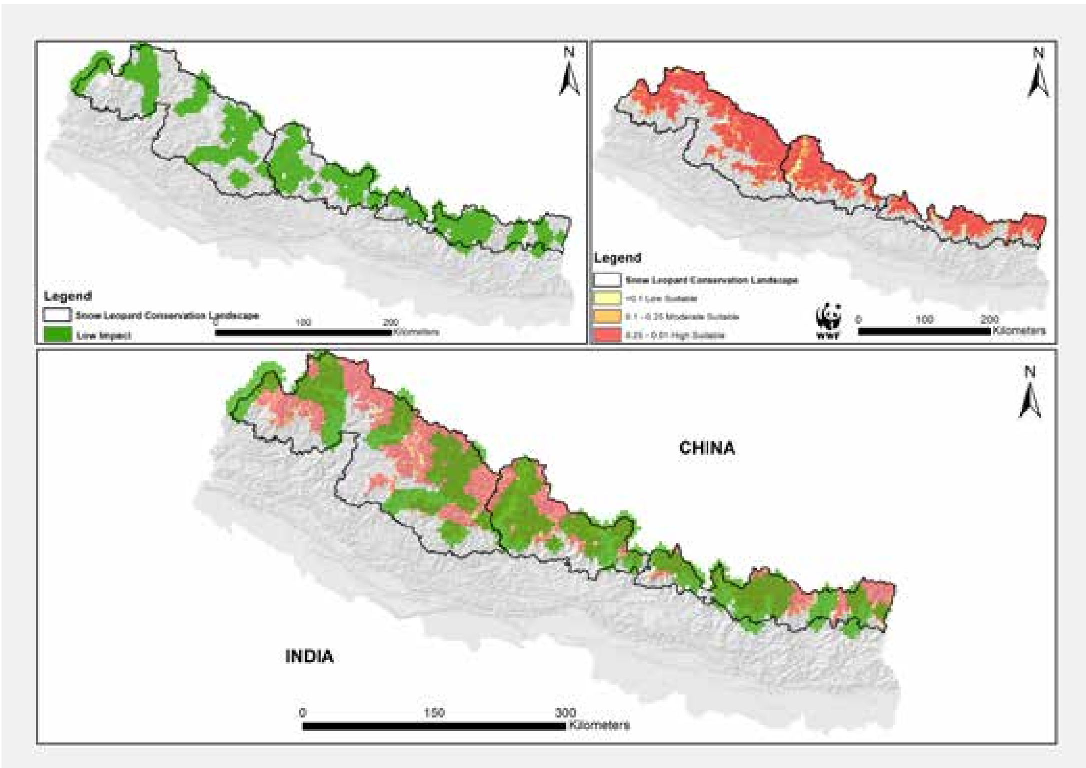

Figure 22: Future impact of settlement in snow leopard habitat. (Top left: Future impact of settlement; top right: habitat suitability map of snow leopard; bottom: impact map overlaid with snow leopard habitat map).

although cumulative impact could be synergetic in combination with other categories of infrastructure development.

5.4 Impact Assessment of Snow leopard Habitat

The first current model considered a total of 25,425 sq. km. area for investigation. The model predicted varying degree of impact (>0 impact) in an area of 16,575 sq. km.. The model showed that high impact zone (above 90% percentile) included 350 sq. km. area. The first future model considered large area for investigation (29,200 sq. km.). The model suggested that the impact zone would increase to 23, 325 sq. km.. The model predicted that the high impact zone (90% percentile) resulting from infrastructure development projects would cover an area of 525 sq. km. in the future.

The second current model considered a total of 28,400 sq. km. area for investigation. The model predicted varying degree of impacts (>0 value) in an area of 17,250 sq. km.. The high impact zone (above 90% percentile) included 400 sq. km.. The second future model considered 33,700 sq. km. area for investigation, in which 21,325 sq. km. habitat was predicted to have a varying degree of impact (>0 impact). According to the model, 625 sq. km. of the habitat would be highly impacted by infrastructure development on snow leopard habitats in Nepal.

The current maps derived from the first and second models showed similar pattern of impacts, so was the case with future impact maps. The current models showed that Mugu, Kaligandaki Corridor (Lete to Chhonhup), Bhakra and Pisang in Manang district, Samagun, Chhaikampar in Gorkha District, Langtang and Everest region (Namche and Khumjung) are predicted to have high impact of infrastructure development in the snow leopard habitats. However, Kaligandaki Corridor does not qualify as a highly suitable area for snow leopard and the actual impact here could be small (Figure 15). Subsequently, future impact maps showed that Dho village of Dolpa District may have a high impact due to infrastructure development. Additionally, development programs in Langtang region, Everest region and few areas in Sankhuwasabha district would have a high impact on snow leopard habitats as all these areas are located within the range of highly suitable snow leopard habitat. Additionally, the suitable area in Langtang is likely to be fragmented with little or no connection with rest of snow leopard habitats (Fig. 23). A high impact thus anticipated

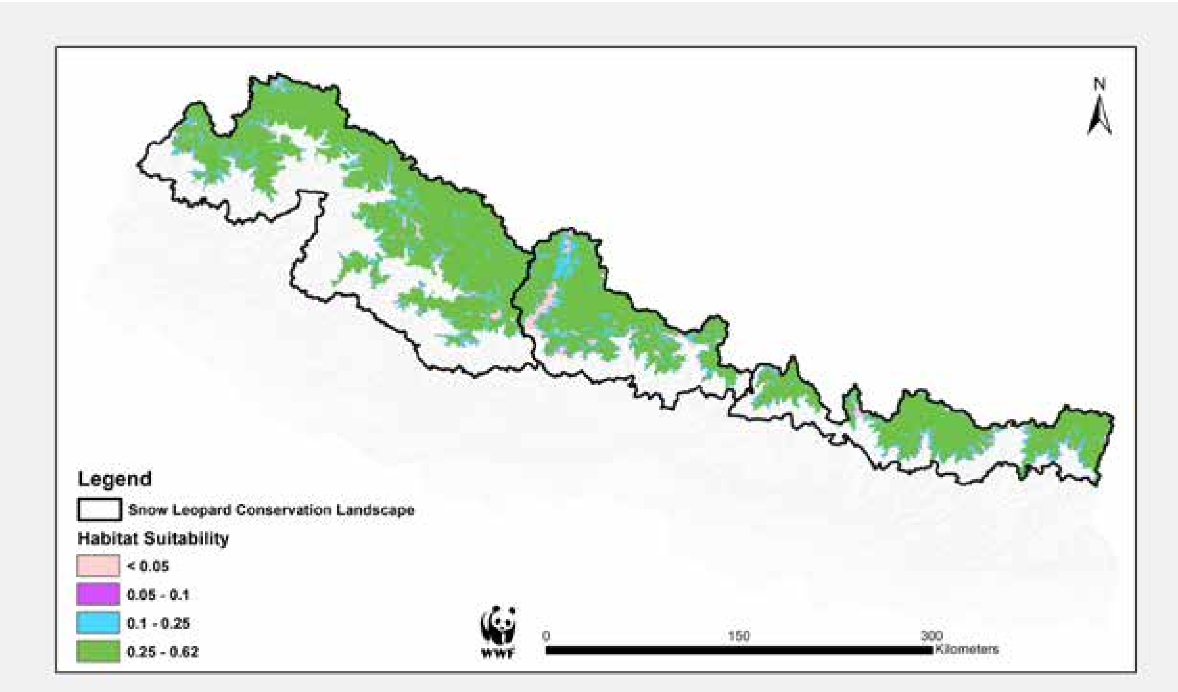

Figure 23: Habitat suitability map of snow leopard

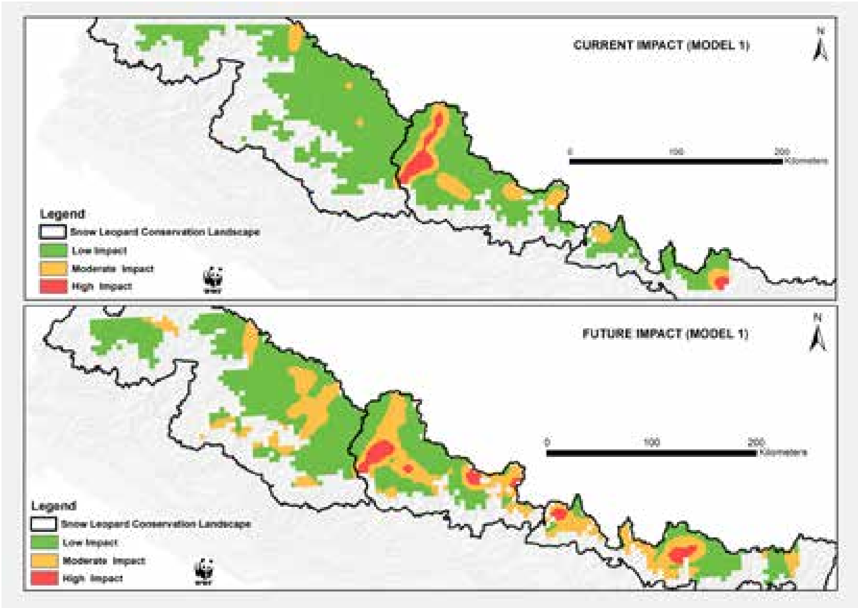

Figure 24: Current and future impact maps of snow leopard habitat by infrastructure development (First Model) (Warmer colors show areas with higher impact zones)

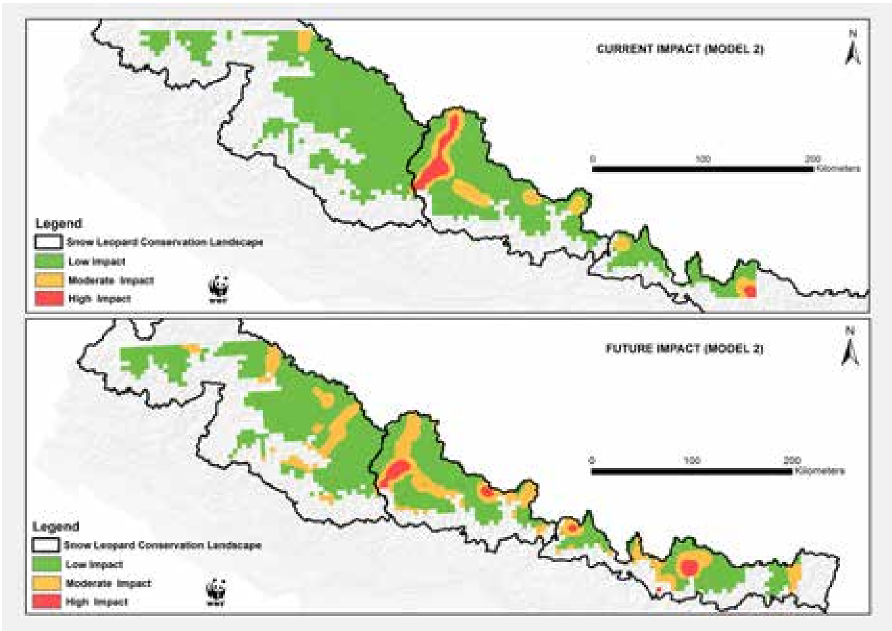

Figure 25: Current and future impact maps of snow leopard habitat by infrastructure development (Second Model) (Warmer colors show areas with higher impact zones)

is alarming (Fig. 24 and 25).

The current impact map shows that areas that are not suitable for snow leopard were impacted by infrastructure development. However, future impact maps suggested that there would be high impacts in the highly suitable habitats of snow leopard[5]. Thus, the success of snow leopard conservation hinges on the degree of careful planning of infrastructure development.

5 Habitat suitability map suggests that impact zones are situated in the high suitable areas of snow leopard. Habitat suitability map suggests suitable areas for snow leopard, but fails to suggest whether or not the areas are actually occupied by snow leopard. Therefore, the availability of a high-quality map of snow leopard distribution map would prove useful.

6.0 CONCLUSION AND WAY FORWARD

Among all categories of infrastructure development projects, transportation projects are identified as the most damaging one to the snow leopard habitats, followed by mines, trail, settlement, airport and hydropower. Northern frontiers of Nepal seem largely inaccessible to humans, owing to their challenging topography and poor resilience to environmental disturbances. Currently, only two highways, namely, Kodari Highway and Pasang Lhamu Highway, connects Nepal with Tibet, while there is a rapid construction work going on with few other North-South roads including Kaligandaki corridor and Rasuwagadhi corridor. Besides, several localized road networks exist in the high mountain. There is no large road network in the snow leopard home range in Nepal. However, large networks of roads (13 proposed) are being constructed throughout the northern borders of the country. Not just roads, even the transboundary railway lines from Kerung – Rasuwagadhi and transmission lines across Nepal-China boundary which are currently under political negotiations, could have high impacts on snow leopard habitats.

The study concludes that cumulative effect of infrastructure development is less, but future impact scenario shows an increase of 50% with most impact in or traversing through core habitats of snow leopard. Therefore, it is likely that snow leopard habitats would be subjected to a high degree of fragmentation aand human disturbances in the future.

Infrastructures are necessary to meet the country's development aspirations. However, prioritizing hasty development while ignoring the negative consequences it could have on nature can be counter-productive. Not all consequences may be identified or predicted with precision, but risks can be anticipated through experiential learning from the past, and modern scientific modelling as highlighted in the study.

Fortunately, today, there is a common understanding on the need to ensure environment sustainability in infrastructure development, for long-term well-being of nature as well as human communities. National policies should reflect this knowledge and continue to make efforts to ensure minimal negative consequences of developmental activities.

Nonetheless, practical opportunities persist in ensuring the use of best-available information and technology in predicting and mitigating negative impacts of infrastructures in Nepal. Improvements in quality of impact assessment and identification of potential risks and solutions during planning, incorporation of mitigation measures during construction and regular monitoring and corrective measures during operation as highlighted in EIA reports, can greatly ensure sustainable development. In addition to that, since most of these transboundary roads lie within protected areas of Nepal, regular coordination between the development and conservation stakeholders is a must so as to ensure the promotion of sustainable green infrastructures.

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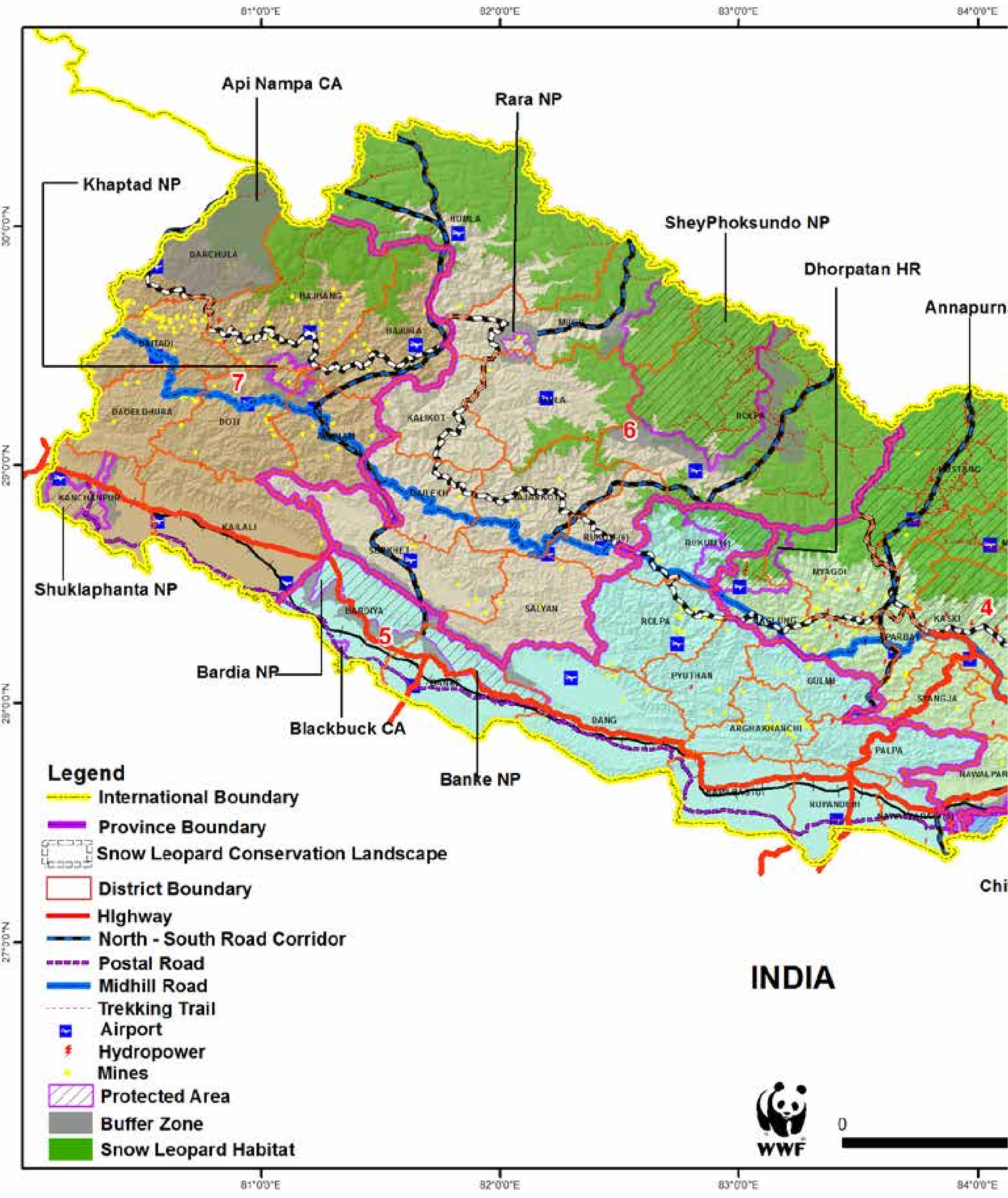
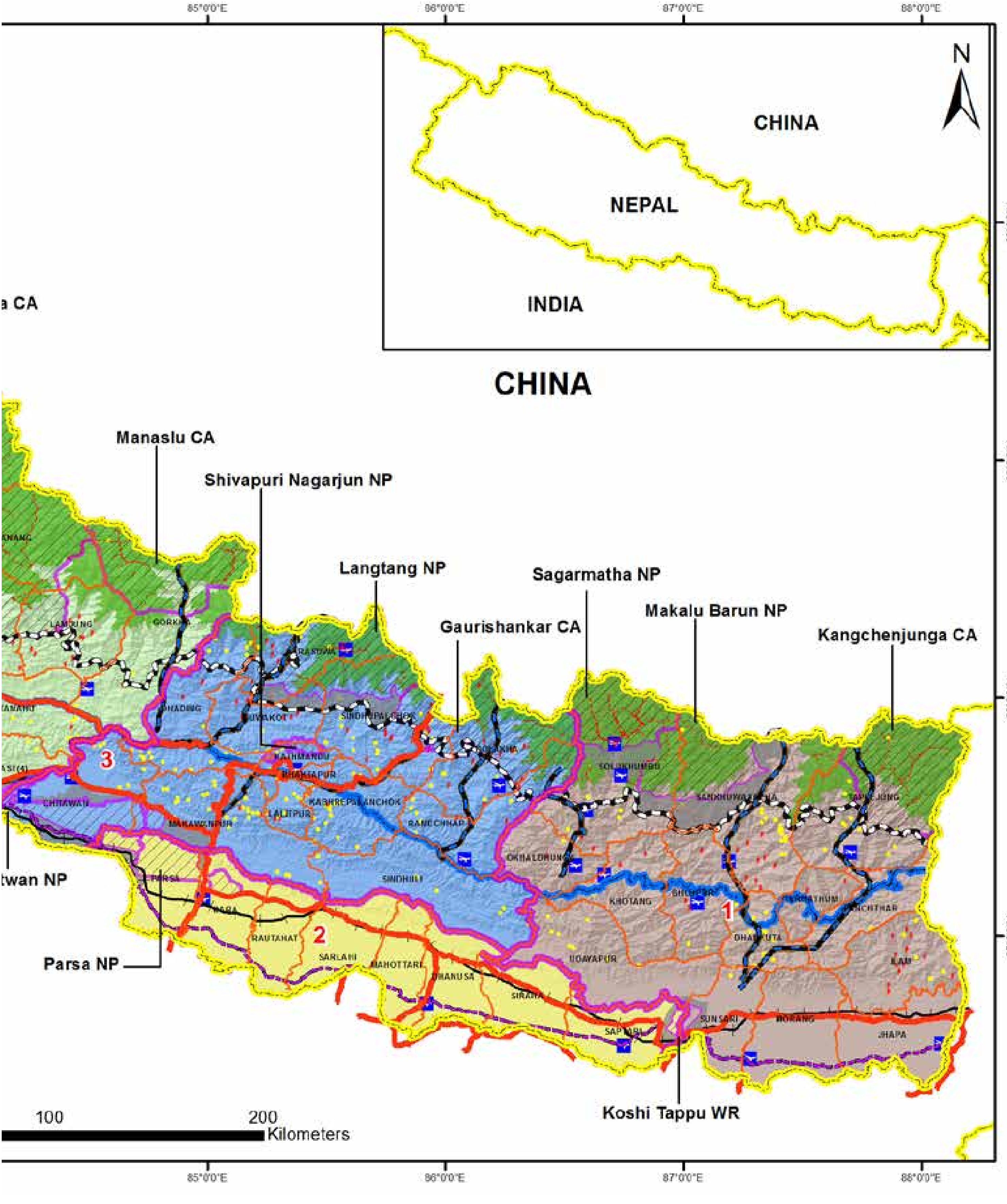
8.0 ANNEX

Annex 1: Snow leopard habitat – provincial maps with infrastructure

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Makalu Barun NP
Kangchenjunga CA
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Parsa NP
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Kilometers

Annex 2: Matrix showing potential impact of infrastructural development, their mitigation measures and available resources

Impact	Situation Analysis	Mitigation Measures
Transportation: Linear infrastructures such as roadways and railways, while critical for a country's development, can have immense impact on biodiversity and natural environment where both resident and migratory species are affected. Understanding such direct and indirect impacts based on previous local and global experiences is necessary to anticipate potential impacts on planned infrastructures.		
(PI)-Land use change, drainage patterns and instability	Road projects contribute enormously to remarkable changes in land use which in most of the cases are irreversible and detrimental to nature and natural habitats. Slope stability depends on the existing geological structures, lithology of the rock units, soil type, topography, vegetation and hydrological condition (active seepage and spring)[6] (Department of Roads, 2016). Haphazard cutting of hill slopes in already weak and fragile geological structures of CHAL area, and use of explosives in some cases, results in slope instability, erosion and landslide. Similarly, clearance of forest cover may further accelerate landslide and instability. The inevitable loss of forested and agricultural land has other indirect impacts and are further exacerbated with increased vehicular access leading to unplanned settlements and haphazard urbanization in otherwise isolated areas. Such activities ultimately build up pressure on the nearby resources and enhances the risk of landslides and soil erosion on either side of the road and in the surrounding settlements. Land use conversion particularly agricultural land causes loss in agricultural products and has an irreversible impact. For example, fresh cuts, steep topography and poor slope triggers landslide and soil erosion especially in monsoon season in Thoche – Larke road in Manang district. Likewise, unprotected cliffs and fissures pose risk for travelers especially in monsoon season on Beshisahar-Chame road. Similarly, excavation, dredging, cutting, filling and removal of vegetation cover has consistently triggered soil erosion and landslide at different sections such as Chandibhanjyang-Panchkilo of Muglin-Narayanghat Road. Additionally, roads initiate change in the natural drainage system when drainage systems are inadequate and lead to blockage of natural flow, increase the possibilities of sediment/mud flow, surface runoff, erosion and even landslide. For example, in Muglin-Narayanghat road, obstruction of existing drainage system in the area (irrigation canals, natural seasonal flow paths) along the road section often inundate areas briefly during heavy rainfalls.	‣ Minimize cut slope with a balance of cut and fill materials ‣ Discourage use of explosives in a large scale or in an uncontrolled manner. ‣ Promote chiseling and hammering for rock cutting as far as possible, or use heavy equipment-based drillers ‣ Carry out cutting and filling of slopes as per the type of slope, soil texture composition, soil type etc. ‣ Maintain proper drainage system in road design and ensure that drainage system functions well after the completion of construction. It is essential to separate out water from all road components ‣ Re-vegetation of exposed area or cut/fill slope should be made mandatory ‣ Apply bio-engineering techniques at exposed and likely unstable slope areas ‣ Regular cleaning and maintenance of drainages adjacent to road should be made mandatory ‣ Maintenance of smooth discharge across culverts and cross drainages by cleaning and maintaining them regularly to avoid water logging on adjacent land due to road do not occur ‣ Roadside drainage should not be discharged into environmentally sensitive areas

6 Environmental Impact Assessment (Draft) NEP:SASEC Roads Improvement Project, 2016.

Impact	Situation Analysis	Mitigation Measures
(PI)-Loss of top soil and spoil disposal	Excavation of agricultural or forest land, tipping of sand and concrete on cultivated land lead to the loss of top soil. For instance, disposal of a large amount of debris or wreckage from excavation and dredging has deteriorated aesthetics of the project area in Mugling-Narayanghat Road.	▸ The land for storage of construction material should be far from agricultural land and water bodies, wetland, culturally sensitive areas, foot trails, and should covered properly ▸ Top soil that has been removed should be restored in its original landscape and blended well with the contours when managed in a new location ▸ The exposed cut and fill surfaces should be covered with vegetation in conjunction with bioengineering measures
(PI)-Change in river morphology and sedimentation	Sediment load in the river might increase due to the debris and other construction materials. For instance, in Mugling-Narayanghat Road, , eroded soil washed out to nearby canals, river and paddy field has caused massive siltation. Likewise, extraction of sand and gravel in excessive amount from river for construction purpose has caused riverbank cutting and erosion. Such change in river regime can eventually lead to landslide and erosion of sensitive agriculture land downstream. Similarly, in Chame-Beshishahar Road, debris generated from road construction were found to be disposed directly in the river, leading to an increase in sedimentation load. Similar incidences are also prevalent in Phewa lake. The surface area of the lake has decreased from 5.8 sq km in 1981 to 4.4 sq km in 2001 which receives sediment consisting from silt, sand and gravel from Harpan Khola, urban sewage/garbage disposal, Seti Canal, Bulandi and Phirke Khola[7] (WWF Nepal, 2014)	
(PI)-Air pollution	The major sources of air pollution during the construction phase include: i) dust from earth works and quarry sites ii) emission from asphalt concrete plant. Operation of asphalt plant leads to thermal pollution and most importantly emission of carbon. Additionally, post construction work, traffic leads to significant and sustained increase air pollution in the vicinity due to vehicular emission as well as dust.	▸ Crushing equipment must be operated with dust control devices ▸ All construction vehicles and equipment should be properly tuned and maintained to meet National Emission Standard ▸ For reduced dust exposure for road neighbors, roadside tree plantation is essential to create barriers that trap the dust in the air

7 Beyond Investment: Developing Sustainable Green Infrastructure in Nepal, WWF Nepal (2014)

Impact	Situation Analysis	Mitigation Measures
(PI)-Noise pollution	Noise and vibrations produced due to crushing of stones, operation of construction equipment such as excavators, dumpers, compactors, and movement of vehicles etc. during construction phase are some of the short-term impacts. Additionally, blasting and drilling can have significant effect in the nearby settlements if concrete mitigation measures are not adopted. Road access inevitably transforms a quiet ambience to a noisy and crowded one with improved access and development of settlements. Even worse, noise produced by vehicles also impacts endangered animals when road passes through conservation areas as is the case in Annapurna Conservation Area (ACA).	‣ As far as possible, devices that minimize and control noise, such as silencers should be installed in crushers, excavators, dumpers, and compactors ‣ Operation of noise producing equipment should be discouraged at night ‣ For longer term protection from noise pollution, plantation of trees on the roadside that creates noise barriers is essential
(PI)-Increase in solid waste	Work sites are often a mess during construction. There is often a large stockpiling of construction materials and waste generated by construction workers that could lead to increase in solid waste in the vicinity if not managed properly. As roads are developed, easy access increases, leading to more influx of people and increased economic activities. Accumulation and sustainable management of garbage is already an issue in ACAP (Magditsch & Moore, 2011). With the increase in settlements, waste generation has seen a rise and in the absence of a good management plan, the experience has been that roads become corridors of plastic and other non-degradable wastes.	‣ Solid waste generated should be minimized by raising awareness on Reduce, Reuse, Recycle (3R) principle ‣ Waste segregation should be promoted amongst the workers ‣ Promotion of bio-manures, compost at settlement levels is needed ‣ Provision of collection bins that are nature friendly and their regular collection and management is essential
(BI)-Forest loss and impact on other vegetation	Site clearance is inevitable in road construction. Most of the strategic road in the CHAL area passes through forest/bushes areas at various stretches. For instance, large number of trees were felled (approx. 10,158 regenerations, 676 poles and 2,455 trees) during the construction (upgrading) phase of the Muglin-Narayanghat Road. Likewise, majority of the length of the road passes through the forest area from Thoche to Bhimtang; a section on the Beshisahar Chame Road. Similarly, Muglin-Narayanghat Road also passes through forest stretches. Besides this, forest encroachment in pursuit of fuelwood access for heating and cooking purpose by construction workers is a common phenomenon in Nepal.	‣ Mandatory compensation plantation of all felled trees in the ratio of 1:25 as specified by Department of Forest ‣ Promote alternative energy sources for heating and cooking to replace firewood ‣ Support community forest user groups to compensate for felled trees ‣ Disallow illegal felling and logging from an unmanaged forest area

Impact	Situation Analysis	Mitigation Measures
	This is further exacerbated at the operational phase. Due to road access, nearby settlements often encroach forest area for settlement and agriculture purposes. Because of this, additional pressure builds up to fetch daily necessities such fire wood for cooking and heating, and timber for construction work. This further accelerates the legal and illegal extraction of timber, medicinal herbs and other forest products for commercial purpose, forest fires, and introduction of invasive plant species. For example, construction of Beshisahar Chame Road opened up access to previously vehicle inaccessible alpine forest areas, thus elevating the risk of illegal logging[8] (WWF Nepal 2014).	
(BI)-Impact on wildlife and their habitat	Road development fragments natural habitat and biodiversity corridors. Additionally, wildlife is often affected by illegal hunting, increased noise level, encroachment of habitat and corridors. Furthermore, is the increased risk of wildlife road collisions especially in areas where roads cut through protected areas and near traditional wildlife routes. For example, sections of the Thoche-Larke Road and Beshisahar-Chame Road lies in the Annapurna Conservation Area (ACA) and is likely to cause disturbance and fragmentation of biodiversity along the road alignment. Operations of a road can be highly disturbing to wildlife. Wildlife corridors that are intersected by roads often report death of wildlife in traffic accidents. Also, accessibility of roads near forests can increase the possibilities of forest encroachment, illegal hunting, and illegal transportation of wild animals and their products. This has been clear along the section of the East –West Highway of the country, especially along Kasara –Madi Road. This 10 km stretches through the core of Chitwan National Park and the extension of the same road between Madi-Nirmal Thori-Birgunj passes through Parsa Wildlife Reserve and its buffer zone[9] (WWF Nepal 2014).	‣ Develop corridors to facilitate animal migration ‣ Transfer and translocate critically endangered species, if any, in the project site and its vicinity ‣ Mandatory provision of sign boards and speed brake when road passes through or near protected areas and conservation areas ‣ Provision of well-designed under and overhead passes for animals
(BI)-Impact on aquatic life	During the construction phase, leakage of chemicals and oil into the river system can increase turbidity, alter the chemical composition of river temporarily and also threaten the health and life of aquatic species. Access to rivers also mean negative contribution to the water bodies through unsustainable fishing, water pollution and use of water sources for consumption that gradually leads to the depletion of aquatic life in the water bodies.	‣ Waste water from the construction site should be treated prior to discharging it into the river ‣ Any new settlements developed should have an approved environmental plan which should include protection of aquatic species

8 Beyond Investment: Developing Sustainable Green Infrastructure in Nepal, WWF Nepal (2014).

9 Beyond Investment: Developing Sustainable Green Infrastructure in Nepal, WWF Nepal (2014).

<table>
<tr><th>Impact</th><th>Situation Analysis</th><th>Mitigation Measures</th></tr>
<tr><td></td><td></td><td>The IEE or EIA for the road should be developed and strictly enforced with monitoring provisions</td></tr>
<tr><td colspan="3">Hydropower:
Power stations are generally located on the mountain gorge to use the gravity of water force to its best potential. Locations of hydropower plants (Fig. 10) support this assumption. However, such gorges are expected to be natural barriers to snow leopard movement. This geographic preference for hydropower plant sites in terms of accessibility precludes much of the prime snow leopard habitat from potential risks of hydropower plants.
Although limited in space and time, anticipated direct risks of hydropower plants on snow leopards, their prey and other large mammal species of mountain landscapes, may include disturbances during construction, and submerging habitats - particularly critical movement corridors, affecting genetic exchange between populations. Associated indirect impacts may materialize from increasing road access - and thereby potential for development of market centers and settlements - to these hydropower sites.
EIAs for hydropower plants in snow leopard habitats must therefore assess potential risk of aggravating natural fragmentation, avoiding critical snow leopard movement pathways with clear assessment of cost and benefits of submerging prime snow leopard habitats.
These impacts may be further aggravated or may bring about other unanticipated risks due to climate change. Climate modeling studies have identified this Himalayan region as relatively more vulnerable to climate change. EIAs for hydropower in these landscapes would therefore benefit from evaluating and integrating these risks.</td></tr>
<tr><td>(PI)-Land use change and instability</td><td>Risks of land instability and erosion significantly exist at the burrow pit sites, quarry sites, dams and powerhouses, access road construction sites and at the spoil disposal sites during construction period. Uncontrolled blasting and steep cutting of the slopes exacerbates slope failure risks because of the weak geological composition, existing unstable slopes and torrential monsoon downpours. Random placement of the excavated materials on or off site also triggers both slope failure and erosion risks. Similarly, unattended loose excavation materials, development of access roads also have long term risks of erosion and slope failure due to the removal of vegetation mostly in the heavy monsoon season[10] (Aryal et al., 2016).

Similarly, raised and fluctuating water level in the reservoir increases instability in the immediate foreshore area. For instance, poorly consolidated alluvial deposits are prone to landslides due to planned project activities in Tanahun Hydroelectric Project Area[11] (Nepal Electricity Authority, 2012).</td><td>Specialized slope stabilization measures in combination with bioengineering
Compensation to land owners if project induced instability occurs in private land</td></tr>
<tr><td>(PI)-Loss of top Soil</td><td>All the structural sites (dam, powerhouse, intake, tailrace) and the construction ancillary facility sites (access roads, quarry, camps, mechanical yards, batching and storage yards etc.) are associated with loss of top soil arising from surface excavation works for structural placement, land planning/leveling, and aggregate extractions (Aryal et al., 2016).</td><td></td></tr>
</table>

10 Budhigandaki Hydroelectric Project EIA Study, 2016

11 IEE Report: Chilime Sub-Station Hub and Chilime Trishuli 220 kv, 2014

Impact	Situation Analysis	Mitigation Measures
(PI)-Change in environmental flow	Hydropower projects disrupt flows and alter the magnitude, frequency, duration, and timing of natural flow regimes of rivers and their sediments. Longitudinal connectivity (i.e. upstream and downstream) is lost or reduced because of the barrier effect of the dam wall and the reservoir; and lateral connectivity between the main channel, floodplains and secondary channels may be lost or diminished because of reduction in the frequency of flooding. This affects aquatic habitats and their life cycle. This also hinders the transport of sediments and organic material downstream[12] (World Bank Group, 2018). The downstream impact can be significantly extensive so as to induce drop in water table. Downstream settlements are then impacted as they do not get enough water for their household chores and irrigation.	Government of Nepal has provided in its guidelines that at least 10% flow downstream of any dams is maintained. However, release of water to maintain ecological and environmental flow is not well monitored and maintained by any agencies in Nepal. For example, in KGAHPP, as per local people, provision of minimum flow and additional flow during festive season in the river to maintain ecological and environmental health was not found to be in practice.
		Similarly, many of the projects including Middle Marsyangdi Hydroelectric Project (69 MW), have not released compensatory water downstream as required, leading to formulation of dewatered section, ultimately impacting aquatic biodiversity[13] (Rijal & Alfredsen, 2015). On the other hand, even when practiced, such release of minimum flow is being carried out without adequate prior understanding of baseline condition and environmental flow topography and ecological function of the river upstream and downstream. For best result, the minimum monthly flow criteria should be set, based on the actual ecological flow requirement of the future (Rijal & Alfredsen, 2015). Further, impact of climate change on precipitation pattern which is one of the major contributing factors of river discharge should also be considered. Change in average monthly discharge, and temporal shifting of peak flows have been reported due to climate change impacts. This practice should also be based on post project assessment of completed HP plants that should be carried out and made mandatory by the government.

12 Environmental Flows for Hydropower Projects, World Bank Group, 2018

Impact	Situation Analysis	Mitigation Measures
(PI)-Change in natural flow	Natural floods inundate downstream regions with nutrient rich sediments which play significant role in shaping traditional farming downstream. However, this natural process is obstructed by the hydropower plants. Sedimentation is one of the serious issues in KGAHPP as Kali Gandaki River contains huge amount of sediments during monsoon which is very erosive (Chhetry & Rana, 2015). On one hand sediment management is important to maintain the longer life of reservoir and turbine components, while on the other, raising of the upstream river bed due to accumulation of sediments as a consequence of backwater, affects the reservoir. Moreover, flushing of large quantity of sediments settled in the settling basin when discharge is low leads to unnatural disposal of this sediment at high concentration downstream. This leads to environmental imbalance in the river[14] (Thapa et al., 2005). It adversely alters the natural flooding of the river which is necessary to maintain the fertility of the floodplain with the nutrient rich sediments. In case of BGHEP, overall impact on the change in riverine morphology during construction period is considered to be of moderate significance, while this could be high in the Trishuli River due to the possibility of change in the river erosion regime around the burrow pit sites and adjoining areas. The tailrace discharged water is poor in suspended sediment concentration and is likely to enhance river bed erosion to maintain the suspended sediment concentration of the flowing river water. The downstream impact of the sediment trapping in the reservoir is on the sediment supply downstream of the project site which ultimately alters river morphology, induces erosion and creates imbalance in sediment equilibrium[15] (Aryal et al., 2016).	‣ The problem with sedimentation in the surroundings of the hydropower plant can be mitigated by constructing small-scale weirs to trap the sands and the particles that can later be manually removed on a regular basis[16] (Mussa et al., 2018) ‣ It is important to control sediment load of the river by developing watershed management plan; and this is possible with the assessment of sediment load through hydrologic/hydraulic modelling carried out as essential component of hydropower design

13 Environmental Flows in Nepal: An Evaluation of Current Practices and an Analysis of the Upper Trishuli 1-Hydro Electric Project, 2015

14 Sediment in Nepalese Hydropower Projects, 2005

15 Budhigandagi Hydro Electric Project EIA Study, 2016

16 Environmental Impacts of Hydropower and Alternative Mitigation Measures, 2018

Impact	Situation Analysis	Mitigation Measures
(PI)-Spoil disposal	During the construction period, generation of large volume of spoil materials from dam site preparation, tunnelling, access road etc., and availability of limited space in the project area for its proper management is a big problem.	▸ Disposal site should be chosen carefully while ensuring that it does not disturb the natural flood flow. An option could be to manage it at riverside degraded land with low production or areas of poor soil ▸ In cases where degraded land is not available, existing top soil should be stripped and stockpiled ▸ Retaining structures and drains should be installed to ensure stability
(PI)-Water pollution	During the construction phase, various explosives and drill equipment are used; therefore, the tunnel discharges are likely to be contaminated with metallic and non-metallic pollutants. In addition, unused slurry and washout water of the batching plants pollute the receiving water bodies. Concentration of such contaminants are not high enough to pollute the entire water body of the receiving water bodies in areas such as Budhi Gandaki, Trishuli or Kaligandaki due to dilution effect. However, this might have an impact on the vicinity of the project area. Hydropower plants can cause water pollution by altering the temperature of water released through dams (Abell, 1994). In bigger projects such as BGHPP, leakage of oil, grease, lubricants and other chemicals from the fuel depots, storage yards (even in small quantities) has a lasting effect on the soil chemistry and the chemistry of the receiving water bodies at the immediate site[17] (Aryal et al., 2016).	▸ Handling and correct storage of chemicals, explosives and other toxic chemicals to prevent leakage, spill and contamination should be done through awareness and training events targeted to the workers ▸ Disposal of chemicals shouldn't be haphazard, and safe disposal methods such as incineration should be practiced ▸ There should be the provision of waste water treatment at work camps
(PI)-Air pollution	Short term fugitive dust and emission from vehicles and equipment used in the construction works have the potential to affect the air quality. Repair and maintenance work, particularly at the powerhouse involve welding, grinding etc., and can cause some amount of indoor air pollution. But, such impacts are short term and site specific. In case of KGAHEP, study shows that the site is well ventilated and the impact of indoor air pollution here is of low significance[18] (Chhetry & Rana, 2015).	▸ Regular sprinkling of water on unpaved road can be solution to reduce local and site-specific air pollution ▸ Regular inspection and maintenance of vehicles and machineries that emit smoke and gases is necessary

17 Budhigandaki Hydro Electric Project EIA Study, 2016

18 Effect of Sand Erosion on Turbine Components: A Case Study of Kali Gandaki 'A' Hydroelectric Project

Impact	Situation Analysis	Mitigation Measures
	According to new studies, HP Plants are also emitters of methane gas — a Green House Gas (GHG) considered 34 times more potent than carbon dioxide. Emissions are mainly reported to originate from the degradation of organic matter in the reservoir[19] (Demarty & Bastein, 2011; Rasanen et al., 2018) . Impact assessment of BGHEP also reports possibility of emission of GHG from reservoirs through four different pathways: i) diffusive flux at the reservoir surface, ii) gas bubble flux in the shallow zones of the reservoir, iii) water degassing flux at the outlet of the powerhouse downstream of turbines and spillways, and iv) flux across the air–water interface in the rivers downstream of the dams[20] (Aryal et al., 2016).	
(PI)-Noise pollution	Noise pollution is at its peak during construction. Major sources of noise include crushers, compressors, vehicular movements, blasting among others. Since the envisaged construction work in hydropower plants does not involve long term heavy equipment operations beyond the construction phase, the expected noise impact is of low significance.	
(BI)- Loss of aquatic biodiversity and species	Hydropower plants have major impact on aquatic habitat and most importantly fish biodiversity. Migratory fish cannot migrate upstream past large dams for spawning and breeding. This leads to a decline in fish population and gene pool as a whole. The Kaligandaki Hydropower Project (KGAHPP), EIA study shows a decline in fish species including that of snow trout. Similarly, some river stretches of Budhi Gandaki and Ankhu Khola are still a habitat of five fish species of conservation significance listed in the IUCN red list. Of the total, three are under near threatened category, while one is vulnerable and the other endangered. All of these species are mid-range to long range migratory species. In the absence of efficient fish ladder and fish hatchery which is described in detail in later sections, these species face a risk of decline.	‣ Fish ladder, hatchery, trapping and hauling and fish passages, whichever appropriate, should be designed based on the fish species and topography ‣ A minimum flow criterion of 10% of the natural flow might not be sufficient to meet environmental water requirement of key ecological targets throughout the year. For example, flow requirement for spawning of fish species might differ for different species in different seasons. Therefore, flow criteria should be set by taking into account the number of important factors such as seasonal natural flow conditions, project scenarios, downward water requirement, and fish species among others.

19 GHG Emissions from Hydroelectric Reservoirs in Tropical and Equatorial Region: Review of 20 years of CH_4 emission measurement, 2011 & Greenhouse Gas Emissions of Hydropower in the Mekong River Basin, 2018

20 Budhigandaki Hydroelectric Project EIA Study, 2016

Impact	Situation Analysis	Mitigation Measures
(BI)- Loss of forest and other vegetation	Forest cover and species richness may also be impacted by hydropower plants. Reduction in downstream flow lead to the disappearance of wetlands. Moreover, due to the reduced water table, trees encroach the grassland. Total forest loss estimated in BGHEP is 2,402.51 ha. Total loss of biomass is 1,202,336.3 mega ton[21] (Aryal et al., 2016). Likewise, 422.6 ha of forest land were affected due to THP and 6,093 trees were estimated to be removed as per the respective EIA reports.	▸ Implementation of afforestation program following the government guideline which requires afforestation of lost tree sized floral species in 1:25 ratio or afforest lost tree sized floral species in area equivalent to the lost forest area. As per the guideline, the option with the larger land area for afforestation should be followed. ▸ Forest Management Plan should be prepared under suitable forest management regime for the remaining forest area in the project site
(BI)- Loss of wildlife	Forest loss and fragmentation due to hydropower development leads to loss of wildlife and its habitat, as described below. Reduction in downstream flow results in less water points for wildlife during the dry season due to which wild animals/birds move out of the dry areas. When there is relocation of human settlements, further impact is induced due to human-wildlife conflict. For example, the BGHEP affected forest area was previously used as a feeding ground by the mammalian species, while the avian species and reptilian species used the areas for nesting and breeding. With the HP construction, loss of habitat due to the project location is a direct impact of the project and cannot be compensated in short term (Aryal et al., 2016). As the project site was a habitat of mammalian species of conservation significance, with the loss of the habitat, the status of those species is of serious concern. The project EIA report states that 19 mammalians, 9 reptilians and 54 avian species habitats are directly and indirectly affected, 15 of which have been listed in GoN, or CITES or IUCN Red List.	▸ Natural corridors with suitable habitats and functional ecological processes need to be identified and protected to facilitate animal movement ▸ Additional corridors should be developed to facilitate easy migration of wildlife if the location of a project hinders animal movement and migration ▸ Translocation of animals with significant conservation significance should be undertaken if necessary ▸ Support ex-situ conservation of rare, endangered, threatened wildlife species should be a priority

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Impact	Situation Analysis	Mitigation Measures
(SI)-Land acquisition	Construction and operation of hydropower plants requires acquisition of temporary and permanent land for reservoir, barrage, sensor building, powerhouse and switchyard, surge shaft and penstock alignment, access road to headwork, campsite at headwork, campsite at powerhouse, quarry sites at headwork and powerhouse, and spoil disposal among others. For example: Tanuhun Hydropower Project (THP), which is under construction, has directly affected 550 households, amongst which 86 households were physically displaced (Tanahun Hydropower Limited, 2017). When land is permanently lost by a family, it takes away productive systems, commercial activities and land-based livelihoods of people. Such displacement can be followed by poverty. Loss of home may trigger social and inter-family changes on family and societal cohesion. Displaced families suffer a loss of access to common natural and social property such as access to forest, water bodies, grazing lands etc. creating an impact on their social and economic wellbeing.	‣ Detailed socio-economic profile needs to be developed by proponents including recognition of vulnerable groups. Proponent should undertake valuation of properties to be affected by the project and compensation offered should comply with the existing laws and sincerely strive to meet the expectations and needs of the affected people. ‣ Provision of compensation or incentives to the extent possible should be made for the loss of ecosystem services (such as that of forest products due to felling of trees) ‣ Risk analysis and counter risk measures in land acquisition and resettlement should be priority issues ‣ Lack of environmental flow lead to reduction of fish biomass which in turn results in reduced access to food and livelihood of those who rely on fishery ‣ The above should be studied and action plan developed, called Resettlement Action Plan (RAP) for fair and timely compensation and support to the affected people ‣ Projects should develop employment and business development plans for displaced households ‣ Projects should maximize and prioritize recruitment of local workers ‣ Community Development Strategy (CDS) should be developed to enhance and catalyze socio-economic development of the project area through key program interventions with especial emphasis on women and socially excluded groups

Impact	Situation Analysis	Mitigation Measures
		‣ Interventions should be participatory and driven by community needs, priorities and concerns. Interventions should particularly empower the socio-economically vulnerable sections of the project affected area
(SI)-Ownership of rivers	The people and communities who have been seeing and using the natural resources and assets such as rivers, or forests and even hills tend to develop a sense of ownership due to their personal association. This is considered normal and are mostly associated with feelings and legalities. As a consequence, when external parties come and exploit these natural resources, there is a tendency to protect these resources. This also means that if this exploitation is financially motivated, there is a desire to benefit from this process. At a more formal level, the ownership also needs to be explored at state level. The rivers and other resources do belong to some entity: either the local or Provincial or the Federal Governments. This needs to be ascertained to avoid conflicts during the implementation and use of the projects.	

General recommendation (Excerpts from WWF Global Network document on Dams): Water is fundamental to life on earth. Healthy freshwater ecosystems provide resources and services our societies rely on: food, water, energy, economic activity and cultural value. Ultimately our well-being depends on how we manage our rivers and water resources. WWF strives for a water secure world for people and nature, where flowing rivers nourish resilient and healthy freshwater ecosystems that sustainably provide ecosystem services for human development.

Globally, nearly 60,000 large dams (World Register of Dams) have caused considerable environmental and social damage. Together with associated activities such as irrigated agriculture and municipal and industrial uses, these dams have been a major contributor to the dramatic global decline in freshwater biodiversity2, mainly through flow alteration and severed connectivity. Also, countless small dams severely fragment river systems with potentially significant cumulative impact. As demand for services provided by dams grows, especially for irrigation and hydropower, the pressure on freshwater ecosystems is increasingly acute. And, the impacts of climate change exacerbate this situation.

Nevertheless, dams can sustain important functions for human development, including water supply, irrigation, renewable electricity generation and flood and drought management, and stimulate economic development. As the world population continues to grow, decisions on dams are increasingly taken in the context of development. Rapid acceleration of construction of dams and other water infrastructure, at all scales, without due consideration of social and environmental impacts, can be counter-productive.

Impact	Situation Analysis	Mitigation Measures

However, with vast previous experiences and learning, bad practices including planning and operation based on feeble economic assumptions and in disregard of fundamental sustainable principles can be now avoided. Likewise, good practice exists and should be applied. Inclusive and transparent decision making on policies, plans and projects, as well as good governance are required. A wealth of knowledge and tools is available for choice and justification, and for siting, designing and operations of projects. Smart and sustainable societal choices rely on comprehensive options and needs assessments, river basin planning and management, appropriate legal frameworks, and recognition and enhancement of ecosystem services. Choices over trade-offs will have to be made in order to maintain vital freshwater systems and processes on which communities depend. By ensuring environmental flows, and connectivity, significant reduction of damage to ecosystems can be achieved and degraded rivers can be revitalized.

Moreover, newer technologies and range of solutions are now available; needs of dams can be assessed with respect to the long-term cost and benefits to human communities and nature. A change toward responsible water and energy use can reduce the need for new dams in several ways. Governments should prioritize measures to reduce demand for the services provided by dams, invest in natural and low impact infrastructure measures, and upgrade and improve existing dams. Adoption of detrimental policies must be avoided.

In order to ensure that dams are not built in, or affect areas of high conservation value that they are built only after full consideration of alternatives, where there is stakeholder support and in the least harmful locations, and that benefits from existing dams are improved, WWF recommends concerted action for:

A. improvement of strategic decision-making processes on dams and locations and their associated infrastructure, and

B. improvement of planning, finance, building and operations of individual projects and developments.

A. Decision Making Processes on Dams:

... should be responsible, accountable and follow principles of good governance. Policies, plans and projects for dams and water infrastructure in general should be considered through transparent multi-criteria approaches involving all stakeholders, members of affected communities with special attention to indigenous peoples and vulnerable groups. Careful consideration of all parties' input and issues will help develop consensus and lead to productive dialogue and understanding about risks and impacts and desired avoidance, protection, enhancement and mitigation measures. Governments should establish strong legal and institutional frameworks to ensure that strategic environmental and social assessments, planning and implementation follow best practices as formulated in the World Commission on Dam principles. Given the high stakes of these often-large-scale projects, public and corporate governance should aim at high levels of integrity and accountability.

... should seek out the opportunities offered by natural infrastructure solutions. Demand and investment for new "hard infrastructure" can be minimized through services contributed by "natural infrastructure" e.g. floodplains for storage, flood and drought management, wetland restoration and watershed management for water retention upstream and resilience to climate change.

... should follow a precautionary approach. Dams have a lifespan of centuries; their investments are locked in for long periods of time and social and environmental impacts are considerable. Planning should be guided by precautionary principles, considering hydrological, social and political uncertainties arising from climate change, economic projections and societal choices, and allow for adaptive management based on monitoring outcomes.

Impact	Situation Analysis	Mitigation Measures
... should be based on sound strategic environmental and social assessments, utilizing the best available knowledge and scientific analysis, considering hydrological uncertainty and adaptability, including current and future climate change scenarios, cumulative impacts of multiple water use and users, and recognition of environmental requirements and services. Such assessments are to be conducted at appropriate river basin or regional scales in an inclusive, transparent manner. This is a prerequisite for choice and justification, and for appropriate siting, design and operations of projects. ... should include assessments of important environmental assets. Freshwater ecosystems of high ecological importance should receive a permanent level of protection from dams and their upstream and downstream impacts. These can be areas, rivers or river stretches of high conservation value in terms of biodiversity or ecosystem services, or as refugia against future pressures, such as climate change. Siting of dams on the main stem or major tributaries that are of high ecological importance should be avoided. Typical no-go areas are protected areas of international, national and regional recognition (e.g. Ramsar sites, World Heritage sites) and indigenous territories. Many no-go areas do not have formal protection status; therefore, governments should ensure their identification and protection. Assessment of environmental assets must take account of connectivity within the river system as well as between areas of high conservation value. **B. Individual Projects and Developments:** ... should follow the mitigation hierarchy for dealing with impacts and risks. Environmental and social impacts and risks must be avoided and minimized through appropriate choice of locations, design, construction and operations. Remaining impacts and risks that cannot be avoided and minimized should be mitigated. Compensation and offsetting apply to the residual impacts and risks only after the potential for avoidance, minimization and mitigation is fully utilized. ... should be scrutinized against a long-term horizon. Proposed dams whose environmental and social costs outweigh the benefits of their services should not be built.... should prioritize environmental flows. Recognizing flows as the master variable of river basin health, all new and existing dams must be designed and operated with environmental flows, defined as "the quantity, timing, and quality of water flows required to sustain freshwater and estuarine/marine ecosystems and the human livelihoods and wellbeing that depend on these ecosystems". In practice, environmental flows will mimic characteristics of natural flow variability of water and sediments. All new and existing dams must also be designed and operated to maintain and restore connectivity. ... should be managed for continuous improvement. Owners, operators and regulators should identify dams whose environmental and social performance can be improved as technologies, science and knowledge progress. Rehabilitation, re-operation and retrofitting of existing dams is increasingly feasible, extending reservoir life, improving services and benefits, and reducing the need for new dams.		
Airport: The Pokhara Regional International Airport under construction in Kaski District, Nepal, will replace the existing Pokhara Airport and is scheduled to begin operations in 2021. It is anticipated to accommodate one million passengers every year. The project is expected to provide improved air transportation services to the growing number of international and domestic passengers. In addition, it will strengthen the country's civil aviation sector and contribute to economic and social development, as well as tourism.		

Impact	Situation Analysis	Mitigation Measures
(PI)-Land use change and instability	A large area of land is taken by airports. The areas are often large forest areas or fertile lands where the surface is undulating significant amount of quarry materials are required for trimming or filling of the airport areas. The collection of quarry material from the fragile geological condition can lead to erosion and landslide. Stock piling of construction materials and spoil generated from excavation affects scenic beauty of the landscape and also has the possibility of disrupting irrigation canals. For example, although outside CHAL area, proposed Nijdhad international airport has been seriously contested for its location in deep forest area with wild elephant corridor route. The more the land is taken up by the airport, the more disruption to natural environment is expected with obvious irreparable and adverse consequences to biodiversity of the area. Impacts at operational phase can be more pronounced. Project site mainly comprise of agricultural land. Present agricultural land will be converted into airfield permanently which is unavoidable and irreversible impact.	
(PI)- Air pollution	Deterioration of air quality due to construction activities (bitumen mixing to blacktop, vehicular emission etc.) are short term and indirect. However, at the operational level, potential sources of direct emission includes aircraft engine emissions, emissions from the Auxiliary Power Unit, emission from the Ground Support Equipment, emission from the Ground Access Vehicles etc. Air pollutants include unburnt hydrocarbon, carbon monoxide, oxides of Nitrogen etc.[24] (CAAN, 2016).	
(PI)- Noise Pollution	Continual noise pollution and visual disruption is expected. The major source of noise at the airport will be aircraft take off, landing and ground operations. Maximum noise of 100-110 dB (A) during takeoff and 90-100 dB (A) during landing is produced. As the project location is predominantly agricultural field, impact of noise level will not impact significant population but is still perceptible within 1-2 km of the airport boundary.	
(BI)-Loss of agricultural land	While the air airport area was used widely for agricultural purpose, project activities will result in loss of vegetation including farmland and grassland.	

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Impact	Situation Analysis	Mitigation Measures
(BI)- Loss of forest and other vegetation	When the project location comprises forest area in the vicinity, construction workers might use forest resources haphazardly for cooking and heating purposes. Increased mobility in the project area may induce illegal logging of the trees including nationally protected species such as Sal (*Shorea robusta*), Kayer (*Acacia catechu*). This gets exacerbated with time as airports expand or settlements increase around airports.	▸ Compensatory plantation should be carried out following the forest guideline ▸ Illegal logging of forest should be strictly prohibited and should be included in the agreement with the contractor
(BI)-Loss/ disturbance of wild animals and their habitat	Increased mobility in the project location increases the chances of illegal poaching, hunting of wild animals in nearby forests. For example, for PIA, the Ritepani and Bharatpokarai species are expected to be adversely affected. Establishment of airport brings along wider road access, increased economic activities and increased settlement in the locality which will limit easy and frequent movement of wild animals in the nearby forests and along their usual habitats.	▸ Natural corridors shouldn't be encroached, and additional corridors should be developed when and where necessary to prevent loss of wildlife due to habitat fragmentation ▸ Ex-situ conservation should be supported by the project if faunal species of conservational importance exist in the project location

General recommendations for responsible tourism: Conceptually, nature-based tourism can be a critical ally of conservation. It has the potential to incentivize sustainable use of resources and thereby nature preservation, by providing better livelihoods for local communities, and additionally promote conservation awareness with involvement of diverse stakeholders.

However, increased affluence due to tourism can jeopardize the basic principles of eco-tourism, with prioritization of profits. Challenges also persist in ensuring awareness on, and implementation of, the principles of responsible tourism among all stakeholders. Monitoring is crucial to ensure implementation of best practices to reduce or mitigate potential negative impacts. Eco-tourism can be defined as tourism to natural areas that is 'determined by, and benefits, local communities and the environment'. It should be seen as a subset of responsible tourism, which 'maintains or enhances the destination environment, and benefits destination residents'.

WWF believes that the tourism sector needs to accept responsibility for its impacts, both on nature and people, and to be proactive in addressing them. The following principles are offered as a guide to the issues that WWF believes should be considered in pursuing more responsible tourism.

Tourism should be part of wider sustainable development and support conservation: Tourism should be compatible with and part of international, national, regional, and local sustainable development and conservation plans. It should be planned, managed and undertaken in a way that avoids damage to biodiversity, and that is environmentally sustainable, economically viable, and socially equitable. All tourism development should be undertaken using a precautionary approach. Tourism should not compromise opportunities for a diversified local economy, should be undertaken within limits of acceptable change, and in preference to other potentially more damaging forms of development. On occasion, tourism itself may be the most damaging activity and may need to be heavily restricted or prevented. Sound land-use planning, including environmental impact assessment, strategic environmental assessment, and respect for natural landscapes and protected areas, can help avoid impacts in sensitive areas.

Impact	Situation Analysis	Mitigation Measures

Whenever possible and appropriate, economic instruments and incentives should be used to achieve responsible tourism. In particular, the polluter pays principle should be applied in mitigating impacts.

Tourism should support nature conservation, especially the protection of terrestrial, coastal and marine wildlife, habitats and ecosystems. It should avoid contributing to the fragmentation of natural landscapes which both reduces the quality of the tourism experience and degrades the environment.

Tourism should be planned in order to prevent the degradation of archaeological, historical, prehistoric, and scientific sites and remains, and should support their conservation.

Tourism should comply with international conventions and national, state, and local laws where these support sustainable development and conservation. Where such regulation does not exist, the tourism sector should support its initiation.

Tourism should use natural resources in a sustainable way: Conservation and sustainable use of natural resources are essential to the long-term health of the environment. The concentration of tourists, both in time and space, can impose a very heavy toll on scarce resources such as water. Tourist management systems should strive for a more even distribution of tourist flows throughout the year, where feasible, and tourism revenue should support sustainable use strategies and technologies.

Sports and outdoor activities in ecologically sensitive areas, including recreational hunting and fishing, should comply with existing regulations on conservation and the sustainable use of species and habitats. Where regulations do not exist, or are ineffective, the tourism industry should seek guidance from appropriate bodies with expertise and knowledge of the particular area where activities are planned.

Tourism should eliminate unsustainable consumption and minimize pollution and waste: Reducing pollution and consumption lessens environmental damage, improves the tourism experience, and reduces both operational costs and the high cost of cleaning up the environment.

The consumption of fossil fuels and motorized transport, both within and between destinations, should be avoided whenever possible. Negative impacts of transport on the environment should be reduced, and particular attention should be devoted to environmental impacts of road and air traffic, especially in ecologically sensitive areas. Seeking cleaner energy sources and pursuing efficient resource use are essential.

Tourism should respect local cultures and provide benefits and opportunities to local communities: Local communities reserve the right to maintain and control their cultural heritage and to manage the positive and negative impacts that tourism brings. Tourism should therefore respect the rights and wishes of local people and provide opportunities for the wider community to participate actively in decision-making and consultations on tourism planning and management issues. Local traditions should be taken into account in buildings, and architectural development should be in harmony with the environment and the landscape. The knowledge and experience of local communities in sustainable resource management can make a major contribution to responsible tourism.

Tourism should therefore respect and value local knowledge and experience, maximize benefits to communities, and recruit, train, and employ local people at all levels.

Tourism should be informative and educational: Education, awareness, and capacity building are key to achieving responsible tourism. All involved in tourism should be made aware of its positive and negative impacts and encouraged to be responsible and to support conservation through their activities. This includes industry, national and local government, local communities, and consumers. Information about environmental, cultural and social issues should be provided to tourists as an essential part of responsible tourism. Tourism should also provide the opportunity for the sharing of local heritage, culture, and traditions with visitors.

Impact	Situation Analysis	Mitigation Measures
Mines Influences of mining on the natural environment, and the extent of impact is determined by the scale of operation and the infrastructure needed to extract and transport prospective minerals. There are both direct and indirect negative impacts of mining. The direct effects occur within the immediate periphery of mining locations (Durán et al. 2013). Destruction of natural habitats are among the most prominent direct threats of mining. Local ecosystems may be impacted through fragmentation caused as a result of mining, affecting movement of long-ranging or migratory wildlife in addition to habitat loss for resident ones; such impacts may particularly be critical on endemic species. Other than that, pollution in various forms are also known to impact wildlife. Pollution as a result of mining may cause contamination of water, land and air, affecting human communities living in the vicinity, as well. Mining has also found to negatively affect people through relocations, preventing access to clean environment, disruption of cultural values and traditions, impacts on health, as well as imbalances in social dynamics. Indirect effects are a consequence activity such as access infrastructure development (e.g., road), which may bring in associated threats of linear infrastructures. In geologically unstable regions, like the Himalayas, mining may also cause seismic imbalances, and thereby increase risks of disasters such as earthquakes, landslides, GLOFs.		
(PI)-Land use change and instability	Land is the natural resource of utmost importance and the major source of mines and minerals; the mining of natural resources are always associated with land use and land cover changes[25] (Garai & Narayana, 2018; Prakash & Gupta, 1998). Some of the physical impacts are: Mining cause significant alteration in topography, hydrology and drainage pattern of the existing land. For instance, flat topography for quarrying and disposal requires clearing of existing forest or agriculture land. Additionally, land will be acquired for construction of access road to the project site. Example: Mining of stones in Hupsekot, Nawalparasi required 4.97 ha of land for quarrying; the removal of rock and soil mass in the quarry site lead to land degradation. Extraction of sand and gravel below bridges using machineries have increased the risk of collapse of bridge and roads in many stretches of rivers. For instance: Approximately 100-200 tractors collect sand and gravel from river banks in Makwanpur district. Makwanpur district has the third highest number of operating crusher industry[26] (Polcom Research Center, 2016). Likewise, bank cutting, slope instability, change in river course due to lack of boulders in river bed followed by flood have become very common in rivers where haphazard and excessive extraction is carried out.	‣ Proper drainage system should be built in excavation sites especially in hilly areas ‣ Loose excavated soil should be compacted and restored in proper place ‣ Cutting and dressing of all the mining benches is needed to create gentle slopes and prevent slope failure and soil erosion ‣ Scientific assessment should be carried out and those with limited impact on the environment should only be allowed to collect/ extract. ‣ Regulation and monitoring of contractors assigned in extraction and transportation activities

25 Landuse/Land Cover Changes in the Mining Area of Godavari Coal Fields of Southern India, 2018 & Landuse Mapping and Change Detection in a Coal Mining area: A Case Study in the Jharia Coalfield, 1998

29 ढुंगा, गिट्टी तथा बालुवाको उत्खनन, संकलन तथा व्यवस्थापन र क्रसर उद्योग संचालन तथा व्यवस्थापनका सम्बन्धमा तयार पारिएको प्रतिवेदन, २०७३

Impact	Situation Analysis	Mitigation Measures
(PI)-Air pollution	Air pollution is mainly due to loading, unloading and operation of mining machineries. Other sources of pollution are combustion of fuels from the operation of heavy mining equipment such as trucks, dozer etc. The burning of fuel in these machines emit pollutant gases, mainly the suspended carbon particles.	▸ Dust pollution can be minimized effectively by sprinkling water over the quarry area and quarry roads and nearby settlements regularly ▸ A good quality of fuel oil should be used to maintain the acceptable gaseous emission ▸ Mining machineries and equipment should be kept in proper condition
(PI)-Noise and vibration	Noise pollution is mainly generated due to rock breaker machine, earth moving equipment, drilling and blasting.	▸ Noise minimizing or controlling devices such as silencers should be installed in crushers, excavators, dumpers, compactors whenever possible ▸ Operation of noise producing equipment should be discouraged at night
(BI)- Loss of forest land and vegetation	Operations of mines are restricted in national parks and conservation areas. But mining areas might be located in forest area and felling of trees may be required. For instance: Mining of stones in Hupsekot requires felling of trees which include Sal, Chilaune, Phusre, Amala, Mauwa and Katus.	▸ Compensatory plantation should be carried out as per the forest guideline ▸ Use of fuel wood for heating and cooking purpose should be discouraged and alternative fuels should be provided to the workers
(BI)- Loss of biodiversity	Mining activities require removal of shrubs, grasses and felling of trees which might cause habitat loss and fragmentation. Example: Mining of stones in Hupsekot requires felling of trees which can possibly impact habitat of local faunal species —*Syal, Badar, Kharayo, Dumsi, Lokharke,* etc. — and bird species *Kalij, Bhangera, Titro, Dhukur, Chyakhura, Jureli,* etc.	

<table>
<tr><th>Impact</th><th>Situation Analysis</th><th>Mitigation Measures</th></tr>
<tr><td colspan="2">General recommendations for mining: A ‘mitigation hierarchy’ concept has been developed and advocated as a global strategy to allow for a balanced development – integrating environment sensitivity into infrastructure projects. This four-tier concept helps plan and implement preventive to curative measures to safeguard the environment, during various phases of infrastructure development, to meet commitments of ‘no-net loss of biodiversity’.

The first tier within this hierarchy involves ‘avoidance’ that stresses on avoiding areas that are critical to biodiversity conservation. These may include protected areas, heritage sites, wildlife corridors. The next tier incorporates ‘minimization’ of unavoidable impacts by considering alternatives that reduce intensity of impacts in space and time, or by applying appropriate mitigative measures. The third tier is ‘restoration’ or ‘rehabilitation’ that includes measures taken to repair unavoidable damages to the environment. The last tier expects ‘offsetting’ unavoidable impacts by contributing equitably to protection of areas not impacted by the project.

Incorporating the ‘mitigation hierarchy’, the ‘Business and Biodiversity Offsets Programme’ – an international collaboration between companies, financial institutions, government agencies and civil society organizations – has developed the BBOP ‘Principles of Biodiversity Offsets. Coordinated by the Secretariat member organizations – Forest Trends and Wildlife Conservation Society – the BBOP Principles on Biodiversity Offsets (in image: Source: forest-trends.org) has been recognized including by international bodies like the UN and IUCN.

Additionally, WWF publication on mining in Central Africa (WWF, 2017. Extractive industry: its interactions with conservation and management of ecosystems in Central Africa), proposes some measures to limit risks on biodiversity:
‣ Better governance of the mining sector, particularly the non-industrial and semi-industrial sectors where there is great anarchy in most production countries and regions, especially for high-value products, sources of conflict and disorder; prohibit leases and subcontracting of mining squares reserved for domestic non-industrial miners;

‣ Develop and adopt a common policy and strategy for the development of the mining sector;
‣ Harmonize national mining codes and related regulatory and tax provisions;
‣ Develop and adopt a sub-regional zoning plan and national and local zoning plans (provinces, regions, departments) backed by development and sustainable development strategies integrating and optimizing the various uses of territories in the best interests of various stakeholders and in strict compliance with international commitments (conventions, treaties) and national law and regulations.
‣ Ensure strict application of international standards by major mining companies in terms of environmental and social responsibility (RSE, ISO 26000, The Equator principles)
‣ Create a sub-regional platform and national platforms for a dialogue between local and national administrations, the private sector and the civil society for a better understanding and definition of the scope of responsibility of the different actors;
‣ Strengthen ecological compensation tools with ‘’biodiversity offsets’’ specific to each major mining project and/or aggregated on a larger scale to offset the impacts of logistics corridors.</td><td>BBOP’ Principles on Biodiversity Offsets
Biodiversity offsets are measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development’ after appropriate prevention and mitigation measures have been taken. The goal of biodiversity offsets is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people’s use and cultural values associated with biodiversity.

These principles establish a framework for designing and implementing biodiversity offsets and verifying their success. Biodiversity offsets should be designed to comply with all relevant national and international law, and planned and implemented in accordance with the Convention on Biological Diversity and its ecosystem approach, as articulated in National Biodiversity Strategies and Action Plans.

1. Adherence to the mitigation hierarchy: A biodiversity offset is a commitment to compensate for significant residual adverse impacts on biodiversity identified after appropriate avoidance, minimization and on-site rehabilitation measures have been taken according to the mitigation hierarchy.

2. Limits to what can be offset: There are situations where residual impacts cannot be fully compensated for by a biodiversity offset because of the irreplaceability or vulnerability of the biodiversity affected.

3. Landscape Context: A biodiversity offset should be designed and implemented in a landscape context to achieve the expected measurable conservation outcomes taking into account available information on the full range of biological, social and cultural values of biodiversity and supporting an ecosystem approach</td></tr>
</table>

Impact	Situation Analysis	Mitigation Measures
		4. No net loss: A biodiversity offset should be designed and implemented to achieve in situ, measurable conservation outcomes that can reasonably be expected to result in no net loss and preferably a net gain of biodiversity. 5. Additional conservation outcomes: A biodiversity offset should achieve conservation outcomes above and beyond results that would have occurred if the offset had not taken place. Offset design and implementation should avoid displacing activities harmful to biodiversity to other locations. 6. Stakeholder participation: In areas affected by the project and by the biodiversity offset, the effective participation of stakeholders should be ensured in decision-making about biodiversity offsets, including their evaluation, selection, design, implementation and monitoring. 7. Equity: A biodiversity offset should be designed and implemented in an equitable manner, which means the sharing among stakeholders of the rights and responsibilities, risks and rewards associated with a project and offset in a fair and balanced way, respecting legal and customary arrangements. Special consideration should be given to respecting both internationally and nationally recognised rights of indigenous peoples and local communities. 8. Long-term outcomes: The design and implementation of a biodiversity offset should be based on an adaptive management approach, incorporating monitoring and evaluation, with the objective of securing outcomes that last at lean as long as the project's impacts and preferably in perpetuity. 9. Transparency: The design and implementation of a biodiversity offset, and communication of its results to the public, should be undertaken in a transparent and timely manner. 10. Science and traditional knowledge: The design and implementation of a biodiversity offset should be a documented process informed by sound science, including an appropriate consideration of traditional knowledge.

Useful Resources

Resources	
Hydropower	**Publications** ▸ WWF Global Network Position – Dams ▸ 2000. Dams and Development – A new framework for decision-making. The World Commission on Dams. ▸ 2010. Hydropower Sustainability Assessment Protocol. International Hydropower Association. ▸ 2010. Protecting Rivers and Rights – Recommendations in Action – Briefing Kit. The World Commission on Dams. ▸ 2017. Developing Better Dams – A primer on strategic approaches to large water infrastructure. WWF. ▸ 2018. Hydropower EIA Manual. GoN. **Useful Links:** ▸ Hydropower Sustainability Assessment Protocol: www.hydrosustainability.org (voluntary process, but no veto possibility) ▸ International Commission on Large Dams: http://www.icold-cigb.net (not very practical, but in principle good) ▸ International Hydropower Association: https://www.hydropower.org/
Tourism	**National Tourism Strategy 2016-2025** ▸ http://tourism.gov.np/files/statistics/2.pdf ▸ https://www.wttc.org/-/media/files/reports/economic-impact-research/countries-2018/nepal2018.pdf ((https://www.wttc.org/) ▸ http://www2.unwto.org/annual-reports ▸ Ecotourism: Principles, Practices & Policies for Sustainability- Megan Epler Wood
Mines	**International Council on Mining and Metals: Good practice guidance for mining and biodiversity** **WWF, 2017. Extractive industry: its interactions with conservation and management of ecosystems in Central Africa** ▸ http://equator-principles.com/ ▸ https://www.sciencedirect.com/science/article/pii/S0301479714002138?via%3Dihub ▸ https://blog.nationalgeographic.org/2017/08/22/mining-and-biodiversity-protection-efforts-at-international-governance/

Annex 3: District covered by the Snow Leopard Conservation Landscape

S. N.	District	GSLEP Priority Landscape	Province	Area in District (sq. km.)	Total District Area (sq. km.)	% in District	Human Population	SL Habitat Area (sq. km.)	Hab_% in (District)	Total landscape width of Snow Leopard Habitat (in sq. km.)
1	Dhading	Central Landscape	3	426	1926	22.12	336067	154	8.00	9487
2	Gorkha	Central Landscape	4	2707	3610	74.99	271061	1711	47.40	
3	Kaski	Central Landscape	4	1386	2017	68.72	492098	648	32.13	
4	Lamjung	Central Landscape	4	1209	1692	71.45	167724	293	17.32	
5	Manang	Central Landscape	4	2246	2246	100.00	6538	2195	97.73	
6	Mustang	Central Landscape	4	3573	3573	100.00	13452	3518	98.46	
7	Myagdi	Central Landscape	4	408	2297	17.76	113641	968	42.14	
8	Rasuwa	Central Landscape	3	335	1544	21.70	43300	0	0.00	
9	Dolakha	Eastern Landscape	3	1372	2191	62.62	186557	759	34.64	7252
10	Nuwakot	Eastern Landscape	3	171	1121	15.25	277471	29	2.59	
11	Panchthar	Eastern Landscape	1	8	1241	0.64	191817	7	0.56	
12	Ramechhap	Eastern Landscape	3	413	1546	26.71	202646	216	13.97	
13	Rasuwa	Eastern Landscape	3	1041	1544	67.42	43300	767	49.68	
14	Sankuwasabha	Eastern Landscape	1	2341	3480	67.27	158742	1132	32.53	
15	Sindhupalchowk	Eastern Landscape	3	1319	2542	51.89	287798	520	20.46	
16	Solukhumbu	Eastern Landscape	1	2448	3312	73.91	105886	1935	58.42	
17	Taplejung	Eastern Landscape	1	2487	3646	68.21	127461	1887	51.76	

S. N.	District	GSLEP Priority Landscape	Province	Area in District (sq. km.)	Total District Area (sq. km.)	% in District	Human Population	SL Habitat Area (sq. km.)	Hab_% in (District)	Total landscape width of Snow Leopard Habitat (in sq. km.)
18	Baglung	Western Landscape	4	878	1784	49.22	268613	141	7.90	19271
19	Bajhang	Western Landscape	7	2920	3422	85.33	195159	1563	45.68	
20	Bajura	Western Landscape	7	1561	2188	71.34	134912	488	22.30	
21	Dailekh	Western Landscape	6	156	1502	10.39	261770	0	0.00	
22	Darchula	Western Landscape	7	2000	2322	86.13	133274	992	42.72	
23	Dolpa	Western Landscape	6	7948	7889	100.75	36700	6956	88.17	
24	Humla	Western Landscape	6	6005	5655	106.19	50858	4593	81.22	
25	Jajarkot	Western Landscape	6	1216	2230	54.53	171304	229	10.27	
26	Jumla	Western Landscape	6	2553	2531	100.87	108921	858	33.90	
27	Kalikot	Western Landscape	6	486	1741	27.91	136948	0	0.00	
28	Mugu	Western Landscape	6	2897	3535	81.95	55268	1851	52.36	
29	Myagdi	Western Landscape	4	1825	2297	79.45	113641	968	42.14	
30	Rolpa	Western Landscape	5	224	1879	11.92	224506	0	0.00	
31	Rukum in Province 5	Western Landscape	5	1514	1161	130.40	53018	534	45.99	
32	Rukum in Province 6	Western Landscape	6	657	1213	54.16	154272	98	8.08	

Annex 4: List of EIA reports reviewed

SN	Project Name/EIA Report	Type of Project	Category	District
1	Arun-3 Hydroelectric project (900 MW), Sankhuwasabha	Hydropower	Run-of-River	Sankhuwasabha
2	Balephi Hydropower Project (20 MW)	Hydropower	Run-of-River	Sindhupalchowk
3	Basantapur-Chainpur-Khandbari Road	Road	Feed Road	Terhathum, Sankhuwasabha
4	Chameliya (Chhetti gad) Hydroelectric Project (CCHEP), Darchula-85 MW	Hydropower	Run-of-River	Darchula
5	Ecotourism project (Simikot- Hilsa, Dolpa, Kanchenjunga,	Tourism		Humla, Dolpa, Sankhuwasabha and Solukhumbu, Taplejung
6	Kharekhola Hydropower	Hydropower	Transmission Line	Dolakha
7	Langtang Khola Hydro-electric project (10 MW)	Hydropower		Rasuwa
8	North-South Lok Marg (Karnali Corridor), Hilsa -Simikot Road	Road		Humla
9	Nyadi Hydropower Project (NHP)- 10 MW	Hydropower	Run-of-River	Lamjung
10	Rasuwagadhi Hydroelectric Project (RGHEP 100 MW)	Hydropower	Run-of-River	Rasuwa
11	SoluKhola (DudhKoshi) Hydroelectricity Project (SKDKHEP)- 86 MW	Hydropower	Run-of-River	Solukhumbu
12	Syafrubesi- Rasuwagadhi Road Project (16 km)	Road	Feeder Road	Rasuwa
13	Thulo Bharkhu- Brabal- ThuloSyafru agricultural road (9.5 km)	Road	Rural Road	Rasuwa
14	TimureKhaidi Agriculture Road (6 km)	Road	Agriculture Road	Sirane and Gummaling
15	Timure-Khaidi Agricultural Road (6 km)	Road	Agriculture Road	Rasuwa
16	Upper Karnali Hydropower Project (900 MW)	Hydropower		Surkhet, Dailkekh, Achham

Annex 5: Different minerals/commodities explore for prospection in Nepal

Mineral	Area (sq. km)
Aquamarine	5.01
Beryl	3.9
Copper	26.4
Corumdum	5
Crystal Quartz	21.75
Dolomite	23.581
Gold	47.53
Iron	30
Kainite	28.576
Kaolin	0.49
Lead	12.33
Limestone	59.702
Magnesite	5.18
Quartzite	53.07
Quartzite (Slab Stone)	0.3
Red Clay	1.992
Silica Sand	9.4
Talc	36.969
Tourmaline	49.528
Zinc	26.612

Annex 6: Mines in Nepal by district and frequency

District	Number of Mines	Area (sq. km)
Baglung	3	12.99
Iron	2	12
Quartzite	1	0.99
Bajhang	4	9.89
Crystal Quartz	2	8.89
Dolomite	1	1
Talc	1	
Darchula	6	23.46
Crystal Quartz	1	2
Lead	3	11.7
Talc	2	9.76
Dhading	54	117.805
Crystal Quartz	1	1
Dolomite	7	22.581
Gold	1	15.83
Kaolin	1	0.49
Lead	2	0.63
Limestone	24	39.702
Quartzite	7	6.26
Quartzite (Slab Stone)	1	0.3
Silica Sand	5	4.4
Zinc	5	26.612
Dolakha	9	20.645
Copper	1	0
Magnesite	2	5.18
Talc	6	15.465
Gorkha	2	6.992
Limestone	1	5
Red Clay	1	1.992
Humla	1	3.05
Crystal Quartz	1	3.05
Jajarkot	37	119.914
Aquamarine	1	3.01
Beryl	1	3.9
Gold	3	31.7

District	Number of Mines	Area (sq. km)
Kainite	12	28.576
Limestone	2	6
Tourmaline	18	46.728
Myagdi	1	5
Talc	1	5
Nuwakot	16	13.63
Limestone	1	3
Quartzite	4	5.63
Silica Sand	11	5
Panchthar	3	18.9
Copper	1	12.9
Limestone	2	6
Ramechhap	3	18.9
Iron	1	18
Quartzite	2	0.9
Rasuwa	1	0
Silica Sand	1	0
Rukum	1	7.5
Copper	1	7.5
Sankhuwasabha	3	4.5
Aquamarine	1	1
Crystal Quartz	1	1.5
Tourmaline	1	2
Sindhupalchok	23	41.234
Quartzite	21	39.29
Talc	2	1.944
Solukhumbu	3	11.8
Aquamarine	1	1
Copper	1	6
Talc	1	4.8
Taplejung	4	11.11
Corumdum	1	5
Crystal Quartz	2	5.31
Tourmaline	1	0.8

WWF® INFRASTRUCTURE ASSESSMENT IN SNOW LEOPARD HABITAT OF NEPAL

3

WWF Nepal works in three landscapes - Terai Arc Landscape, Chitwan Annapurna Landscape and Sacred Himalayan Landscape

1993

WWF Nepal office was established in 1993

4

WWF Nepal's programs focus on 4 goals: Forests, Wildlife, Climate & Energy and Freshwater

1500+

WWF Nepal works with 1500+ community-based organizations in conservation nationwide

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To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

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