Appendix D: Final Report

Cumulative Impact Assessment

Upper Trishuli-1 Hydropower Project, Nepal

Prepared for

NWEDC NEPAL WATER & ENERGY DEVELOPMENT COMPANY

IFC International Finance Corporation World Bank Group

Prepared for:
Nepal Water and Energy Development Company
&
International Finance Corporation

Appendix D:
Cumulative Impact Assessment

Supplemental ESIA-

Upper Trishuli-1 Hydropower Project, Nepal

December 2014

Cover Photo:
Trishuli River downstream from the proposed powerhouse site, facing upstream. October, 2013. [Photo: P. de la Cueva]

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Executive Summary

The Upper Trishuli-1 Project is a run-of-river type 216-MW hydropower facility located in Rasuwa District in central Nepal. Once in operation, this hydropower project will be the largest hydropower facility in the Trishuli watershed.

As per IFC Performance Standard 1 (PS1): Assessment and Management of Environmental and Social Risks and Impacts, clients are expected to ensure that their own assessment determines the degree to which the project under review is contributing to cumulative impacts, in association with other projects and activities. Since the Project will be located in the Trishuli Watershed where other infrastructure projects are currently being built and planned, most notably multiple hydropower facilities, an evaluation of potential cumulative impacts was required. This analysis of cumulative impacts was not included in the original ESIA (Jade Consult 2011).

ESSA Technologies Ltd. (ESSA) has conducted the following Cumulative Impact Assessment (CIA) to bring the environmental and social management of the Upper Trishuli-1 Hydropower Project (UT-1 Project) in compliance with international standards (e.g. IFC Performance Standards).

The assessment of cumulative impacts presented in this report has followed a 6-step methodological approach that follows the same logic framework usually applied for an ESIA and it is based on international best practice; mainly the *Good Practice Handbook on Cumulative Impact Assessment and Management for the Private Sector in Emerging Markets* (IFC 2013). This methodology is based on a Valued Environmental and Social Components (VEC)-centered approach in which the focus of the analysis is the VEC that are impacted by multiple projects and developments and subject to the influence of various natural and social pressures/stressors.

The key VECs selected for this assessment, and identified with the input from local stakeholders, include the following: water resources (quantity, quality and availability), fish and fish habitats, terrestrial ecosystems, erosion and sedimentation processes, use of natural resources by local communities and cultural and religious sites

To assess the cumulative impacts on each VEC, potential impacts have been first identified using an impact hypothesis approach by which the cause-effect chains leading from project action and stressor towards the VECs are conceptualized using impact hypothesis diagrams. Based on the interactions identified in these diagrams, impact indicators for each VEC and potential impact have been identified.

Given the lack of information on some of the VECs, the indicators used for this assessment are spatial indicators of pressures and risks affecting the VECs rather than on the evaluation of specific impacts (i.e. ecological processes underlying the cumulative impacts under study). As simple surrogates for complex ecological processes watershed habitat indicators are unlikely to accurately represent direct cause-and-effect relationships but act as estimates for the pressures or risks acting on the VECs.

Although clearly a fast-growing sector in the Trishuli basin, there is a certain degree of uncertainty as to the number of hydro projects that will be finally implemented in the watershed. For this reason, two hydropower development scenarios have been considered for the assessment of impacts: (i) a moderate development in which all operative and under construction projects are finalized and functioning within the watershed; and (ii) a high intensity development scenario in which all the projects currently under planning are added to the hydropower pipeline in the Trishuli watershed.

The identified cumulative impacts have been assessed in terms of its significance taking into consideration the Project's contribution to such impacts under the two scenarios, and the current state and expected evolution of the VECs' status based on the available baseline information. The most significant cumulative impacts include: reduced water availability (locally along the stretched or the river under reduced-flow); fragmentation (especially by the barrier effect of the weirs/dams) and degradation of aquatic habitats, and the increased risk of landslides.

Based on the results of the cumulative impacts analysis, a number of mitigation and monitoring measures are proposed to help minimize potential cumulative impacts on the selected VECs. These measures follow the mitigation hierarchy recommended by IFC and build on existing environmental and social activities and action items proposed in the approved 2011 EIA (Jade Consult 2011). These measures should be developed and implemented within the framework of a *Cumulative Impacts Management Plan*, to be implemented throughout the life of the Project.

1 Overview

1.1 Context for Cumulative Impact Assessment in the Upper Trishuli-1 Hydropower Project

Cumulative impacts can be defined as the change to the environment caused by the incremental and/or combined effects of an action/project in combination with other present, past, and reasonably foreseen future actions (Hegmann *et al*. 1999). These changes may result in significant impacts that would not be expected in the case of stand-alone projects. For practical reasons, the identification and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concerns and/or concerns of affected communities.

Although the Environmental and Social Impact Assessment (ESIA) process is essential to assessing and managing the environmental and social impacts of individual projects, it is recognized that it often may be insufficient for identifying and managing incremental impacts on areas or resources used or directly affected by a given development. This is especially true in situations where multiple projects occur, or are planned, in the same geographic area. This is the case for the Trishuli watershed, where multiple hydropower projects are under different stages of development and a growing trend in this sector is expected in the near future (see Section 1.3 for a description of hydropower development status in the Trishuli watershed).

Under the current system of environmental assessment in Nepal, environmental and social impacts of government or private-sponsored projects are evaluated on an individual basis based on the 1997 Environment Protection Rules (EPR) applicable sectorial guidelines and policies (Bhatt and Khanal 2009).

The government-approved Environmental Impact Assessment (EIA) for Upper-Trishuli Hydropower Project (Jade Consult 2011) did not address cumulative impacts as part of its assessment. However, a number of ESIA studies (CEPAD 2011) for other hydropower projects in the Trishuli basin have considered the cumulative implications of these projects to a certain extent. The commonly identified cumulative impacts included the following:

- Changes in land use;
- Reduction of water flow along certain river stretches;
- Increase in sediment loads to the watershed and alteration of the sediment dynamics;
- Loss of agricultural land;
- Impacts on livelihoods dependent on altered ecosystem services;
- Aquatic impacts, in particular fish;
- Interference with migratory routes and/or terrestrial wildlife movement; and

- Loss of aesthetic and/or recreational values.

In light of the current hydropower development trends in the Trsihuli watershed, there is a need for assessments that employ available information to examine the potential cumulative effects of existing and proposed hydropower facilities on broader scales (i.e. river basin) than is currently being realized.

It should also be noted that the participation of the International Financial Corporation (IFC) in the Upper Trishuli-1 Project requires compliance with international environmental and social standards as well as alignment with best practices in the assessment of potential impacts. In this respect, IFC's Performance Standard 1 (*Assessment and Management of Environmental and Social Risks and Impacts*) stipulates that private sector proponents are expected to determine the degree to which their project is contributing to cumulative impacts, in association with other projects and activities. The extent and the level of the cumulative impacts assessment should be commensurate with the incremental contribution, source, extent, and severity of the cumulative impacts anticipated.

It is in this context of bringing the UT-1 Project in conformance with international standards (including IFC PS 1) ESSA has conducted the present assessment of cumulative impacts and risks, according to international best practice, particularly IFC's 2013 *Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets,* and commensurate to the significance of the anticipated impacts and the expected contribution of the Project's to these incremental impacts in the Trishuli watershed.

1.2 The Upper Trishuli-1 Hydropower Project

The UT-1 Project is a 216-MW run-of-river hydropower facility located in Rasuwa District in central Nepal (Figure 1-1), approximately 70 km north from Kathmandu. The Project's concession area extends into three Village Development Committees (VDCs): Haku, Dhunche and Ramche.

All the Project's associated infrastructure - including the intake structure, the headrace tunnel, the 19-km access road, and the underground power station - are located in the northwest bank of the Trishuli River. Langtang National Park extends along the southeast bank. At this stage, the Project has started construction and earthworks are being carried out in the powerhouse area. It is expected that the Project will be completed in five years. It should be noted that, at the time of this assessment, the transmission line, subject to a separate EIA which has not been released yet, has not been considered in this assessment.

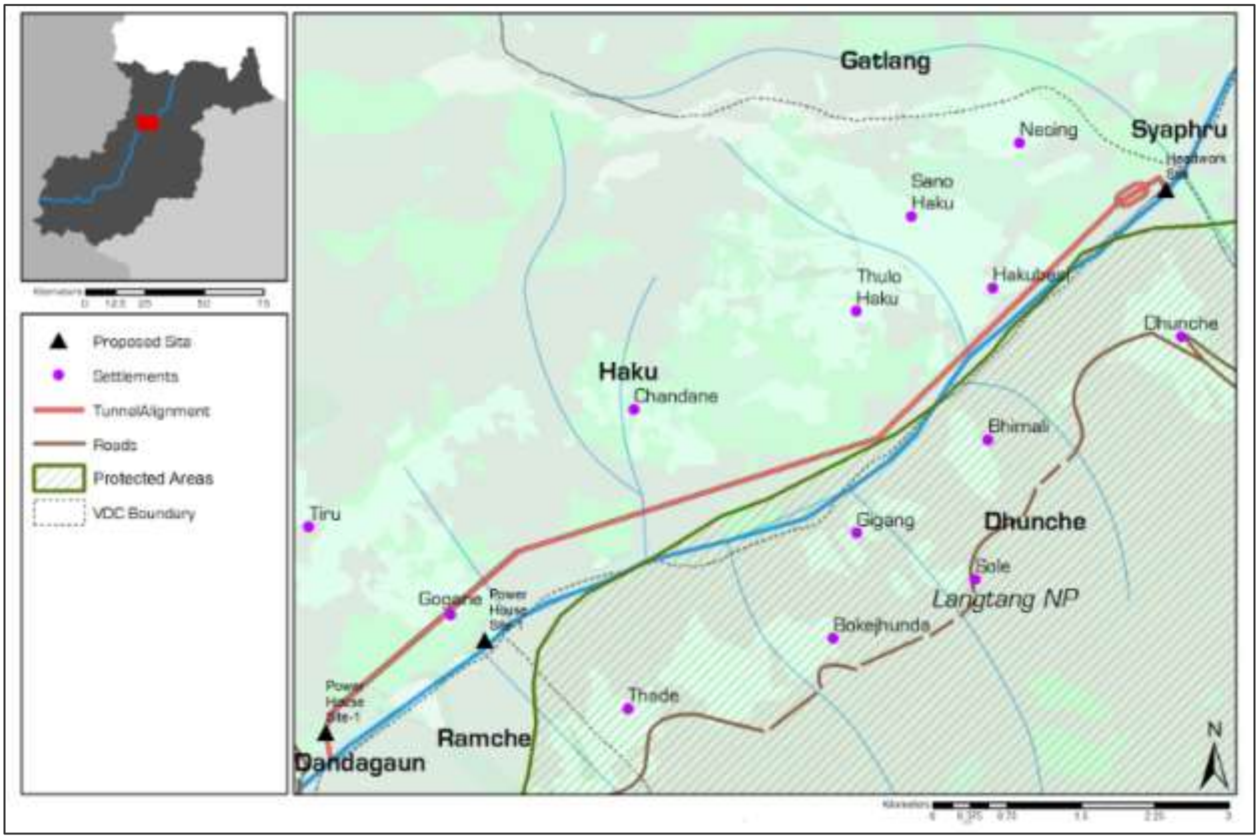

Figure 1-1: Location and main features of the UT-1 Project

The diversion structure for this project is a 77 m wide dam. The hydropower facility is designed to work at a constant water level of 1255 m. This involves a storage capacity in the reservoir to compensate for low flows, although it is expected that the operation mode will be run-of-river most of the time (no peaking operations).

Table 1-1: Salient features of UT-1 Hydropower Project

Project component	Description
Installed capacity	216 MW
Net head	333.41m
Average annual energy	1440 GWH
Head race tunnel length	About 9.82 km, 6.5 m Circular shape
Design discharge	Q_{50} = 74 m³/s
Maximum diversion flow	74 m³/s
Type of powerhouse	Underground
Turbine	3 Francis turbines of 72 MW capacity
Access road	19.3 km road from Mailung Dhovan (powerhouse site) to the intake site
Transmission line	Initial Environmental Examination (IEE) recently completed. Not included in the CIA

Source: Jade Consult 2011

The diversion reach between the intake site and the tailrace extends for 10.7 km. The catchment area of the Trishuli watershed at the UT-1's intake site is 4350 km^2, and 71 % of this surface is located in the Tibet Autonomous Region in Chinese territory.

The 2011 EIA study (Jade Consult 2011), approved by the Government of Nepal, did not address the cumulative impacts associated to the construction and operation of the Upper Trishuli-1 Project but identified the following main impacts at the project level:

- Alteration of the hydrological regime along the 10.7 km diversion reach with potential loss of aquatic habitat for the species of snow trout (*Schizothorax richardsonii*) present in the area
- Acquisition and land conversion (as of June 2014, the total area required for the project is 99.89 ha, including 76.7 ha of community forests and 19.5 ha of agricultural land).
- Loss of vegetation
- Disruption to local wildlife especially during the construction activities
- Increased pressure on local natural resources (i.e. fuel-wood consumption, hunting, habitat degradation) due to the influx of migrant workers to the area
- Increased economic activity and employment opportunities in the Project's area of influence.

1.3 Hydropower development in the Trishuli watershed

Nepal has a significant potential for hydropower development given the perennial nature of Nepali rivers and the steep gradient of the country's topography. Currently, the installed capacity generated by the 38 operative hydropower facilities in Nepal is 700.379 MW. Hydropower contributes with 90 % to the power system and the rest of the balance is met by multi-fuel plants. Only about 40% of Nepal's population has access to electricity.

The hydropower sector in Nepal opened formally to private sector developers in the late 1990's, with the enactment of new Hydropower Development Policy 1992, and has since then rapidly developed. The government body in charge of issuing hydropower licenses is the Department of Electricity Development, dependent of the Ministry of Energy of Nepal. It is estimated that the total theoretical hydroelectricity potential of the country is 83,000 MW; 42,000 MW out of this potential capacity would be economically feasible (ADB and ICIMOD, 2006). Therefore, it is expected that the hydropower market in Nepal will grow significantly in the coming years to address both the growing domestic and regional demand. There are nine major basins in Nepal (i.e. Seti, Karnali, Bheri, Rapti, Kali, Trishuli, Narayani, and Kosi) where most of the hydropower potential is concentrated.

As of November 2013, and according to the licenses registry of the Department of Electricity Development[1] (DOED), there were 20 operative hydropower projects in the Gandaki system (Figure 1-2), 33 projects under construction, and a total of 53 projects in a planning phase (with survey licenses). Most of the projects under planning (41) correspond to small hydropower plants with a generation capacity of less than 25 MW.

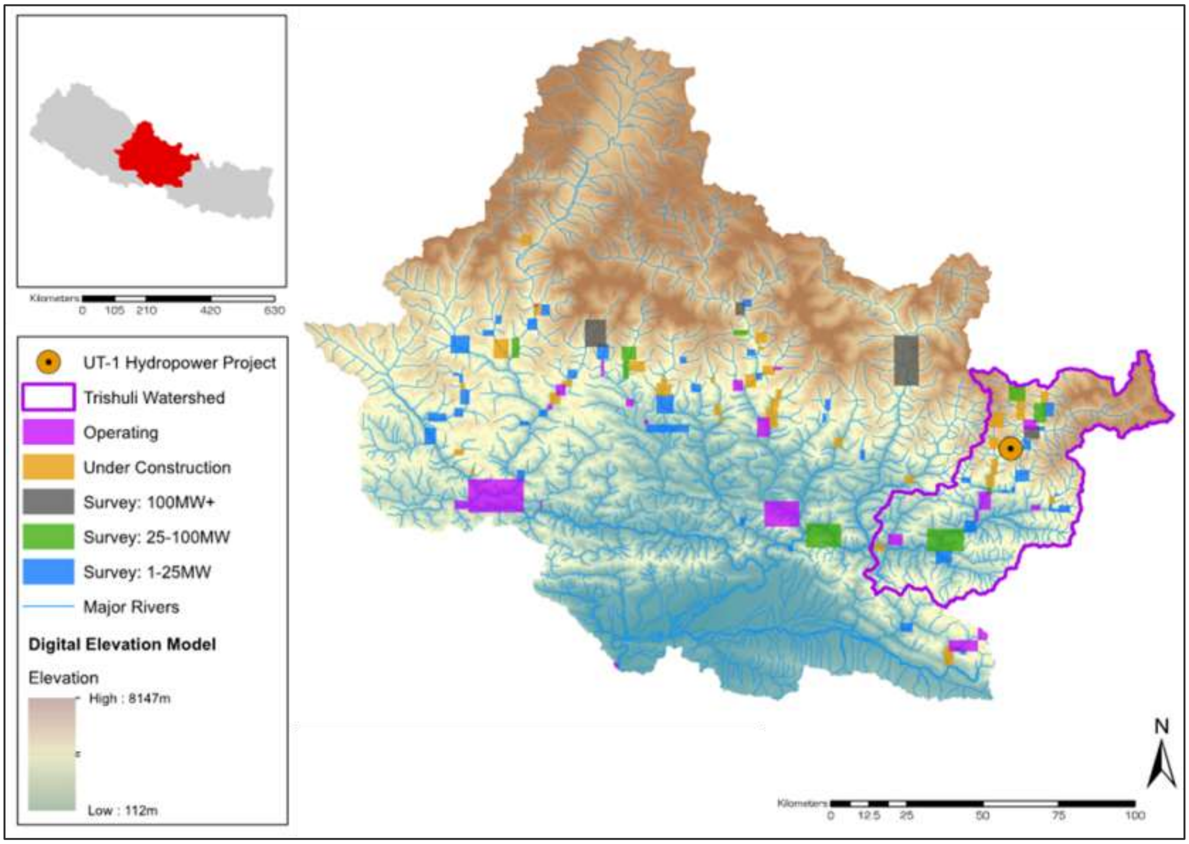

Figure 1-2: Hydropower development in the Gandaki basin

The Trishuli (Figure 1-3) is the sub-basin of the Gandaki River with the highest intensity in hydropower development. There are currently (DOED November 2013) 5 hydropower projects in operation, 9 under construction, including the UT-1 Project, and another 19 have a survey license. The salient features of these projects, all of them run-of-river type with generation capacities ranging between 1 and 216 MW, are included in Annex 1.

Once finished, the UT-1 Project will be the facility with the highest generation capacity (216 MW) in the watershed. It should be noted that, out the total power generation capacity licensed in the Trishuli River (839 MW for 14 projects), only 38.1 MW (0.05%) have been developed; with the rest of the projects at different stages of development and assessment.

[1] http://www.doed.gov.np/issued_licenses.php

From the total issued license for power generation in the Trishuli tributaries (245 MW for 25 projects), a capacity of 23.65 MW (0.09%) has been developed.

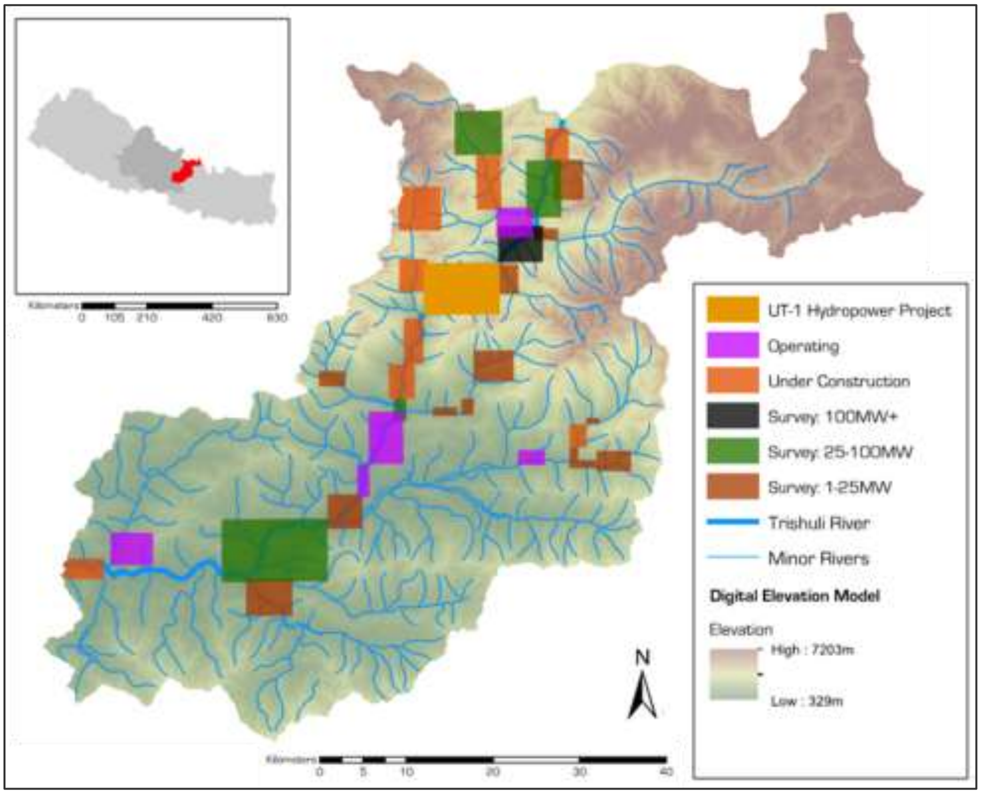

Figure 1-3: Hydropower development in the Trishuli watershed

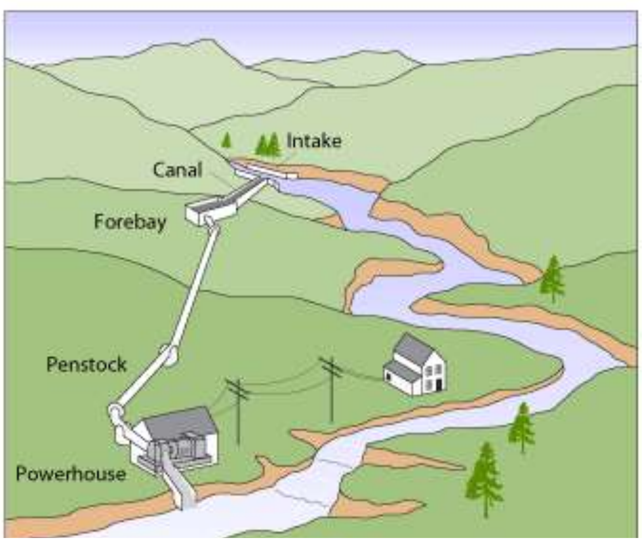

Figure 1-4: Schematic representation of a run-of-river project type
(Source: Nepal Energy Forum, 2013)

Most of the power plants in Nepal are run-of-river type with energy available in excess of domestic demand during the monsoon season and deficit during the dry season. Under this type of hydropower generation (see Figure 1-4 for a schematic representation), a portion of the river's flow is diverted off-channel and transported downhill to a powerhouse, where the water turns turbines, generating electricity, before being restored to the natural stream flow. As a result of this process, a portion of the river channel between the intake structure and the outlet from the powerhouse experiences reduced flow levels.

2 Objectives and methodological approach

2.1 Objectives

The overall goal of the CIA study is to identify environmental and social impacts and risks associated with the UT-1 Project that, when placed in the context of existing, planned, and reasonable predictable developments in the future, may generate cumulative impacts that could jeopardize the overall long-term environmental, social and economic sustainability of the Project and the watershed.

Since the issues and dynamics in the Trishuli basin are complex and there is significant level of environmental degradation involving many stakeholders, we anticipate that the solution for cumulative impacts in the watershed is beyond the control of any individual project sponsor. In this context, this CIA aims at helping NWEDC with:

1. ***Engaging with local stakeholders*** to identify key Valued Environmental and Social Components (VECs) potentially affected by cumulative impacts;
2. ***Assessing cumulative impacts and risks on selected VECs***, and determining their significance and the Project's contribution to these impacts;
3. ***Identifying environmental and social management actions***, both within NWEDC's leverage and requiring coordination with third parties, to mitigate and monitor the cumulative impacts.

2.2 Methodology

2.2.1 Approach

The assessment of cumulative impacts presented in this report has followed a 6-step methodological approach (Figure 5) that follows the same logic framework usually applied for an ESIA and it is based on international best practice; mainly the *Good Practice Handbook on Cumulative Impact Assessment and Management for the Private Sector in Emerging Markets* (IFC 2013). It should be noted that the steps in this approach do not necessarily proceed in sequence and some iteration was applied throughout the process as information was generated and some steps were revisited based on the outcomes of successive steps.

The first two steps (Section 4 of this report) of this approach correspond to the scoping of the CIA analysis. The goal of the scoping exercise is to identify the key Valued Environmental and Social Components (VECs) on which the assessment of effects will focus, the temporal and spatial boundaries for the assessment, and the various activities and natural stressors acting on the watershed that may also contribute to cumulative impacts on the VECs.

For each of the selected VECs (Section 5), the cumulative impacts affecting the component were identified, assessed and evaluated in terms of their significance. The assessment of cumulative impacts has analyzed two potential hydropower development scenarios. Based on these results, and considering the mitigation and monitoring measures proposed in the approved EIA (Jade Consult 2011), management and monitoring measures were proposed (Section 6) for the mitigation and management of the expected cumulative impacts.

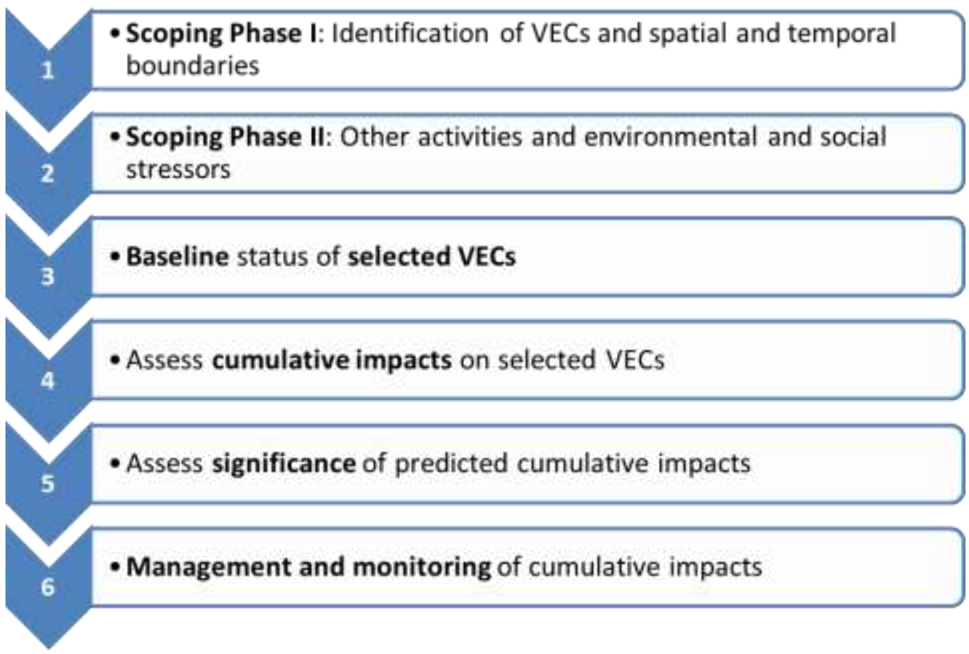

Figure 2-1: Methodological approach used for the CIA process

This methodology is based on a VEC-centered approach (Figure 2-2) in which the focus of the analysis is the Valued Environmental and Social Components that are impacted by multiple projects and developments and subject to the influence of various natural and social pressures/stressors (i.e. climate change, increasing water demand, etc.). The goal of the analysis is to identify the cumulative impacts affecting the key VECs and assess how their future status could be affected by these pressures.

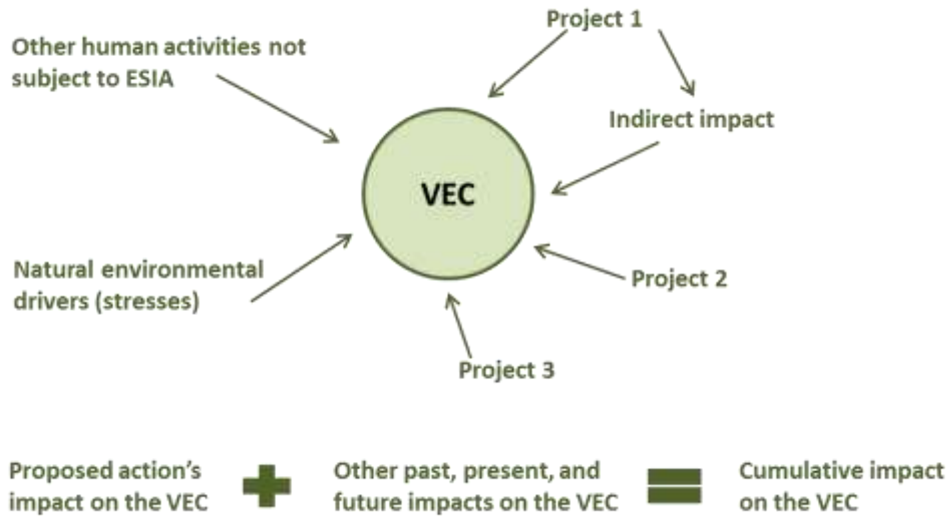

Figure 2-2: Representation of the VEC-centered approach
(Source: Adapted from IFC 2013)

2.2.2 Sources of information and limitations of the study

The study is mainly based on the analysis of secondary data and information collected through literature review and contacts with relevant stakeholders. Primary data from the complementary environmental and social baseline surveys recently conducted by Nepal Environmental & Scientific Services (NESS) have also been incorporated in the assessment. In addition, consultations were held at the district and community level with local stakeholders (Annex 2) to help define the scope of the CIA and select the key VECs.

The report also integrates outputs from the other tasks under these IESC services, especially the GIS Mapping and Spatial Analysis and the Environmental Flows Assessment tasks. The assessment of cumulative impacts is limited by the available information and reflects the existing gaps on the baseline data. The following are the main limitations of the present CIA:

- **Transmission lines** of the hydropower projects have not been included in the analysis because information on the existing and/or planned transmission infrastructure in the Trishuli watershed was not available at the time of the assessment. Since there are no major electricity consumers in the direct area of influence, potential developers of hydropower in the Trishuli basin will need to build transmission lines to evacuate power. At this stage, the final design option and EIA for the UT-1 transmission arrangement has not been finalized.
- Given the **limited information**, the assessment of impacts, which has been done based on a set of spatial indicators (Section 5), is based on pressures and risks affecting the VECs rather than on the evaluation of specific impacts (i.e. ecological processes underlying the cumulative impacts under study).

3 Trishuli Watershed General Context

3.1 Regional context

The Trishuli watershed is one of the eight sub-basins of the Gandaki River basin, which covers an area 32,000 km² in central Nepal (Figure 3-1). The Trishuli watershed occupies 13% of the total Gandaki area and it is the tributary located more to the East, within the physiographic Highland and Midland zones, characterized by average altitudes of 2000 m and high valley landscapes.

The Trishuli River originates in the Tibet Autonomous Region of the People's Republic of China, where it is known as Bhote Koshi. The catchment area of Bhote Koshi in Tibet is about 3,170 km^2 for a river length of 120 km. The approximate 106 km of Trishuli River within Nepal show a high gradient in the initial 40 km with. Rapids predominate all along the longitudinal profile but there are no impassable falls.

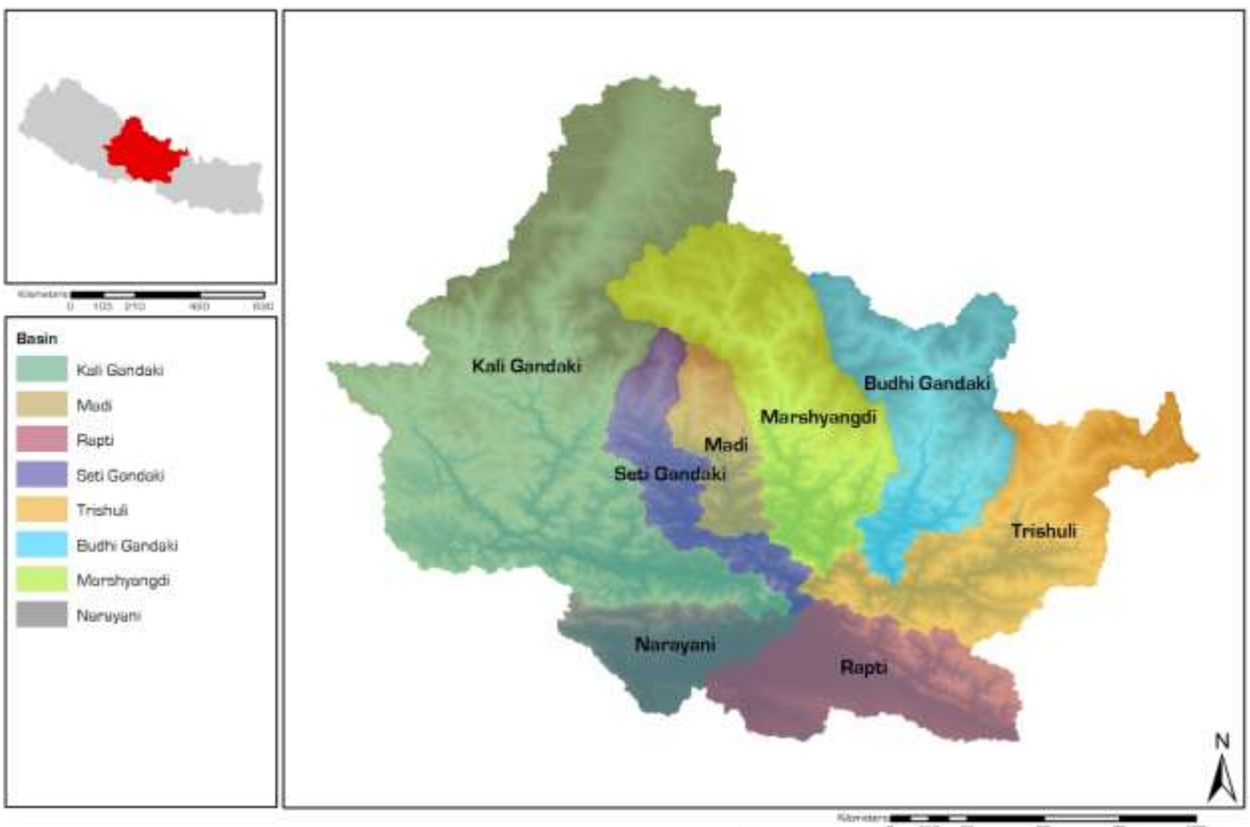

Figure 3-1: Gandaki basin and its eight constituent sub-basins

From a conservational and planning perspective, the Gandaki system constitutes what is known as the Chitwan-Annapurna Landscape (CHAL); a region that the Government of Nepal is envisioning as a north-south linkage vital to provide a safe passage of river and forest corridors for wildlife, migratory birds and aquatic animals (WWF-Nepal 2013).

3.2 Environmental conditions

As previously indicated, the Trishuli basin has already been altered by anthropogenic activities, with five hydropower projects currently in operation, and existing cumulative impacts are evident not only in terms of aquatic habitat fragmentation but also in terms of overall degradation of the catchment area (e.g., deforestation, erosion, multiple access roads, and transmission lines).

As part of the *GIS Mapping and Spatial Analysis* task (Appendix C in Supplemental ESIA, ESSA 2014) conducted for this project, we have developed a set of watershed pressure indicators (Table 3-1) for the sub-basins in the Gandaki system. These indicators characterize the level of pressure from different development factors (e.g. roads, population density, hydropower development, etc.) on each sub-basin. These indicators were ranked giving the lowest score to the sub-basins with the highest level of pressure and an overall score of cumulative pressure was estimated. The Trishuli watershed came as second, after the Madi basin, for the highest level of stress/pressure for the selected indicators. Table 3-2 and Figure 3.2 show the results of this regional assessment on watershed pressures.

Table 3-1: Pressure/risk indicators used for the regional assessment of the Gandaki sub-basins

Factor of watershed pressure/risk	Pressure/risk Indicator	Metric
Surface erosion	**Road density**: Total length of roads divided by the total watershed area.	km/km^2
	Road density in proximity of streams: Length of roads within 100 m of a stream, divided by total area of the watershed.	km/km^2
	Stream crossing density: Number of road-stream crossings in the watershed by the total area of the watershed.	$no./km^2$
	Road density on unstable slopes: Length of roads on slopes > 45% divided by the total watershed area.	km/km^2
Mass wasting	**Landslide potential**: Total surface of terrain with slopes >45% divided by the total watershed area.	km^2/km^2
Impacts from human populations	**Population density**: Population counts of VDCs with more than 100 inhabitants (based on national census) divided by the total watershed area.	$Persons/km^2$

Factor of watershed pressure/risk	Pressure/risk Indicator	Metric
Hydropower development	**High hydropower development scenario**: Percentage of hydropower concession areas (including operating, under construction and survey licenses) over the total watershed area.	%

Table 3-2: Regional assessment of watershed health within the Gandaki system

Watershed Number	Watershed Name	Roads	Road Streams	Road Slope	Road Crossing	Slide Potential	Population Density	Hydro Development	Summary	Rank
1	Budhi Gandaki	8	7	5	7	1	8	6	42	7
2	Kali Gandaki	6	6	6	6	4	6	5	39	6
3	Madi	1	1	1	1	6	3	3	16	1
4	Marshyangdi	5	5	3	5	2	7	4	31	4
5	Narayani	7	8	8	8	8	4	8	51	8
6	Rapti	4	4	7	4	7	2	7	35	5
7	Seti Gandaki	2	3	4	3	5	1	2	20	3
8	Trishuli	3	2	2	2	3	5	1	18	2

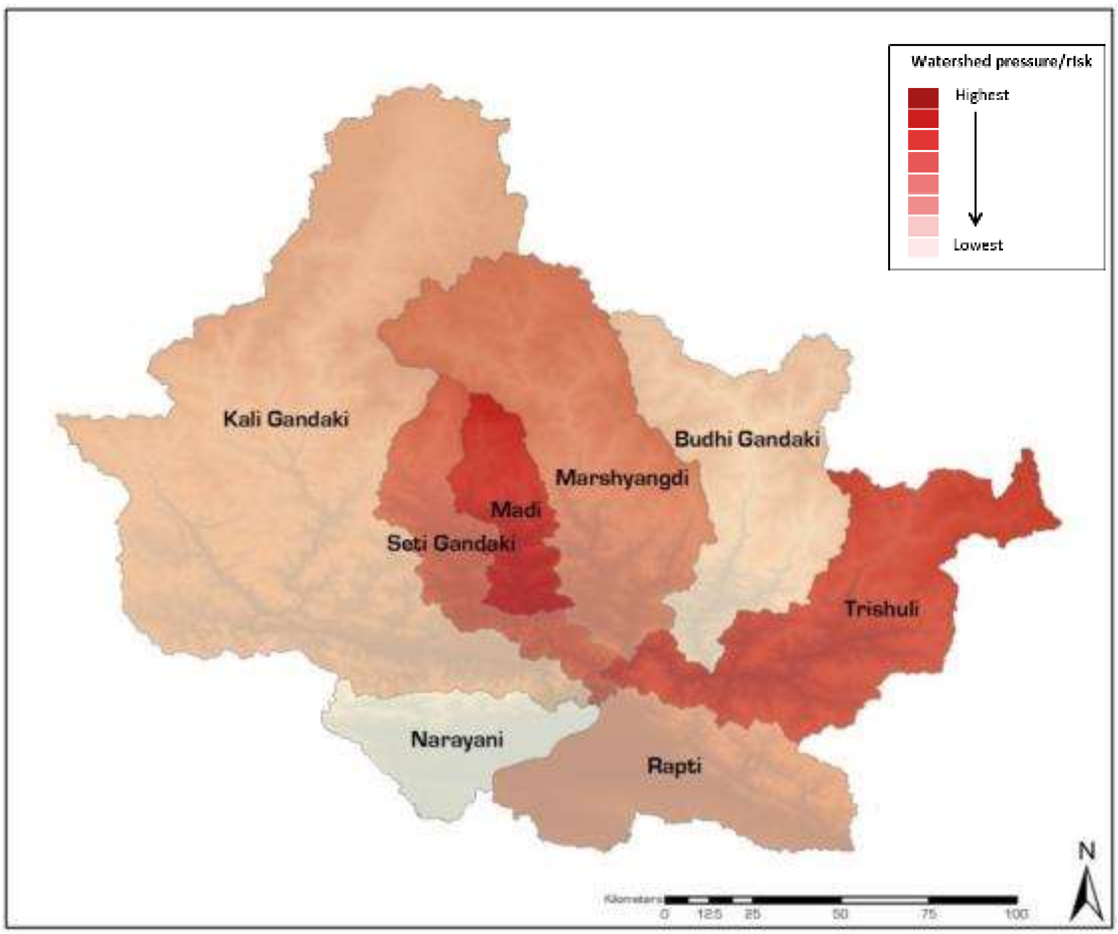

Figure 3-2: Watershed pressure across the sub-basins in the Gandaki basin

The Trishuli watershed has the highest level of hydropower development of all the sub-basins in the Gandaki system. Road density, with its associated impacts on erosion and aquatic habitats, is also a significant pressure in the Trishuli in comparison with the other sub-basins.

From a conservational perspective, and within the broader CHAL (Chitwan-Annapurna Landscape) area, the Trishuli River is considered a naturally occurring corridor that provides critical linkages north-south in the landscape. Common biodiversity conservation issues affecting the CHAL region include: deforestation, overexploitation of community forests, illegal harvest of non-timber forest products, hydropower development affecting freshwater ecosystems connectivity, poaching, and forest fires and landslides as commonly occurring natural hazards.

3.3 Socio-economic conditions

86% of the total population of Nepal lives in rural areas. Since 1981, national and rural population growth rates have been rapid, putting tremendous pressure on natural resources such as agricultural land and forests (ADB and ICIMOD, 2006).

According to the 2001 census, 66% of the active population is engaged in the primary sector, including agriculture, forestry, and fisheries (ADB and ICIMOD, 2006). In the Trishuli watershed, the main economic activities are forestry and small scale agriculture in the upper part of the watershed, and agriculture in the lower part. Figure 3-3 shows the contrast in land uses between the upper and the lower part of the watershed. The upper part is characterized by steep, difficult access and the predominance of forest cover.

Subsistence production is the typical form of agriculture in the region, with one-fourth (24%) of the surveyed rural population produced food sufficient for whole year, and one-third produced enough food only for six months (WWF-Nepal 2013). Forests in the watershed are managed either by the government or by Community Forest Users Groups (CFUG). In the Rasuwa District, there are 76 CFUG involving over 5,000 households (Jade Consult 2011).

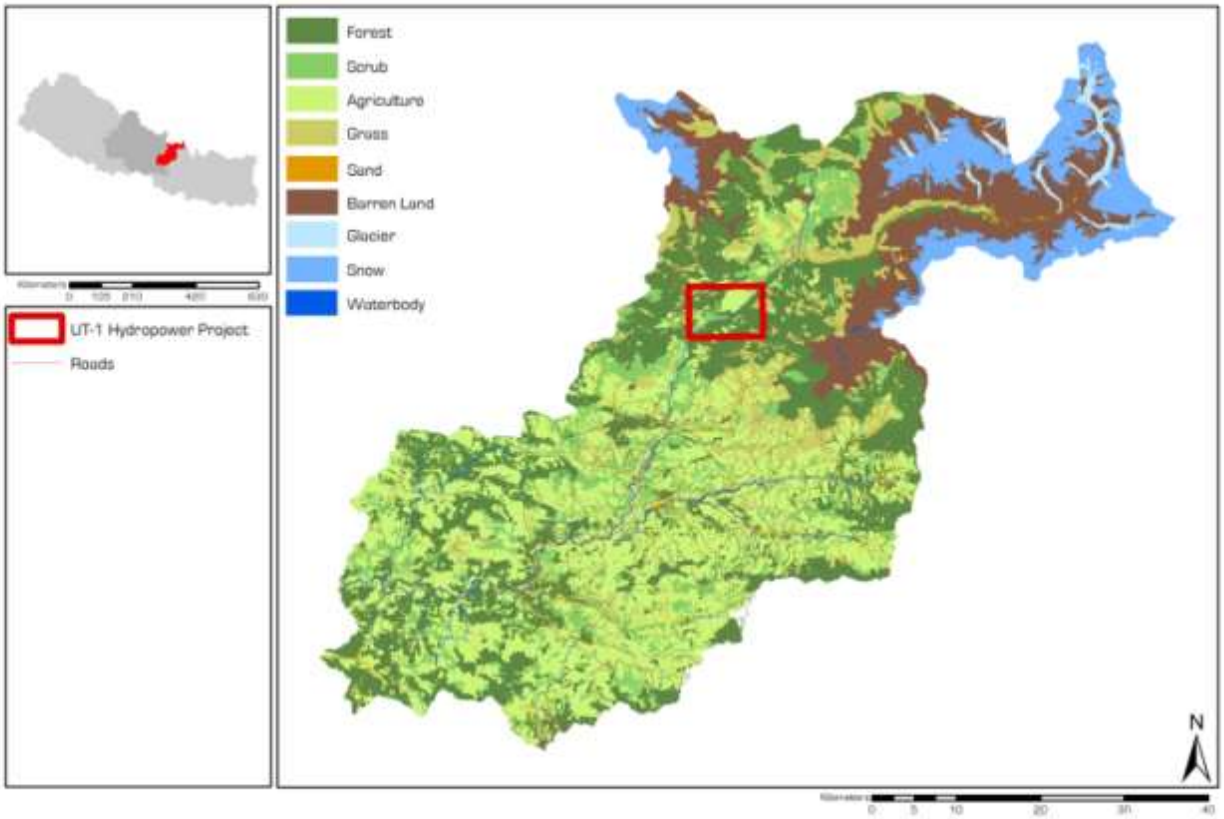

Figure 3-3: Land use (2010) in the Trishuli watershed

Local communities also depend on local resources for their energy supply, with firewood being the most common (used for 80% of the population) fuel. In general, health, water and sanitation and energy status is poor in the region, as it is in most of rural Nepal. Less than 40% of households overall have electricity. The Hill region has electricity connections in nearly 43% of households; whereas nearly 80% of Mountain households do not have electricity (ADB and ICIMOD, 2006).

The population of Nepal includes diverse ethnic groups (Janjatis) and castes, languages, religions, and cultural traditions. In the upper part of the watershed, the predominant ethnic group is Tamang, and the Rasuwa District is popularly known as “Land of Tamangs”.

Population is more concentrated in the lower part of the watershed (Figure 9), while the upper part is more sparsely populated. Out-migration rates are high in the region due to the lack of employment opportunities. Within the Project’s direct area of influence, Haku VDC has the highest number of labor migrants (Jade Consult 2011).

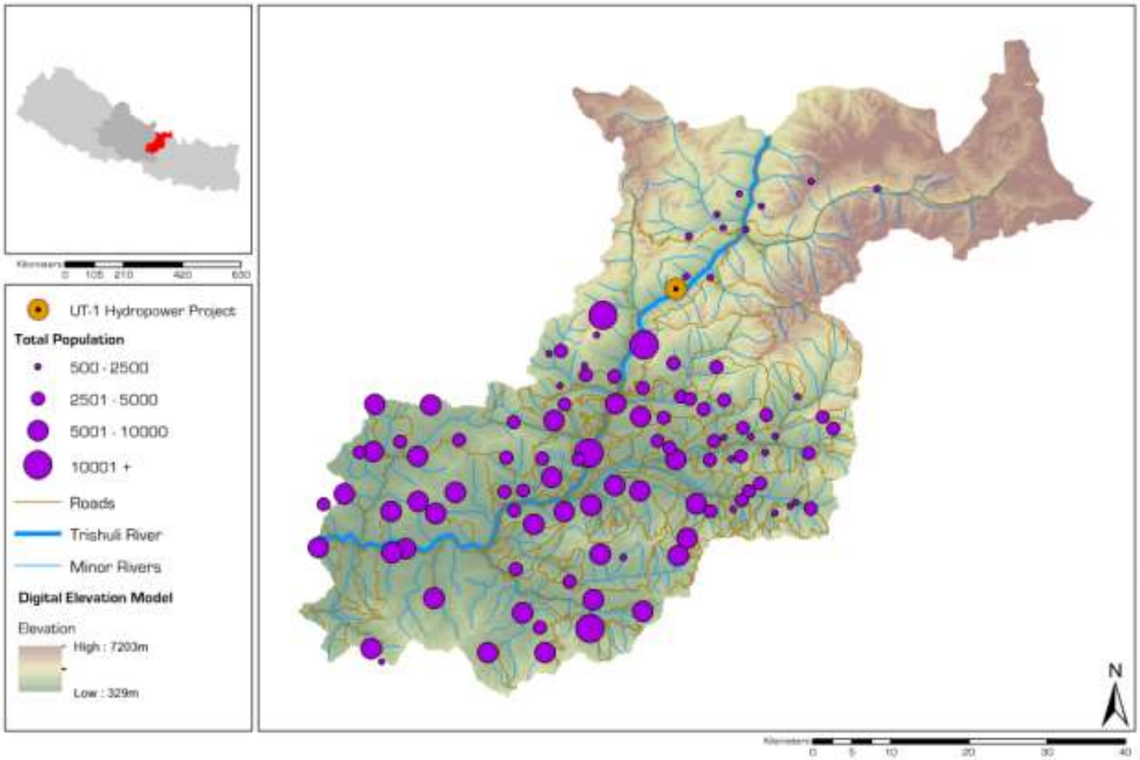

Figure 3-4: Population distribution in the Trishuli watershed

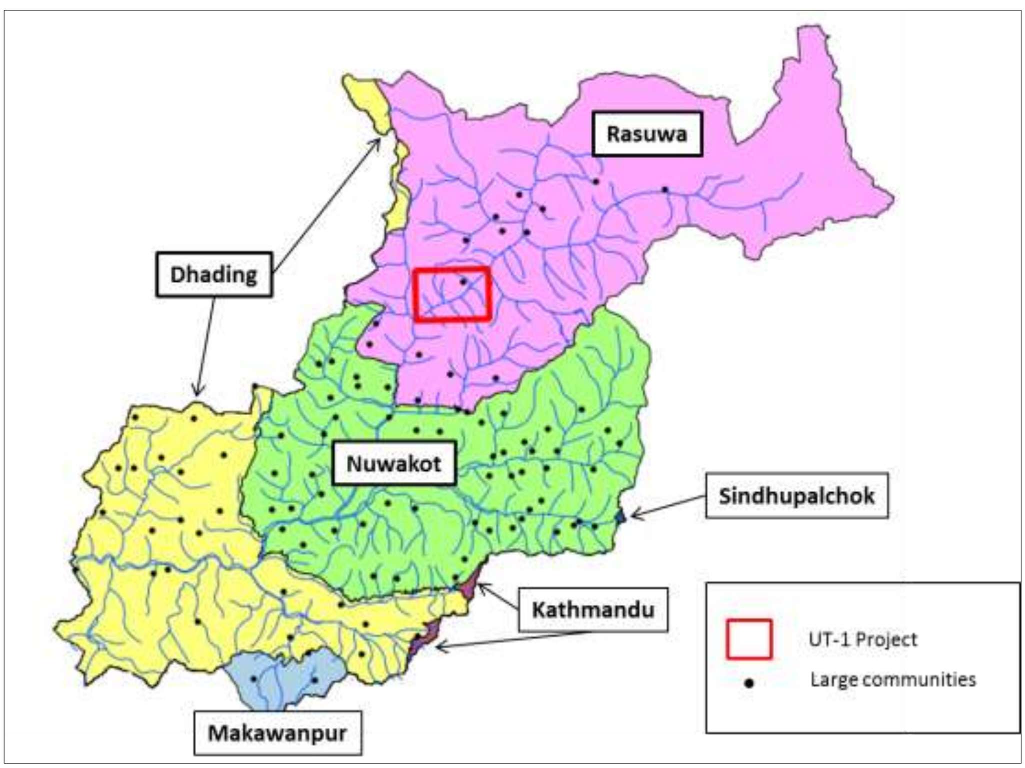

Figure 3-5: District boundaries within the Trishuli watershed

3.4 Developmental status

The main development activity that is experiencing a rapid growth in the recent years, in the Trishuli and in other watershed in Nepal, is hydropower. By January 2008 the Nepal government had issued survey licenses (for hydropower projects with capacity above 1 MW) for 4,520 MW of electricity generation throughout the country (Jade Consult 2011). As previously mentioned, and according to the scenarios considered in this assessment, future hydropower scenarios in the Trishuli basin could vary from 14 to 33 operating projects.

Currently, there are five hydropower facilities operating in the watershed. The oldest facility, Trishuli Hydropower Project with a capacity of 24 MW, is located in the middle part of the watershed, in the proximity of Betrabati, and has been operative since 1967. The most recent project, Tadi Khola, started operations in 2013. Figure 3-6 shows the operational hydropower projects and the road network in the Trishuli basin.

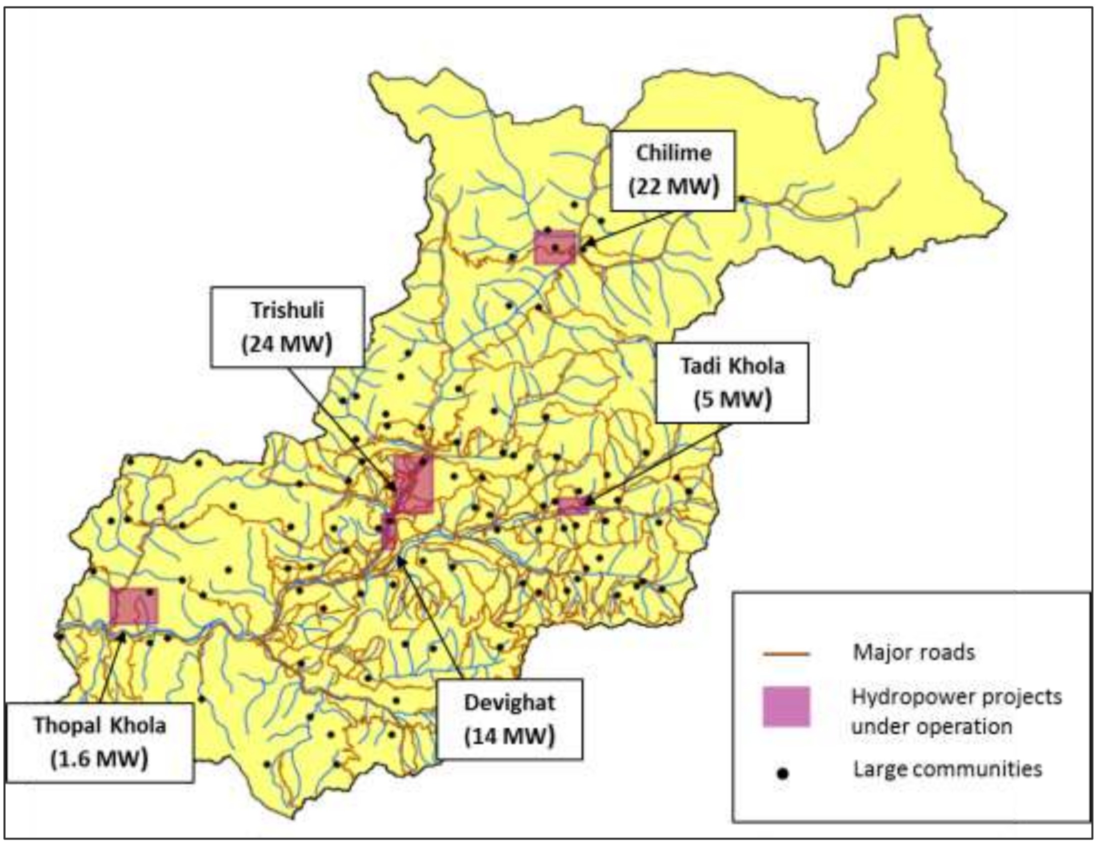

Figure 3-6: Current developmental status of the Trishuli watershed

Roads in the Trishuli are concentrated in the middle part of the watershed, where the population density is higher and the topography is more favorable. The development of hydropower projects in the upper part is driving the extension of the road network into this region. As in all Hill and Mountain districts in Nepal, construction of roads in this part of the watershed requires huge investment in both construction and maintenance. Common adverse environmental impacts associated to road expansion in mountainous areas include: landslides, slope instability, soil erosion, and roadside runoff.

A total of 111 km of roads have been developed in the district, connecting 11 VDCs out of 19 VDCs of the district. The road density is about 6.61km per 100km^2. Out of the total nearly 66 km (from the Rasuwa - Nuwakot Boarder to Rasuwagadhi) is paved, while the rest are gravel roads.

3.5 Regulation and institutional context

The Government of Nepal made environmental impact assessments (EIAs) compulsory since 1993 under the EIA National Guidelines for all hydroelectric projects above 5 MW. Sectorial policies such as the Water Resources Development Policy (2002) and the Hydropower Development Policy (2002) have also established some general guidelines in relation to environmental management. Under the Hydropower Development Policy (2002), hydropower facilities are required to release a minimum environmental flow equal to 10% of the minimum of the mean monthly flow, or a higher amount as determined in the EIA.

The primary responsibility for watershed management in Nepal lies with the Department of Soil Conservation and Watershed Management (DSCWM) within Ministry of Forest and Soil Conservation. To our knowledge, no watershed management plan has been formulated for the whole Trishuli basin, although priority micro-watersheds have been identified in the watershed and some local actions have taken place (Figure 3-7).

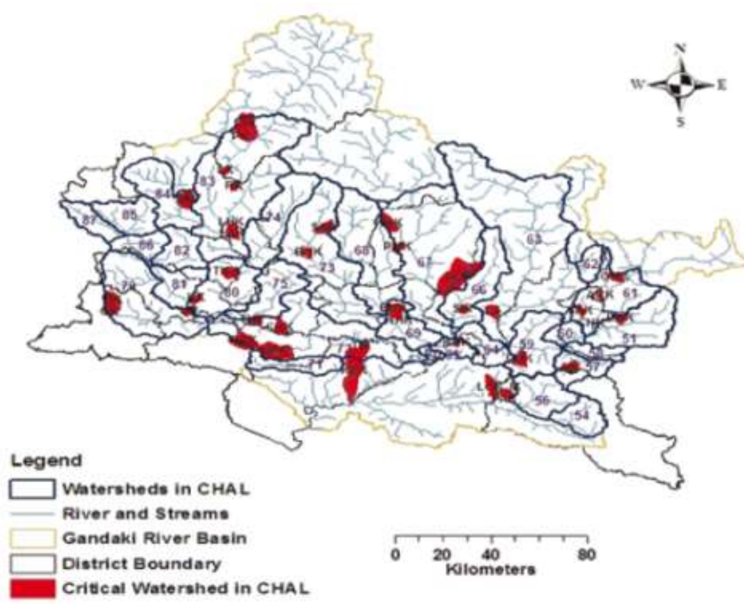

Figure 3-7: Location of critical watersheds within the Gandaki/CHAL area
(Source: WWF-Nepal 2013)

4 Scope for Cumulative Impact Assessment

4.1 Scoping Phase I: Identification of VECs and spatial and temporal boundaries

4.1.1 Valued Environmental and Social Components (VECs)

Since it is unrealistic to address every environmental or social aspect that could be potentially subjected to cumulative impacts, it is good practice to focus the assessment and management strategies over environmental and social attributes that are considered to be important in assessing risk: the *Valued Environmental and Social Components* (VECs).

These VECs, which may be physical features (e.g. habitats, wildlife populations), natural processes or ecosystem services, social conditions (e.g. health, economics) or cultural aspects (e.g. temples); tend to be at the end of ecological pathways and are therefore considered the ultimate recipient of cumulative impacts. The importance of these VECs may be determined on the basis of cultural values or scientific concern (Hegmann *et al*., 1999)

Good practice recommends that VECs should be identified by both social and ecological scoping (IFC 2013); with social scoping implying participatory, meaningful, and transparent consultation with affected communities and/or stakeholders and ecological knowledge based on expert knowledge. Taking these aspects into consideration, the identification of VECs for the current assessment was based on the following key inputs:

- **Consultations with local stakeholders and communities**: NESS conducted a series of Focus Discussion Groups (FDG) with key stakeholders, including vulnerable and river/water uses groups, in January 2014 (please see Annex 2 for more details). The main goal of these consultations was to inform stakeholders about the CIA process and facilitate their identification of key VECs.
- **Knowledge about the Project works and activities and the environment likely to be affected**, as captured in the original 2011 EIA (Jade Consult 2011) and informed by the baseline information compiled as part of the documentation for the CIA process and the complementary social and environmental baselines conducted by NESS as part of this IESC assignment.
- **VECs identified in other CIA exercises in Nepal**, particularly the Rapid Cumulative Impacts Assessment (RCIA) conducted for the Kabeli-A Hydropower Project (World Bank 2013). This RCIA assessment identified the following key VECs: surface water (quantity and quality); landslide/erosion and sedimentation; resident and migratory fish population; spiritual and religious components; and landscape.
- **Common understanding in the literature about environmental and social impacts of hydropower projects and affected VECs:** There exists in the

international literature (IEA 2000, WB 2012) a body of knowledge on the most common documented environmental and social effects of hydropower facilities, located across a range of geographic settings, and the most likely VECs by these impacts.

Based on all the above sources of information, the VECs selected for the CIA analysis were the following:

Table 4-1: List of selected VECs

VEC	Comments
Water resources • Water quantity • Water quality • Water users	• The major impacts associated with the UT-1 Project, and generally with hydropower development, will be on hydrological variables and other users of the water resource. • Local communities expressed concern over scarcity of drinking water and the potential impacts of the environmental flow regime. • Impacts in flow-reduced stretch of the river (irrigation water use, water mills) are a common concern for communities
Fish and aquatic habitats	• The main impact on biodiversity will be on aquatic habitats. • Fish and people whose livelihoods (or part of them) depend on fishing were consistently identified through consultations with local stakeholders
Erosion/landslide and sedimentation processes	• Landslides are known to be problem in the region and have been identified by locals as a major concern.
Terrestrial habitats	• The Project is located next to Langtang National Park. Forests host most of the remaining natural habitats. • Issues related to impacts on wildlife and their habitats (e.g. fragmentation) were identified during stakeholder consultations.
Natural resources use	• Locals have expressed concern over land use changes and their related impacts (reduction of agricultural land, less productivity, general non-availability of land, etc.). • Harvesting/illegal harvesting of trees, degradation of forest, loss of forest products including NTFP (non-timber forest products) are other major concerns for local communities.
Cultural and religious sites	• The access and use to these sites is extremely valuable for local communities. • Cross-cultural Sensitivities – tentions and conflicts related to culture and traditions

4.1.2 Geographical and temporal boundaries

It has been suggested by many authors that the most effective way to approach cumulative impacts affecting fish and other aquatic values is to consider them at the "watershed" level, where the fundamental connection among all components of the landscape is the network of streams and associated water bodies that define the basin (Reid *et al* 1996; Williams *et al*. 1997; NRC 1999; Sedell *et al*. 1990, Newbold 2002; Smith *et al*. 2005; as cited in Potyondy and Geier 2011). The Trishuli basin is a transboundary watershed with a significant part of its river (120 km) in Chinese territory. However, considering the potential limitations in access to information and the difficulties of working with institutional, regulatory and environmental frameworks of two different countries, we proposed to set the spatial boundaries at the Nepalese part of the watershed.

Temporal boundaries could be fixed taking into account the hydropower planning and project cycle characteristics in Nepal. Given the high volatility of current hydropower market in Nepal; a temporal limit of ten (10) years is considered adequate to frame the two hydropower development scenarios considered, and therefore the timeframe for the development of pressures. The temporal extent of the impacts is expected to be higher; from perpetuity for permanent impacts to the order of 100 – 150 years.

4.2 Scoping Phase II: Other activities and environmental and social stressors

The purpose of this step is to identify the totality of stresses that determine the condition of VECs selected for this CIA. These stressors may include past developments whose impacts persist, existing developments, predictable future developments, as well as any other relevant natural or social stressor.

4.2.1 Other activities

The impacts of agriculture, forestry, and tourism are likely to affect the VECs in the watershed. However, the main activity that needs to be considered is hydropower development, which is rapidly growing in the basin.

Agriculture is the main activity in terms of land use, followed by forestry. As part of the *GIS Mapping and Spatial Analysis* task, we have analyzed the changes in forest and agricultural land for the period 1990-2010. Forest cover has experienced a net decrease of 1.6% throughout this period. Agricultural land increased by 3.1% in the same period. These slight changes are in line with the observed land use change dynamics in the CHAL region, where forest area has remained largely the same for the period 1990-2010 and agricultural land has slightly increased. In the lower areas (Siwaliks) substantial loss of forest area has occurred to infrastructure development, resettlement, urban expansion, and agriculture expansions (WWF-Nepal 2013). Unplanned and unregulated construction of rural roads by village development committees (VDCs) and district development committees (DDCs) is a major direct cause of deforestation and forest degradation in the mid-hill districts.

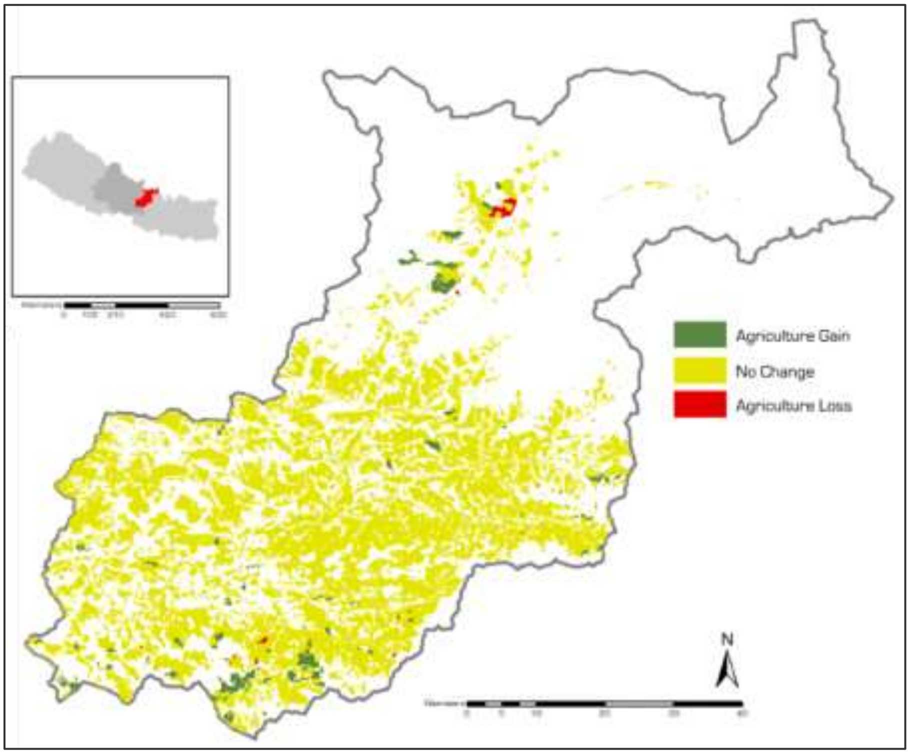

Figure 4-1: Changes in agricultural land (1990-2010) in the Trishuli watershed

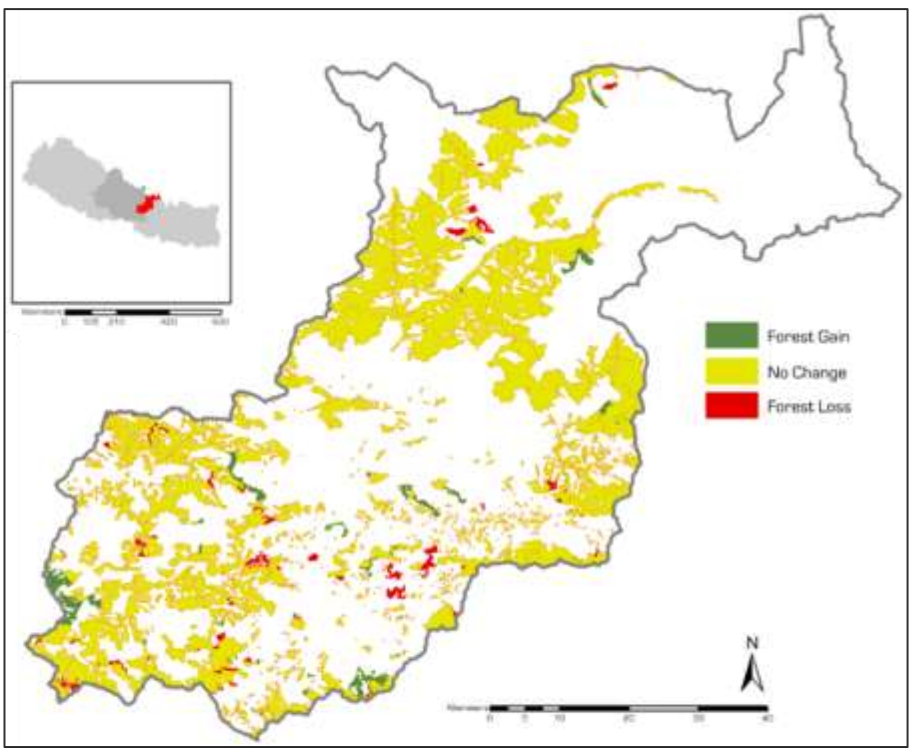

Figure 4-2: Changes in forest land (1990-2010) in the Trishuli watershed

4.2.2 Environmental stressors

Natural environmental processes have significant impacts on a variety of environmental and social components. Nepal is highly vulnerable to droughts, floods, earthquakes, landslides, forest fires, storms and hailstorms, avalanches, glacial lake outburst floods, and the effects of global warming (ADB and ICIMOD, 2006). The following sections discuss the information available on the main natural hazards that could affect the state of VECs in the Trishuli watershed.

Landslides

Landslides are the most important factor in land degradation in Nepal. Landslides occur almost every year, particularly in the sloping areas of high mountains and low hills during the monsoon season. Based on slope (> 45°) and land cover, areas with high landslide potential were spatially identified in the Trishuli watershed (see Figure 4-3). The upper part of the basin is especially affected by this problem.

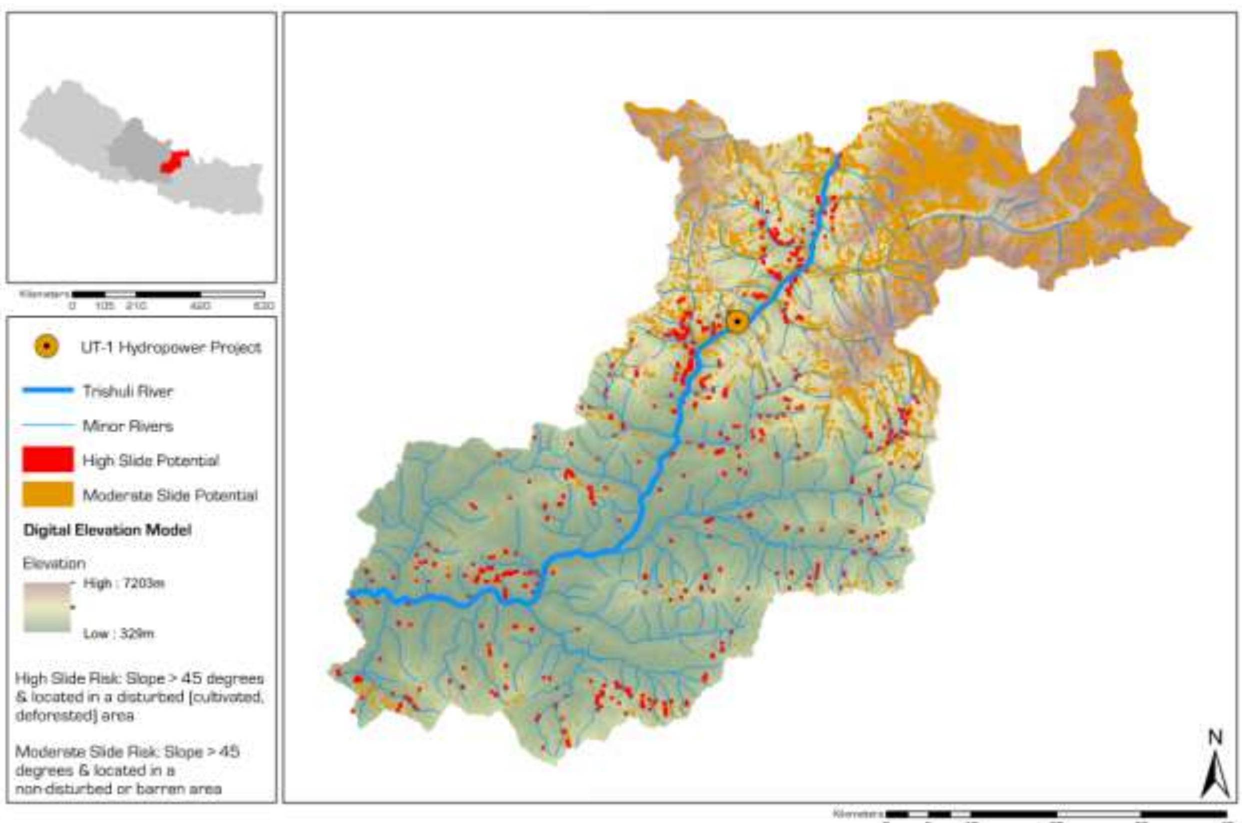

Figure 4-3: Landslide risk in the Trishuli watershed

Both natural (e.g. high relief or steep slopes, unstable geology, and concentrated rainfall) and human factors (deforestation, improper land use and construction, and agricultural activities on hill slopes) can induce landslides. The consequences of landslides include topsoil erosion; damaged and destroyed roads, trails, and bridges; loss of land, lives, and property; and siltation in low-lying areas resulting in unproductive land. About 1.8 million ha (13%) of the land in the Mountains is estimated to be severely degraded by landslides (ADB and ICIMOD, 2006).

Forest fires

Forest fires are common in Nepal during the spring season, particularly during the period from March to May, coinciding with the end of the dry period. A recent record (2003-2011) of forest fires shows a high concentration of these events in the upper part of the Trishuli watershed, in proximity to the UT-1 Project (Figure 4-4). It is suspected that most of these fire events have an anthropogenic origin, probably linked to inadequate agricultural/forestry practices, negligence, and extension of development into forest areas.

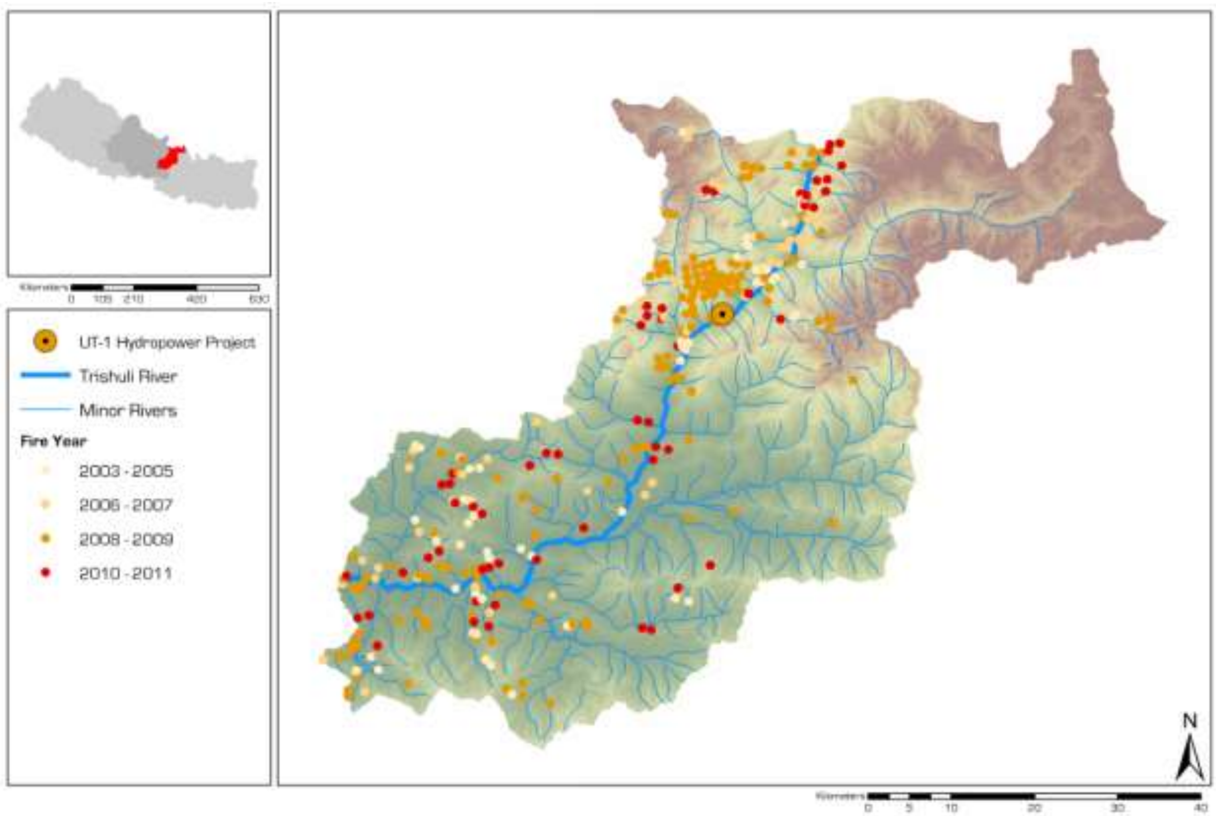

Figure 4-4: Incidence of forest fires (2003-2011) in the Trishuli watershed

Beside the loss of habitat and forest biodiversity, forest fires can also cause soil erosion and induce floods and landslides due to the destruction of the natural vegetation.

Climate change

The International Center for Integrated Mountain Development (ICIMOD 2007) has reported that warming in Nepal has increased progressively within a range of 0.2-0.6 °C per decade between 1951 and 2001, particularly during autumn and winter. These findings are in tune with local people's perceptions as recorded during the community level consultations. In terms of changes to precipitation, similar analysis of long-term data for the same period did not show a clear trend of change in average annual precipitation.

Evaluating the impacts in water resources is challenging because water availability, quality and stream flow are sensitive to both changes in temperature and precipitation. Some studies (Bajracharya *et al*. 2011) have looked at trends for flows in the Trishuli basin over the last decades. Figure 4-5 shows the annual maximum, mean and minim flow at the intake site, calculated using the 44-year daily flow series from Betrabati station and correcting for the differences in catchment area.

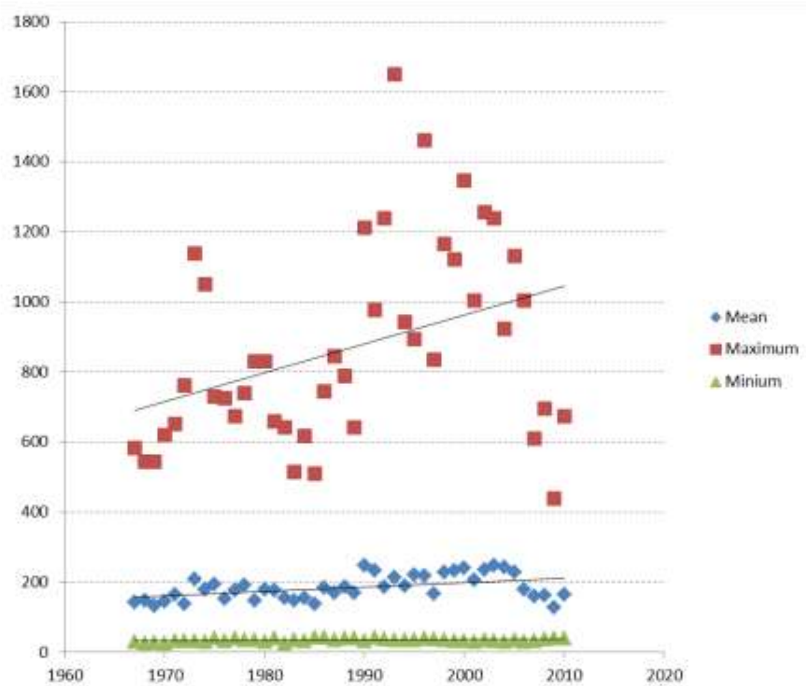

Figure 4-5: Flow trends at the intake site

Overall, it seems that mean flow during the dry season is decreasing at a very slow rate, whereas there is no clear trend for mean annual flows. An increasing trend for maximum flows, with high variability, has also been observed. This reflects that the glacier contribution at the dry season is becoming less over time while the rain contribution during the wet season is not uniform.

In particular, greater unreliability of dry season flows poses potentially serious risks to water supplies in the lean season. Hydroelectric plants are highly dependent on predictable runoff patterns. Therefore, increased climate variability, which can affect frequency and intensity of flooding and droughts, could affect Nepal severely in hydroelectric production.

In terms of changes to glacier cover, the overall glacier area of Nepal has reduced by 20% from 3.6% to 2.9% of total land of Nepal from 1970 to 2008 (Bajracharya et al., 2011). The inventory of 2010 shows that the number of glaciers in Nepal has increased by about 17% compared to 2001 inventory. This process of fragmentation was accompanied by a reduction in the total glacier area of 15 km^2 and of 4.7 km^3 in the volume of ice reserve. Particularly in the Langtang sub-basin, during the period 1977 to 2009 the glacier area has been reduced by 26% (Bajracharya *et al*. 2011).

A more recent study by ICIMOD (Bajracharya *et al*. 2014) provides a comprehensive account of the decadal change (1980, 1990, 2000, and 2010) of glaciers of Nepal based on a semi-automatic standardized analysis of satellite images. The results for the Gandaki basin confirmed this trend in the reduction of the glacier area; with the number of glaciers increasing by 12% (147) over the 30-year period, the glacier area decreasing by 22% (461 km^2) and the estimated ice reserves by 27% (51 km^3).

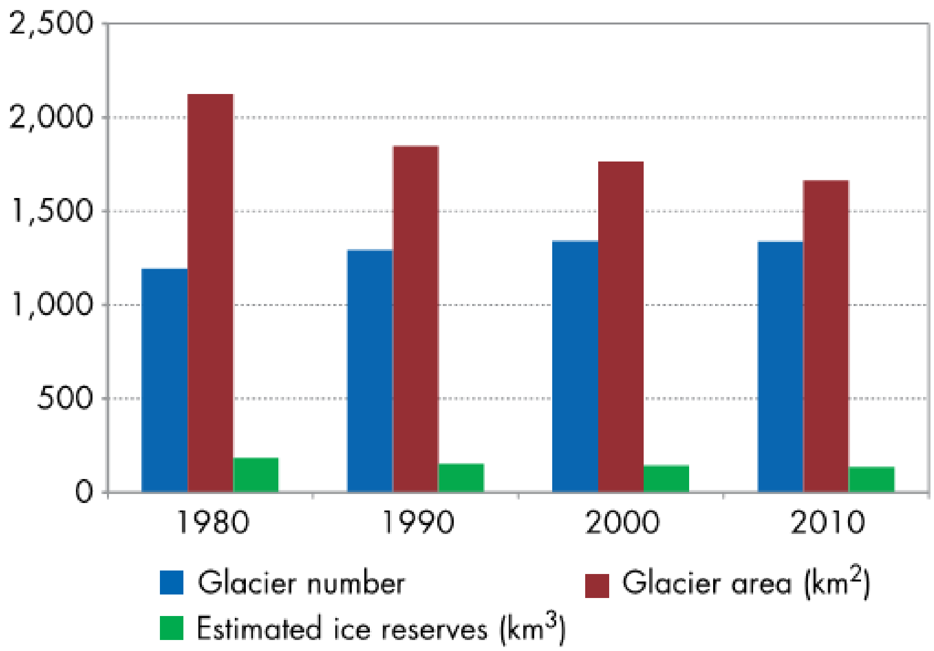

Figure 4-6; Decadal change in glacier number, area, and estimated ice reserves in the Gandaki basin
(Source: Bajracharya *et al*. 2014)

It should be noted that a slight increase in glacial extent in the Trishuli basin for the period 1990-2010 was identified as part of the GIS analysis (Appendix C of the Supplemental EIA). Differences in the source data and the imagery classification techniques can lead to errors in the estimation of the glacial surface. These results should therefore be interpreted with caution.

At a smaller scale, a detailed case study in the Langtang Valley, within the Trishuli watershed, shows clear evidence of a progressive reduction of the glacier area (Bajracharya *et al*. 2014). The total glacier area decreased from 191 to 142 km2 (26%) in Langtang valley. During this period, the average annual mean temperature increased by 0.12°C/year at the Langtang station. The temperature rise is considered to be the primary factor responsible for glacier retreat.

It is increasingly being observed that biological systems are being disrupted, migrations are starting earlier and species' geographic ranges are shifting towards the higher altitudes. However, in general, there is a need for a comprehensive study to fully assess the impacts and severity of climate change impacts on different ecosystems, key species, hydrological systems and people in different physiographic zones of Nepal (Sharma 2013).

Glacial lake outburst floods (GLOFs)

As a consequence of climate change, glacier thinning and retreat in the Himalayas has resulted in the formation of new glacial lakes and the enlargement of existing ones due to the accumulation of meltwater behind loosely consolidated end moraine deposits (ICIMOD 2011). These lakes are inherently unstable and can lead to sudden discharges known as a glacial lake outburst flood (GLOF).

Glacial recession can be associated with the formation and expansion of glacial lakes below the retreating terminus, with the associated risk of a glacial lake outburst flood (GLOF); continued recession may lead to an increase in the number of glacial lakes and in the frequency of GLOF events (Bajracharya *et al*. 2014).

A GLOF risk assessment recently conducted by ICIMOD (2011) reported two historic GLOF events (August 1964 and June 1995) for the Trishuli watershed that originated in the Tibet Autonomous Region of China. Large debris flows were experienced in Nepal as a consequence of these events. On average, one GLOF event is recorded every three to ten years in the Himalayan region. The study identified that the six glacial lakes in the watershed (Nepali part of the basin) and none of them was classified under GLOF risk.

However, because of the proximity of these glacial lakes to the Project (e.g. the Langtang glacier is located 37 km from the head works), and the processes of glacier retreat discussed in the previous section that could lead to an increase in GLOF risk, this is an important natural risk in the region that should be monitored, along with other occurring natural risks and hazards (e.g. landslides).

5 Assessment on Cumulative Impacts on Selected VECs

5.1 Development Scenarios

Hydropower development depends on a number of factors, including the local and regional socio-economic conditions. Although clearly a fast-growing sector in the Trishuli basin, there is a certain degree of uncertainty as to the number of projects that will be finally implemented in the watershed. Considering this uncertain context, we opted for analyzing the potential cumulative impacts in the Trishuli watershed under two potential hydropower development scenarios:

5.1.1 Scenario 1: Moderate hydropower development

This scenario (Figure 5-1) assumes that all the projects with a construction license will materialize and become operative. Under this scenario, a total of 14 projects would be operating in the watershed. The total area under the concession areas of these projects would be 226 km^2.

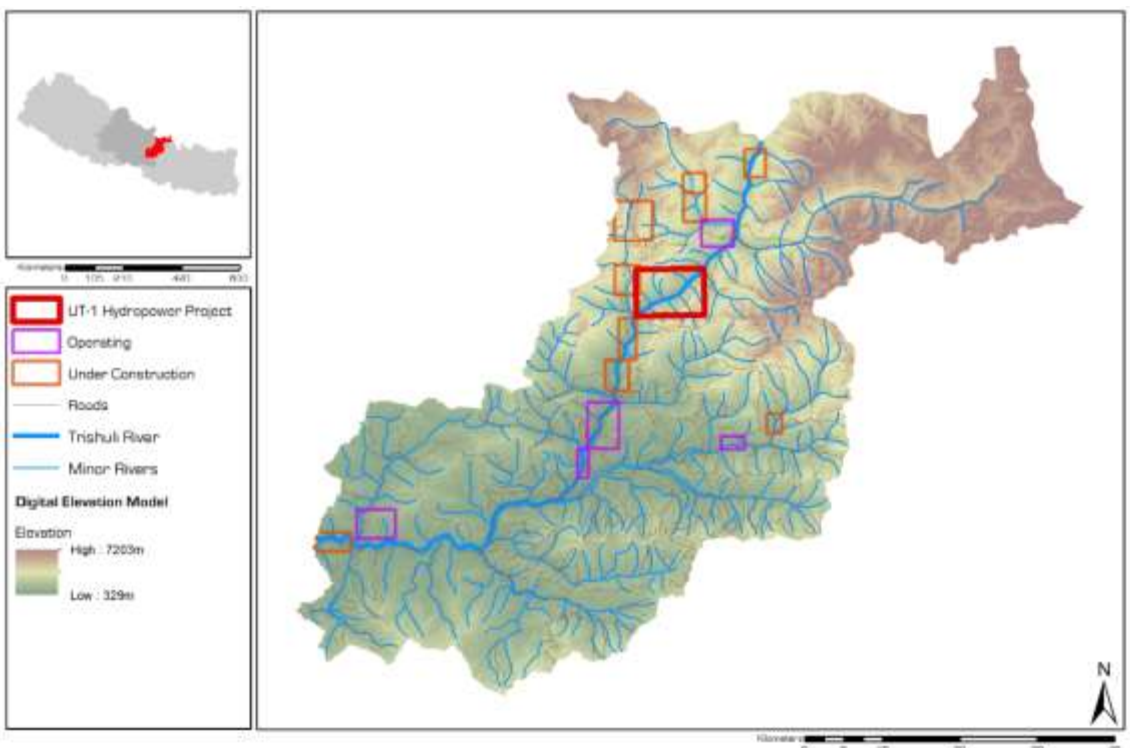

Figure 5-1: Scenario 1 (moderate hydropower development)

5.1.2 Scenario 2: High hydropower development

This scenario (Figure 5-2) assumes that all the projects with a construction license, plus all the projects currently under planning, will materialize and become operative. Under this scenario, a total of 33 projects would be operating in the watershed. The total area under the concession areas of these projects would be 506 km2. In terms of likelihood, this scenario is considered less likely.

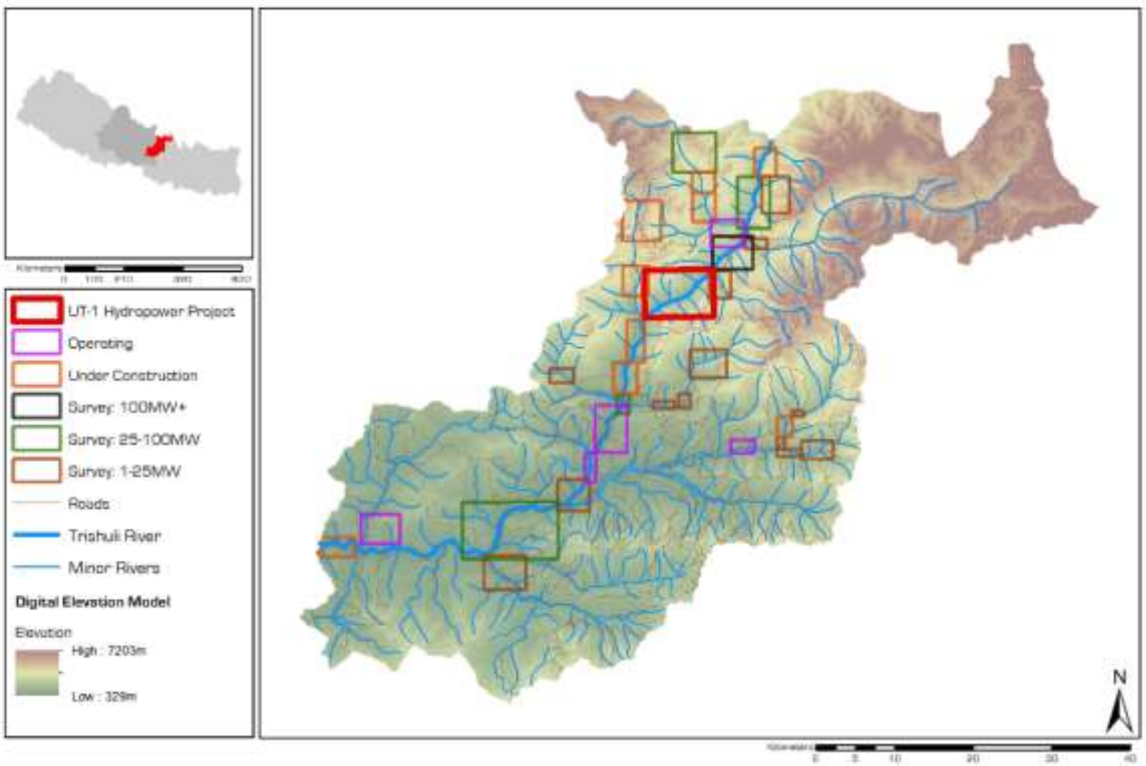

Figure 5-2: Scenario 2 (high hydropower development)

Considering that all hydropower projects in the Trishuli basin will follow a similar scheme than the UT-1 Project (run-of-river type of generation with a flow-reduced river section between the intake and the powerhouse site), we have adopted the hydropower concession area (Figure 5-3) as a proxy for the area of influence for each project.

Although the particular footprint of the different facilities and activities associated to each project (i.e. reservoirs, water channels or tunnels, weirs, access roads, etc.) is unknown, it can be assumed that most of the activities will take place within the borders of the concession area and it is within this rectangle (Figure 5-3) that most of the impacts will concentrate.

Figure 5-3: Concession area for the UT-1 Project
(Source: Daelim Kyerong 2013)

5.2 Structure of the Assessment

For each selected VEC, we have first identified the main potential impacts through the use of **impact hypothesis approach**; a simple diagrammatic representation of a cause-effect relationship between two related states or actions that illustrates an impact model. ESSA has been successfully applying the impact hypothesis approach for the analysis of fisheries and water resources issues for more than 30 years of (Connors *et al*. 2014, Greig *et al.* 1992)

The impact pathways included in these models are based on our understanding of the usual impacts of hydropower projects, the baseline information on the selected VECs, and the feedback provided by consultations with the local stakeholders (Annex B).

Based on the anticipated impacts according to these impacts models we have identified a number of ***pressure or risk indicators*** (Table 2) to assess the future VEC condition under each scenario. The selected indicators can be defined as relatively simple quantifiable or qualitative measures of the condition or dynamics of broader, more complex (and generally difficult to assess) attributes of the ecosystem or watershed state. Indicators act as surrogates for the underlying ecological processes that maintain watershed functionality and condition (Potyondy and Geier 2011). As simple surrogates for complex ecological processes watershed habitat indicators are unlikely to accurately represent direct cause-and-effect relationships but act as estimates for the pressures or risks acting on the VECs.

Table 5-1: Proposed indicators for the assessment of cumulative impacts on selected VECs

VECs		Pressure/risk indicator (metric)
Environmental	**Water quantity and quality**	**River under reduced flow** (percentage of river length within concession areas)
		Competition with other users (number and percentage of settlements within concession areas)
	Fish and aquatic habitats	**River under reduced flow** (percentage of river length within concession areas)
		Barriers for fish movement (number of weirs/barriers along the river network)
		Stream cross density (number of stream crossings per km^2 of concession area)
	Erosion and sedimentation processes	**Risk of landslide** (percentage and area of high slide potential sites within concession areas)
		Road density (km of road per km^2 of concession areas)
		Road density in proximity of streams (km of road within 100 m of stream per km^2 of concession areas)
		Road density on unstable slopes (km of road on slope >45° per km^2 of concession areas)
	Terrestrial habitats	**Proximity to protected areas** (percentage of protected areas within concession areas)
		Pressure on forest land (percentage of forest land within the concession areas)
Socio-economic	**Use of natural resources**	**Pressure on forest use** (percentage of forest land within the concession areas)
		Pressure on agricultural land (percentage of agricultural land within the concession areas)
	Cultural and religious sites	**Pressure on water-consumptive cultural uses** (number of cremation sites within the concession areas)
		Interference with access and use of cultural sites (number of cultural sites per km^2 of concession area)

Within a **pressure-state response (PSR) framework** (Bertram and Stadler-Salt 2000, Ironside 2003, Newton 2007), two types of habitat indicators ("pressure" and "state") are typically developed to inform two scales of decision making and management action: regional and local scales. Pressure (aka stressor) indicators (e.g. road density, land cover alteration, etc.) in this case are intended to provide information on the relative degree of potential stress on VECs and act as a proxy for cumulative impacts.

State indicators (generally more difficult and more expensive to obtain) describe habitat condition at a much more localized scale and are intended for more focused monitoring in areas where initial broad assessment of pressure indicators has identified a higher risk of potential problems.

Based on the GIS information at the watershed level that was generated as part of the *GIS Mapping and Spatial Analysis* task under Phase II, and the level of effort, we have selected a set of spatial indicators of pressure or risk to evaluate the potential future condition of the selected VECs under the two hydropower development scenarios. Appendix C includes the maps of the spatial indicators used in this assessment.

Finally, for the evaluation of the significance of the cumulative impacts, we have taken into consideration the magnitude at the watershed scale of the particular impact, the contribution of UT-1 Project, and the foreseen mitigation measures that would act on the affected VEC and counteract the effects of the cumulative impacts.

5.3 Water resources (quantity, quality and water users)

5.3.1 Baseline status

Water quantity

The Trishuli is a glacier-rainfall fed river typical of the mountainous region of Nepal. The basin receives 80% of the annual rainfall (2000-2500 mm) during the monsoon period, from June to September. During this time, erosion and sediment transport rates are at their highest (Jade Consult 2011). Flow is derived from a mixture of seasonal monsoon precipitation and melted water from the glaciers at higher elevations. Figure 5-4 shows the characteristic mean year hydrograph at the Betrabati station (44-year series), located 20 km downstream from the Project.

Besides Betrabati, there are other hydrological stations in some of the Trishuli tributaries: Tadi Khola, Budhi Gandaki. All these stations are managed by the Department Of Hydrology and Meteorology of the Ministry of Science, Technology & Environment[2].

[2] http://www.dhm.gov.np/hydrological-station

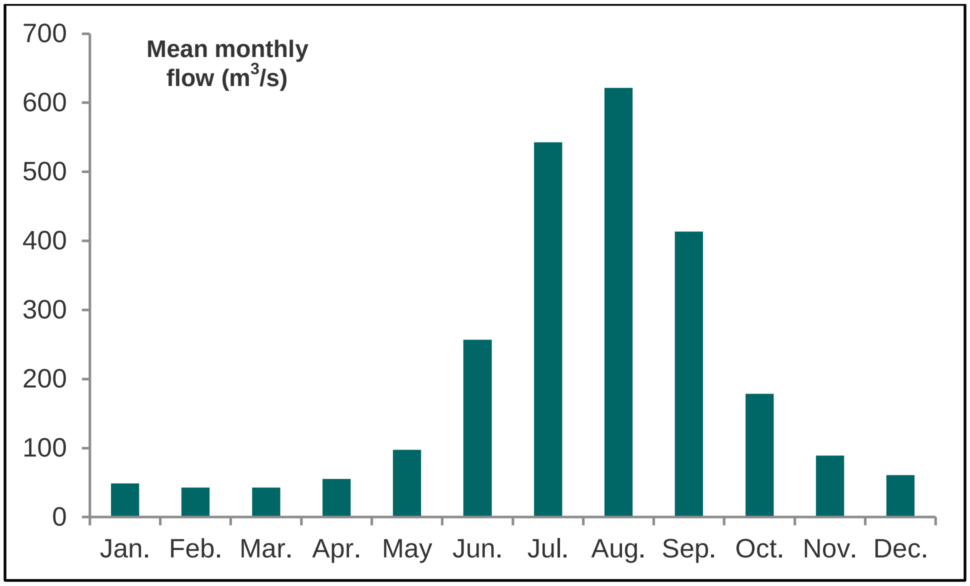

Figure 5-4: Characteristic hydrograph at the Betrabati hydrological station (period 1967-2010)

Water quality

In terms of water quality, the watersheds of the hills and mountain regions, under pre-impoundment conditions, are in general well-oxygenated, unpolluted, and suitable for cold fish (Gubhaju 2002), due to the sparse population and the lack of industries in the region.

There are no permanent water quality stations in the Trishuli watershed although occasional sampling has occurred for the EIA studies of the hydropower projects. In general, the observed parameters are within WHO guidelines. Turbidity and sediment concentration do experience seasonal variation and increase significantly during the monsoon period.

A recent one-year aquatic survey conducted for this Supplemental ESIA (see Appendix B) suggests that the water quality in the project area is overall good and anthropogenic impacts have been limited so far. Events of reduced quality for physical (e.g. suspended solids) and chemical/microbiological parameters (e.g. organic contamination) happen yearly during the monsoon season due to the increased run-off.

Water uses

At the national level, it is estimated (WECS 2011) that Nepal has 225 billion m^3 per annum of surface water available and only about 7% of this water is in use. An increase in total annual withdrawal was detected for the period 1995-2001 (ADB and ICIMOD, 2006). Agriculture used about 96% of the total withdrawal in 2001, mostly for irrigation. Over the last few decades, the population has grown at a rate of over 2% per annum. The area of agricultural land has also increased (ADB and ICIMOD, 2006), demanding additional irrigation water. Natural factors such as landslides and floods have also put pressure on water resources by damaging reservoirs and irrigation canals. The pressure on water resources is more intense on large towns and cities due to rapid urbanization.

The total cultivated area is 20% of the area of the country as a whole; the Terai has the largest proportion of cultivated area with 40% and Mountains the least with 5%. The Terai also has the highest proportion of irrigated area (50%) relative to its cultivated area and Mountains the lowest with 8%. More than 50% of the irrigated area is by seasonal canal. The total cultivated area is 20% of the area of the country as a whole; the Terai has the largest proportion of cultivated area with 40% and Mountains the least with 5%. The Terai also has the highest proportion of irrigated area (50%) relative to its cultivated area and Mountains the lowest with 8%. More than 50% of the irrigated area is by seasonal canal.

At the district (Rasuwa) level, the surveys for the complementary social baseline (Appendix A) found that nearly 88% of the households are supplied with tap/piped water at the community level, while the rest of the households depend on springs and rivers nearby the settlement. Even the water supplied with pipe at community level is not treated and had a risk of water pollution in the dry as well as in the wet monsoon season.

As for the water and river use in the watershed, although we do not have figures of water demand at this stage, it is expected that the main consumptive uses in the basin will be for agriculture and domestic uses. Cultural and spiritual uses (e.g. cremation) have been reported for the upper part of the watershed, as well as other small-scale industrial uses for local mills (ghatta). Fishing is also practiced by communities in the upper part to complement the diet. The extent of these fishing practices and the existence of commercial (aquaculture) at the watershed scale are to be determined.

As part of the complementary environmental survey, NESS identified a number of river users along the diversion reach of the Upper Trishuli-1, which has a total length of 11 km. Although there are no engineered water supply intakes, local communities do use water from the Trishuli river, especially during the dry season. There are two water mills (*ghatta*) within the diversion reach and an area of irrigated agriculture.

In terms of river/water users in the Project area, NESS has recently (August 2013) conducted a river users inventory as part of the complementary environmental and social baseline, and identified a number of river and water uses along the 11 km diversion reach of the Upper Trishuli-1. These uses are concentrated on the lower part of the diversion reach (see Figure 5.5 for approximate locations) and include: (i) two traditional watermills (ghatta) which are used throughout the year for grain grinding and are supplied with water from the Trishuli by earthen canals; (ii) an area of irrigated agricultural land of approximately 0.2 hectares where rice is grown during the monsoon season; (iii) a stretch of the river used by inhabitants of Gunchet settlement for domestic purposes (drinking, bathing, etc.) during the dry season; and (iv) non-commercial fishing is practiced, particularly during the fish migration periods of the monsoon season, by local fishermen in the lower part of the diversion reach and around the powerhouse area.

Figure 5-5: River uses in the diversion reach of the Project

As for other river uses in the diversion reach, it should be noted that rafting is not practiced in the area, due to the difficult access and rugged topography, and no cremation or other ritual sites were identified during the survey for water users. Local communities in the Project area are predominantly non-Hindu and the only known ritual use of the Trishuli takes place in Betrawati, about 14 km downstream of the powerhouse.

Baseline surveys (NESS 2013) have also found that fishing is practiced for non-commercial, livelihood-complementary purposes in a stretch of the river upstream of the tailrace. The usual method for fishing is setting traps during the monsoon period when fish migration takes place.

5.3.2 Cumulative Impact Assessment

The construction and operation of the hydropower projects foreseen for Scenarios 1 (moderate development) and 2 (high development) would create a highly regulated system of cascading projects in the Trishuli River that will alter the natural flow regime, the sediment dynamics, and, likely, water quality parameters. The different run-of-river projects under the two scenarios will create several stretches of the river with reduced flow (the minimum environmental flow required by Nepali regulations is 10% of mean minimum monthly flow). The timing as well as the allocation of water flow will be modified.

The creation of flow-reduced sections between the intake site and the powerhouse will result in the local reduction of water availability, especially during the dry period. Figure 22 shows the mean hydrograph at the intake site for pre-operational and operational scenarios. Under operations, a minimum flow of 10% of the mean monthly flow will release in the diversion reach. The maximum diversion capacity of the facility is 76 m^3/s; a value that is highly exceeded during the monsoon flows.

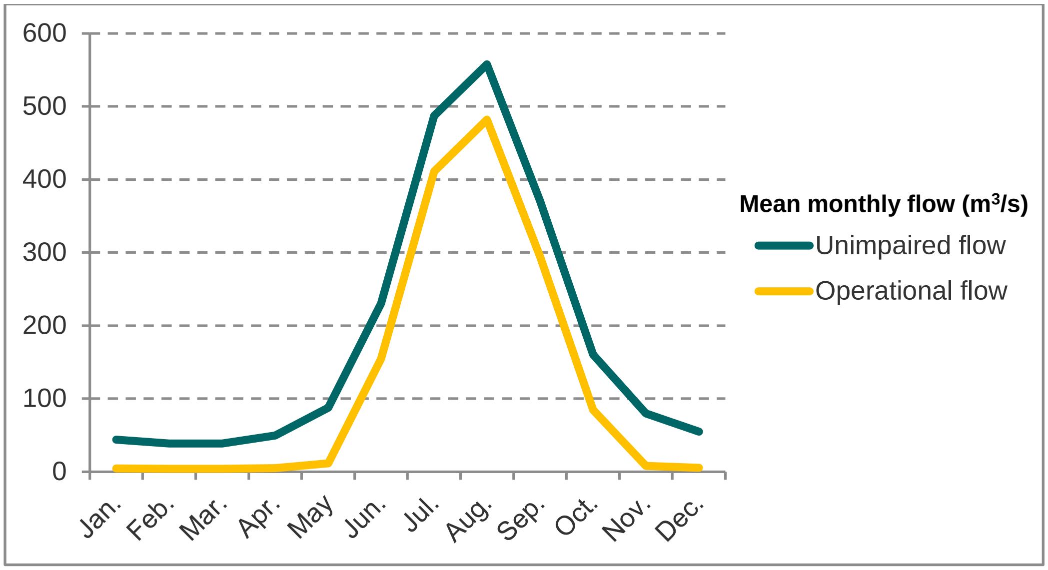

Figure 5-6: Hydrographs at the UT-1 Project intake site for pre-operational and operational conditions

Upper reaches of the reservoir may not be affected very much as the original riverine conditions are still retained in most Nepali reservoirs, because of their general reduced size, as run-of-river type, compared to storage reservoirs. Downstream of the dam the flow rate in the river will depend on the amount of the compensation flow. Water volume is considerably reduced during the dry season. As a result the downstream may change to pools alternating with dry stretches for about nine months from November to June.

Reduced flows in the dewatered sections will have impacts on water quality. The diversion reach likely be warmer, dissolved oxygen reduced, and any pollutants, microbiological contamination, as well as suspended solids may be present at higher concentrations. This will be aggravated if water is extracted for human consumptive uses from any of the dewatered segments, or if they are subjected to domestic wastewater discharges.

Changes in quantity and timing of flows could affect other water users, especially those located along the diversion reach. It should also be noted, that changes in flow are also subject to the effects of climate change. Figure 5-7 shows the proposed impact model representing these effects.

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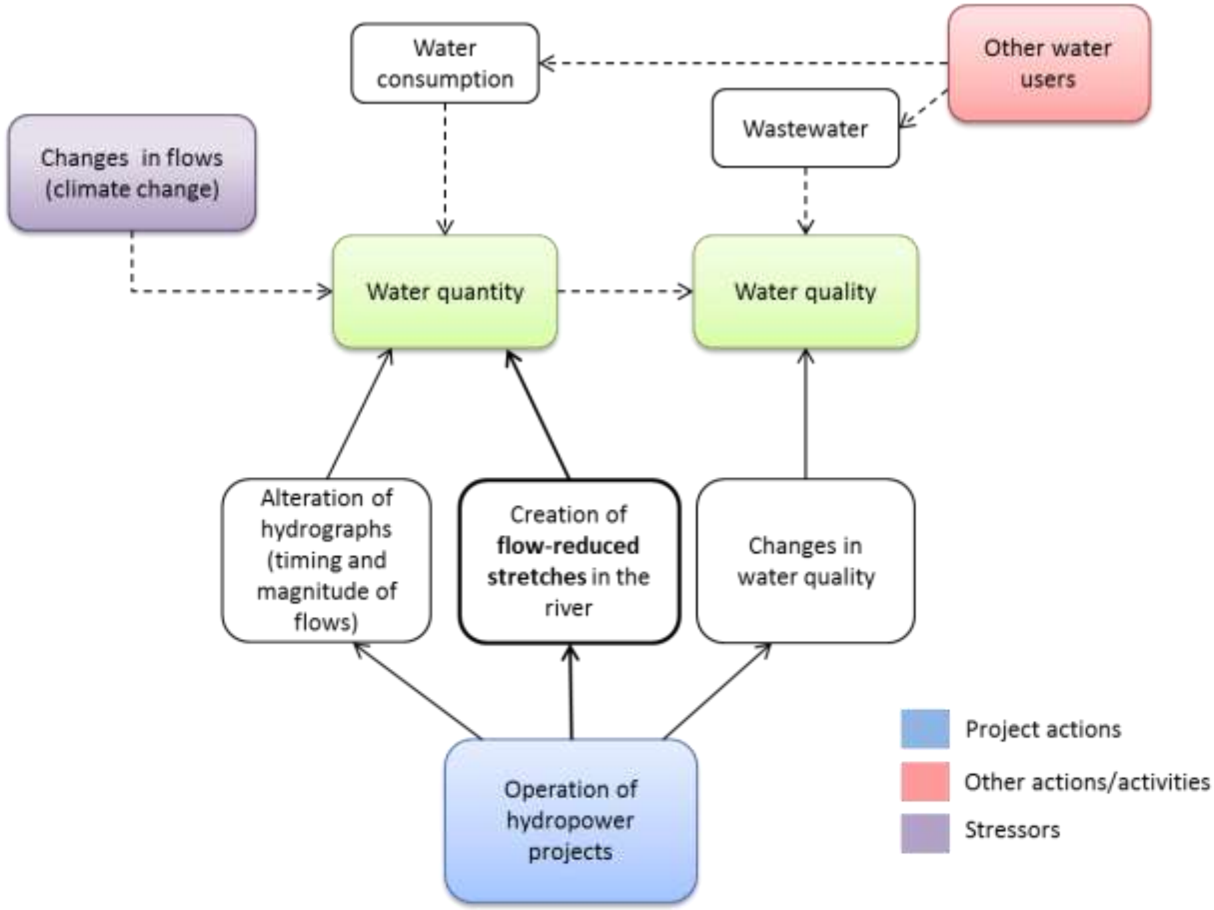


Figure 5-7: Impacts model diagram for VEC 'Water resources'

Based on the expected impacts and the available information for these VECs, we have selected two indicators that can inform on the future pressure on water resources in the Trishuli watershed under the two hydropower development scenarios (the results of these indicators for both scenarios are shown in Table 6):

- **River under reduced-flow**: This indicator estimates the length of channel to which flows are reduced as the distance between locations of water withdrawal (from the reservoir) and return to the natural river system (at the tailrace leaving the penstock).
- **Presence of settlements within concession areas**: This indicator is a proxy for the presence of other users within the concession areas. It does not measure actual water consumption/withdrawal from the Trishuli River, but high settlement densities (more population) would indicate higher level of pressure on water resources, both from consumption or interference with non-consumptive uses (e.g. recreational, cultural, etc.) and from potential impacts on water quality (i.e. more densely populated areas will generate higher volumes of wastewater).

Table 5-2: Indicators for cumulative impacts on the VEC 'Water Resources'

VEC	Cumulative impact	Pressure indicator (metric)	Scenario 1	Scenario 2
Water resources (quantity, quality and water uses)	**Reduction in water availability**	**River under reduced flow** (percentage of the total length of the river under reduced flow)	43%/5%/0.6%[1]	80%/12%/1.1%
	Increased competition with other uses	**Presence of settlements within concession areas** (density-no./km^2; and percentage relative to total settlements in the Trishuli)	0.73 no./km^2 (6.7%)[2]	0.73 no./km^2 (16.5%)

(1) Percentages relative to: total length of the Trishuli River main stem (98 km) within Nepal; the main stem and the primary and secondary tributaries (1496 km); and total length of the river network (12,008 km).

(2) Percentage of settlements within the concession areas (164 for Scenario 1 and 402 for Scenario 2) relative to the total number of settlements within the Trishuli basin (2430).

5.3.3 Significance of Identified Impacts

If unmitigated, potential cumulative impacts on water quality and availability at the Trishuli watershed could be significant. Given the limited data available, the exact magnitude and significance of the potential degradation of water quality and the reduced quantity cannot be presently assessed with a reasonable degree of certainty. This assessment would further baseline data collection, simulation models, integral flow measurements, and quality monitoring across the whole watershed.

The river length within the diversion reach for the UT-1 Project is 10.7 km. The contribution of this flow-reduced section to the total flow-reduced length under both scenarios is considered significant, as indicated in Table 5.3. The impacts on other water users, although potentially locally important in the lower part of the watershed where agricultural land and population density is higher, are considered less significant. It should be noted that impacts on water resources will be more important during the dry season (November-April) and any mitigation and monitoring measure should predominantly address this critical period.

Table 5-3: Significance of impacts on VEC 'Water Resources'

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Water quantity and quality	Reduction in water availability	25.3%/14.8%	13.6%/6.9%	High
	Increased competition with other water uses	6.1%	2.5%	Low

5.4 Fish and aquatic habitats

5.4.1 Baseline status

Among the five larger basins of the Gandaki River, the Trishuli River basin has the highest species diversity with historical surveys recording 47 species. At higher elevations a subset of 19 species has been recorded within the Upper Trishuli basin (DOFD 2008), with species presence declining with increasing elevation and at smaller sampling locations. For example, only two species have been recorded as part of the UT-1 project (Jade Consult 2011, NESS 2013); of which one species (*Schizothorax richardsonii*) is listed by the IUCN as Vulnerable.

It is believed that fish assemblages in the tributaries of the Gandaki would follow an altitudinal distribution of fish assemblages along the river profile based on their ecological preferences, as observed in the Bagmati River (Shresta 2002): Snow trout zone (1875 m - 3125 m), dominated by *Schizothorax plagiostomus* and S.spp; Stone carp zone (1250 m - 1875 m) dominated by Stone carp (*Psilorhynchus pseudecheneis*), stone roller (*Garra gotyla*), loach (*Noemacheilus spp*) and sucker catfish (*Glyptothorax spp*); and Hill barbel zone (625 m - 1250 m) dominated by mahseer (*Tor tor*, T. putitora) and *kabre* (*Neolissocheilus hexagonolepis*).

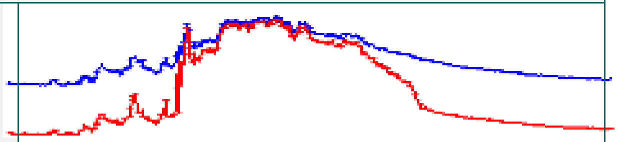
Figure 5-8: S. richardsonii specimen carrying eggs
(Source: NESS, September 2013)

The limnological and biological study conducted by Directorate of Fisheries Development (DOFD 2008) in 2006-2007 found that S. richardsonii is the dominant fish species in the upper part of the Trishuli watershed, in the Rasuwa and Nuwakot districts. It contributed to 75% of the total catch at the five sampling locations that were surveyed for this study.

This study also found that S. richardsonii breeds twice per year: in autumn (September/October) and spring (March/April), with the fall spawning suspected to be the most important. This species prefers rapids, pools and riffle types of habitat. These findings are in line the results of the monthly fish surveys that NESS is conducting as part of the complementary environmental baseline.

Higher concern is often expressed for migratory species which may be particularly sensitive to river barriers. As noted above, *S. richardsonii* has been recorded at the UT-1 site (with egg-bearing females recently observed, NESS 2013) and is of special interest both because of its migratory habits and its IUCN Vulnerable (VU) status. This species of snow trout migrates upstream during the pre-monsoon period of low flow in March-April, spawning preferentially in gravel/pebble substrates at the beginning and end of the monsoon, returning downstream following the monsoon. Table 5 provides an overview of the annual life cycle of migratory species in the Trishuli watershed, as compared with natural (blue) and operational (red) hydrographs.

Table 5-4: Migratory fish species in the Trishuli watershed

Species	IUCN Category	Distance	Spawning Migration & Timing 											
			M	A	M	J	J	A	S	O	N	D	J	F
Tor putitora	EN	L			↑	↑	↑	↑	↑	↓	↓			
Neolissochilus hexagonolepis	NT	M			↑	↑	↑	↑	↑	↓	↓			
Schizothorax richardsonii	VU	M	↑	↑						↓	↓			
Labeo angra	LC	M	↑	↑	↑	↑	↑	↓	↓					
Labeo dero				↑	↑	↑	↑	↓	↓					
Schizothorax progastus			↑	↑						↓	↓			

Across Nepal, indigenous fish stocks have been declining due to over-fishing, harmful fishing practices (electro-fishing, dynamiting, use of chemicals), pollution, and development work (Shrestha 1999 cited in ADB and ICIMOD, 2006), such as river damming and hydropower projects.

A recent aquatic survey in the project area (see Appendix B) found that the snow trout *S. richardsonii*, locally known as Buche Asla, is the most abundant fish species in the area and has been consistently sample for one year. It is a mid-range migratory species which has been identified as vulnerable in the IUCN Red List. Despite its wide geographic distribution in the Himalayan region, recent observations over the last 5 to 10 years indicate drastic declines in many areas of its range due to introduction of exotics, damming and overfishing (Vishwanath 2010). The current trend of hydropower development in the Trishuli watershed (see Figure 2-5) and other sub-basins in the Gandaki river system suggests that there is a potential for cumulative impacts to these species

During the 2013-2014 aquatic baseline survey, field observation of female gonads of the captured specimens of Schizothorax richardsonii showed presence of ovaries with mature eggs starting from July to February. No eggs were found during the months of March and April and immature ova were observed in the months of May and June. These observations suggest that spawning in the project area occurs from March to May, before the monsoon season.

5.4.2 Cumulative Impact Assessment

As pointed out in a recent report by WWF-Nepal (2013), hydropower development is one of the main threats to freshwater biodiversity in the CHAL region. The construction of multiple hydropower facilities in the Trishuli watershed is likely to result in the fragmentation of aquatic ecosystems through two processes (Anderson et al. 2008): (i) the presence of dams acting as physical barriers to the longitudinal movement of water, matter and organisms; and (ii) the creation of a series of flow-reduced river section between the intake sites and the powerhouses. These flow-reduced section or diversion reaches are characterized by slower water velocities, warmer water temperatures, and shallower habitats than the adjacent upstream and downstream areas. Figure 5.9 represents the impact model for this VEC.

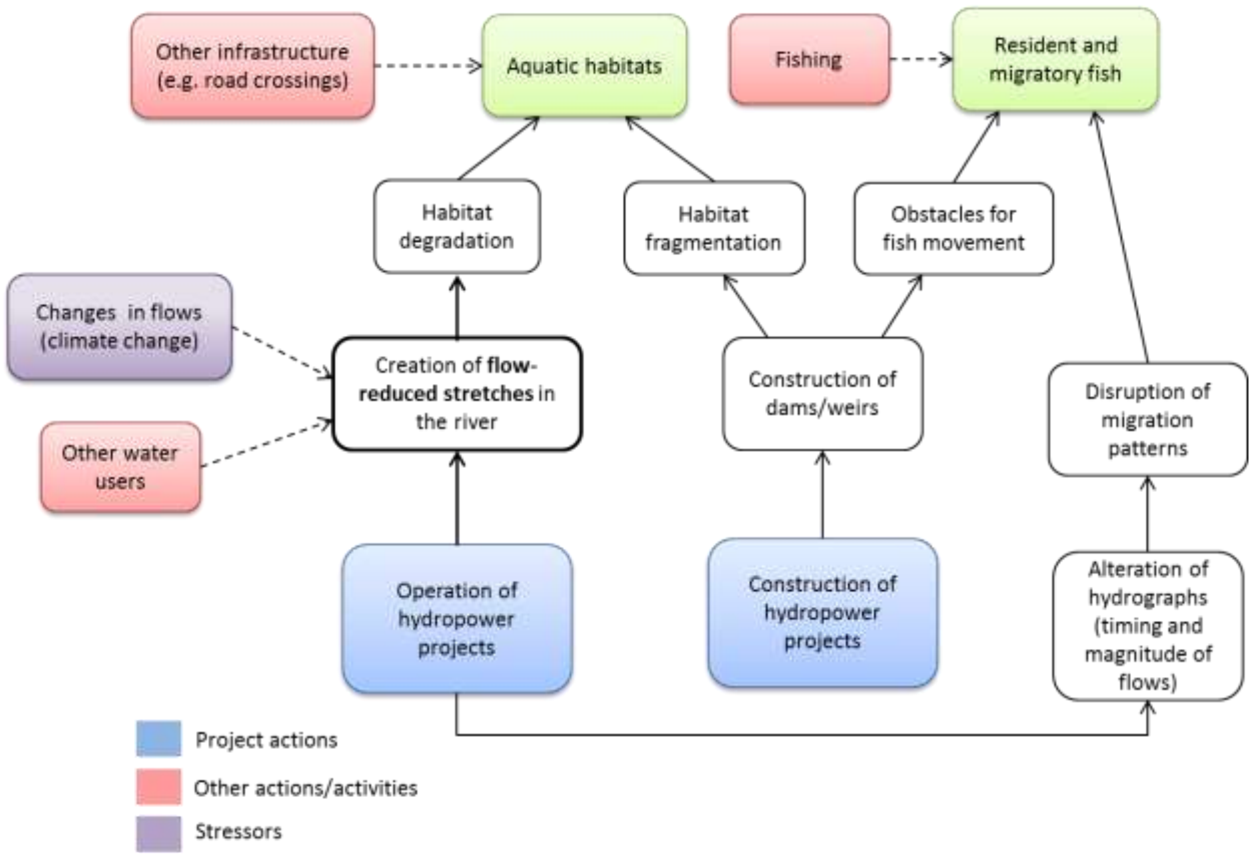


Figure 5-9: Impacts model diagram for VEC 'Fish and aquatic habitats'

This fragmentation will interfere with the upstream and downstream fish migration as well as with lateral in-stream movements in-and-out of the riverbanks. In the case of the Trishuli watershed, long distant migrants such as Tor sp., Bagarius, Pseudeutropius, Clupisoma and Anguilla, and mid-distance migrants N. hexagonolepis and Labeo species would be the most affected by hydropower development. It is expected that populations of snow trout (S.

richarsonii) would be less affected, as they make a small-to-medium scale migration to tributaries to breed in clear and cool water during the monsoon and return to the main stream during the low flow period.

The presence of existing or associated infrastructure, such as stream crossings, can also have impacts on aquatic habitats. Stream crossings in particular represent potential focal points for fine sediment input and intercepted flow delivery, as well as potential physical impediments to fish movements.

In summary, whole watershed connectivity is critical for effective conservation of rivers and networks of wetlands to ensure natural processes (Moilanen *et al*. 2009; Nel *et al*. 2009); including upstream connectivity, maintenance of biological diversity, fish migratory routes, free-flowing rivers, significant water yield areas and water quality.

Based on the expected impacts, the following indicators have been selected to characterize the future condition of this VEC under the development scenarios (Table 9):

- **River under reduced-flow**: This indicator estimates the length of channel to which flows are reduced as the distance between locations of water withdrawal (from the reservoir) and return to the natural river system (at the tailrace leaving the penstock). Due to the hydrological alteration in these river segments, aquatic habitat might be lost or degraded.
- **Dam density**: The number of dams per stream kilometer gives an indication of the degree of fragmentation. This indicator has been assessed for both the dams on the main stem of the Trishuli and for the dams on the tributaries.
- **Stream cross density**: This indicator measures the number of road crossing streams within concession areas and it is a proxy for aquatic habitat disruption.

Table 5-5: Cumulative impacts on the VEC 'Fish and Aquatic Habitats'

VEC	Cumulative impact	Impact indicator (metric)	Scenario 1	Scenario 2
Fish and aquatic habitats	Aquatic habitat loss/ degradation	**River under reduced flow** (%)	43%/5%/0.6%[1]	80%/12%/1.1%
	Aquatic fragmentation	**Dam density** (numbers of dams per stream km)	0.07/0.01	0.12/0.02
		Stream cross density (number of stream crossings per km^2 of concession area)	0.97 crossings/km^2 (220)	1.06 per crossings/km^2 (535)

5.4.3 Significance of Identified Impacts

The disturbance of aquatic habitats under the two hydropower scenarios is expected to be significant. A significant portion (43% for Scenario 1 and 80% for Scenario 2) of the Trishuli River will be under reduced flow in both scenarios; and this is likely to cause significant impacts on aquatic habitats for fish species in the Trishuli. The density of crossings within the concession areas is already high (Fiera, 2012, used a value of 0.6 crossings/km^2 to represent a “high pressure” on aquatic biodiversity) and will increase as the construction of associated facilities of the hydropower projects (e.g. access roads) progresses.

Table 5-6: Significance of impacts on the VEC ‘Fish and Aquatic Habitats’

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Fish and aquatic habitats	Aquatic habitat loss/degradation	25.3%/14.8%	13.6%/6.9%	High
	Aquatic habitat fragmentation	➢ 0.6 crossings/km^2		High

In terms of potential mitigation of the barrier effect of dams and weirs, it should be noted that most of the existing and proposed water development projects in Nepal do not have fish ladders. There are only few examples of fish ladders (e.g., Koshi barrage, Chandra Nahar in Trijuga, Andhi Khola and Gandak barrage) and very little is known about their performance.

5.5 Erosion and sedimentation processes

5.5.1 Baseline status

Soil erosion is one of the most serious environmental issues in the steep and fragile hill slopes of Nepal. The main reasons for soil erosion in the region include (Higaki et al. 2005): expansion of agriculture and grazing into marginal steep lands, deforestation and unsustainable forest management, and construction of infrastructure (e.g. rural roads). The Department of Soil Conservation and Watershed Management (DSCWM) has conducted some soil conservation activities in the watershed, including the testing of different soil conservation practices on the slopes of the Tadi Khola, atributary to the Trishuli River (Higaki et al. 2005). At that particular site at the Tadi Khola, erosion rates and rainfall were measured through a period of four years (1994-1999) and it was observed that the highest erosion rates occurred during the maximum rainfall events during the monsoon season.

Soil degradation and loss of productive land are serious environmental problems. With the increasing population and growing need for food, agriculture is being expanded to sloping lands and forests. The heavy monsoon rains make fragile mountain slopes vulnerable to loss and degradation of land and soil through landslides, erosion, and river cutting. As much as 5% of all landslides in Nepal are associated with newly-constructed roads and trails (ADB and ICIMOD, 2006). At the UT-1 project site, there are two active landslides.

As part of Phase I of the *GIS Mapping and Spatial Analysis* task (ESSA, November 2013), we have identify sites with erosion/slide potential within the watershed (Figure 26) based on the slope and land cover type. Thus, areas with a slope higher than 45° that intersect with land cover classes susceptible to erosion (i.e. bare soil, agriculture, sand and cliff) were identify as slide prone. The presence of these areas in proximity (within 1 km) to water sources would indicate a high slide potential, whereas slide prone sites in drier areas were classified as having a moderate slide potential. Figure 5-10 shows how, based on this analysis, areas with slide/erosion potential concentrate on the upper part of the watersheds, where slopes are steeper, or on the valley slopes in proximity to water courses. The total area with slide potential (slope higher than 45°) in the Trishuli basin is 243 km^2.

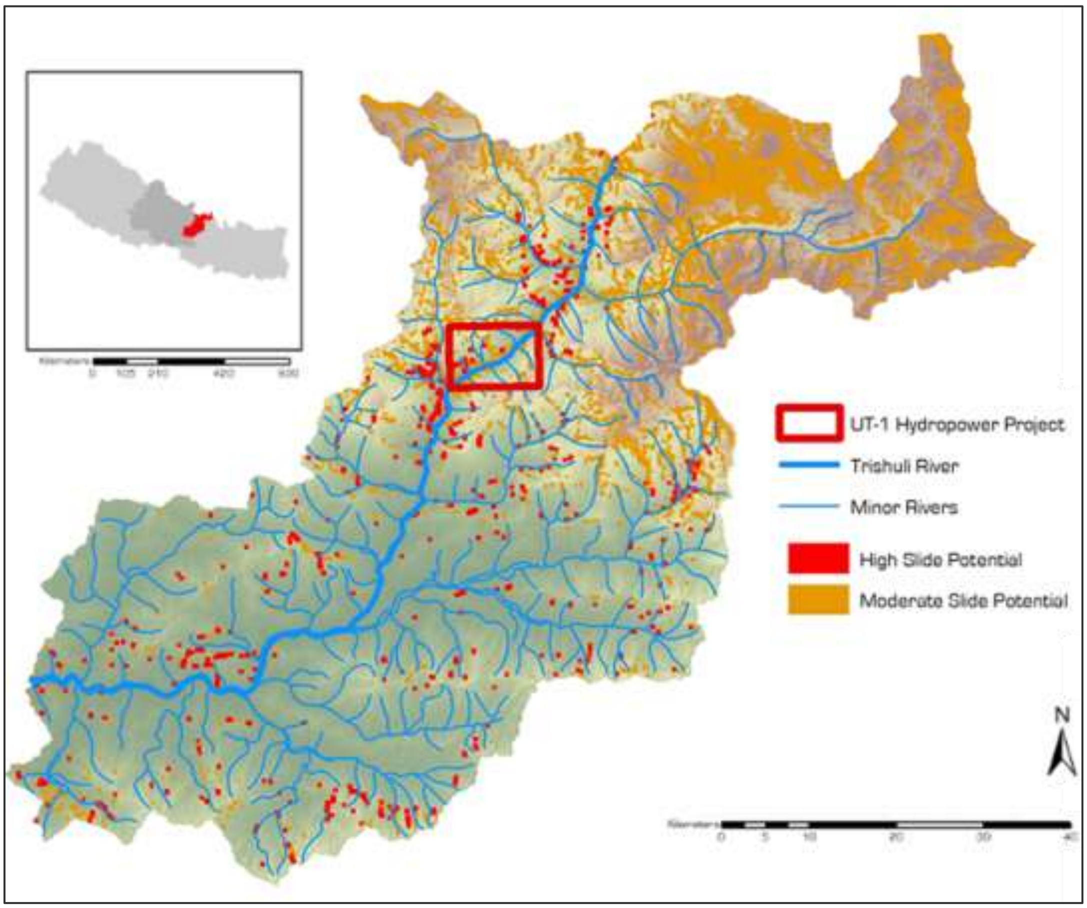


Figure 5-10: Slide/erosion potential in the Trishuli watershed

In terms of sedimentation, siltation was identified as one of the major problems for the operating hydropower plant of Chilime (Bhatt and Khanal 2011), a 22-MW facility located upstream from the proposed UT-1 Project.

5.5.2 Cumulative Impact Assessment

The construction of the hydropower projects and associated infrastructure (i.e. access roads and transmission lines) implies earth works, clearing of vegetation in some areas and activities along the banks of the river that can induce increased erosion, especially in sensitive areas prone to landslides; a common situation in the upper part of the watershed.
In the run-of-river (RoR) projects the in-river sediment transport is not significantly affected as these projects often flush sediments directly into the river downstream of the head-works, as previous experience with other projects in Nepal shows.
Flow modification will have implications on river morphology and hydraulics/ sediment loads and dispersion dynamics. Sand, gravel, and boulder deposition dynamics will likely change. Debris flows are also likely to be modified. As stated above, Himalayan Rivers are characterized by an ever changing dynamics in the riverbed and in the flood plain morphology. This natural annual dynamics may be modified. Increased up-slope erosion during the operation phase is likely to be significant because of the fragmentation of the river's natural morphology by the diversion structures and reduced sediment transport capacity of the river for more than 6 months annually. In addition, daily flow fluctuations and water pulses are also likely to modify the river geomorphology downstream from the tailraces.

However, expected impacts on sediment dynamics and changes to channel-forming processes are difficult to assess without a better understanding of the processes involved and, possibly, a runoff-sedimentation modeling approach that would allow the simulation of sediment transport along the Trishuli River taking into account the sediment inputs across the watershed and the operating rules of the different hydropower facilities.

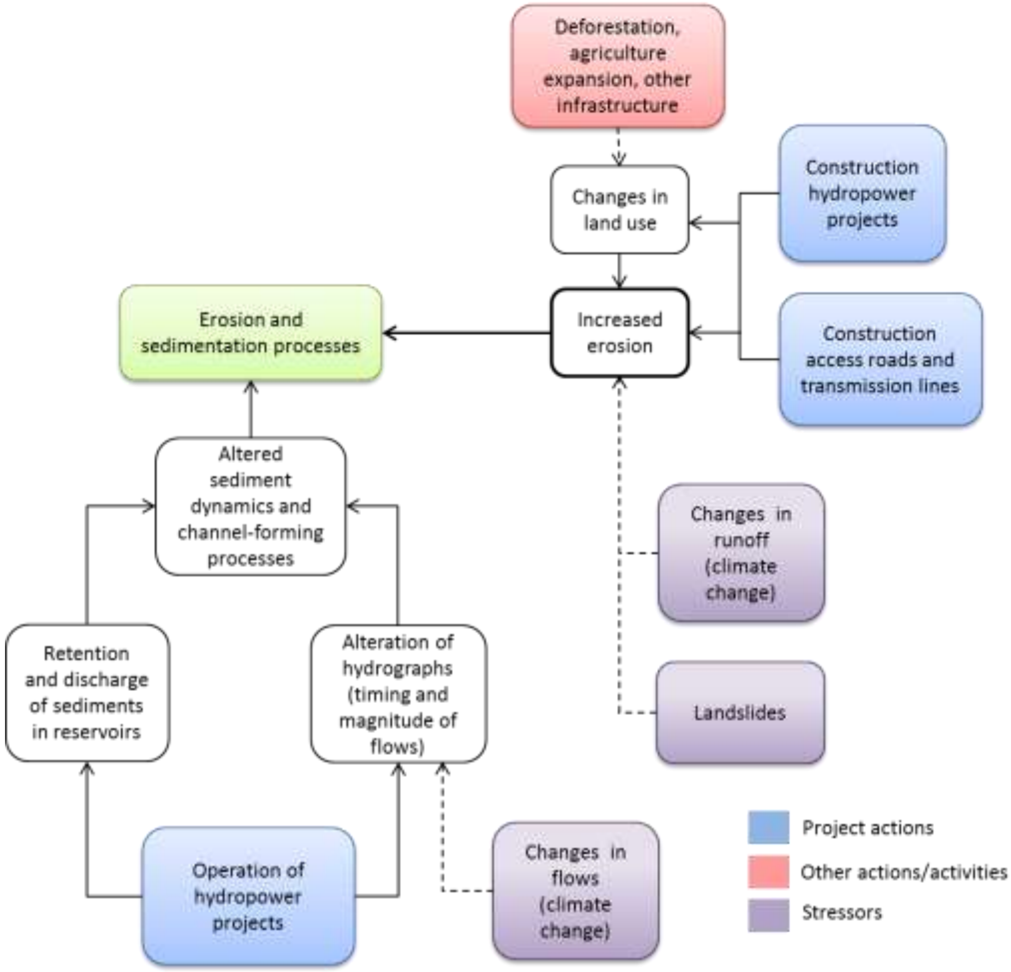


Figure 5-11: Impact model diagram for VEC 'Erosion and sedimentation processes'

Based on these impacts, we have selected the following indicators to assess the pressure/risk on erosion and sedimentation processes (Table 5-7):

- **Risk of landslides**: This indicator estimates the area of high slide potential sites within concession areas. Construction on areas prone to landslides can trigger or reactivate mass wasting movements.
- **Road densities**: High road densities within a watershed indicate a greater risk to magnified surface erosion and landslide risk, with associated increases in stream turbidity and potential disruptions to aquatic functions. Roads situated in close proximity to streams (<100m) can pose serious threats to stream channel stability. Road construction and maintenance can be very disruptive to streams, with frequent incidences of channel disturbance and point-source pollution.

Table 5-7: Cumulative impacts on the VEC 'Erosion and Sedimentation Processes'

VEC	Cumulative impact	Risk indicator (metric)	Scenario 1	Scenario 2
Erosion and sedimentation processes	**Risk of landslides**	**Risk of landslides** (% and area of high slide potential sites within concession areas)	6.7% (16.3 km^2)	11.13% (27.1 km^2)
	Increased surface erosion	**Road density** (km of road per km^2 of concession areas)	0.7 per km^2 (151.8 km)	0.7 per km^2 (363.5 km)
		Road density in proximity of streams (km of road within 100 m of stream per km^2 of concession areas)	0.34 per km^2 (77.6 km)	0.40 per km^2 (202.92 km)
		Road density on unstable slopes (km of road on slope >45° per km^2 of concession areas)	0.007 per km^2 (7.6 km)	0.005 per km^2 (10.8 km)

5.5.3 Significance of identified impacts

Landslides are one of the main concerns expressed by stakeholder during consultations for the Project, and it is likely that it will be a major risk in the upper part of the watershed. The area with unstable slope within the UT-1 concession area is 5.78 km^2. The risk of landslides is therefore considered an impact of high significance. In terms of the other indicators used in the analysis of this VEC; the total existing road length in UT-1 concession area is 8.3 km; 1.60 km out of this length is in proximity to streams and 0.3 km on unstable slopes. The contribution of these figures, considered low, to the total road lengths within the concession areas is shown in the table below:

Table 5-8: Significance of impacts on the VEC 'Erosion and Sedimentation Processes'

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Erosion and sedimentation processes	Risk of landslide	35%	21%	High
	Induced surface erosion	5%/2%/4%	2%/0.8%/3%	Low

5.6 Terrestrial habitats

5.6.1 Baseline status

The Mid-Hills, Central Nepalese biogeographic region, constitute the greatest ecosystem and species diversities in Nepal. Nearly 32% of the forests in Nepal are found in the Mid-Hills, and the zone includes 52 types of ecosystem (Figure 5-12). Studies indicate that about 1989 species of flowering plants found at between 2000-3000 m, followed by 1645 species between 3000-4000 m. 38% of the 399 endemic flowering plants are from Mid-Hills region. Three distinct life zones and vegetation types are observed in the region namely Subtropical (1000-2000 m), Temperate (2000-3000 m), Subalpine (3000-4000 m). Phytogeographical studies of Nepali flowering plants indicate that the central belt, composed of upper subtropical and temperate bioclimatic zones at altitudes ranging from 1500 to 3000 m are floristically related to the sino-Japanese floristic region.

Forests are the most important natural ecosystem in Nepal. The total extent of forest cover within the Trishuli watershed for 2010 was 1077.89 km^2. A total of 20 species of mammals were recorded at the Project area during the field trip by direct observation or secondary sources. The complex topography and geology together with the varied climatic patterns have enabled a wide spectrum of vegetation types that in turn has supported a good faunal diversity. The forested western slopes of the Trishuli, located out of the Langtang NP boundary, offer habitat for protected species like Assamese monkeys. The slope with forest provide habitat for Ghoral and barking deer too. Most of the animals at the project sites exhibit seasonal migration locally.

During the field surveys (transect walks and questionnaire surveys with locals) in the Project area (NESS 2013), four species of mammals included in the IUCN red list were identified, including: *Macaca assamensis (*Assamese monkey) and *Selenarctos thibetanus (*Himalayan Black Bear), both classified as vulnerable, and *Macaca mullata (*Rhesus Monkey) and *Nemorhedus goral (*Himalayan Goral), which are considered near threatened. Ten species of birds fall under CITES Appendix II and III and the Asiatic rat snake (*Ptyas mucosus*) is listed under CITES Appendix II.

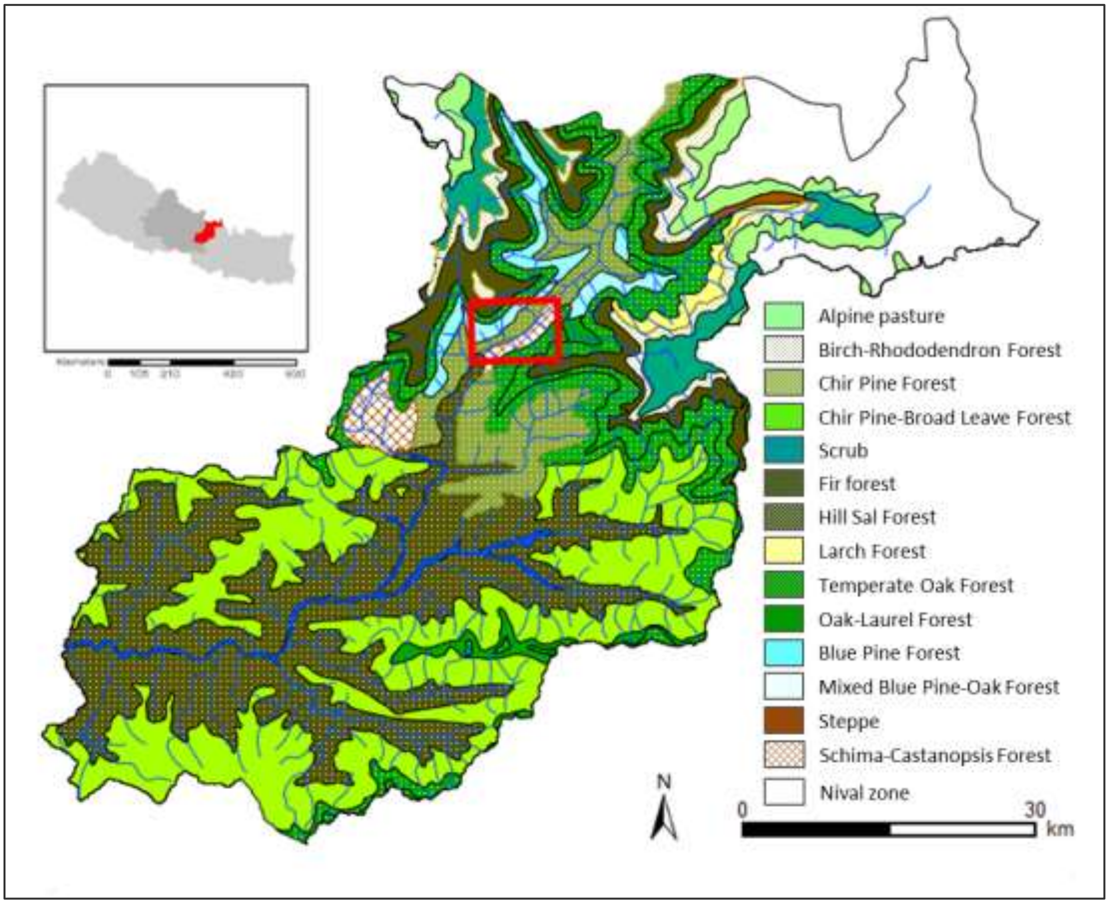


Figure 5-12: Potential vegetation types in the Trishuli watershed

Figure 5-13: Assamese monkeys observed during additional baseline studies
(Source: NESS, September 2013)

Within the Trishuli watershed, the main biodiversity conservation feature is the Langtang National Park, located in the northeast part of the basin. This is a large protected area that includes much of the forest cover in the Rasuwa District. The length of the river affected by the UT-1 Project borders the Langtang Park. Although mostly undeveloped, the Langtang National Park has been impacted by developments such as roads and transmission lines. Currently under construction and future hydropower projects are located in proximity of this park and could result in impacts in this protected area.

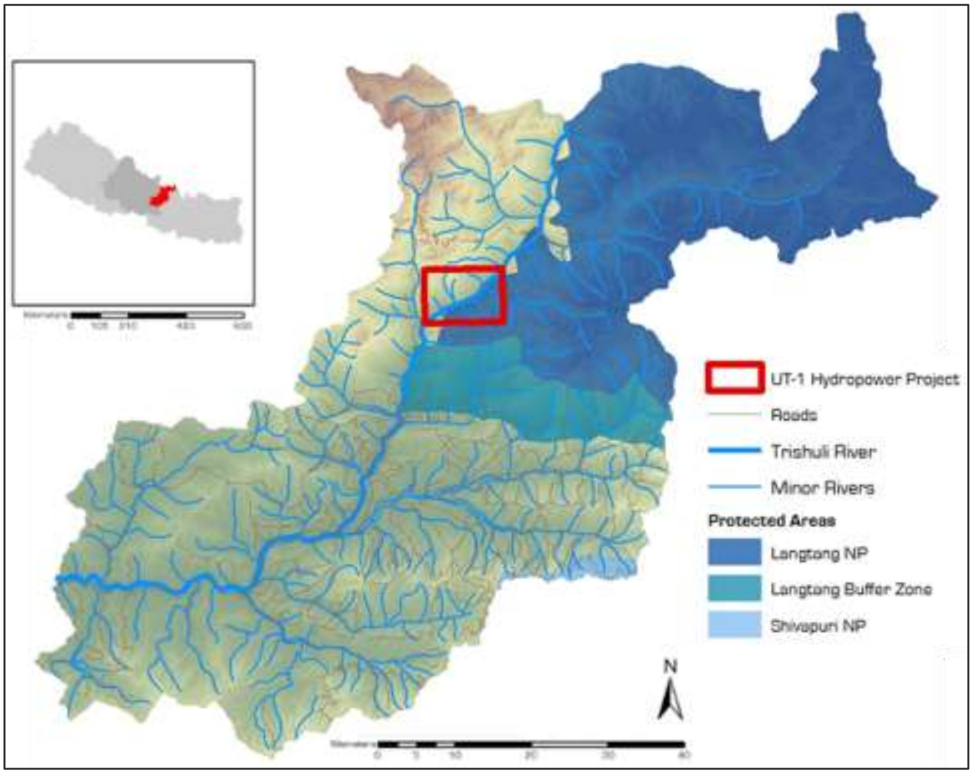


Figure 5-14: Protected areas within the Trishuli watershed

5.6.2 Cumulative impact assessment

The construction of the different hydropower projects will imply land conversion that could potentially affect natural habitats, such as forests. Although the footprint of the run-of-river projects is usually smaller than storage hydropower facilities, the multiple projects across the watershed could add to forest fragmentation and induced deforestation due to improved access to previously remote areas, as represented in Figure 5-15.

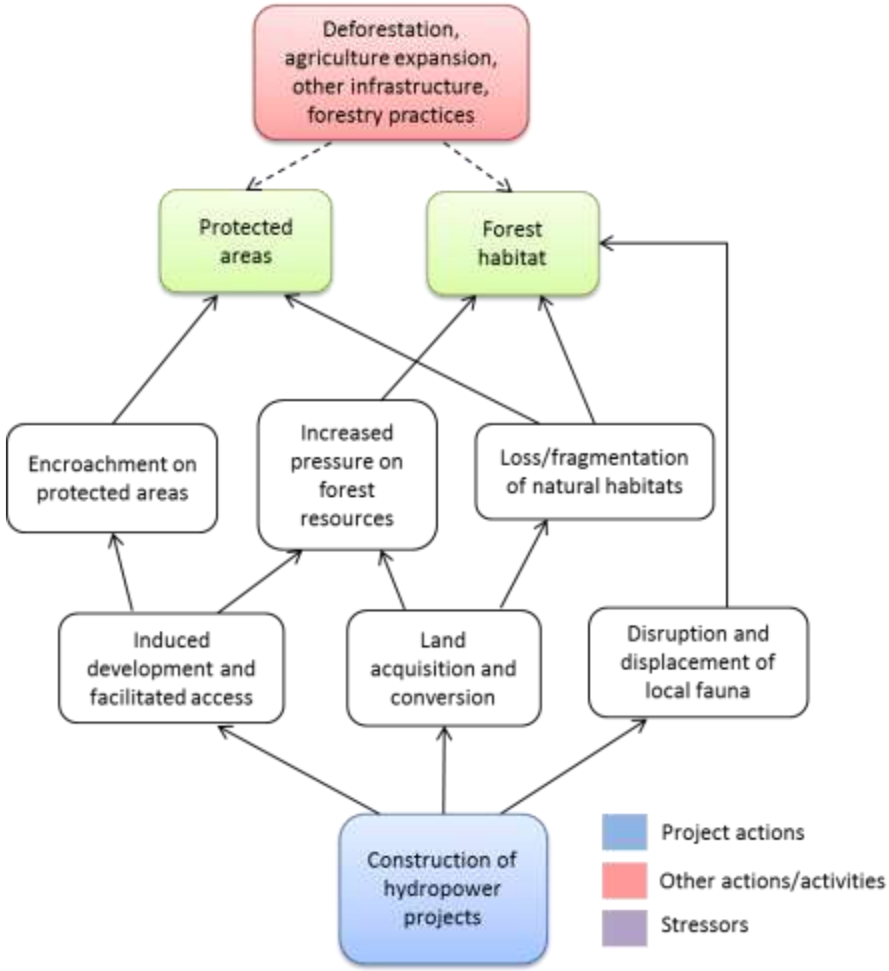


Figure 5-15: Impacts model for VEC 'Terrestrial habitats'

Species and ecosystem impacts are caused by a range of direct (e.g. clearing forest for roads or flooding by reservoirs) and indirect (e.g. the impact of itinerant workers in areas of high biodiversity) impacts during project construction and operation (Carew-Reid *et al*. 2010). Construction of the 19-km access road on the western slope of the valley can result in the loss of available habitat and fragmentation of the existing habitat patches. The noise and machinery movement during the construction works will likely disturb fauna and displace mobile species. The large spike in the number of workers can create problems of illegal hunting and extraction of timber and NTFPs (non-timber forest products), such as medicinal plants.

Another potential impact to take into consideration in relation to terrestrial habitats is the presence of hydropower facilities in the proximity of protected areas. There may be some impacts on animal and bird movements, temporarily during construction work due to human and heavy equipment´s movement, noise, and vibration. Locals from the Mailun Dovan area have reported that construction works for the Mailun Hydropower Project have disrupted local fauna (monkeys and the deer Ghoral) and pushed them form their local habitats to the

Langtang NP bufferzone (NESS 2013). The indicators used to evaluate the pressure on terrestrial habitats are indicated in Table 5-9.

Table 5-9: Cumulative impacts on the VEC 'Terrestrial Habitats'

VEC	Cumulative impact	Pressure indicator (metric)	Scenario 1	Scenario 2
Terrestrial habitats	**Encroachment on protected areas**	**Proximity to protected areas** (km^2 of concession areas within 100 m of protected/buffer zone areas; and %)	39.63 km^2 (3.28%)	95.99 km^2 (7.93%)
	Pressure on forest habitats	**Presence of forest land within concession areas** (Percentage of forest land within the concession areas)	6.8% (73.38 km^2)	13.7% (147.87 km^2)

5.6.3 Significance of identified impacts

In the case of the UT-1 Project, the forest cover (land cover of 2010) within the concession area is 3023 ha (30.23 km^2). This surface represents 41% of the total forest cover within concession areas under Scenario 1 and 20% under Scenario 2. As for the proximity to protected areas, 22.31 km^2 of the UT-1 Project lie within the designated area for Langtang National Park. These impacts are considered of medium significance.

Table 5-10: Significance of impacts on the VEC 'Terrestrial Habitats'

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Terrestrial habitats	**Encroachment on protected areas**	56%	23%	Medium
	Pressure on forest habitats	41%	20%	Medium

5.7 Use of natural resources

5.7.1 Baseline status

Being a rural environment, livelihoods in the Trishuli basin depend fundamentally on local natural resources, mainly agriculture and forestry. In the Rasuwa District, 89% of the households report agriculture integrated with animal husbandry as their primary occupation.

In the Project's area of influence, most of the households own non-irrigated agricultural land (usually located on the slopes of the valley), whereas irrigated land Khet is less available and concentrated on the bottom of the valley, close to the river for water access. Major cash crops produced in the VDCs in the Project area (Dhunche, Ramche, and Haku) include: potato, cabbage, cauliflower, onion, garlic and carrot. The major crops produced were maize, wheat, millet, buckwheat, barley and beans. Buffalo, cow, goat, sheep, yak, and chicken as poultry.

Figure 5-16: Khet land on the bank of the Trishuli River
(Source: ESSA, October 2013)

The total forest coverage in the Rasuwa district is 42,616 hectares, about 28.20% area of total district. Out of this, 23,539 hectares of forest is under the Langtang National park and 19,077 hector forests are headed by the district forest office. Out of the 19,077 hectors forest 2747 hectares have been officially handed to the community. Altogether, 76 community forest user groups within the 18 VDCs of the district registered until 067/68.

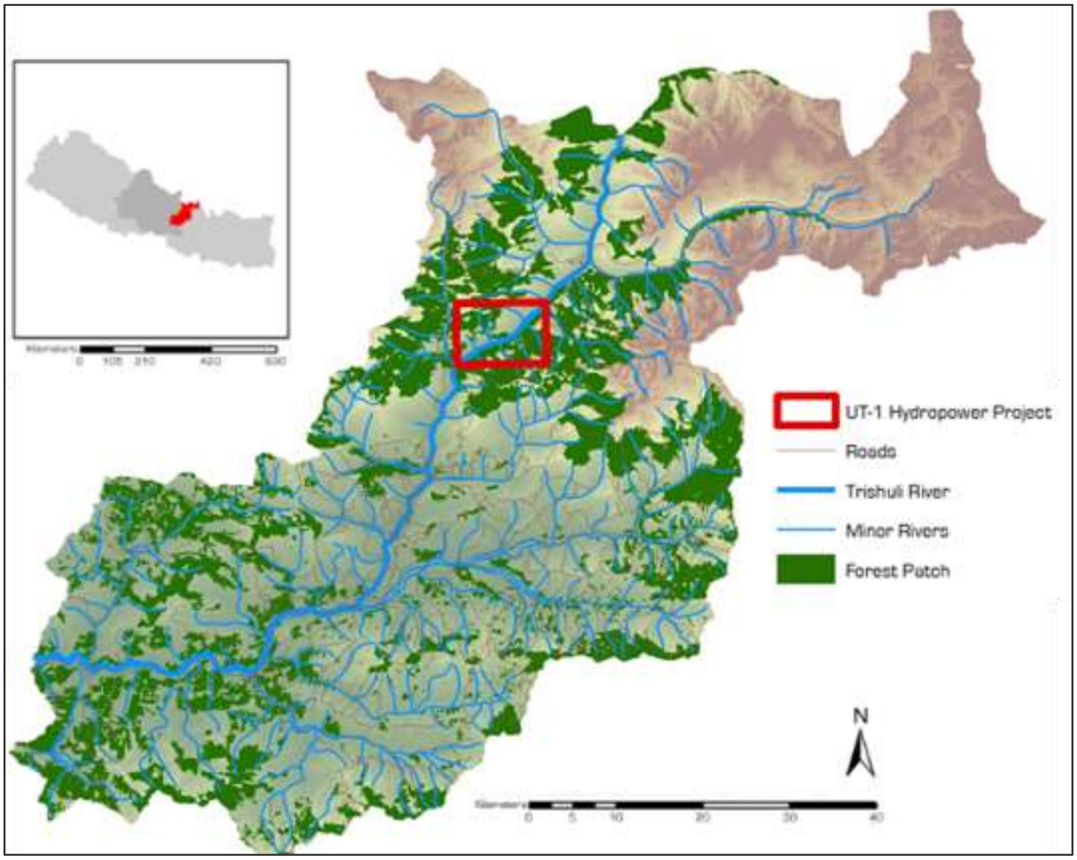


Figure 5-17: Distribution of forest cover within the Trishuli watershed

The predominant management form for the forest in the area is under the community forest. The forest is conserved and managed by the local communities. The local Forests Users Groups (FUGs), with the support and direction of the Distric Forest Office, protect and manages the forest as well as conducts local community development activities. The District Forest Office develops the regional operational management plan.

Within the Project's area of influence, almost all the households in Haku VDC benefit, and derive part of their livelihoods, from the community forest (Jade Consult 2011). Forest provide a number of services and products for local communities. Flora surveys have identified a total of 110 regional plant species with ethnobotanical value, including: medicine (72), fuel-firewood (37), food (35), timber (18), fodder (14) and other miscellaneous purposes.

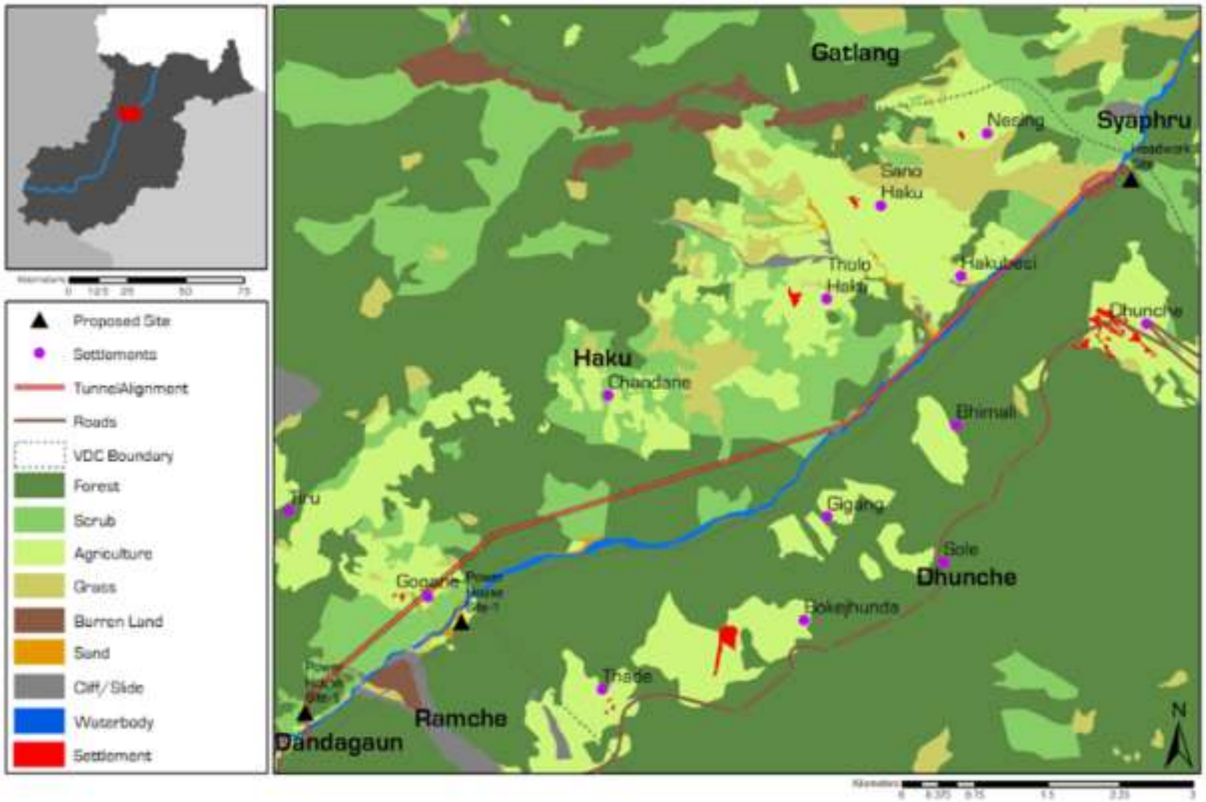


Figure 5-18: Land use in the UT-1 Project Site area

Some of the key issues that are common to all forests outside protected areas are: (i) forest loss due mainly to encroachment for expansion of settlements and urban areas, infrastructure development, and agriculture, (ii) invasion by alien plant species, (iii) uncontrolled and repeated forest fires, and (iv) inadequate capacities of District Forest Offices and user groups. Non timber forest product (NTFP) species (including high value medicinal herbs) suffer from inefficient and unsustainable harvesting practices (WWF 2013). Unplanned and unregulated construction of rural roads by village development committees (VDCs) and district development committees (DDCs) is a major direct cause of deforestation and forest degradation in the midhill districts.

Other natural resources uses

Nine fishermen are actively involved in fishing business the average income from the fish was found to be Rs. 1562/month. However, income from fish depends on the season, for instance October and November is good in terms of fish demand due to high influx of tourist in Dhunche (Jade Consult 2011).

5.7.2 Cumulative impact assessment

As previously discussed, livelihoods in the Trishuli depend greatly on agriculture and forest resources. The construction of the infrastructure associated to the hydropower projects could result in loss of agricultural or forest land and on the disruption of access and use of these lands, especially during the construction phase of the hydropower facilities. The influx of migrant workers and the creation of new roads could facilitate the access to increase the pressure on forest resources.

In the case of irrigated land in proximity to the river, the creation of a water-reduced zone along the diversion reach could potentially affect the quantity of water available for irrigation during the dry period. This situation would be probably more likely in the lower parts of the Trishuli watershed where agriculture activity is more important.

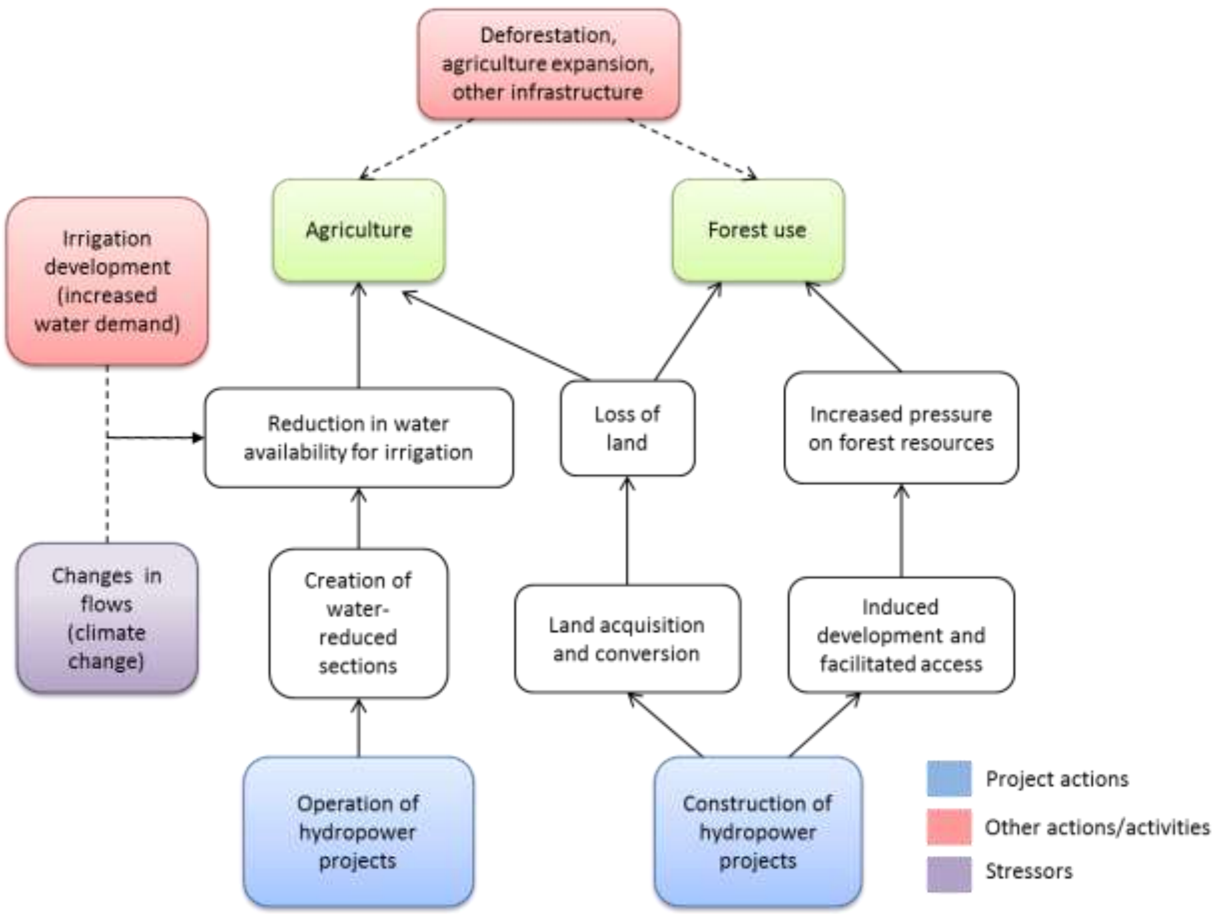


Figure 5-19: Impacts on natural resources use

Two indicators of pressure on forest and agricultural land have been selected to assess the impacts on this VEC: the percentage of forest and agricultural cover within concession areas under each scenario. The total area of agricultural land within the Trishuli watershed (2010) is 1302.86 km^2.

Table 5-11: Cumulative impacts on the VEC 'Use of Natural Resources'

VEC	Cumulative impact	Pressure indicator (metric)	Scenario 1	Scenario 2
Use of natural resources	**Pressure on forest uses**	**Presence of forest land within concession areas** (Percentage of forest land within the concession areas)	7.6% (73.38 km^2)	15.4% (147.87 km^2)
	Pressure on agricultural land	**Presence of agricultural land within concession areas** (Percentage of agricultural land within the concession areas)	5.3% (69.45 km^2)	12.4% (162.18 km^2)

5.7.3 Significance of identified impacts

Given that run-of-river projects do not usually result in big reservoirs covering large areas, a significant conversion across the Trishuli watershed of forest and agricultural land to non-productive uses is not expected. However, changes and pressures on natural resources use could potentially be an issue at the local scale; for instance in hilly areas where land suitable for agriculture is limited and farmer could be displaced from the flatter, more productive areas on the valley bottom. The forest and agricultural land areas within the UT-1 concession area are, respectively, 30.23 and 12.01 km^2.

Table 5-12: Significance of impacts on the VEC 'Use of Natural Resources'

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Terrestrial habitats	**Pressure on forest uses**	41%	20%	Medium
	Pressure on agricultural land	17.3%	7.4%	Low

5.8 Cultural and religious sites

5.8.1 Baseline status

At the watershed level, there are numerous temples, especially in the middle and lower parts of the watershed (see Figure 25). Population in the upper part of the watershed are predominantly Buddhist and do not practice cremation.

As part of the complementary social baseline (see Appendix A), the cultural and religious sites of the three VDCs affected by the Project were inventoried. Burial places are normally located in the upper part of the hills.

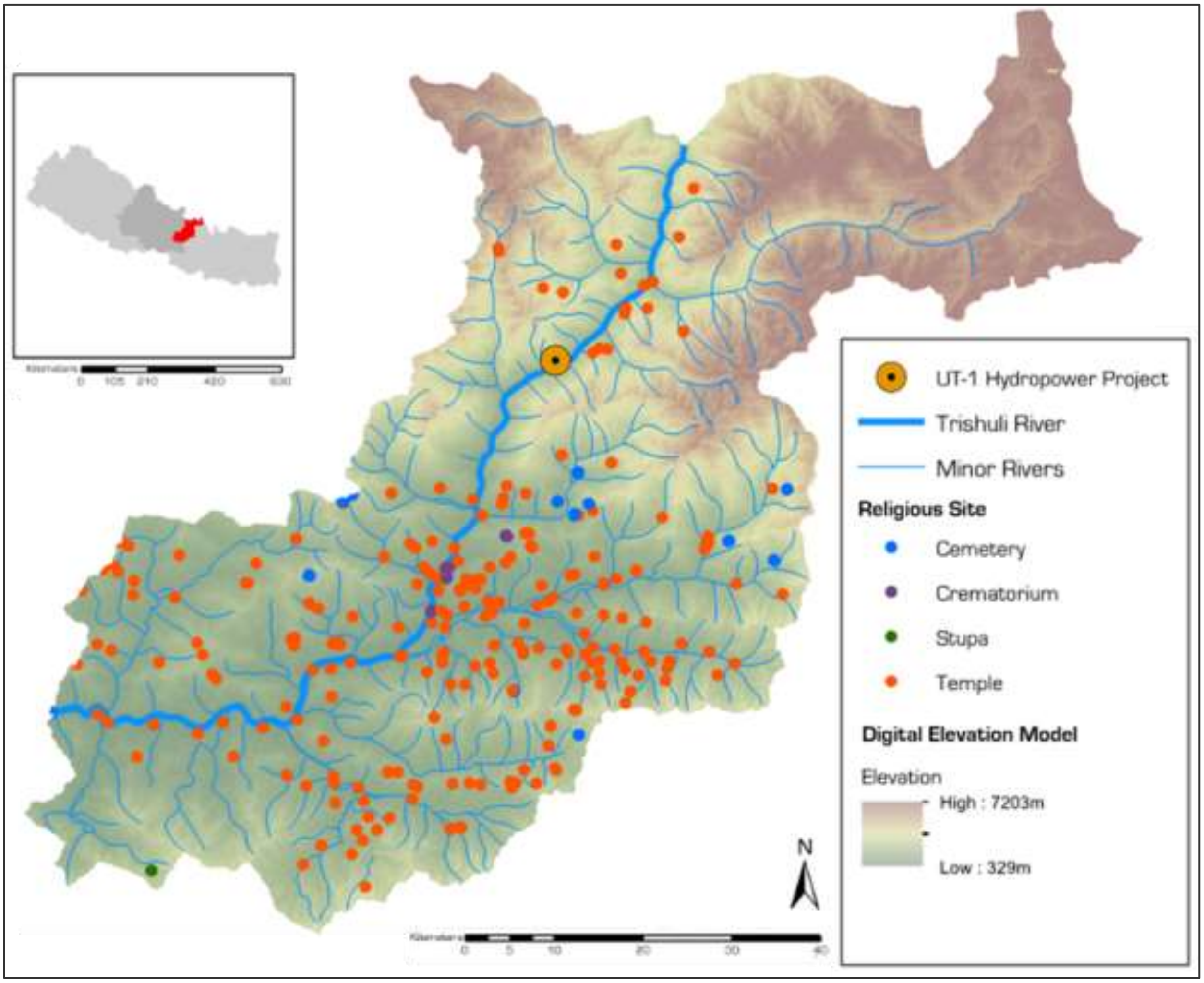


Figure 5-20: Cultural sites in the Trishuli watershed

5.8.2 Cumulative impact assessment

We anticipate two main potential impacts to cultural sites in the Trishuli watershed associated to hydropower development. On the one hand, the construction of the different hydropower projects and their associated infrastructure (i.e. access roads, transmission lines, working camps, etc.) could interfere with the access and use of cultural sites located within the projects' area of influence. This impact is likely to be limited to the construction phase and would be likely more problematic during festivals or pilgrimage periods when the affluence to cultural sites is higher.

The other impact that the development of cascading hydropower projects in the Trishuli basin could bring is the potential affection to water availability and quality required for religious ceremonies. Cremation sites ("ghats") require clean water in sufficient quantity and at chess-high depths, for people to perform their traditional ceremonies and rituals. Pure and clean flowing water is a pre-requisite to perform these rituals. Minimum depth of water in the river is also required for these traditional cultural and religious activities. These two main impact pathways are represented in Figure 5-21:

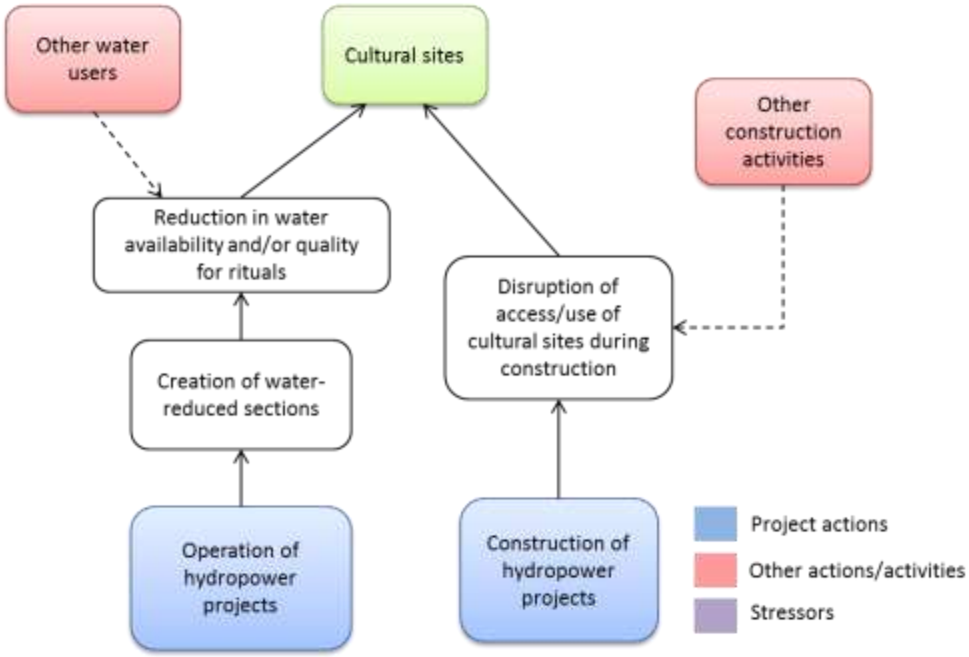


Figure 5-21: Impact diagram for cultural and religious sites

Based on the spatial information on the location of cultural features (i.e. temples, cemeteries, and cremation sites) in the Trishuli basin and of the hydropower concession areas, it is possible to identify those cultural sites located with a concession area and, therefore, potentially subject to the two main impacts that we have anticipated for this VEC.

Table 5-13: Cumulative impacts on the VEC 'Cultural and Religious Sites'

VEC	Cumulative impact	Pressure indicator (metric)	Scenario 1	Scenario 2
Cultural and religious sites	**Reduction in water availability for rituals**	**Presence of cremation sites within the concession areas** (Number of cremation sites within the concession areas)	10	10
	Interference with access and use of cultural sites	**Presence of cultural sites within the concession areas** (Density, no./km^2, and total number of cultural sites within the concession areas)	0.03 per km^2 (35)	0.03 per km^2 (60)

(1) Since it is assumed that the river stretch within the concession corresponds to the diversion reach, it is expected that the cremation sites in these areas will be along the water-reduced section of the river.

5.8.3 Significance of identified impacts

As discussed above, there are a limited (10) number of cremation sites in the Trishuli basin that are located within a hydropower concession area. Within the UT-1 concession area, there is no cremation site so the contribution to this effect is considered insignificant. However, there are a higher number of other cultural sites (e.g. temples and cemeteries) whose access and use could be potentially affected by the construction of the hydropower facilities. These impacts would be limited in time to the construction phase and should be easily avoided and/or mitigated through coordinated planning with the local communities, in order to guarantee access to these cultural facilities, especially during festivals and other significant dates. The significance of the two impact indicators for this VEC is considered as low (Table 18).

Table 5-14: Significance of impacts on VEC 'Cultural and religious sites'

VECs	Cumulative impact	UT-1 Contribution		Significance
		Scenario 1	Scenario 2	
Cultural and religious sites	**Reduction in water availability for rituals**	N/A	N/A	N/A
	Interference with access and use of cultural sites	17.3%	7.4%	Low

In the UT-1 Project's area, because the population is largely non-Hindu, consumptive use of water and ceremonies is not expected to be a significant issue. The complementary social baseline data did not identify any cultural use of water along the affected reach of the Trishuli.

6 Cumulative Impact Management and Monitoring Framework

This section identifies potential mitigation measures to address the identified cumulative impacts. We have taken into consideration existing measures or activities proposed in the original ESIA (Jade Consult 2011) that could play a role in mitigating/minimizing he cumulative impacts. The proposed measures/actions should be integrated into a ***Cumulative Impacts Management Plan***.

It should be noted that, since cumulative impacts typically result from the actions of multiple stakeholders, the responsibility for their management is collective. A distinction between individual actions within the Proponent's control and those measures that require coordination and collaboration with third parties (e.g. other hydropower sponsors) has been made (Table 6-2) to clearly identify the scope of responsibilities for the cumulative impacts management framework.

Considering that the Trishuli watershed has already been impacted by hydropower development, upstream and downstream of the UT-1 Project, NWEDC should focus their efforts on mitigating those impacts for which a significant contribution of the UT-1 is expected and on engaging and collaborating on regional coordinated actions to prevent further degradation of the Trishuli basin.

6.1 Management framework

According to Nepalese Environmental Protection Rules, environmental and social management of the UT-I Hydroelectric Project is the responsibility of the Proponent. The Proponent's Project Management Office (PMO) will have this responsibility during the construction and operation phase.

A separate Environmental and Social Management Cell (ESMC) will be established, reporting to the PMO, to address social, environmental and safety issues. The UT-1 Project recently appointed an Environmental Manager to ensure that the EIA recommended mitigation and monitoring actions are duly implemented, monitored, assessed, evaluated and disseminated to project stakeholders for feedback and improvements. The ESMC is led by the Environmental Manager.

The ESMC (Figure 6-1) will have the responsibility to implement environmental provisions not included in the contract documents of the Contractor and liaison with the other governmental and nongovernmental organizations, as well as the responsibility for monitoring of environmental and social provisions during construction and operation.

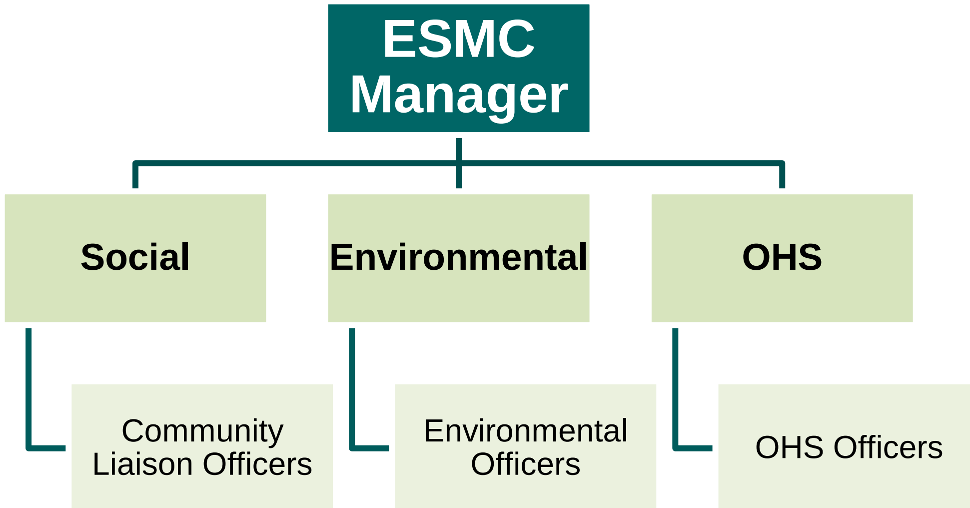


Figure 6-1: ESMC Staffing Chart

The ESMC will have full time social, environmental, and Occupational, Health & Safety (OHS) professionals on staff to directly lead the supervision and management efforts for social, environmental, and safety aspects of project preparation and construction. ESMC staff will be based in Kathmandu and at the project site. It is recommended that two Community Liaison Officers be located in the field in close proximity to affected communities and the project site. Environmental Officers will also be required to be located near the project site to be able to monitor ongoing construction activities.

It is expected that the responsibility in the implementation and oversee of the activities required to mitigate the identified cumulative impacts will be assumed by the ESMC.

6.2 EIA mitigation and monitoring measures relevant for selected VECs

Some of the mitigation and monitoring actions proposed in the approved EIA (Jade Consult 2011) for the UT-1 Project could also contribute to the mitigation and management of the cumulative impacts identified in this report. Table 19 provides a summary of the management actions proposed in the 2011 EIA that are relevant for the selected VECs.

Table 6-1: EIA mitigation and monitoring measures relevant for the selected VECs

Mitigation and monitoring measures as proposed in the 2011 EIA	
Water resources (quantity, quality and water uses)	• Release of the proposed environmental flow (10% of the mean monthly flow) in the diversion reach. • Create an *Environmental Flow Stakeholders Committee* with representation from local communities, Langtang National Park and government representatives, the operator and independent environmental specialist. • Engage in watershed management activities with other stakeholders. • Monitoring of water quality, springs, and groundwater during construction. • Water Source Protection Programs. • Water supply and irrigation facilities should be monitored (e.g. via interviews with water user groups in the affected communities) as part of the Construction Impact Monitoring Plan
Fish and aquatic habitats	• Release of the proposed environmental flow (10% of the mean monthly flow) in the diversion reach. • Develop an *Aquatic Ecology Management Plan* • Enhancement of fish communities (e.g. opening up of new stretches of river with fish ways, flow control devices, such as artificial riffles, dikes or weirs, stocking of adults or fries, and installation of fish incubators. • There will be a need of installing fish elevators, or the capture and transportation of fish upstream provisions of fish ways and fish ladders. • Explore options for aquaculture and fish hatcheries in the reservoir • Monitoring of fish habitat and population during construction
Erosion and sedimentation processes	• Protection of natural vegetation to minimize erosion (e.g. river banks restoration). • Management of sediments and monitoring of sedimentation. • Stabilization and protection of slopes. • Catchment Area Management and Treatment Plan will be implemented in the reservoir area. • Settlement basins and watering of roads during the dry period to minimize sediments and erosion run-off.
Terrestrial habitats	• Protection of land area equivalent or better in ecological value to lost land. • Creation of ecological reserves with rigorous and effective protective measures. • Enhancement of riparian vegetation. • Doing specific inventories and acquiring better knowledge on the fauna, flora and specific habitats within the studied zone. • Enhancement of riparian vegetation. • Establish a Biodiversity Monitoring Unit (BMU) and, at local level, Biodiversity Monitoring and Coordination Committee (BMCC) including representatives from Forest User Groups (FUGs), Village Development Committee (VDC), District Development Committee (DDC), District Forest Office (DFO), District Soil Conservation Office (DSCO), and other concerned stakeholders. • Conservation awareness program on local biodiversity should be conducted for all project field staffs and workforce. • Illegal hunting and poaching of wildlife species from the workforces should be strictly prohibited • Monitoring wildlife habitat during construction • Development of the Terrestrial Ecology Management Plan and the Biodiversity and Wildlife Conservation Management Plan.

Use of natural resources	• Involve the different resource users (i.e. farmers, Community Forest groups, fishermen, Langtang National Park, etc.) in a collective mitigation approach. • Compensatory plantation and/or protection of existing degraded forestland should be carried out to compensate the forest area removed during the project implementation. • Comprehensive Land Acquisition and Resettlement Plans. • Develop a *Community Forestry Support Program*, including establishment of nurseries, and an *Agricultural Enhancement Program*, including resource inventory and baseline and creation of technical assistance (e.g. soil fertility management, cultivation techniques, demonstration plots, etc.)
Cultural and religious sites	• Shifting of the local religious and cultural places that are likely to be demolished during the construction of project with consent of the local people to an appropriate place

6.3 Proposed actions for the mitigation and monitoring of cumulative impacts

Table 6-2 presents the management and monitoring measures that will contribute to mitigating the cumulative impacts identified in this study. The proposed actions build on the existing environmental management framework for the UT-1 Project and, following best practice guidelines (IFC 2013), are structured around two levels of responsibility:

(i) Measures that fall within NWEDC control and could be directly implemented by the proponent; and

(ii) Actions that require collaboration and coordination of multiple stakeholders (e.g. Government of Nepal, other hydropower sponsors in the Trishuli basin, etc.)

These measures should be formally developed and implemented within the framework of a ***Cumulative Impacts Management Plan***, which is one of the action items proposed in Environmental and Social Action Plan of the Supplemental EIA (ESSA 2014). It is expected that internal capacity (i.e. staff and resources) on the part of NWEDC will be required to implement and follow up on the mitigation measures and coordinate as needed with other regional stakeholders (hydropower operators, NGOs, government, Community Forest Groups, etc.) to engage in and support regional initiatives.

Table 6-2: Management and monitoring actions for cumulative impacts mitigation

Selected VECs		Cumulative impacts (indicator)	Proposed mitigation and management actions	
			Within NWEDC control	Collaborative/regional efforts
Environmental	**Water resources (quantity, quality and water uses)**	**Reduction in water availability** (creation of flow-reduced segments)	- Create an Environmental Flow Stakeholders Committee (originally proposed in the 2011 ESIA). - Monitor environmental flows within the diversion reach (included in the Environmental Flows Management Plan)	- Engage and support watershed management initiatives in the Trishuli basin.
		Competition with other users (presence of settlements within the concession areas)	- Engage with water users groups and monitor impacts on water supply as part of Construction Impact Monitoring Plan (originally proposed in the 2011 ESIA). - Continue water quality monitoring during operations (included in the Environmental Flows Management Plan) - Develop Water Source Protection Programs (originally proposed in the 2011 ESIA).	- Engage and support watershed management initiatives in the Trishuli basin. - Support collaboration and exchange of data with relevant stakeholders (e.g. Langtang Park authorities, Water District Offices, etc.)
	Fish and aquatic habitats	**Aquatic habitat loss/degradation** (creation of flow-reduced segments)	- Develop an Environmental Flow Management Plan[3] with *Schizothorax richardsonii* as key species (included in the Environmental Flows Management Plan) - Monthly monitoring for 5 years after the start of operations (included in the Environmental Flows Management Plan)	- Engage in coordinated monitoring efforts and explore joint mitigation options with other hydropower sponsors.
		Aquatic habitat fragmentation (construction of dams and other physical barriers)	- Integrate the Aquatic Ecology Management Plan (originally proposed in the 2011 ESIA) as part of the Environmental Flow Management Plan. - Explore and develop mitigation options suggested for the barrier effect (2011 EIA): fish ladder, hatcheries and stocking, etc. (included in the Environmental Flows Management Plan)	- Engage and support initiatives aiming to mitigate/restore aquatic connectivity (e.g. coordinated capture and release, multi-stakeholder fish rearing program, etc.)
	Erosion and sedimentation processes	**Landslides and other risks** (presence of high slide potential areas in the concession areas)	- Develop the Catchment Area Management and Treatment Plan and stabilize slopes (originally proposed in the 2011 ESIA). - Monitor landslides and other natural risks (i.e. GLOFs) in	- Engage and support soil conservation and erosion reduction initiatives in the Trishuli basin.

[3] Refer to the more detailed recommendations in the *Environmental Flows Assessment* report (Appendix E, ESSA 2014).

Selected VECs		Cumulative impacts (indicator)	Proposed mitigation and management actions	
			Within NWEDC control	**Collaborative/regional efforts**
			the Project area (included in the Catchment Area Management and Treatment Plan)	
		Increased surface erosion (density of roads within the concession areas)	Protect natural vegetation, provide adequate drainage retention facilities during construction (included in the Catchment Area Management and Treatment Plan)	- Engage and support soil conservation and erosion reduction initiatives in the Trishuli basin.
	Terrestrial habitats	**Encroachment on protected areas** (proximity of concession areas to protected areas) **Pressure on forest habitats** (presence of forest habitats within concession areas)	- Develop the Terrestrial Ecology Management and the Biodiversity and Wildlife Conservation Management Plans (originally proposed in the 2011 ESIA) - Extend wildlife and biodiversity monitoring in selected locations into the operational phase (included in the Biodiversity and Wildlife Conservation Management Plan) - Develop a Riparian Vegetation Restoration Program (originally proposed in the 2011 ESIA)	- Engage and support stakeholders (e.g. Langtang National Park, WWF-Nepal) working on biodiversity protection initiatives in the Trishuli watershed. - Explore opportunities for coordinated re-vegetation-reforestation actions with other hydropower sponsors (i.e. maximize terrestrial habitats connectivity).
Socio-economic	**Use of natural resources**	**Pressure on forest uses** (presence of forest land within concession areas)	- Develop the Community Forestry Support Program (originally proposed in the 2011 ESIA) - Monitor impacts on Community Forests (e.g. impacts on productivity/livelihoods) (included in the Land Acquisition and Livelihood Restoration Plan)	- Coordinate reforestation/re-vegetation actions with existing/future initiatives in the watershed.
		Pressure on agricultural land (presence of agricultural land within concession areas)	- Develop Agricultural Enhancement Program (originally proposed in the 2011 ESIA) - Monitor impacts on livelihoods due to the loss of agricultural land (included in the Land Acquisition and Livelihood Restoration Plan)	- Support farmers in the Project area to participate in agriculture enhancement opportunities at the district or watershed level.
	Cultural and religious sites	**Reduction in water availability for rituals** (cremation sites within the concession areas)	- The few existing cremation sites are located within the concession area of an existing hydropower project. Further disruption is not expected.	- Collaborate with the Government and other stakeholders in cultural-related issues.
		Interference with access and use of cultural sites	- Coordinate with local communities to minimize disruption of cultural/religious activities, especially significant dates (included in the Construction ESMP)	

References

ADB (Asian Development Bank) and ICIMOD. 2006. Environment Assessment of Nepal: Emerging Issues and Challenges [http://lib.icimod.org/record/7410]

Anderson, E.P., C.M. Pringle, and M.C. Freeman. 2007. Quantifying the extent of river fragmentation by hydropower dams in the Sarapiquí River Basin, Costa Rica. *Aquatic Conserv: Mar. Freshw. Ecosyst*. 18: 408–417.

Bajracharya, T.R., Acharya, S. and B. Ale. 2011. Changing climatic parameters and its possible impacts in hydropower generation in Nepal (A case study on Gandaki River basin). *Journal of the Institute of Engineering* 8:160-173.

Bajracharya, SR; Maharjan, SB; Shrestha, F; Bajracharya, OR; Baidya, S. 2014. Glacier status in Nepal and decadal change from 1980 to 2010 based on landsat data. Kathmandu: ICIMOD

Bhatt, R.P. and S.N. Khanal. 2009. Environmental Impact Assessment system in Nepal - an overview of policy, legal instruments and process. Kathmandu University Journal of Science, Engineering and Technology (5): 160-170

Bhatt, R.P. and S.N. Khanal. 2011. Impoundment after Damming the Rivers Change in Flow Regime and Effect in Water Quality of Chilime Hydropower Project in Rasuwa District Nepal. *Advances in Bioresearch* (2): 33- 39

Carew-Reid, J., J. Kempinski and A. Clausen. 2010. Biodiversity and Development of the Hydropower Sector: Lessons from the Vietnamese Experience – Volume I: Review of the Effects of Hydropower Development on Biodiversity in Vietnam. ICEM – International Centre for Environmental Management, Prepared for the Critical Ecosystem Partnership Fund, Hanoi, Viet Nam.
[http://www.icem.com.au/documents/biodiversity/bioHPdevt/Volume%20I%20Biodiversity%20and%20development%20of%20hydropower-Vietnam%20experience.pdf]

Connors, B.M., D.R. Marmorek, E. Olson, A.W. Hall, P. de la Cueva Bueno, A. Bensen, K. Bryan, C. Perrin, E. Parkinson, D. Abraham, C. Alexander, C. Murray, R. Smith, L. Grieg, and G. Farrell. 2014. Independent Review of Run-of-River Hydroelectric Projects and their Impacts on Salmonid Species in British Columbia. 157 pp + xiv.

CEPAD Hydro Consultants (P) Ltd. April 2011. Final Report on Environmental Impact Assessment of Sanjen (Upper) Hydroelectric Project (SUHEP)

Daelim Kyerong. March 2013. UT-1 HEP Basic Design Report

DOFD (Directorate of Fisheries Development). 2008. Limnological and biological study report of Tirsuli River. Fiscal Year 2065/2066. Government of Nepal, National Inland Fisheries and Aquaculture Development Programme. Balaju, Nepal. 14 p.

Fiera (Fiera Biological Consulting Ltd.). 2012. Athabasca State of the Watershed Report: Phase 2. Report prepared for the Athabasca Watershed Council. Fiera Biological Consulting Report #1142. Pp. 100.

Greig, L.A., J.K. Pawley, C.H.R. Wedeles, P. Bunnell, and M.J. Rose. 1992. Hypotheses of effects of development in the Moose River Basin: Workshop summary. Prepared by ESSA Ltd., Richmond Hill, ON for Department of Fisheries and Oceans, Burlington, ON. 136 pp.

Gubhaju, S.R. 2002. Impact of damming on the aquatic fauna in Nepalese rivers. p. 129-146. In: Petr, T. and Swar, S.B. (eds.). Cold water fisheries in the Trans-Himalayan countries, FAO Fisheries Technical Paper 431, Rome, 2002. 376p. [http://www.fao.org/docrep/005/y3994e/y3994e00.htm]

Hegmann, G., C. Cocklin, R. Creasey, S. Dupuis, A. Kennedy, L. Kingsley, W. Ross, H. Spaling and D. Stalker. 1999. Cumulative Effects Assessment Practitioners Guide. Prepared by AXYS Environmental Consulting Ltd. and the CEA Working Group for the Canadian Environmental Assessment Agency, Hull, Quebec.

Higaki, D., K.K. Karki, and C.S. Gautam. 2005. Soil erosion control measures on degraded sloping lands: A case study in Midlands of Nepal. *Aquatic Ecosystem Health & Management*. 8(3):243–249

IEA (International Energy Agency). 2000. Survey of the environmental and social impacts and the effectiveness of mitigation measures in hydropower development. Volume 1 in *Implementing Agreement for Hydropower Technologies and Programmes* (Annex III: Hydropower and the Environment), 111 p.

ICIMOD (International Centre for Integrated Mountain Development) .2011. Glacial lakes and glacial lake outburst floods in Nepal. Kathmandu, 109 p.

IFC (International Financial Corporation). 2013. Good Practice Handbook on Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets [http://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/ifc+sustainability/publications/publications_handbook_cumulativeimpactassessment]

Jade Consult. 2011. Upper Trishuli I Hydropower Project: Environmental Impact Assessment Report.

Nepal Environmental and Scientific Services [NESS]. 2010. Environmental Impact Assessment report; Rasuwagadhi Hydroelectric Project.

NESS (Nepal Environmental & Scientific Services P Ltd.). 2013a. Report on Social Baseline Data of Upper Trishuli-1 Hydroelectric Project (216 MW)

NESS (Nepal Environmental & Scientific Services P Ltd.). 2013b. Report on Vegetation Study of Upper Trishuli-I Hydroelectric Project (216MW)

NESS (Nepal Environmental & Scientific Services P Ltd.). 2013c. Report on Wildlife of Upper Trishuli-1 Hydroelectric Project (216 MW)

Rajbanshi, K.J. 2002. Zoo-geographical distribution and the status of coldwater fish in Nepal. *In:* Petr, T. and Swar, S.B. (eds.). Cold water fisheries in the Trans-Himalayan countries, FAO Fisheries Technical Paper 431, Rome, 2002. 376 p. [http://www.fao.org/docrep/005/y3994e/y3994e00.htm]

Sharma, U.R. (Ed.). 2013. Chitwan-Annapurna Landscape: Biodiversity Areas and Linkages. Hariyo Ban Program-WWF Nepal

Swar, D.B. 2002. The status of cold water fish and fisheries in Nepal and prospects of their utilization for poverty reduction. In Swar, D. B. and Petr, T. (Eds.) Cold water fisheries in the trans-Himalayan countries. Rome: Food and Agriculture Organization of the United Nations.

Water and Energy Commission Secretariat (WECS). 2011. Water Resources of Nepal in the Context of Climate Change. Singha Durbar, Kathmandu, Nepal. 89 p.

WB (World Bank). 2012. Sample Guidelines: Cumulative Environmental Impact Assessment for Hydropower Projects in Turkey (Report No. 76998). Ankara, 84 p.

WB (World Bank). 2013. Environmental Impact Assessment Study of Kabeli ‘A’ Hydroelectric Project- Chapter VII: Rapid Cumulative Impacts Assessment and Proposed Management Measures

WWF (World Wildlife Fund) Nepal. 2013. Chitwan Annapurna Landscape (CHAL): A Rapid Assessment, Nepal, August 2013

Annex 1: Inventory of Hydropower Projects in the Trishuli watershed

#	Project	Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
1	**Trishuli Hydropower Project (THP)**	Nepal Electricity Authority	Run-of-River	24	45.3	134.8	1967	4792	72	66 (27.2)[1]
2	**Devighat Hydropower Project (DHP)**	Nepal Electricity Authority	Run-of-River (cascade to THP)	14.1	45.3	105.089	1984	4500	10	66 (5)
3	**Chilime Hydropower Project (CHP)**	Chilime Hydropower Co, Ltd.	Run-of-River (peaking reservoir)	22	15	137.9	2003	2826.5	5	66 (38)
4	**Thoppal Khola**	Thoppal Khola Hydropower Company	Run-of-River	1.65	3.5	10.62	2008	30000	0.5	11 (10)
5	**Thadi Khola**	Hiraratna hydropower Pvt. Ltd	Run-of-River	5	5.75	34.59		2800	0.4	33 (3)

#	Hydroelectric Project	EPC Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Expected start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
1	**Rasuwagadhi Hydroelectric Project (RGHEP)**	Rasuwagadhi Hydropower Co.Ltd.	Run-of-River	111	80	613.9	2016	4203	3	132 (10)[1]
2	**Upper Sanjen Hydroelectric Project (USHEP)**	Sanjen Jalviduit Co. Ltd.	Run-of-River (peaking)	14.8	11.1	82.4	2015	1369.5	10	132 (5)
3	**Sanjen Hydroelectric Project (SHEP)**	Sanjen Jalviduit Co. Ltd.	Cascade to USHEP	42.5	11.57	241.9	2015	3629	0	132 (1.2)
4	**Upper Trishuli 1 (UT 1 HEP)**	Nepal Water and Energy Development Co.Ltd.	Run-of-River	216	76	1533.1	2018	9715	19.5	220 (10)
5	**Upper Trishuli 3A (UT 3A HEP)**	Nepal Electricity Authority	Run-of-River	60	51	489.76	2013	4095	2.3/upgrading 11.3	220 (48)
6	**Upper Trishuli 3 B Hydroelectric Project (UT 3 B HEP)**	Nepal Electricity Authority	Cascade to UT 3A HEP	37	51	303	2013	4095	2.3	220 (48)
7	**Mailung Khola**	Mailun Khola Hydropower Company Pvt. Ltd	Run-of-River	5						
8	**Upper Mailun Khola**	Molinia Power Limited	Run-of-River	14.3	3.53			1855		132 (3)

#	Hydroelectric Project	EPC Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Expected start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
9	**Super Trishuli Ganga Nadi HPP**	River Connect Pvt. Ltd	Run-of-River	10						
10	**Upper Mailung -A**	Energy Engineering Pvt. Ltd	Run-of-River	5						
11	**Tadi Khola (thaprek) (TKHP)**	Aadi Shakti Bidhut Bikash Co. P. Ltd	Run-of-River	4.2	7.2	29.267	2015	2.371	0	33 (8)
12	**Third Trishuli Nadi (TTNHEP)**	Stef Energy Trishuli Thrird Hydropower Company Pvt. Ltd	Run-of-River	20.1	115.25	137.43		500/2240	2	132 (0.5)
13	**Upper Tadi Hydroelectric Project**	Surya Kunda Hydroelectric Private Limted	Run-of-River	11	6.93	61.479		2416	2	132 (8)

#	Hydroelectric Project	EPC Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Expected start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
1	**Upper Trishui-2 HPP**	Hydro China Corporation	Run-of-River	102						
2	**Sanjen Khola**	Sala Sungi P Ltd	Run-of-River	78	9.3	423.748		4411.5	25	132 (10)
3	**Rasuwa Bhotekoshi Hydroelectric Project**	Dipak Khaka	Run-of-River	105	86.77	607		5427	3	132 (5)
4	**Middle Trishuli Ganga Nadi Hydropower Project**	Perfect Energy Developmnet Pvt. Ltd, KTM,	Run-of-River	55/65	140	308.37		1320 (tunnel) or 2100 (canal)	3	132 (6)
5	**Nyam Nyam**	Tudi Power Company Pvt.Ltd.	Run-of-River	6	1.9	32.473		2197.6		33 (8)
6	**Trishuli Khola**	Shahid Diksha Jalbidhut Ayojana PVT.Ltd.	Run-of-River	1.35	1.45	11.64			1.5	11 (3)
7	**Middle Tadi**	Dupcheswor Mahadev Hydro Co. Pvt. Ltd.	Run-of-River	5.5	6.349	31.63		1624	7	11 (7)
8	**Devighat Cascade HPP**	Devighat Hydropower Pvt Ltd	Cascade to Devighat	9.6	45.3	56.3		4948.75		66 (5)

#	Hydroelectric Project	EPC Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Expected start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
9	**Lower Phalaku HPP**	Bisham Hydropower Company Pvt Ltd	Run-of-River	3.35						
10	**Salankhu Khola**	Salankhu Khola Hydropower P. Ltd.	Run-of-River	2.2	1.95	14.405		3209		33/11 (2)
11	**Mahesh Khola**	Mk Hydropower Co Pvt Ltd	Run-of-River	2.17						
12	**Trishuli Galchhi HEP**	Siddhakali Power Pvt.Ltd	Run-of-River	75	169.4	465.97		8000	3	132 3)
13	**Chake Khola HPP**	Nobel Hydropower Pvt Ltd	Run-of-River	1.8						
14	**Phalakhu Khola HPP**	Rasuwa Hydropower Company Pvt Ltd	Run-of-River	3						
15	**Phenlun Briddhin Diversion HPP**	Public Nepal Hydropower Pvt Ltd	Run-of-River	4.5						
16	**Phalakhu Khola HPP**	Betrawati Hydroelectric Co. Ltd	Run-of-River	14.7						
17	**Saptang Khola HPP**	Saptang Hydropower Pvt Ltd	Run-of-River	2.5	1.87	13.78		1416, 581		6

#	Hydroelectric Project	EPC Operator	Type of Scheme	Capacity (MW)	Design Flow (m^3/s)	Annual energy generation (GWh/yr)	Expected start of operations	Length of penstock (m)	Access roads (km)	Transmission line (km)
18	**Tadi Khola Cascade**	Hira Ratna Hydropower Company Pvt. Ltd	Run-of-River	3						
19	**Small Likhu Khola HPP**	Department of Electricity Development	Run-of-River	1.5						
20	**Phalakhu HPP**	Department of Electricity Development	Run-of-River	5.5						
21	**Chandravati Khola**	Public Consulting Engineers, Madhukar Pandey, Durga Prasad Bhattarai and Rosan Karki	Run-of-River	4						

Annex 2: Stakeholders consultations-Focus Discussion Groups

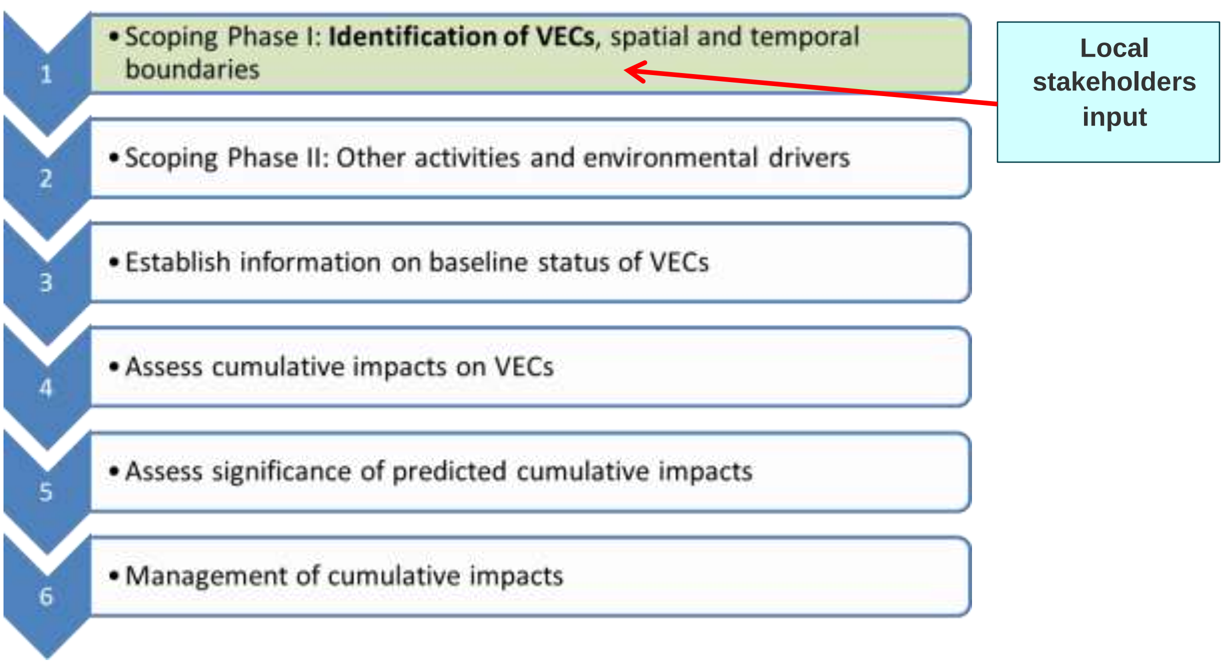
Objectives of the stakeholders consultations

As required by good practice in the Cumulative Impacts Assessment process (IFC 2013), a series of public consultations, in the form of Focus Discussion Groups (FDGs), with local stakeholders were conducted by a team of social experts of Nepal Environmental & Scientific Services (NESS) during 25-27 January 2013.

The specific goals of these consultations were the following:

1. Facilitate the identification by local stakeholders of Valued Environmental and Social Components (VECs);
2. Elicit stakeholders views on the importance, state and trends of the identified VECs;
3. Gather any other considerations or concerns relevant for the VECs analysis or the CIA process.

The figure below shows how consultations with local stakeholder fit within the overall CIA process:



The consultations took place in the **VDCs** of **Dhunche**, **Ramche**, and **Haku**; the three village development committees that will be directly impacted by the Project, and where the land and property directly impacted by the development are located. The following table shows the calendar of activities developed for the consultation process. In total, five FDGs sessions were conducted.

Activities	Date	Location
In-house preparation by experts (team building, orientation, preparation of brochure, maps etc.)	21-22 January, 2014	Kathmandu
Information dissemination to local participants about the FGD	23-24 January, 2014	Dhunche, Ramche, and Haku VDC
FGD Session	25 January, 2014	Mailung Besi, Haku VDC
FGD Session	25 January, 2014	Thade-1, Dhunche VDC
FGD Session	26 January, 2014	Haku Besi-3, Haku VDC
FGD Session	27 January, 2014	Dhunche VDC
FGD Session	27 January, 2014	Grang, Ramche VDC

The consultations included the views of specific relevant groups, such as vulnerable groups (e.g. women), and river users (e.g. fisherman, people using it for recreational purposes, etc.). NGOs, private, public, and government offices and institutions were invited in an interaction at Dhunche and their feedback was obtained.

Criteria for the selection of local stakeholders

- Geographic scope: Prior the consultation exercise, the consultant had in-house discussion among experts regarding the selection of the site for consultations and stakeholders. The most affected areas of the project impacted VDCs where majority of impacted people reside, and people whose land and property falls under such project influenced areas were selected for FGD consultations. Based on these criteria, the public consultations and FGDs were conducted in 3 VDCs, namely: Dhunche, Ramche, and Haku. At Dhunche VDC, public consultations were carried out in 2 places namely at the district headquarter, and at a place called Thade. Similarly, in Haku VDC, public consultations were conducted in 2 places namely at Mailung, and at Haku Besi -Sano Haku. For Ramche VDC, public consultations were carried out in a place called Grang. The list of pubic attended in consultations is included in annex 1 of this report;
- The consultations covered the project influence areas and views of vulnerable groups, River users (fisherman, people using it for recreational purposes etc)were captured; and
- The NGOs, private, public, and government offices and institutions were invited in an interaction at Dhunche and their feedback was obtained.

Development of the FDGs

NESS study team had in-house meeting and prepared materials to be disseminated during the FGDs to provide participants with a general understating of the Project, the anticipated impacts, and the CIA process. Large size maps of the Project and its area of influence were also used for disseminations purposes.

The venue, time, and objectives of the meeting were informed a few days prior to the consultations to the people from each VDC. At each Focus Group, the facilitators ensured that all participants understood the CIA process and their role within this process, and had enough knowledge about the Project to allow them to select the VECs.

The identification of key VECs built on the preliminary components that the consulting team had identified based on our knowledge of the Project and its anticipated impacts, on the baseline information available for the Project area, and on CIA analysis for hydropower projects in other parts of Nepal. This information was briefed to the participants.

The participants of the Dhunche VDC FGD, conducted at the district level, included all the relevant government stakeholders of the district, private and public institutions, representative of political parties, journalists, project affected people and related stakeholders.

Outcomes of the FDGs

Common VECs and concerns identified by local stakeholders

Physical Environment

- Landslides/erosion
- Drying of spring sources along tunnel alignment and vicinity
- Scarcity for drinking water and arable land
- Land use change and its related impacts (reduction of agricultural land, less productivity, non-availability of land even for important and for future planning
- Issues pollution (air, water, noise, solid waste,)
- Issues of improper management of spoil/muck, issues related to siltation and its impact on private property, forest areas
- Impact in dewatered zone (irrigation water use, water mills), climatic imbalances in dewatered stretch
- Issues related to minimum environmental flow release

Biological Environment

- Impact on forest, vegetation
- Issues of deforestation, harvesting/illegal harvesting of trees, degradation of forest, loss of forest products including NTFP
- Forest fragmentation
- Impact on national park, community forest
- Issues related to impacts on wildlife and their habitat, habitat fragmentation
- Movement of wildlife towards settlements after access over the River and their impacts on human and properties
- Impact on fish due to dam, dewatered stretch, impact on people dependent to fish

Socioeconomic and Cultural Environment

- Deterioration of safety and security
- Increase in ill social behavior (gambling, alcoholism, prostitution, girl trafficking)
- Accidents and casualties
- Emergence of new types of diseases
- Disputes related to work, contracts, priority hiring etc
- Impact on infrastructure due to influx of people
- Constrains in local commodities supply and demand
- In migration and change in demography
- Cross-cultural Sensitivities – tentions and conflicts related to culture and traditions

VECs identified per FGD session

Outcomes of FGDs conducted at Mailung, Haku VDC

VEC components	components-VEC Sub	Concern
Physical Environment	Air quality	C,ommunity health, visibility
	Noise	Community health, disturbance to wildlife
	Surface water quantity	water mills, ,Shortage of water for water supply irrigation, etc. aquatic life/fish, cultural and religious purpose
	Surface water quality	Community health, aquatic life, religious and spritual uses
	Groundwater	Drying of spring water sources lying in tunnel alignment
	and Landslide/erosion sedimentation	Informed/observed that the whole area is erosion/landslide prone. The construction of infrastructure for may trigger existing landslide, and may create new landslides/erosion, It may damage to safety of infrastructures like road, land, canal, lacks people while travelling, loss of agriculture, housing .structures, sediment deposition to River etc
	Land Use	Land use change resulting to loss of productive .agricultural land, land, pasture/grass land etc

VEC components	components-VEC Sub	Concern
Biological Environment	ish habitatsFish and f	Decline in the fish population, further decline of the locally valued fishes due to interventions
	Terrestrial Ecosystem/Vegetation	Loss of plants (due to land acquistion, spoil deposition, impact of pollutiion, lack /inadequate volume of irrigation water, loss of forested ecosystem which is already dwindling; Loss of medicinal plants (study limited, over harvesting and ,traditinal knowledge base eroding illegal harvesting on rise
	Wildlife and Wildlife Habitats	.ented and wildlife are decliningHabitats already fragm
-Socio economic and Cultural Environment	economic-Socio	Loss of land for development by projects has a serious implication on the local food security apart from rehabilitation and resettlment of the affected people. :Other concerns are Influx of labors in projects and impact on –infrasgtructures, implication on the service facilities ;on, etcwater supply, health, educati ;Implication on law and order occurenace of –Implication on community health unkonwn new diseases Increase in ill social practices/behavior (gamblimg, (alcholism, prosititution etc .Increase price of commodities Cross-cultural Sensitivitiestions and conflicts ten – related to culture and traditions

Outcomes of FGD conducted at Thade, Ward no 1: Ramche VDC

VEC components	components-VEC Sub	Concern
Physical Environment	Surface water	Reduced flow of water in dewatered section will have climatic effect on people and ecosystem (people won't get cool breeze)
	Surface water quantity	Shortage of water for consumptive and non consumptive users
	Groundwater	Drying of spring water sources lying in tunnel alignment and its vicinity
	Landslide/erosion and sedimentation	The area is landslide prone, may create casulties and damage to properties. The construction of roads, other project activities, and use of heavy equipment may .trigger landslides in the project influence areas
	Pollution	Air, noise, water and soil pollution, impact on agricultural land due to spoil depositto loss of productive agricultural land
	Water use (D/S)	Impact on agricultural land irrigated through Trishuli River in dewatered stretch, impact on water mills
	Land Use	Land use change resulting to loss of productive .agricultural land, land, pasture/grass land etc

VEC components	components-VEC Sub	Concern
Biological Environment	Terrestrial Ecosystem/Vegetation	Pressure on forest and more deforestation Ecological imbalances in d/s of dam Loss of plants (due to land use change , spoil deposition, impact of pollutiion, lack /inadequate volume of irrigation water, loss of forested ecosystem which is already dwindling, loss of valuable plants (like medicinal). Reduciton of grazing land, fodder, and impact on livestock production
	Wildlife and Wildlife Habitats	Habitats already fragmented and wildlife are declining, chances of wildlife entering the settlement due to construction of passage (bridge) over the River and .deforestation
	habitats Fish and fish	Impact on fish due to dam construciton and impact due to dewatered zone
-Socio economic and Cultural Environment	economic-Socio	Illegal harvesting and trade of medicinal plants, valuable herbs, contraband items due to accessibility and influx of people. Likely exploitation of children and women Loss of land for development by projects has a serious implication on the local food security apart from rehabilitation and resettlment of the affected people. occurenace of –Implication on community health unkonwn new diseases e.g diseases caused by mosquito bite and communicatble diseases Influx of labors in projects and impact on infrastructures, implication on the service facilities – water supply, health, education, etc; Implication on law and order; Increase in ill social practices/behavior (gamblimg, alcholism, prosititution etc) Increase price of commodities infrastructures due to influx of people Impact on local .from outside Outside effects on traditional practices, belief, culture of Tamanag commuity (majore ethinic group in the community) and chances of identity crisis in later stages Social conflicts

Outcomes of FGD at Haku Besi, Haku VDC

VEC components	components-VEC Sub	Concern
Physical Environment	Groundwater	Drying of spring water sources lying in tunnel alignment and its vicinity
	Landslides/erosion	The project influence area is situated in old landslides; this may trigger due to project related construction activities. There is a possibility of wash out of houses/community structures by landside debris during construction
	Drying up of spring sources	Due to construction of tunnel, the spring sources lying in tunnel alignment may dried up
	Earthquake	This is very uncertain and if occurred, there will be more devastation.
	Land	Agricultural and other land use will be reduced resulting in loss of productivity and unavailability of land for future planning and rational use even if required in future. There will be non-availability of land even for graveyard.
	Landslide/erosion and sedimentation	prone, might have high risk to The area is landslide .human and property
	Pollution	Air, noise, water and soil pollution, impact on agricultural land due to spoil depositto loss of productive agricultural land
	Water supply	As there is limited source of water, the drying of springs and influx of people will have water scarcity in the area
	Land Use	Land use change resulting to loss of productive .agricultural land, land, pasture/grass land etc
Biological Environment	Terrestrial Ecosystem/Vegetation	Loss of NTFP and chances of promotion of illegal trading of such items Fragmentation of forest, deterioration of forest quality, Pressure on forest and more deforestation, Loss of plants (due to land use change , spoil deposition, impact of pollutiion, lack /inadequate volume of irrigation water, loss of forested ecosystem which is already dwindling, loss of valuable plants (like medicinal). Reduciton of grazing land, fodder, and impact on livestock production
	Wildlife and Wildlife Habitats	wildlife are declining, Habitats already fragmented and chances of wildlife entering the settlement due to construction of passage (bridge) over the River and .deforestation Risk of attacks by wild animals to humans and domestic animals Impacts on crops due to wild animals
	fish habitats Fish and	Impact on fish due to dam construciton and impact due to dewatered zone, non availability of fish as a .supplementary food
-Socio economic and	economic-Socio	Possibilities due to casualties (more road accidents and other casualties) and natural calamities will be high in

VEC components	components-VEC Sub	Concern
Cultural Environment		project influenced area as compared to other region. Demand for share in hydropower projects for local people like offered by Chilime Hydropower Project. Shortage of labor, disparity in wages Shortage of water and create water scarcity and may invite sanitation problems Illegal harvesting and trade of medicinal plants, valuable herbs, contraband items due to accessibility and influx of people. Price of locally produced commodities (organic vegetable, crops, livestock)will increase and imported and impure products will dominate the market Non availability of agricultural land/limited agricultural land will have impact on food security Increase in ill social practices/behavior (gamblimg, alcholism, prosititution etc) Deteriorate safety and security in hydropower project influenced areas.

Outcomes of FGD Conducted at Office of District Development Committee, Dhunche VDC

VEC components	components-VEC Sub	Concern
Physical Environment	Disaster	Many types of project induced disasters like landslides, fire etc (with high probability of risk), and associated natural calamities
	Groundwater	Drying of spring water sources lying in tunnel alignment and its vicinity
	D/S release	D/S release must be quantified and ensured. The D/S release during the festivals and special religious days should be enough to meet such religious demands even during dry season.
	Muck/Debris	Due to lack of land muck and debris management is a big issue in hydropower projects in Trishuli basin so muck is not managed properly. Improper dumping has caused impact on land, River.
	Drying up of spring sources	Due to construction of tunnel, the spring sources lying in tunnel alignment may dry up
	Land Availability	Agricultural and other land use will be reduced resulting in loss of productivity and unavailability of land for future planning and rational use even if required in future. There will be non availability of land even for needful purpose in future.
	ion in RiverSedimentat	Due to project related activities and landslides, the sediment load in River may increase
	Pollution	Air, noise, solid waste (including toxic waste) , water and soil pollution, impact on agricultural land due to spoil depositto loss of productive agricultural land

VEC components	components-VEC Sub	Concern
	Water supply	As there is limited source of water, the drying of springs and influx of people will have water scarcity in the area and in district headquarter like Dhunche and nearby small towns/settlements
	Use Land	Land use change resulting to loss of productive .agricultural land, land, pasture/grass land etc
Biological Environment	Impact on Langtang National Park (LNP)	The hydropower projects in vicinity of LNP may have direct impact. Previously the River was protecting the national park, now due to construction of bridges and roads, the people have direct access to the national park and possibility of encroachment and other illegal activities will be high. Need more pressure and resources for security due to increased mobility of people and associated risks
	Community Forestry	Due establishment of hydropower project facilities, the resources of community forestry are cleared (trees, NTFPs etc) The people dependent to community forestry for the resources will deprive from such facilities, so an alternative means for fuel and fodder should be arranged. Deteriorate security of community forest due to mobility of people and vehicles of hydropower projects
	Terrestrial Ecosystem/Vegetation	Loss of tress and vegetation (huge number of trees needs to be chopped in hydropower projects, in many instances more trees than predicted in EIA were found removed during the construction). Even there is a tendency to show less number of trees to be cut during EIA stage and later during implementation stage actual required is more than that predicted earlier. Deforestation due to influx of people, poor monitoring and control by the hydropower project Illegal harvesting and trading of forest products
	Wildlife and Wildlife Habitats	Habitats already fragmented and wildlife are declining, chances of wildlife entering the settlement due to construction of passage (bridge) over the River and .deforestation
	Fish and fish habitats	impact due Impact on fish due to dam construciton and to dewatered zone, decline/extinction of certain fish .species
-Socio economic and Cultural Environment	economic-Socio	- Demand for shares in hydropower projects by local affected people of the VDC/district - Disputes related to contracts, jobs, and associated activities - Possibilities of more casualties (more road accidents and other casualties) and natural calamities will be high in project influenced area as compared to other region. - Shortage of labor, disparity in wages - Shortage of water and create water scarcity and may invite sanitation problems

VEC components	components-VEC Sub	Concern
		- Illegal harvesting and trade of medicinal plants, valuable herbs, contraband items due to accessibility and influx of people. - Price of locally produced commodities (organic vegetable, crops, livestock)will increase and imported and impure products will dominate the market - Non availability of ag land/limited agricultural land will have impact on food security Increase in ill social practices/behavior (gamblimg, alcholism, prosititution, girl trafficking etc) Deteriorate safety and security in areas

Outcomes of FGD Conducted at Grang-3, Ramche VDC

VEC components	components-VEC Sub	Concern
Physical Environment	Landslides/Erosions	The area is landslide prone, very unstable. The activities associated with hydropower projects may trigger issues related to landside
	Drying up of springs	The construction of tunnel may dry up spring sources lying in alignment and its vicinity
	Land	Issues related to less land availability/less land holding, less production, land fragmentation,
	Spoil and muck management	Poor management of spoil and its impact on land, water, and forest
	Infrastructures	Infrastructures like road, buildings will create more disturbance to the natural settings resulting in disasters.
	Pollution	The hydropower project in region create more air, noise, soil pollutions in nearby settlements, vehicle in route to project and in project influenced areas.
Biological Environment	Community Forestry	Due establishment of hydropower project facilities, the resources of community forestry are cleared (trees, NTFPs etc) The people dependent to community forestry for the resources will deprive from such facilities, so an alternative means for fuel and fodder should be arranged.

VEC components	components-VEC Sub	Concern
	Terrestrial Ecosystem/Vegetation	Loss of tress and vegetations due to project related activities, Forest fire due to increased mobility Deforestation and illegal harvesting of tress and NTFP from forest and national parks
	Wildlife and Wildlife Habitats	Loss of wildlife, habitat fragmentation
	Fish and fish habitats	Impact on fish due to dam construciton and non .availabiilty of fish
-Socio economic and Cultural Environment	economic-Socio	Pressure on local infrastructure due to increase of people from outside. Demand for shares in hydropower projects by local affected people of the VDC/district Use of more inorganic products, fertilizers and pesticides (introduction of harmful chemicals in environment)to grow more in limited areas and for more production Disputes related to contracts, jobs, and associated activities Possibilities of more casualties (more road accidents and other casualties) and natural calamities will be high in project influenced area as compared to other region. Non availability of ag land/limited agricultural land will have impact on food security Increase in ill social practices/behavior (gamblimg, alcholism, prosititution, girl trafficking etc) More violance and unrest in projet influenced areas

List of participants in the FGDs

(District): Rasuwa
(VDC): Haku (Ward No): 9
(Name o place): Mailung Besi (Date) 2070/10/11 (25 Jan 2014)

S.N	Name	Address	Age
1.	Eeman Tamang	Haku -9	21
2.	Bhim Bahadur Kumal	Bidur Municipality 5	52
3.	Gonda Tamang	Haku -2	40
4.	Durga Bahadur Tamang	Haku -9	35
5.	Sunita Tamang	Haku -9	27
6.	Pancha Bahadur Tamang	Haku -9	47
7.	Man Bahadur Tamang	Dada Gaun 7	45
8.	Eenam Tamang	Haku -9i	26
9.	Bipana Tamang	Haku -9	25
10.	Shrijana Tamang	Haku -9	29
11.	Dhan Maya Tamang	Haku -9	21
12.	Om Bahadur Tamang	Haku -9	24
13.	Dawa Mingma Tamang	Haku -9	24
14.	Suku Maya Tamang	Haku -9	44
15.	Sabina Tamang	Haku -7	20
16.	Dawa Budhi Tamang	Haku -9	23
17.	Sherpa Tamang	Haku -5	75
18.	Birat man Tamang	Haku -9	25
19.	Bir Tamang Tamang	Haku -9	30
20.	Kripa Sanga Tamang	Haku -9	38
21.	Ganga Maya Tamang	Haku -9	66
22.	Shrijana Tamang	Haku -9	25

(District): Rasuwa
(VDC): Dhunche (Ward No): 1 and 2
(Name o place): Thade (Date) 2070/10/11 (25 Jan 2014)

S.N	Name	Address	Age
1.	Kalu Tamang	Dhunche-1 Thade	64
2.	Dorje Tamang	Dhunche-1 Thade	18
3.	Dolma Ghale	Dhunche-2 Thade	23
4.	Lanam Ghale	Dhunche -2 Thade	32
5.	Nema Ghale	Dhunche -2 Thade	30
6.	Kamisa Ghale	Dhunche -2 Thade	45
7.	Mina Shrestha	Dhunche -2 Thade	22
8.	Ashmita Shrestha	Dhunche -2Thade	20
9.	Kami shekar Tamang	Dhunche -1 Thade	22
10.	Dawa Senam Tamang	Dhunche -2 Thade	35
11.	Santosh Ghale	Dhunche -2 Thade	25
12.	Rinchen Dawa Tamang	Dhunche -1 Thade	45

13.	Urpaa Ghale	Dhunche -2 Thade	30
14.	Suku Ghale	Dhunche -1 Thade	35
15.	Dawa Gumfu Tamang	Dhunche -1 Thade	26
16.	Sonam Chiring Tamang	Dhunche -1 Thade	28
17.	Waisal Ghale	Dhunche -1 Thade	60
18.	Lama Larkhu	Dhunche -1 Thade	22
19.	Wang Jalbo Ghale	Dhunche -1 Thade	45
20.	Santa Bahadur Ghale	Dhunche -2 Thade	28
21.	Farphu Gyalfu Ghale	Dhunche -1 Thade	70
22.	Sonam Gyalfu Ghale	Dhunche -1 Thade	21
23.	Man Bahadur Ghale	Dhunche -1 Thade	24
24.	Bimal Ghale	Dhunche -1 Thade	26
25.	Butti Tamang	Dhunche -1 Thade	46
26.	Suku Tamang	Dhunche -1 Thade	44
27.	Wangcheng Tamang	Dhunche -1 Thade	50
28.	Lamanarfu Tamang	Dhunche -2 Thade	16
29.	Bishal Ghale	Dhunche -1 Thade	15
30.	Tenjing Ghalmu Ghale	Dhunche -2 Thade	60

(District):Rasuwa
(VDC): Haku (Ward No):3,2
(Name o place): Haku Besi and Sano Besi (Date) 2070/10/12, 26 Jan, 2014

S.N	Name	Address	Age
1.	Som Bahadur Tamang	Haku-2	22
2.	Nurup Sambo Tamang	Haku-4	48
3.	Puri Yelmu	Haku-3	27
4.	Pimba Tamang	Haku-3	52
5.	Faisam Tamang	Haku-2	25
6.	Furwa Tamang	Haku-3	70
7.	Buddha Maya Tamang	Haku-3	29
8.	Chirinh Devi Tamang	Haku-3	22
9.	Manjit Tamang	Haku-3	24
10.	Manmaya Tamang	Haku-3	43
11.	Buddhiman Tamang	Haku-3	19
12.	Lama Dorje Tamang	Haku-3	28
13.	Kep Chiring Tamang	Haku-3	34
14.	Nim Geljung Tamang	Haku-3	60
15.	Govinda Tamang	Haku-3	14
16.	Sherchawanga Tamang	Haku-3	18
17.	Dawa Tamang	Haku-3	48
18.	Didtha Tamang	Haku-3	54
19.	Sangamendo Tamang	Haku-3	25
20.	Buddha Tamang	Haku-3	18
21.	Milan Tamang	Haku-2	19
22.	Falam Tamang	Haku-3	50
23.	Faichiring Tamang	Haku-3	60

S.N	Name	Address	Age
24.	Sonam Tamang	Haku-3	23
25.	Kami Tamang	Haku-3	60
26.	Upendra Tamang	Haku-3	38
27.	Dawa Kesung Tamang	Haku-3	39
28.	Nima Kesung Tamang	Haku-3	37
29.	Nimgel Tamang	Haku-3	60
30.	Laji Sangwa Tamang	Haku-3	48
31.	Sonam Tamang	Haku-3	33
32.	Mendo Tamang	Haku-3	42
33.	Gyanghing Tamang	Haku-3	48
34.	Chiring Dolma Tamang	Haku-3	30
35.	Sangh Buddhi Tamang	Haku-3	26
36.	Budhi devi Tamang	Haku-3	20
37.	Chingwangomo Tamang	Haku-3	21
38.	Kami Dolmo Tamang	Haku-3	22
39.	Mijong Tamang	Haku-3	34
40.	Namin Tamang	Haku-3	45
41.	Mindo sang Tamang	Haku-3	41
42.	Nima Yangiching Tamang	Haku-3	38
43.	Dawa sambo Tamang	Haku-3	42
44.	Chimpu Tamang	Haku-3	50
45.	Sano Chimpu	Haku-3	53
46.	Wang Rasi Tamang	Haku-3	39
47.	Dawa Lama	Haku-3	70
48.	Sango B.Ka	Haku-3	80
49.	Suk Bahadur B.Ka	Haku-3	35
50.	Kamini Tamang	Haku-3	20

(District):Rasuwa
(VDC): Dhunche (Ward No): 5
(Name o place): Dhunche DDC Building (Date) 2070/10/13, (27 January, 2014)

S.N	Name	Address	Age
1.	Punya Prasad Poudel	District Forest office	36
2.	Keshav Chanda Lal Das		54
3.	Binod kumar Poudel	FECOFUN-Rasuwa	30
4.	Nalraj Adhikari	DDC	40
5.	Basudev Neuapne	Nepal agricultural Council	36
6.	Sukdev Gautam	Gharelu Samitti	38
7.	Mukti Ghimire	Nepal Redcross	35
8.	Bodhraj Baral	Agriculture Investigation Centre	34
9.	Yogendra Yadav		50
10.	Bhisma Bahadur Basnet	District Agricultural development Office Rasuwa	30
11.	Sandhu Regmi	DDC-Rasuwa	26

S.N	Name	Address	Age
12.	Prem Bahadur Basnet	District administration Office	45
13.	Sarswoti Neupane	Journalist Trishuli Prabaha	23
14.	Sandhya Rajeshwori Singh	Women and Children Office-Rasuwa	50
15.	Shiv Kumar Parajuli		35
16.	Tir Bahadur Gurung	Nepali Congress-Rasuwa	
17.	Dhurbaraj Paneru	Land Revenue office	55
18.	Gautam Rimal	District Administration	34
19.	Shan Raj Pandey	District Development Committee	49
20.	Rajendra Prasad Niroula	District Forest Office	52
21.	Bishnu Prasad Acharya	NGO Fed-Rasuwa	35
22.	Ramesh Basnet		42
23.	Hemshankar Bastola		39
24.	Lal Bahadur Aale	Dimega-Rasuwa	31
25.	Thakindraraj Dahal	Saramthali VDC	34
26.	Ganga Devi Sunar	Ramche and Haku	30
27.	Subash Poudel	VDC Secretary	32
28.	Uttam Kumar Katuwal	Chilime VDC Secretary	40
29.	Dr.Ramesh kumar kharel	District Health Office	50
30.	Anurag Trivedi	District Administration Office	
31.	Deepak Kumar shrestha	Brabal Barack	35
32.	Om Raj Dhungana	District Administration Office	42
33.	Pisang Nupung Tamang		25
34.	Dawa Tasi Tamang		37
35.	Manoj Bhusal		25

(District): Rasuwa
(VDC): Ramche (Ward No): 3
(Name o place): Grang (Date) 2070/10/13 (27 Jan 2014)

S.N	Name	Address	Age
1.	Sete Tamang	Ramche -3	40
2.	Risang Lotcheng	Ramche-3	56
3.	Ralpa Sangwa	Ramche-3	30
4.	Kami Sedar Tamang	Ramche-3	30
5.	Mendu Tamang	Ramche-3	30
6.	Pemba Tamang	Ramche-3	27
7.	Kancha Tamang	Ramche-3	55
8.	Lawang Mindro	Ramche -3	45
9.	Mindir Wang	Ramche -3	55
10.	Anggi Tamang	Ramche -3	35
11.	Temba Sherpa	Ramche -3	55

12.	Minam Buchhi	Ramche -3	35
13.	Sahilee Tamang	Ramche -3	50
14.	Chesang Tamang	Ramche -3	80
15.	Nirpu Lopche Tamang	Ramche -3	55
16.	Asang Kripa Tamang	Ramche -3	70
17.	Sete Lopchen Tamang	Ramche -3	35

Annex 3: Spatial indicators of cumulative impacts

Pressure Indicators for the VEC 'Water Resources'

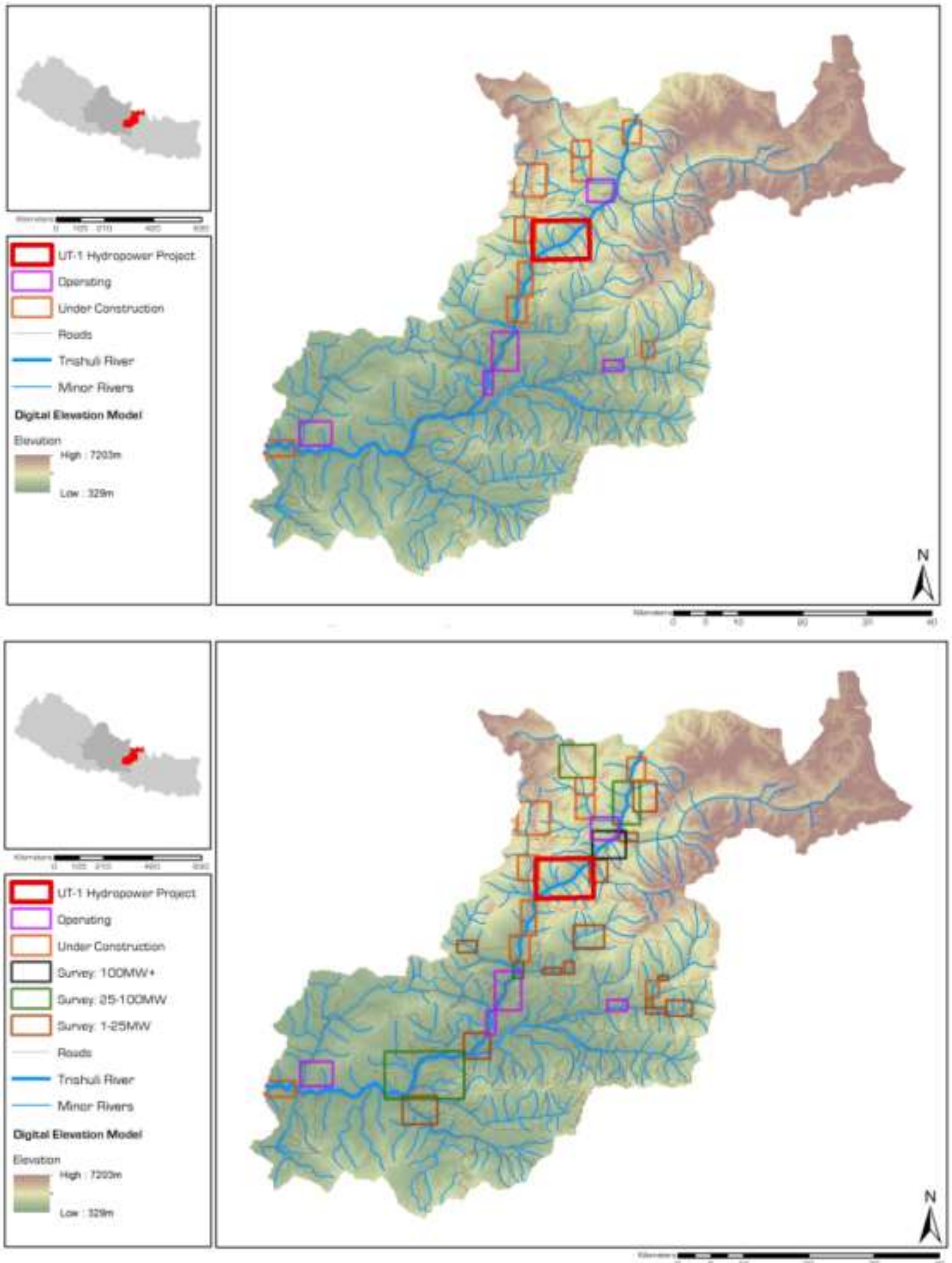
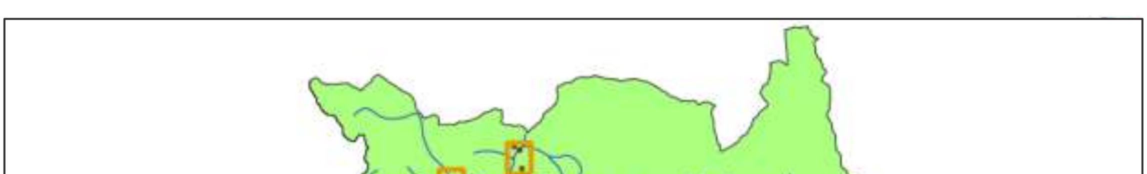


Figure A3-1: River length under reduced flow for Scenarios 1 (above) and 2 (below)



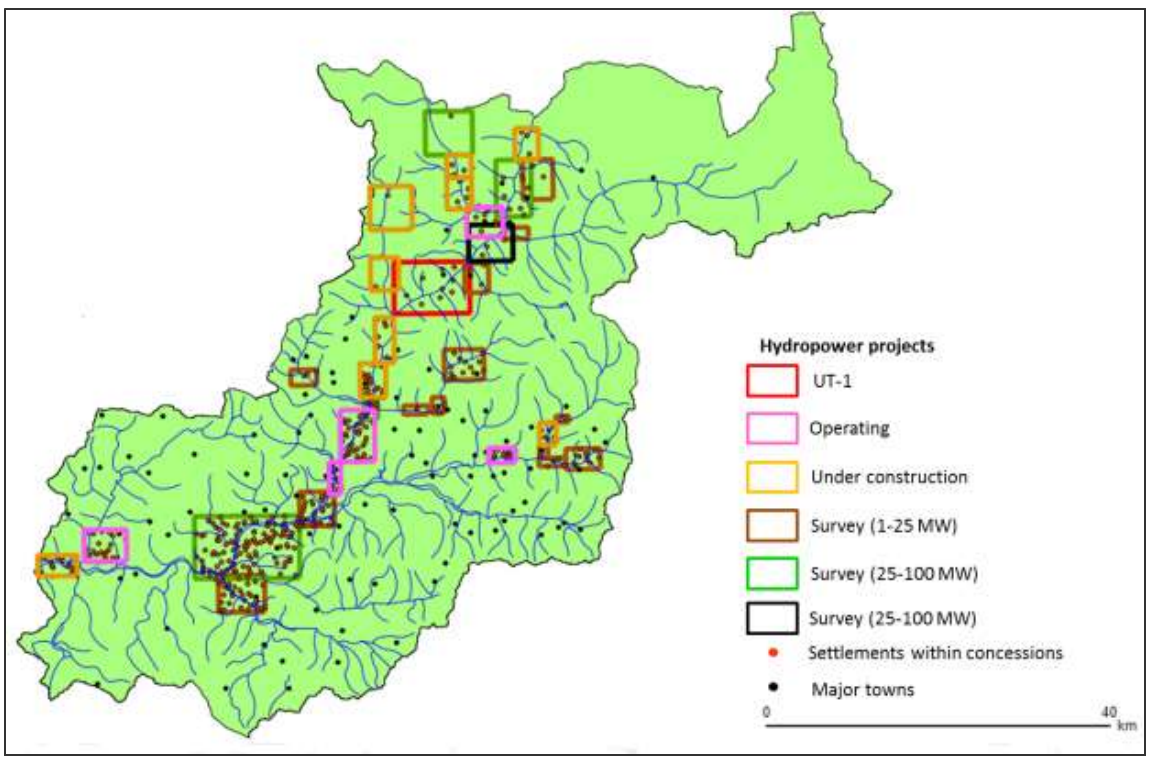
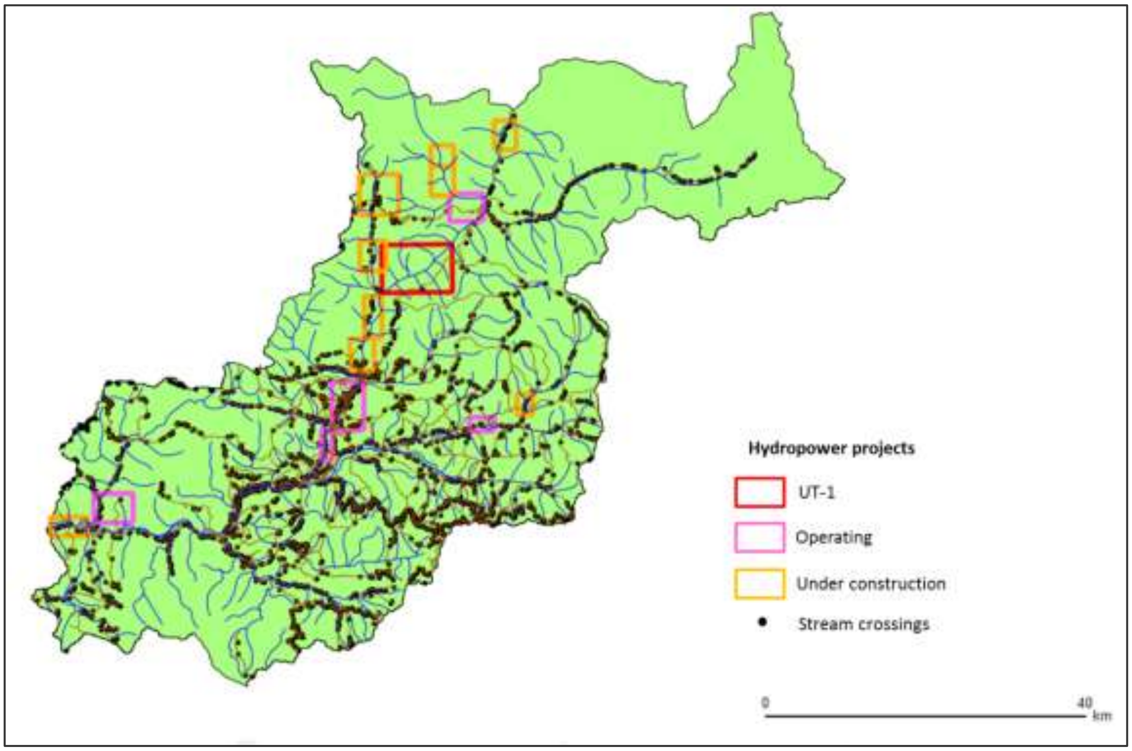


Figure A3-2: Presence of settlements (water users) within the concession areas under Scenarios 1 (above) and 2 (below)

Pressure Indicators for the VEC 'Fish and Aquatic Habitats'



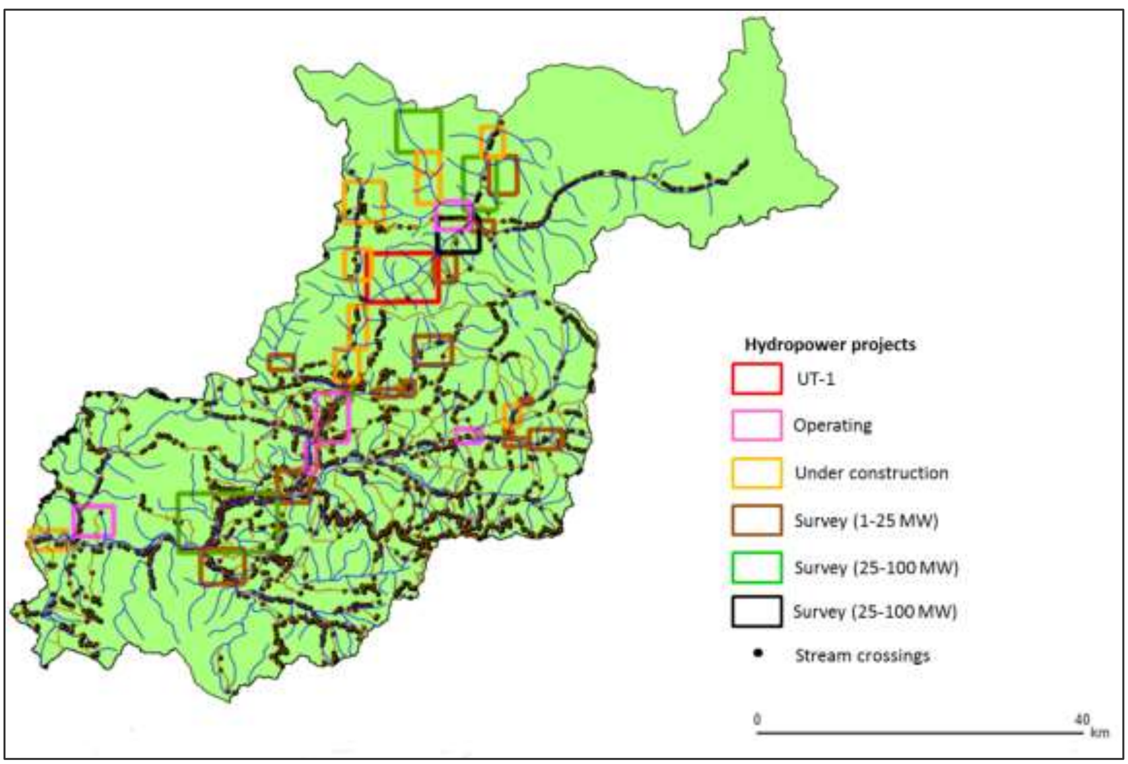


Figure A3-3: Stream cross density under Scenarios 1 (above) and 2 (below)

Pressure indicators for the VEC 'Erosion and Sedimentation Processes'

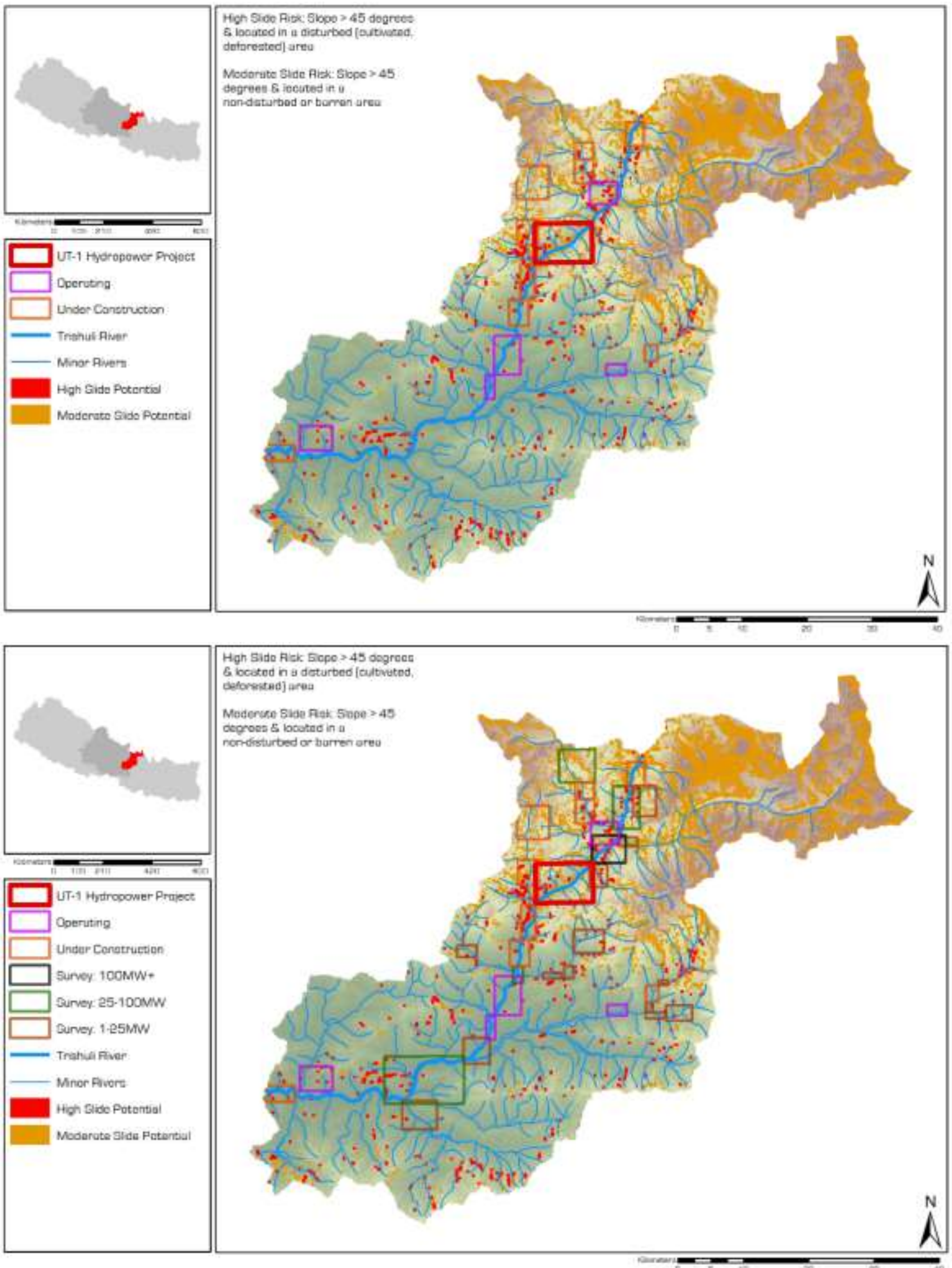
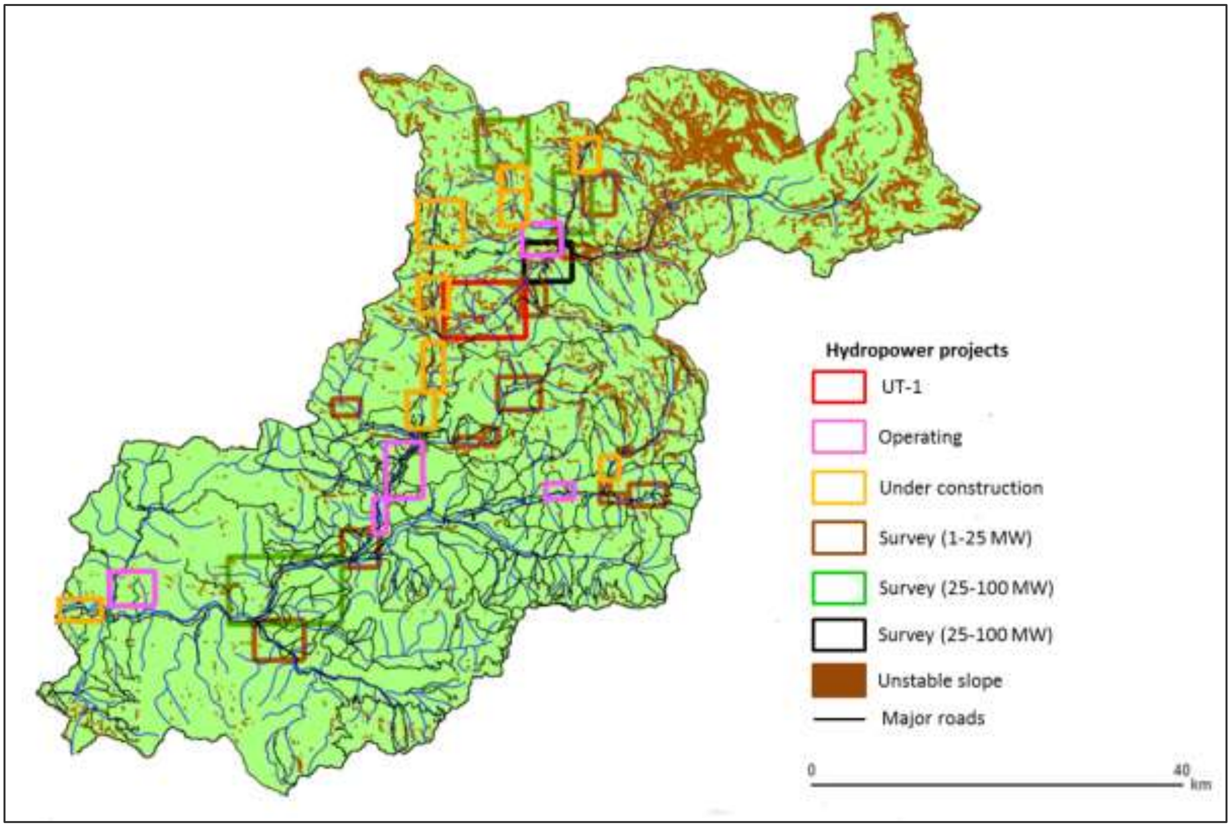


Figure A3-4: Landslide risk under Scenarios 1 (above) and 2 (below)



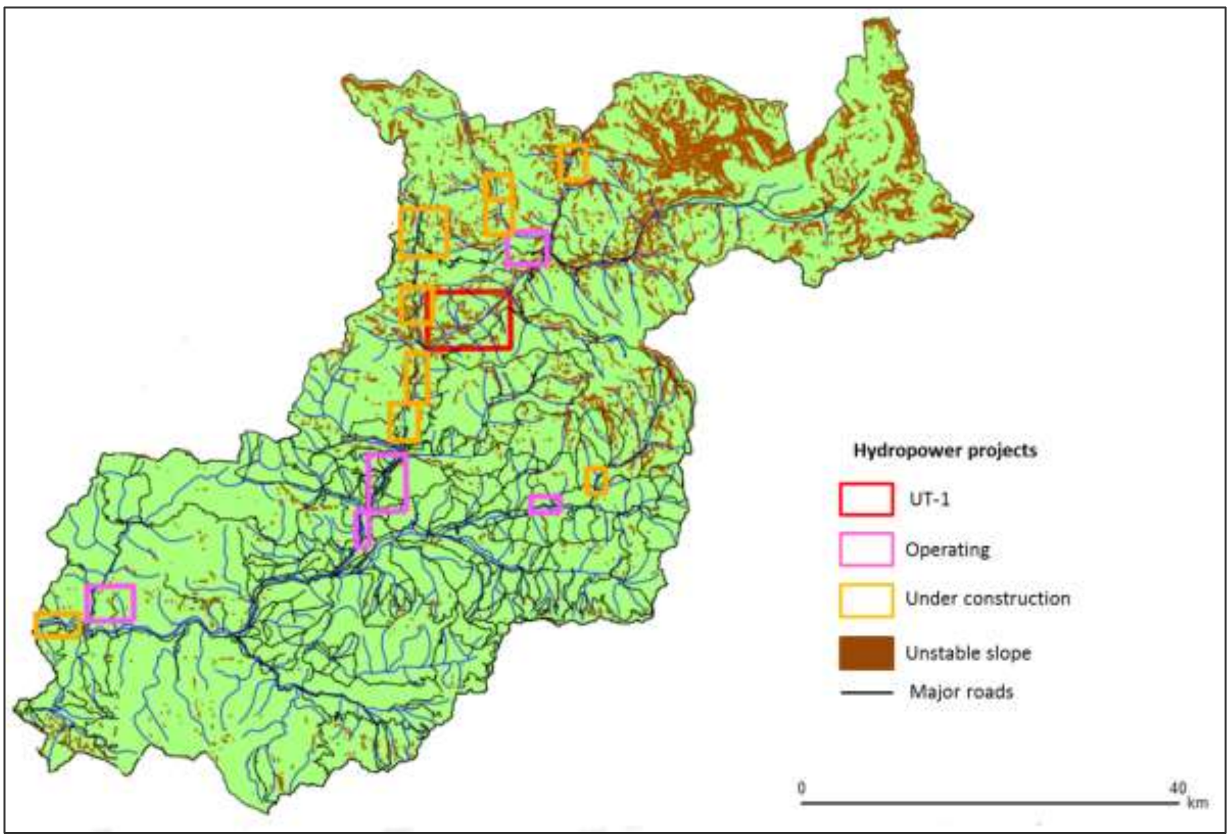
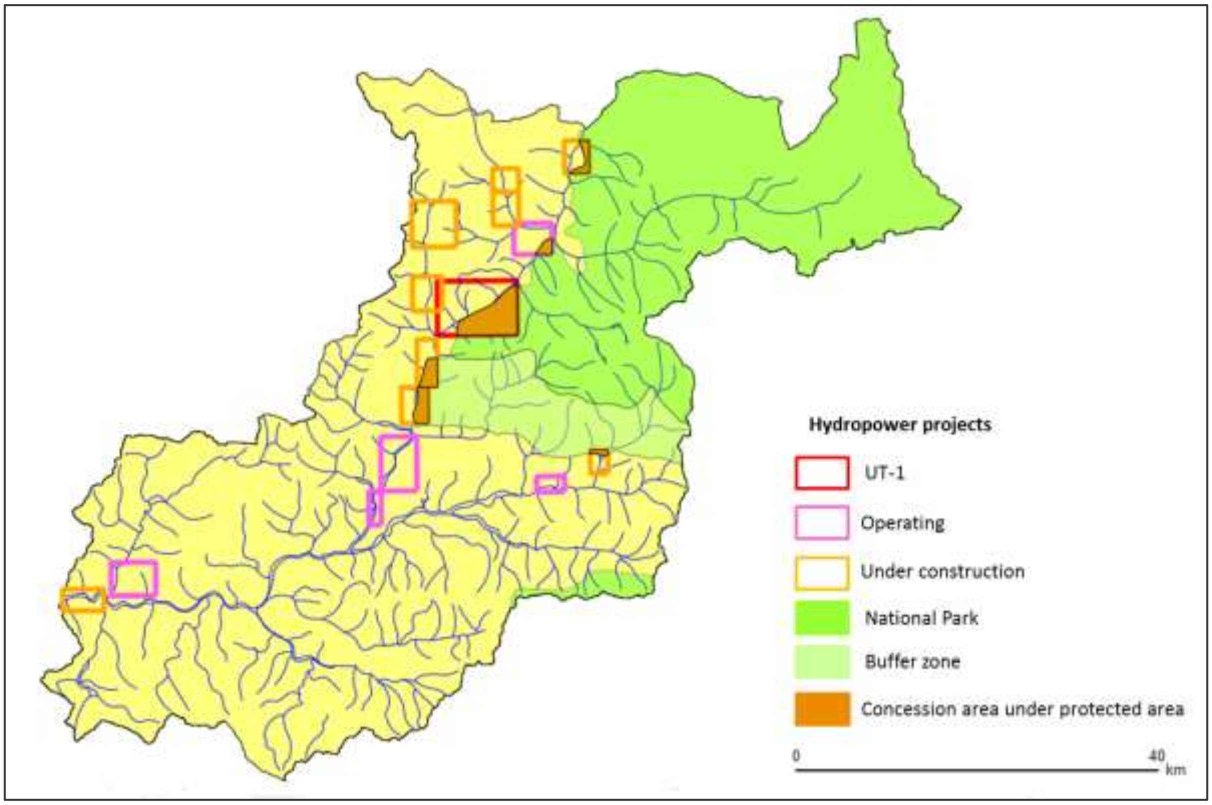


Figure A3-5: Roads network and unstable slope under Scenarios 1 (above) and 2 (below)

Pressure indicators for the VEC 'Terrestrial Habitats'



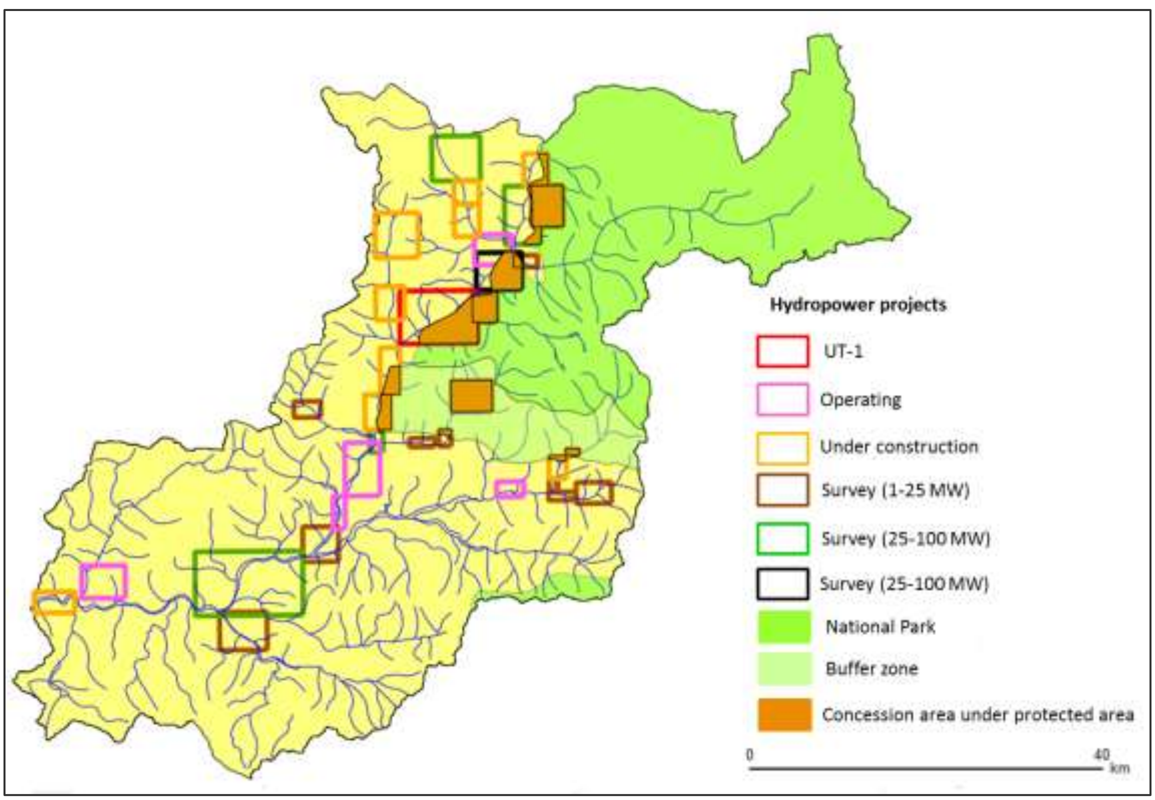


Figure A3-6: Encroachment on protected areas under Scenarios 1 (above) and 2 (below)

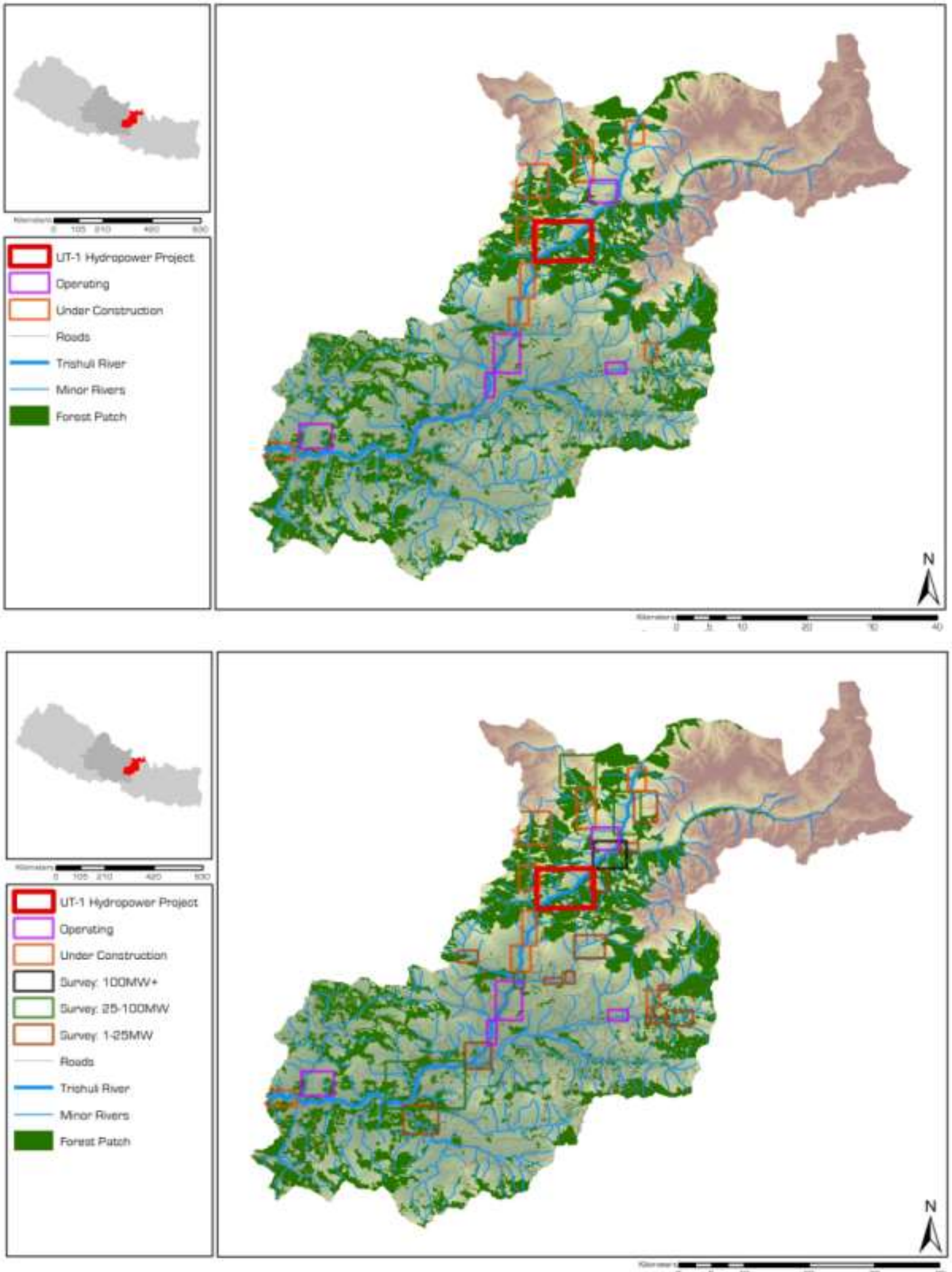


Figure A3-7: Pressure on forest land under Scenario 1 (above) and Scenario 2 (below)

Pressure indicators for the VEC 'Use of Natural Resources'

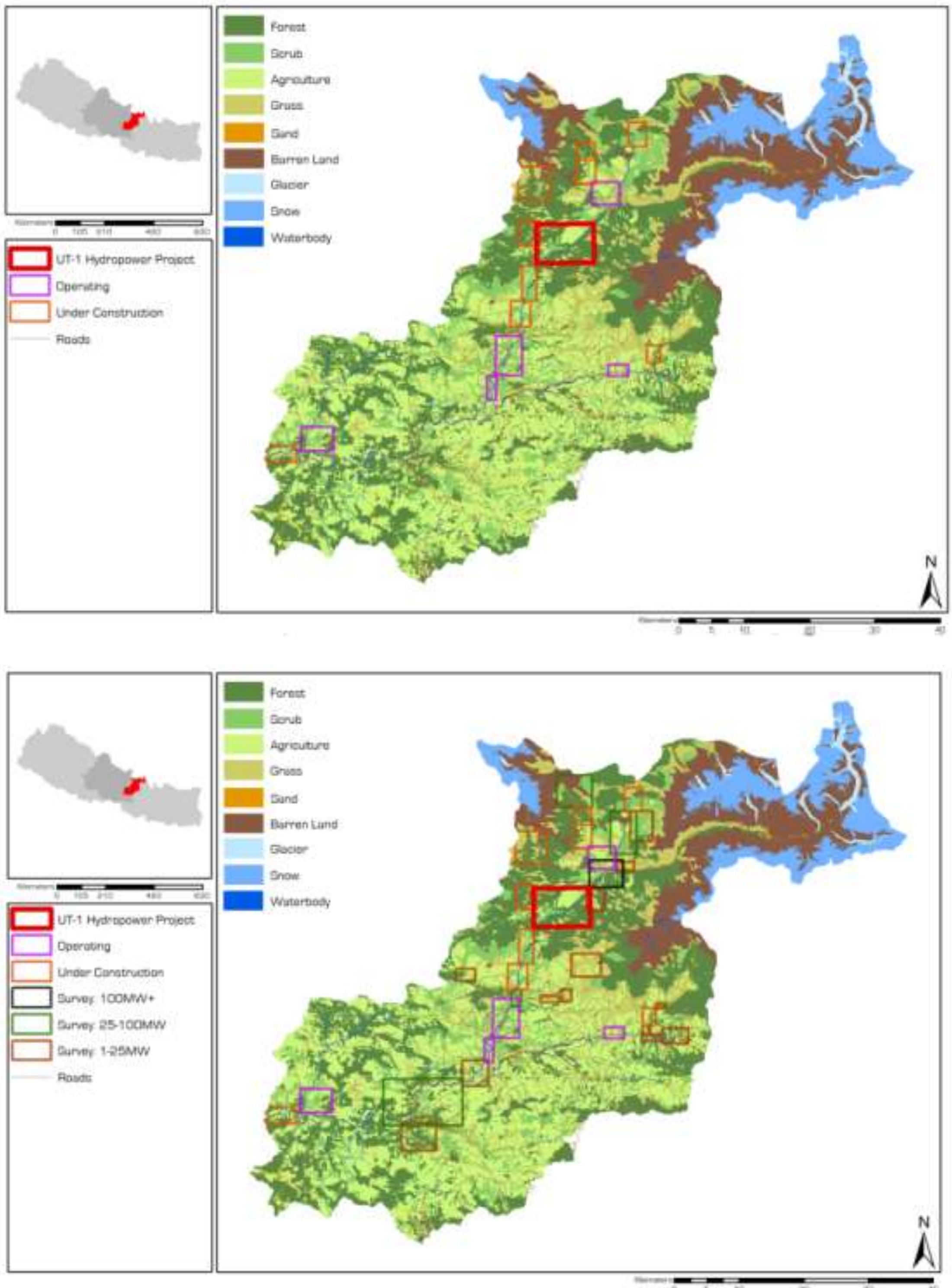


Figure A3-8: Land uses under within concession areas under Scenario 1 (above) and 2 (below).
(Note: Only agricultural and forest land use haven considered for the evaluation of pressures on this VEC)

Pressure indicators for the VEC 'Cultural and Religious Sites'

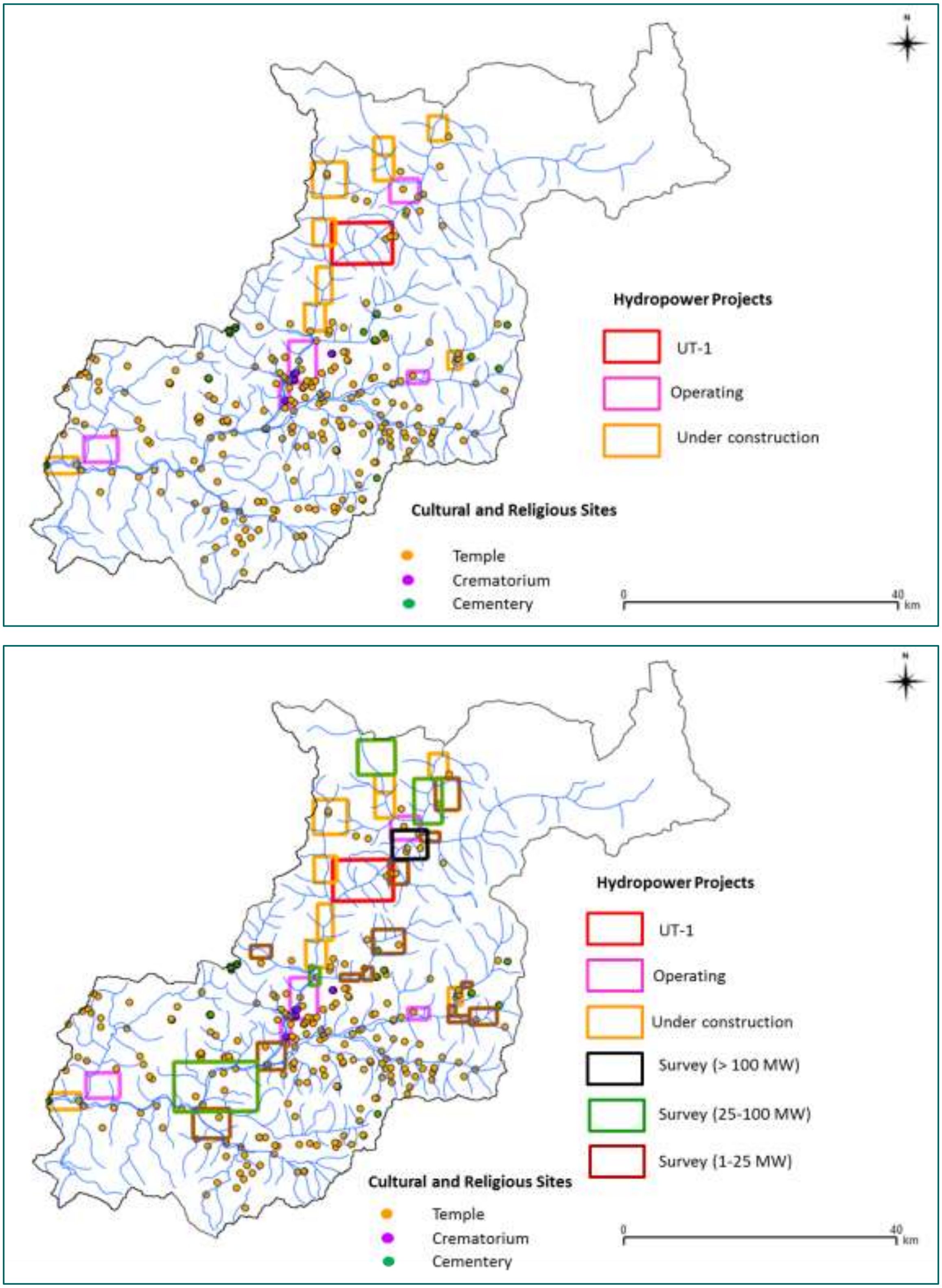


Figure A3-9: Presence of cultural/religious sites under Scenarios 1 (above) and 2 (below)

Appendix D: Final Report