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UAHEP Cumulative Impact Assessment

Appendix E

January 2024

Disclaimer: *This Upper Arun Hydro-electric Project's draft Environmental and Social Impact Assessment (ESIA) was prepared by UAHEL broadly following Good International Industry Practices (GIIP) as those required under the Bank's Environmental and Social Framework (ESF).*

The review of this ESIA is a key part of the Bank's due diligence process and is currently ongoing. This draft ESIA may still contain gaps to fully address all pertinent E&S issues in the project. Any gaps will be covered through supplemental studies, assessments, and/or plans that will be completed in a reasonable timeframe to ensure compliance with the ESF.

For the benefit of potentially project affected people (PAP) and other interested stakeholders, and in alignment with the Bank's Policy on Access to Information this draft ESIA is being disclosed as soon as it became available. This disclosure, however, should not be considered as a final clearance of the ESIA by the World Bank.

26 January 2024

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Acronyms and Abbreviations

ADB	Asian Development Bank
BOOT	Build, Operate, Own, and Transfer
BS	Bikram Sambat (Nepali Calendar)
CBS	Central Bureau of Statistics
CCI	Chamber of Commerce and Industry
CEDB	Commerce and Economic Development Bureau
CF	Community Forest
CFPCC	Central Fisheries Promotion and Conservation Centre
CFUG	Community Forest Use Group
CH	Critical Habitat
CIA	Cumulative Impact Assessment
CR	Critically Endangered
DAI	Direct Area of Influence
DCC	District Coordination Committee
DEM	Digital Elevation Model
DFID	Department for International Development
DFRS	Derbyshire Fire and Rescue Service
DHM	Department of Hydrology and Meteorology
DKSHEP	Dudhkoshi Storage Hydropower Project
DNA	Deoxyribonucleic Acid
DNPWC	Department of National Parks and Wildlife Conservation
DoED	Department of Electricity Development
DOI	Department of Information
DPR	Detailed Project Report
DWIDP	Department of Water Induced Disaster Prevention
EBA	Endemic Bird Area
EFlow	Environmental Flow
EIA	Environmental Impact Assessment
EN	Endangered
EPA	Environmental Protection Agency
EPC	Energy Performance Contract
EPR	Environment Protection Rules
ERM	ERM-Siam Company Limited
ERMC	Environment and Resource Management Consultancy Limited
ESF	Environmental and Social Framework
ESIA	Environmental and Social Impact Assessment
ESS1	Assessment of Management of Environmental and Social Risks and Impact
FAO	Food and Agriculture Organization
FECOFUN	Federation of Community Forest Users Nepal
FGD	Focus Group Discussion
FPIC	Free, Prior and Informed Consent
FRB	Fisheries Research Branch
FS	Feasibility Study
GAP	Gender Action Plan
GBV	Gender Based Violence
GDP	Gross Domestic Product

GESI	Global Enabling Sustainability Initiative
GLOF	Glacial Lake Outburst Floods
GRM	Grievance Redressal Mechanism
HDI	Human Development Index
HDP	Hydropower Development Policy
HEP	Hydroelectric Project
HH	Household
HPP	Hydropower Project
IBA	Important Bird Area
IBAT	Integrated Biodiversity Assessment Tool
IBN	Investment Board Nepal
ICIMOD	International Centre for Integrated Mountain Development
IEE	Initial Environmental Examination
IFC	International Finance Corporation's
IKHPP	Ikhuwa Khola Hydropower Project
ILO	International Labour Organization
INGO	International Non-Governmental Organization
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
KAHEP	Kimathanka Arun Hydropower Project
KBA	Key Biodiversity Areas
KHARDEP	Kosi Hill Area Rural Development Programme
KV	Kilovolt
LC	Least Concern
LGU	Local Governance Unit
LLR	Land and Land Resources
LULC	Land Use and Land Cover
LUP	Land Use Plan
LUZ	Land Use Zone
MBNP	Makalu Barun National Park
ML	Magnitude
MoALD	Ministry of Agriculture and Livestock Development
MoE	Ministry of Energy
MoEWRI	Ministry of Energy, Water Resources and Irrigation
MoFE	Ministry of Forests and Environment
MT	Metric Ton
MW	Megawatt
NA	Not Applicable
NARC	National Agriculture Research Centre
NDC	Nationally Dalit Commission
NEA	Nepal Electricity Authority
NEFIN	Nepal Federation of Indigenous Nationalities
NERC	Nepal Electricity Regulatory Commission
NGO	Non-Governmental Organization
NPC	National Planning Commission
NPR	Nepalese Rupee
NT	Near Threatened
NTFP	Non-Timber Forest Product

ODA	Overseas Development Administration
OECD	Organisation for Economic Co-operation and Development
PFS	Pre-Feasibility Study
PPP	Public Private Partnership
PS	Performance Standard
QNNP	Qomolangma National Park
RAP	Resettlement Action Plan
RFFA	Reasonably Foreseeable Future Action
ROR	Run-of-River
RPGCL	Rastriya Prasaran Grid Co Ltd
SEP	Stakeholder Engagement Plan
SKSKI	Sun Koshi Sapta Koshi Investigation
ToR	Terms of Reference
TIP	Trafficking in Persons
TL	Transmission Line
UAHEP	Upper Arun Hydroelectric Project
UN	United Nations
UNDP	United Nations Development Programme
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
USAID	United States Agency for International Development
USD	United States Dollar
VDC	Village Development Committees
VEC	Valued Environmental, Social and Ecosystem Component
VU	Vulnerable
WAPCOS	WAPCOS Limited
WECS	Water and Energy Commission Secretariat
WUA	Water Users Association

EXECUTIVE SUMMARY

Introduction

The Project Terms of Reference (ToR) call for the preparation of a Cumulative Impact Assessment (CIA) for the Upper Arun Hydroelectric Project (UAHEP) and the Ikhuwa Khola Hydropower Project (IKHPP) in conjunction with the Environmental and Social Impact Assessment (ESIA). Accordingly, the ERM team has conducted a CIA for the UAHEP and IKHPP within the Arun River Basin in accordance with the International Finance Corporation’s (IFC's) *Good Practice Handbook on Cumulative Impact Assessment and Management* (IFC 2013).

The objective of the CIA is to assess the impacts of UAHEP and IKHPP, in combination with other existing and proposed hydroelectric projects (HEPs) and external stressors within the Arun River Basin. The specific objectives are to:

- Identify valued environmental, social and ecosystem components (VECs) that could be impacted cumulatively in areas potentially affected by the HEPs, including the UAHEP and IKHPP, considering input from stakeholders and the scientific community through a consultation process.
- Identify other existing and planned HEPs and associated transmission line and access road developments, other road developments, and external stressors (e.g., climate change and natural hazards) that could cumulatively impact VECs.
- Assess the potential cumulative impacts on VECs from past, existing, and planned HEPs, road developments, and other and external stressors.
- Recommend project-level as well as strategic planning-level recommendations for minimizing negative cumulative impacts and maximizing the positive impacts associated with hydropower development at a basin scale.

Scope of the CIA

The Arun River is the largest trans-Himalayan river passing through Nepal and also has the greatest snow and ice-covered area of any Nepalese river basin. The Arun River drains more than half of the area contributing to the Sapta Koshi river system. Overall, the Arun Basin covers an area of 30,041 km^2, of which 24,888 km^2 (83%) is situated in China and 5,153 km^2 (17%) in Nepal. The CIA Study Area (***Figure 1***) focuses on the Upper Arun River reach, and considers significant impacts in the upstream reach within the Tibet Autonomous Region (TAR) of China, as well as downstream towards its confluence with the Sapta Koshi.

Most of the projects identified within the boundary are hydropower, transmission line, and transportation projects. A limit of 10 years is adequate to frame the hydropower projects considered (as shown in ***Figure 1*** and detailed in **Section 5.3.1**) in this CIA, as it is assumed that these projects will be at least under construction within this period. The temporal extent of these impacts is longer, as HEPs typically have a long life expectancy. Hydropower projects are designed to operate for at least 50 years, and are expected to operate for 80 or more years, especially if they implement an effective sediment management strategy to minimize sediment deposition in the project reservoir. It is difficult to predict impacts with any certainty that far into the future; as such, the temporal scope of the CIA was established as a maximum 50-year timeframe.

The timeframe for potential hydropower project decommissioning is so far in the future as to make any impact assessment unreliable. Further, the transmission line and transportation projects will be maintained and repaired, but are unlikely to be decommissioned. For these reasons, decommissioning of these projects was not considered in this CIA.

Past, Future, and Reasonably Foreseeable Future Actions

Key past, present and future actions within the Arun Basin include hydropower, road infrastructure, agriculture, and sand and gravel extraction – as well as other external stressors (e.g., climate change and natural hazards) – as summarized below:

- *Hydropower*: Within the Arun River Basin there are 9 operating HEPs, 22 under construction (i.e., obtained construction license), 12 have applied for a construction license, and 17 have obtained a survey license, all of which total approximately 4,763 megawatt (MW).
- *Road infrastructur*e: The North-South Highway (Koshi Highway) connects India to China across the Himalayan Mountains in Nepal. The construction of the Koshi Highway will also use materials extracted from the Arun River. The 1,776 km Mid Hill Highway is under construction to connect east and west Nepal, and partially passes through the Arun Basin.
- *Agricultur*e: Agricultural is the predominant economic activity in the Koshi Hills (Sankhuwasabha, Bhojpur, Dhankuta, and Terhathum districts). The agricultural system is predominantly subsistence in nature, except in a few areas accessed by roads, where the intensive cultivation of vegetables is being practiced.
- *Sand and gravel extractio*n: Gravel, sand and stone are extracted from Shaba Khola, Sishwa Khola, and Nepa Khola and partly from the Arun River. The extracted materials are typically used within the district, for instance, for road construction.
- *Natural hazards and climate risk*s: Sankhuwasabha and Bhojpur districts are ranked as having "high" climate change vulnerability (which includes changes in rainfall and temperature, landslides, flooding, droughts, and glacial lake outburst floods) and Dhankuta is ranked as "moderate."

Valued Environmental and Social Components

Valued environmental, social, and ecosystem components (VECs) are defined as fundamental elements of the physical, biological, or socio-economic environment that are likely to be the most sensitive receptors to the cumulative impacts of other projects and stressors in combination with the proposed project. Using the results of stakeholder consultations, field surveys, data analysis, and literature review, the following seven VECs were selected for the CIA study: natural forest integrity, Makalu Barun National Park (MBNP), water resources, fish and aquatic habitat, river-based livelihoods, settlement, and social cohesion.

Summary of Cumulative Impacts on the Selected VECs

There would be significant adverse cumulative impacts on the river and communities if each of the 30+ planned HEPs in the Arun River Basin (***Table 5.3***) were constructed. These impacts would be further exacerbated by road and transmission line development, climate change, and natural hazards, which would be even more significant for vulnerable groups.

In general, hydropower projects that are on the main stem of the Upper Arun River (i.e., Kimathanka, Upper Arun, Arun-4) will affect the MBNP Buffer Zone and fish movement/migration. Projects on Upper Arun River tributaries, especially clear water tributaries, will affect important fish spawning areas and generally result in more forest clearing and impacts on ecosystem services per MW generated than large mainstem dams.

Hydropower projects located on the mid Arun River (i.e., Arun-3) will have more significant biological impacts, but similar social impacts on those projects on the Upper Arun. Projects on the lower Arun River (i.e., Lower Arun, Sapta Koshi) will likely have more significant physical, biological, and social impacts. Projects located on glacial fed tributaries will generally have fewer biological impacts than those located on clear water tributaries.

If the planned main stem hydropower projects are built with limited reservoir storage capacities (which appears to be the case, according to currently available information, with the exception of Sapta Koshi), there would likely be relatively small effects on flow regulation. More severe impacts would likely incur from fragmentation, which would be significant under a full development scenario of over 30 hydropower projects, and result in a significant reduction in river connectivity. Moreover, even a single dam on the main stem typically results in significantly higher fragmentation than dams on tributaries (Grill 2014). Moreover, a reduction in river connectivity could significantly impact on the ecological integrity of the Arun River network, which would negatively affect livelihoods, particularly of fishing-based livelihoods and vulnerable groups.

Cumulative Impact Significance

The focus of this CIA is to predict to what extent HEPs may contribute, in combination with the other proposed projects and activities selected for this assessment, to cumulative impacts on the selected VECs. The significance of cumulative impacts is considered for each VEC – the significance is not evaluated in terms of the magnitude of change, but in terms of VEC response and the resulting condition and sustainability. Cumulative impact significance definitions used in this CIA are:

- **Negligible** – VEC would not experience noticeable changes
- **Moderate** – VEC would experience noticeable changes, but within natural variations
- **Substantial** – VEC would experience changes beyond natural variation, but within its range of tolerance/resilience
- **High** – VEC would experience changes that would likely exceed the range of tolerance/resilience and the viability of the VEC would be threatened

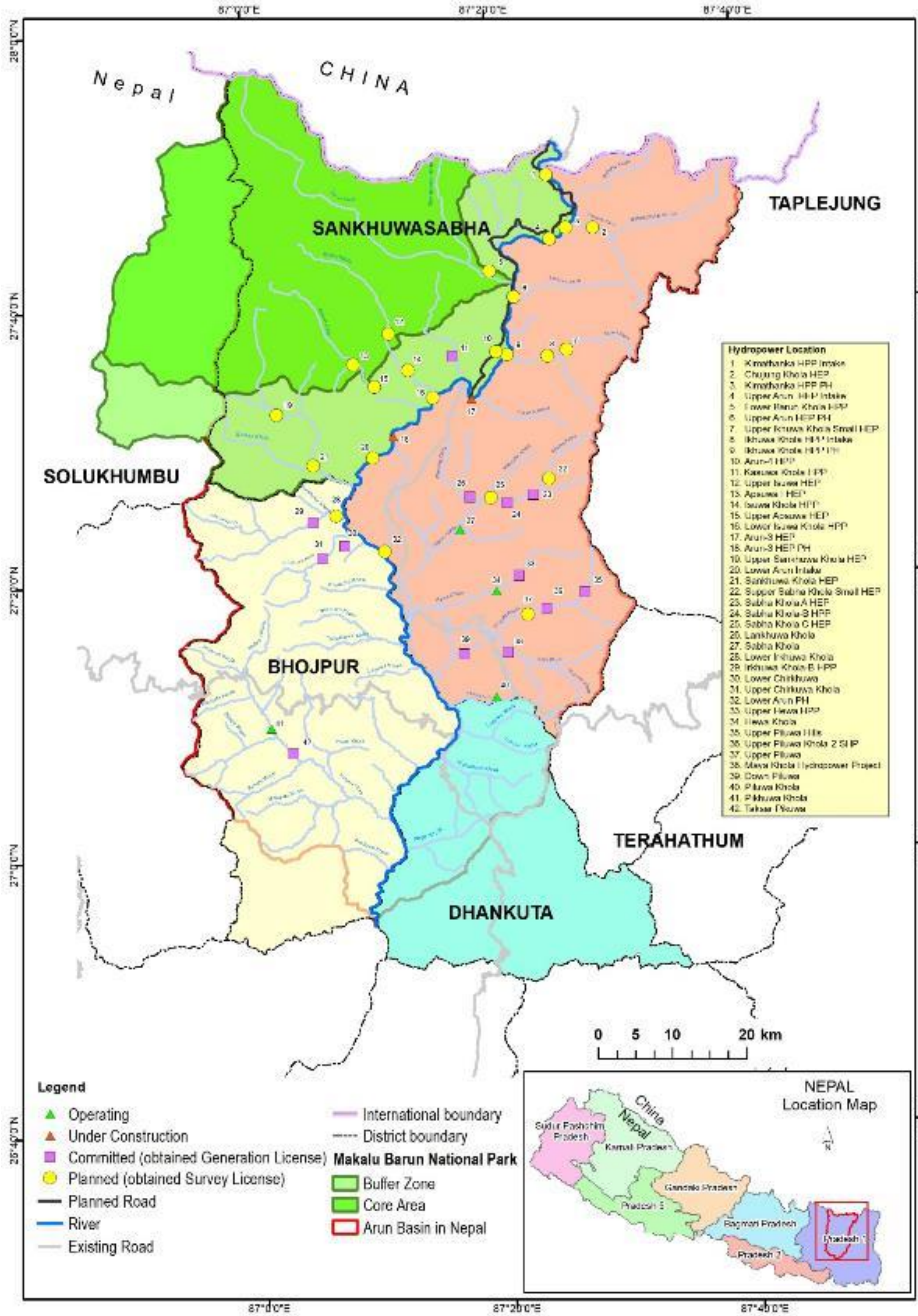
A summary of the cumulative impact significance for the selected VECs is provided in the ***Table 1.1*** below.

Table 0.1: Summary of Cumulative Impact Significance for each VEC

VEC	Metric	Cumulative Impact Significance
Natural forest integrity	Forest loss and fragmentation	Upper Arun River Basin: **High**
		Middle Arun River Basin: **Moderate**
		Lower Arun River Basin: **High**
Makalu Barun National Park	Forest loss and fragmentation	MBNP: **High**
Water resources	River flow	**High**
	River water quality	**Moderate**
	Geomorphology	**Moderate**
	Sediment transport	Upper Arun River: **Moderate**
		Lower Arun River**: High**
Fish and aquatic habitat	Changes in ecological integrity	Cold Zone: **High**
		Cold-Cool Zone: **High**
		Cool Zone: **Moderate**
River-based livelihoods	Impacts on irrigation	Upper Arun River Basin: **Negligible**
		Lower Arun River Basin: **High**
	Impacts on artisanal fishing	Overall basin: **Negligible**
		Sabha Khola: **High**
	Impacts on rafting outfitters	If Sapta Koshi Project is built: **Moderate**

VEC	Metric	Cumulative Impact Significance
Settlement	Changes in settlement demographics patterns	Upper Arun River Basin: **High**
Social cohesion	Impacts on sense of place	Upper Arun River Basin: **High**
	Deterioration or loss of social safety nets	Upper Arun River Basin: **High**
		Mid/lower Arun River Basin: **Moderate**
	Access to local power structures/social capital	Upper Arun River Basin: **High**
		Mid/lower Arun River Basin: **Moderate**
	Generation of social tension	Upper Arun River Basin: **High**
		Mid/lower Arun Basin: **Moderate**

Figure 1: CIA Study Area in Nepal



Source: ERM 2020

Key Management Recommendations

The key recommendations regarding managing cumulative impacts within the Arun River Basin include:

- *River Basin Planning:* Even with the adoption and effective implementation of recommended mitigation and management measures, construction and operation of the over 30 HEPs currently proposed within the Arun River Basin will exceed the carrying capacity of the river basin and inevitably result in significant adverse cumulative environmental and social impacts. Over 30 HEPs within this relatively small basin is simply not sustainable. The Government of Nepal should develop a River Basin Management Plan, which protects key fish spawning tributaries, minimizes social impacts, and establishes guidelines relative to fish passage, sediment management, and water quality. There is guidance available for preparing river basin management plans, such as hydropower by design approach recommended by The Nature Conservancy (2017). This Management Plan should critically review the need for this many projects and prioritize the most important and most sustainable ones. HEPs with the features listed in ***Table 1.2*** are not preferred and should be carefully considered before approving.

Table 0.2: Non-Preferred HEP Features

Non-preferred HEP Features	Example HEPs in the Arun Basin
HEPs located in the MBNP Core Area and other protected areas and key biodiversity areas (KBAs)	Apsuwa I, Upper Apsuwa, Upper Isuwa, and Lower Barun
HEPs requiring long access roads and/or transmission lines that result in significant habitat fragmentation and/or physical displacement	Additional field studies need to confirm access and transmission line routes, but potentially including Lower Barun, Chujung Khola, Upper Ikhuwa Khola Small, Super Sabha Khola Small, Sabha Khola-B, Sabha Khola A, Apsuwa I, Upper Apsuwa, Upper Isuwa
HEPs with long diversion reaches	To be determined based on feasibility studies documenting the proposed length of the diversion reach
HEPs located along important fish migratory routes without effective fish passage plans	To be determined, but effective fish passage at Sapta Koshi High Dam and Lower Arun are very important
HEPs located on clear water tributaries that are important for fish spawning	Additional field studies need to confirm, but potentially including Chujung Khola, Ikhuwa Khola, Ikhuwa Khola Small, Sankhuwa Khola, Lower and Upper Chirkhuwa Khola, Hewa Khola, Sabha Khola C, Lakhuwa Khola, Maya Khola, Piluwa Khola
HEPs requiring significant physical resettlement	Sapta Koshi High Dam Multipurpose Project, possibly others based on site-specific field studies
HEPs impacting areas providing important ecosystem services	To be determined based on site specific field studies

- *Protection of MBNP:* There are five HEPs planned on the Upper Arun River along the edge of MBNP Buffer Zone (Kimathanka Arun, UAHEP, Arun-3, Arun-4, and Lower Arun), three planned HEPs on tributaries in the MBNP Core Area (Lower Barun, Apsuwa I, and Upper Isuwa), and four planned HEPs on tributaries within the MBNP Buffer Zone (Upper Apsuwa, Isuwa, Lower Isuwa, and Kasuwa). The need for these HEPs within the Core Area and those within the Buffer Zone, but with lower capacity, should be carefully balanced with their environmental and social impacts, including the construction of project access roads and transmission lines that contribute to fragmentation.

Support the management initiatives of the MBNP conservation authorities and Community Conservation Programmes, so that they are better able to cope with the increased pressure from influx and other impacts. Support should be towards improved park facilities (e.g., offices, communications, vehicles, and maintenance capacity), infrastructure to access areas for easier management, boundary demarcation, staff training and equipment, revision of management plans, and others. A mechanism needs to be developed at the level of the Nepal Ministry of Finance to retain funds generated from hydropower to be allocated to MBNP management purposes.

- *Natural forest integrity (impact of transmission lines on birds*): Transmission lines represent key risk to birds and all of these HEPs will require construction of new transmission lines. To minimize the risk to birds within MBNP and other KBAs, projects should minimize transmission line crossings of rivers/important bird flyways, be required to share transmission lines corridors, and design transmission line voltages to accommodate future planned hydropower projects; in addition, all projects should adopt bird friendly transmission line design to minimize bird collision and electrocution risk.
- *Migratory fish (provision of fish passage facilities):* Golden mahseer and other migratory fish species are found within the Arun River Basin. It is important that fish passage is provided along their migratory routes at proposed HEPs to maintain their access to critical spawning grounds. It is especially important for the lower main stem projects to provide effective fish passage, as they could block migratory fish access to a significant number of spawning areas – this is specifically the case for the Sapta Koshi and Lower Arun HEPs, as there is documented important spawning habitats upstream from these dams. The Sapta Koshi as currently proposed (over 200 m high) is too high for a fish ladder, but other fish passage options should be explored like trap and trucking or even the creation of a nature-like fishway, as the topography at this project is more suitable for this option than farther upstream on the Arun River. The Arun-3 HEP is currently approved without fish passage, which will prevent mid-range migrants (e.g., common snow trout) from reaching potential habitats upstream. This project is already under construction, so it is likely too late to retrofit a fish ladder, but options like trap and trucking should be considered, at least as an adaptive management measure, if monitoring indicates that the population of common snow trout upstream from Arun-3 HEP is not sustainable. The approved fish hatchery will likely contribute to the loss of native fish stocks. Tributary streams important for fish spawning (e.g., Ikhuwa Khola) should be protected (e.g., remain free of hydropower projects).
- *Fish and aquatic habitat (provision of EFlow):* Provision of a scientifically-based environmental flow (eFlow) within the diversion reaches of the proposed HEPs is critical to maintain the ecological integrity of the Arun River and its tributaries and the ecosystem services that they provide. The goal should be to maintain naturally reproducing populations of all native fish species in each segment of the Arun River between the main stem hydropower projects. This will require protecting key clear water tributaries, which could be used by the common snow trout and golden mahseer for spawning. In the case of the Upper Arun, this would mean protecting Ikhuwa Khola from hydropower development.
- *River-based livelihoods:* Conduct regular socialization, consultation, and monitoring activities with relevant stakeholders; ensure that a HEP grievance mechanism is well socialized; and develop relevant community development programs for the HEP-affected people in coordination with government authorities. Provide livelihood restoration for residents affected by the conversion of the Arun River into a series of reservoirs, diversion reaches, and modified flow reaches.
- *Social cohesion*: Develop a strategic plan and provide funding to help local indigenous peoples (especially upstream from Num) to retain their social identify, cohesion, and heritage in response to both significant improvements in access to this area and labour influx.
- *Cultural heritage:* A cultural heritage management plan should be developed to manage impacts on tangible and intangible cultural heritage resources. In addition, a chance finds procedure shall be developed and implemented for all tangible heritage resources that may be uncovered during

the construction period – the procedure should be disclosed to the energy performance contract (EPC), contractors, and community. HEPs must also consult local leaders before construction activities to discuss cultural heritage sites and understand when planned ceremonies/rituals take place within/near the construction area.

- *Settlement (management of influx and project-related social issues)*: Maximize the recruitment of local workers where feasible and provide training to increase the capacity of eligible local people; establish a grievance mechanism (including a gender based violence [GBV] reporting and management system) accessible for all community groups (and workers) to report concerns associated with workers, conduct investigations into the grievances, and address them in a timely manner.

- *Sediment management (related to water resources):* All proposed HEPs must include an effective strategy for managing sediment, both to sustain their own operations, as well as to maintain downstream river geomorphic functioning and minimize the river's erosion potential. Sediment flushing during the monsoon season should be considered as part of the sediment management strategy, but project developers must demonstrate that this sediment will not silt up the project's diversion reaches.

- *Capacity Building, Regulatory Review, Monitoring, and Enforcement.* There is a need for more capacity building within the key hydropower regulatory agencies in Nepal. The Department of Electricity Development (DoED) and Ministry of Forests and Environment (MoFE) need to carefully review proposed HEPs to ensure they are properly managing key environmental and social impacts, including physical and economic displacement, EFlows, fish passage, sediment management, and habitat fragmentation. There is also a need for effective construction and operation phase monitoring and enforcement. A recent review of hydropower projects in Nepal (Dangol and Uprety 2019) found that many that hydropower construction contractors were unaware of required mitigation measures and many HEPs were not complying with environmental impact assessment (EIA) approval conditions. Recent studies have found little compliance with required EFlows and required fish ladders are not designed for native fish, thereby undermining their likely effectiveness. Further, little government compliance monitoring or enforcement is occurring and there are no efforts at adaptive management. A much more robust compliance monitoring and enforcement program is needed, together with adaptive management, to achieve sustainable hydropower in Nepal. The DoED and MoFE should consider more use of participatory monitoring of HEP construction and operation by local communities, especially in the Arun River Basin, which is far from agency headquarters in Kathmandu and more difficult to monitor because of distance and cost, and stronger enforcement measures.

1. INTRODUCTION

The Project Terms of Reference (ToR) call for the preparation of a Cumulative Impact Assessment (CIA) for the Upper Arun Hydroelectric Project (UAHEP) and the Ikhuwa Khola Hydropower Project (IKHPP) in conjunction with the Environmental and Social Impact Assessment (ESIA).

The Project's ToR states that the CIA will include:

- Cumulative effects of hydropower development and other projects, activities, and stressors in the Arun River Basin
- Cumulative effects on the riverine fishery of Arun River Basin, including rare and endangered species
- Cumulative effects on culture and well-being of ethnic minorities whose lives are dependent on natural resources and eco-system services

1.1 Scope and Objectives

In conjunction with the ESIA, the ERM team has conducted a CIA for UAHEP and IKHPP within the Arun River Basin in accordance with the International Finance Corporation's (IFC's) *Good Practice Handbook: Cumulative Impact Assessment and Management* (IFC 2013). This Good Practice Handbook provides a methodology for identifying the most significant cumulative impacts, focusing on valued environmental and social components (VECs), which are: (1) rated as highly valued by potential project-affected communities and/or the scientific community; and (2) cumulatively impacted by the project under evaluation, and by other projects and/or by natural environmental and social external stressors.

This methodology, which was applied in this CIA (see **Section 2**) follows a six-step process**.** The methodology is considered consistent with the IFC Performance Standards (PS), especially PS 1 – Assessment and Management of Environmental and Social Risks and Impacts, and PS 6 – Biodiversity Conservation and Sustainable Management of Living Natural Resources (IFC 2012).

The objective of the CIA is to assess the impacts of UAHEP and IKHPP, in combination with other existing and proposed HEPs and external stressors within the Arun River Basin. The specific objectives are:

- Identify valued environmental, social and ecosystem components (VECs) that could be impacted cumulatively in areas potentially affected by the HEPs, including the UAHEP and IKHPP, considering input from stakeholders and the scientific community through a consultation process.
- Identify other existing and planned HEPs and associated transmission line and access road developments, other road developments, and external stressors (e.g., climate change and natural hazards) that could cumulatively impact VECs.
- Assess the potential cumulative impacts on VECs from past, existing, and planned HEPs, road developments, and other and external stressors.
- Recommend project-level as well as strategic planning-level recommendations for minimizing negative cumulative impacts and maximizing the positive impacts associated with hydropower development at a basin scale.

1.2 Limitations

The CIA report was drafted in view of the following limitations and caveats:

- Incomplete information about other projects and activities (e.g., the information is not available in the public domain)
- Incomplete baseline information on the selected VECs
- Uncertainty with respect to the implementation of future projects

1.3 Key Terminology

The following are definitions of some of the key terms used in this CIA (IFC 2013):

- **Cumulative impact:** Impacts that result from the successive, incremental, and/or combined effects of an action, project, or activity added to other existing, planned, and/or reasonably anticipated actions, projects, or activities. For practical reasons, the identification, assessment, and management of cumulative impacts are limited to those effects generally recognized as important on the basis of scientific concern and/or concerns of affected communities.
- **CIA:** Cumulative impact assessment is an instrument to consider the cumulative impacts of a project in combination with impacts from other relevant past, present, and reasonably foreseeable developments, as well as unplanned but predictable activities enabled by the project that may occur later or at a different location (World Bank 2018, Annex 1 [d]).
- **Other projects**: Existing, planned, or reasonably expected future developments, projects and/or activities potentially affecting VECs.
- **External stressors or drivers:** Sources or conditions that could affect or cause physical, biological, or social stress on VECs, such as natural environmental and social drivers, human activities, and external stressors. These can include climate change, population influx, natural disasters, or deforestation, among others.
- **VEC:** Environmental and social components considered important by the scientific community and/or potentially-affected communities. VECs may include:
  - Physical features, habitats, wildlife populations (e.g., biodiversity, water supply)
  - Ecosystem services (e.g., protection from natural hazards, provision of food)
  - Natural processes (e.g., water and nutrient cycles, microclimate)
  - Social conditions (e.g., community health, economic conditions)
  - Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites)

  VECs reflect the public and scientific community's "concern" about or special interest in environmental, social, cultural, economic, or aesthetic values. VECs are considered the ultimate recipients of cumulative impacts, because they tend to be at the end of ecological pathways.

1.4 Report Layout

The remaining sections of this Report are structured as follows:

Section 2	**Approach and Methodology,** including a detailed description of the CIA methodology and a determination of the CIA spatial and temporal boundaries
Section 3	**Administrative and Regulatory Framework**, as relevant to the study including the implementation of mitigation measures
Section 4	**Arun River Basin General Context**, including a description of the general environmental and social setting
Section 5	**Scope of the Arun River Basin CIA**, including the spatial and temporal boundaries, project development scenarios, preliminary VECs, and past, present and reasonably foreseeable future actions
Section 6	**Valued Environmental and Social Components**, including the screening and selection results and a description of their present conditions
Section 7	**Baseline Status of Selected VECs**
Section 8	**Cumulative Impact Assessment**, including a description of the impacts and a determination of their significance

Section 9 **Proposed Cumulative Impacts Management Strategy**

Section 10 **References**

2. APPROACH AND METHODOLOGY

Unlike an environmental and social impact assessment (ESIA), which focuses on a project as a generator of impacts on various environmental and social receptors, a CIA focuses on VECs as the receptors of impacts from different projects and activities (see ***Figure 2.1***). In a CIA, the overall resulting condition of the VEC and its related viability are assessed.

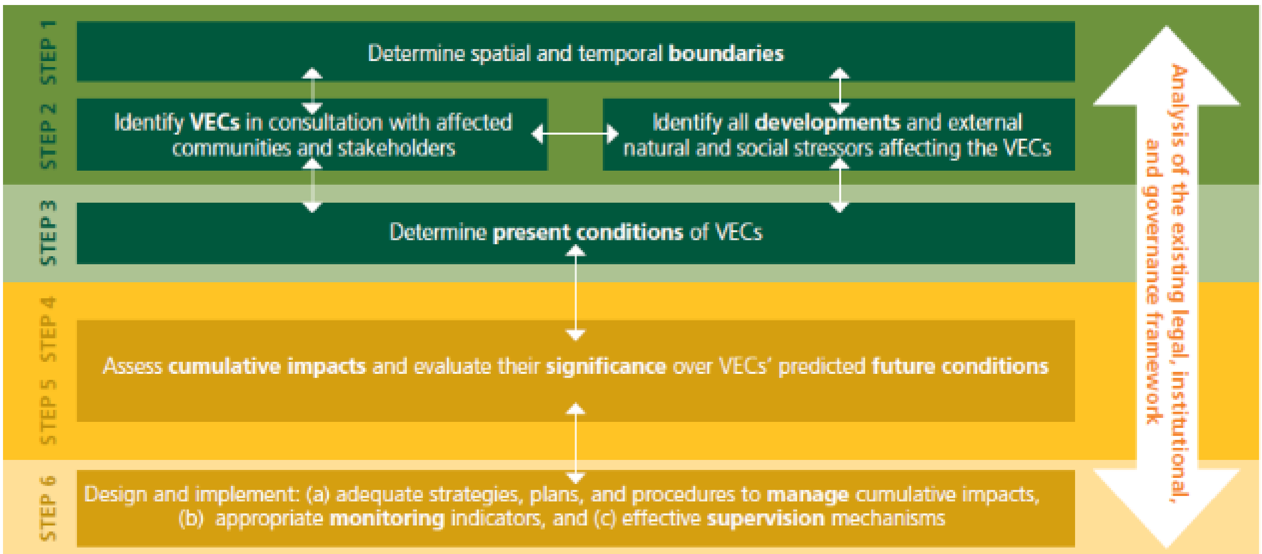
Figure 2.1: Comparing an ESIA and a CIA

ESIA: Project-Centered Perspective **CIA: VEC-Centered Perspective**

Source: IFC 2013

The IFC's *Cumulative Impact Assessment and Management: Guidance for the Private Sector in Emerging Markets Good Practice Handbook* (IFC 2013) outlines a six-step process (see ***Figure 2.2***), which is iterative and flexible, with some steps having to be revisited in response to the results of others. The steps are described in detail in **Section 2.2**.

Figure 2.2: Conceptual CIA Process



Source: IFC 2013

2.1 Sources of Information

ERM have reviewed existing documentation and information provided by the NEA and/or available in the public domain, including the following sources:

- Primary data collected as part of the UAHEP ESIA and CIA
- IKHPP Initial Environmental Examination (Water Resources Consult (P.) Ltd., *et al*. 2015)
- Arun-3 Environmental Impact Assessment (EIA) (WAPCOS 2015)
- Arun-4 Feasibility and EIA Study Interim Design Report (DoED, date not available)
- Lower Arun Feasibility and EIA Study Interim Design Report (DoED, date not available)
- Num-Kimathanka Road (Koshi Highway) EIA (ERMC (P.) Ltd., 2019)
- Kimathanka Arun Feasibility Study Report
- Nepal government agencies and national and regional development plans including Department of Electricity Development (DoED), Nepal Electricity Authority (NEA), Department of Energy, Water Resources and Irrigation (DoEWRI), Ministry of Forest and Environment (MoFE), Ministry of Energy (MoE), Ministry of Energy, Water Resources and Irrigation (MoEWRI), Ministry of Agriculture and Livestock Development (MoALD), Department of Water Supply and Sanitation, Department of Roads, and Department of Disaster Water Induced Management
- Research and academic institutions including the International Union for the Conservation of Nature (IUCN) Nepal, National Agriculture Research Centre (NARC), Fisheries Research Branch (FRB), Central Fisheries Promotion and Conservation Centre (CFPCC)
- Other articles and literature, as detailed in **Section 10 References.**

2.2 Methodology

2.2.1 Overall Methodology

This CIA follows a six-step process based on IFC's Good Practice Handbook on CIA. These steps are described in ***Table 2.1*.**

Table 2.1: Arun River Basin CIA Study Methodology and Corresponding Report Sections

Step	CIA Report Section
Step 1: Determine spatial and temporal boundaries Determine the timeframe and spatial boundaries (study area) of the CIA.	***Sections 5.1 and 5.2*** *Spatial and temporal boundary*
Step 2a: Hold initial public consultations Consult with relevant government agencies, universities, and other key stakeholders to identify the VECs, developments, and external natural and social stressors within the study area.	***Section 2.2.2*** *Stakeholder Engagement*
Step 2b: Identify preliminary VECs. Develop a preliminary list of VECs based on the consultations conducted in Step 2a.	***Section 6*** *VEC Screening and Selection*
Step 2c: Identify all developments and natural and social stressors that may affect the VECs Based on findings from the initial public consultations and literature review, identify past and present actions (other projects and other stressors) that have influenced the current condition of the resources or VECs within the CIA study area, as well	***Section 5.3****, Past, Present and Reasonably Foreseeable Future Actions*

Step	CIA Report Section
as reasonably foreseeable future actions (RFFA) that may affect VECs in the future.	
Step 2d: Screen VECs Screen potential VECs based on the following criteria: – Would the UAHEP or IKHPP affect this VEC? – Would other identified projects/stressors in the area potentially affect this VEC cumulatively? – Would the impacts be potentially significant/meaningful? – Apply other screening criteria if necessary.	***Section 6**, VEC Screening and Selection*
Step 2e: Select final VECs Further define and validate these VECs to determine the final VECs that will be the ultimate focus of the CIA assessment. VEC indicators and thresholds are defined during this process.	***Section 6**, VEC Screening and Selection*
Step 3: VEC baseline Collect primary and secondary information on the final VECs. Define the baseline for the final VECs, their spatial and temporal extent, existing conditions, sensitivity to change, resilience/recovery time, existing stressors, and trends in condition. VEC indicators and thresholds are refined during this step. This assessment is informed by public consultations and baseline studies conducted as part of the CIA and ESIA.	***Section 7**, Baseline Status of Selected VECs*
Step 4: Assess cumulative impacts on VECs Assess the cumulative impacts arising from interactions between UAHEP, IKHPP, other projects, and other stressors (as identified in *Step 2c*) on the VECs. Focus on projects and stressors that have a temporal and spatial overlap with one another. Evaluate the significance of predicted cumulative impacts on the viability/sustainability of the affected VECs.	***Section 8**, Cumulative Impact on Selected VECs*
Step 5: Evaluate significance of the cumulative impacts on the predicted future conditions of VECs Evaluate the significance of predicted cumulative impacts on the viability/ sustainability of the affected VECs.	***Section 8**, Cumulative Impact on Selected VECs*
Step 6: Design and implement management and mitigation measures Design and implement additional management and mitigation measures to those already identified in the ESIA required to manage UAHEP and IKHPP's contribution to the predicted cumulative impacts. This includes not only the management of impacts where the project has control, but also consulting and liaising with government officials and third parties where impacts are outside of the project's direct control.	***Section 9**, Proposed Management Strategy*

2.2.2 Stakeholder Engagement

The UAHEP developed a Stakeholder Engagement Plan (SEP) early on in the Project's planning phase to ensure effective stakeholder engagement during the course of the Project. The SEP includes information on key standards and legislation guiding stakeholder engagement, stakeholder identification, analysis and mapping, strategies for communication with each stakeholder group, and grievance redressal mechanism (GRM), among other things.

The UAHEP has, thus far, conducted multiple rounds of consultations on various issues, including scoping meetings to identify environmental and social concerns for ESIA, consultation meetings on the Resettlement Action Plan (RAP) to solicit feedback on proposed entitlements, consultation with indigenous people to identify issues particular to indigenous peoples, and consultations with women based organizations and individuals to inform the Gender Action Plan (GAP). VECs were identified based on these consultations. Stakeholders consulted during the UAHEP ESIA included:

- Local communities including *Dalits*, indigenous communities and women groups near the UAHEP and IKHPP
- Local NGOs
- Local authorities at the ward, district and rural municipality level
- Agencies including Waters Source and Divisional Office, Agriculture Knowledge Centre, Divisional Forest Office, Drinking Water and Sanitation Units, Tourism Development Centres
- Federation of Community Forest Users Group
- Local businesses, health posts, police offices, schools
- Workers' camps

Additionally, the Project conducted separate consultations to collect primary data during UAHEP CIA consultations at the government-level and with communities near and downstream from the UAHEP. This CIA also draws upon the environmental and social data gathered as part of the UAHEP ESIA stakeholder engagements, as detailed above. A summary of the stakeholder consultations that were conducted specifically for this CIA are summarized below:

- *UAHEP CIA consultation workshop* held on 11 November 2019 in Kathmandu. Representatives from the UAHEP, DoED, Water and Energy Commission Secretariat (WECS), NARC, and Makalu Barun National Park were in attendance to discuss the tentative VECs and potential cumulative impacts of the UAHEP and other hydropower projects in the Arun River Basin. The minutes from this workshop are presented in **Annex A**.
- *UAHEP CIA downstream consultations* were conducted by the CIA Team in Khandbari Urban Municipality, Sankhuwasabha District in March 2020. Specific settlements for CIA consultations were chosen based on interaction and recommendation by the local community, as well as the local authorities, based on the identified VECs. All major local government bodies concerned with the VECs were also consulted. The objective was to understand the dependency of communities in the Arun Basin on fishing, use of rivers for drinking and irrigation, religious and spiritual activities, recreational activities, and use of community forest, as well as to understand various infrastructure projects planned or under development.

  The team conducted focus group discussions (FGDs) and key informant interviews (KIIs) with various stakeholders to understand dependencies on the identified VECs, including:

  - Ethnic communities (e.g., Bhote, Kumal, Majhi, Rai, Limbu, Dalit and Bahun/Chhetri)
  - Local government representatives at Khandbari Urban Municipality, District Coordination Committee (DCC), Water Resources and Divisional Irrigation Office, Agriculture Knowledge Center, Divisional Forest Office, Drinking Water and Sanitation Unit
  - Federation of Community Forest Users Group
  - Local communities and businesses

  A brief field report for these consultations is provided in **Annex B**.

Based on these consultations, a set of preliminary VECs were identified as follows:

- Physical components:
  - Air quality
  - Noise
  - Water resources

- Biological components:
  - Natural forest integrity
  - Makalu Barun National Park
  - Fish and aquatic habitat
- Social components:
  - River-based livelihoods
  - Settlement
  - Social cohesion

Following the identification of preliminary VECs, screening and selection of VECs was conducted (**Section 6)** to determine the final VECs for the basis of this CIA.

3. ADMINISTRATIVE AND REGULATORY FRAMEWORK

A number of existing legal instruments have a direct bearing on hydropower development and water resources management, as listed in ***Table 3.1***. However, the only reference to CIAs within these existing legal instruments is in the 2018 *Hydropower Environmental Impact Assessment Manual,* as detailed in **Section 3.3**.

Table 3.1: Compendium of Legal Instruments Related to Water Resources and Land Use in River Basins

Constitution
Constitution of Nepal, 2015
Plans
National Water Plan, 2005
Brief Guideline for Preparation of Water Use Master Plan, 2017
Strategies
Agriculture Development Strategy 2015–2035
Forest Sector Strategy 2016–2025
National Energy Crisis Reduction and Electricity Development Decade, 2015
National Energy Strategy of Nepal, 2013
National Water Resources Strategy, 2002
Rural water supply and Sanitation National Strategy, 2004
Policies
Climate change Policy 2019
Draft Water Resources Policy, 2019
Forest Policy,2000
Hydropower Development Policy (HDP), 1992 and Hydropower Development Policy, 2001
Irrigation Policy, 2013
Land Acquisition, Resettlement and Rehabilitation Policy, 2015
Land Use Policy, 2015
National Agriculture Policy, 2004
Public-Private Partnership Policy, 2015
Water-induced Disaster Management Policy, 2015
Acts
Aquatic Protection Act, 1960
Civil Code, 2017
Consumer Protection Act, 1999
Criminal Code, 2017
Development Board Act, 2706
Disaster Risk Reduction and Management Act, 2017
Draft Irrigation Act, 2015
Draft Water Supply and Sanitation Act, 2018

Electricity Act, 1992
Environment Protection Act, 2019
Essential Commodity Protection Act, 1955
Forest Act, 1993 and Forest Act, 2019
Guthi Corporation Act, 1976
Industrial Enterprises Act, 1992
Inter-governmental Fiscal Management Act, 2017
Land Acquisition Act, 1977
Lands Act, 1964
Land Use Act, 2019
Local Government Operation Act, 2017
Natural Resources and Fiscal Commission, 2017
Nepal Electricity Authority Act, 1984
Nepal Electricity Regulatory Commission Act, 2017
Public Private Partnership (PPP) and Investment Act, 2019
Water Resources Act, 1992 and Draft Water Resources Act, 2019
Water Supply Management Board Act, 2006
Provincial Acts
Irrigation Act, 2018 (P-1)
Rules
Drinking Water Rules, 1998
Electricity Rules, 1993
Environment Protection Rules, 2020
Forest Rules, 2020
Irrigation Rule, 2000
Rafting Rule, 2006
Water Resources Rule, 1993
Guidelines/Directives/Manuals/ Working Procedures
Directives for Use of Forest for National Prioritized Projects, 2017
Guidelines to Provide Land for Construction of Infrastructure Projects in Conservation Areas 2024
Directives on Licensing of Hydropower Projects, 2016
Drinking Water Service Operation Directive, 2012
EIA/IEE Working Procedure for Hydropower and Transmission Lines, 2016
Hydropower Environmental Impact Assessment (EIA) Manual, 2018
Gender Equality and Social Inclusion Mainstreaming Guideline for Irrigation and Water Induced Disaster Prevention Sectors, 2014, Ministry of Irrigation
Guidelines for Study for Hydropower Projects, 2003
Land Ceiling Exemption Order, 2017
Local Energy Development Directive, 2017
National Drinking Water Quality Standard, 2005

National EIA Guideline, 1993

3.1 Authority and Responsibility

The *Constitution of Nepal, 2015* mandates the federal government to conserve water resources and to develop policies and standards for multiple water uses; and mandates the provincial government to manage water resources within their jurisdiction. Drinking water and watershed management is under the jurisdiction of local government. However, water resource management is also under the concurrent rights of the state, province and local government.

Table 3.2 summarizes Nepal's administrative framework with respect to legislative matters pertaining to water resources management at the federal, provincial, and local levels.

The *Three Tiers Government Project Classification and Distribution Standard*, 2076 BS (2019 AD) – issued by Nepal Planning Commission and approved by Federal Council of Ministers – refers to guiding principles from *Constitution of Nepal,* 2015 and the *Natural Resources and Fiscal Commission Act*, 2017. The Standard recommends that energy projects (hydro and solar) more than 20 MW/33 kilovolt (KV) transmission lines shall fall under federal jurisdiction; projects from 3 to 20 MW/11 to 33 KV transmission lines shall fall under provincial jurisdiction; and projects up to 3 MW shall fall under local jurisdiction. Notably, the Standard's local jurisdiction provision contradicts 11(2)-N(3), which provides that projects up to 1 MW fall under local jurisdiction.

Table 3.2: Current Administrative Framework for Water Resources

River Basins

The function, duties and rights of the WECS are:

- To review multipurpose, mega and medium scale water resources projects before they are sanctioned by the Government of Nepal, and recommend their implementation.
- To formulate necessary policies and strategies conducting study, research, survey and analysis with regard to various aspects of water resources and energy development in keeping with priorities and targets of the Government of Nepal.
- To analyze bilateral or multilateral projects relating to the development of water resources and energy, to formulate policies in this respect, and to review the detailed study and analysis of such projects.
- To enact necessary laws pertaining to the development of water resources and energy.
- To establish the coordination among national and sectoral policies relating to water resources and energy sector.

Federal

Organizational roles of different federal government agencies:

- MoEWRI: implements policies, laws, standards and regulations for water resources sustainable development, conservation, uses, water resources distribution
- Nepal Electricity Authority (NEA)
- Department of Electricity Development (DoED): reviews and forwards Initial Environmental Examination (IEE) to concerned agencies for approval
- Ministry of Forests and Environment (MoFE): approves of environmental study – IEE or EIA
- Investment Board Nepal (IBN): Facilitates environmental clearance/approvals for large projects
- WECS: assists Government of Nepal, different ministries relating to water resources, and other related agencies in the formulation of policies and the planning of projects in the energy resources sector
- Federal matters include international boundary river, preservation of water resources, big hydro-electricity and irrigation projects, environment management, national forests within provinces, water use, environment management, national parks and reserves, wetlands, forest policy, land use policies, and tourism development.

Provincial

- Governments at the provincial level have been in place since January-February 2018

- Provincial matters include provincial roads, land management records, mining, research and management, national forest within provinces, water use, and environment management.

Local
■ The district assembly and district coordination committees (DCCs) coordinate between the Federal government, provincial government offices, village bodies, and municipalities within a district; monitor development and construction work; manage natural disaster resilience; and issue working procedures, directives, and standards within their jurisdiction. ■ Associations such as community forest user groups (CFUGs), village development committees (VDCs), and *aama samuhas* (or mothers' groups) have an established governance mechanism for managing resources such as forests, pasturelands, irrigation systems, and community assets. ■ Local governance units (LGUs) co-exist with traditional and formal institutions such as the CFUGs to implement legislative matters within their jurisdiction on watersheds, wildlife, mining protection, small hydro projects, alternative energy, and issues to do with the environment. ■ Each LGU has an established administrative structure that includes departments such as social justice, environment development and economic affairs.

Source: ERM 2019

3.2 Environmental Impact Assessment

The Environment Protection Rules (EPR) 2020, which came into force on 15 June 2020 (repealing EPR 1997) is the major guiding document for conducting EIAs and IEEs for projects in Nepal. The current EPR does not specifically address cumulative impacts or require a CIA.

3.3 Hydropower Environmental Impact Assessment Manual, 2018

The Hydropower Environmental Impact Assessment Manual (Hydropower EIA Manual) encourages hydropower project sponsors to manage cumulative impacts within a given river basin. The International Finance Corporation is currently working with the Ministry of Forests and Environment and the International Centre for Integrated Mountain Development (ICIMOD) to encourage application of CIA in Nepal. The IFC sponsored a workshop on CIA in Kathmandu in 2017 and supported the development of the Hydropower EIA Manual. Shown in **Box 3.1** are the CIA references within the Hydropower EIA Manual.

Box 3.1: CIA References in the Hydropower EIA Manual

Box 5: Cumulative Impact Assessment

- Environmental impacts are often assessed at the project level, but when a number of projects are considered together, global experience shows that cumulative impacts can cause significant adverse environmental and social issues.
- Cumulative impacts result from the successive, incremental or combined effects of a project or activity when considered with existing, planned or reasonably anticipated future ones. For practical reasons, the identification and management of cumulative impacts are limited effects generally recognized as important on the basis of scientific concerns or concerns of affected communities. These impacts are incremental effects of past, present, or future activities combined with the proposed project.
- Examples of cumulative impacts that could be attributed to a hydropower project in Nepal include:
- Reduction of water flow in a river basin due to multiple projects / reservoirs combining to affect both upstream and downstream river reaches / users.
- Increases in sediment loads on a watershed or increased erosion which can result in the loss for example, of important sediment and nutrients for agriculture in the Terai.
- Secondary, consequential or induced social impacts, such as collective in-migration of construction workers for multiple projects.
- Cumulative Impact Assessments (CIA) are not required by the Rules (1997) or National EIA Guideline. However, hydropower project proponents are encouraged to try and understand, assess and effectively engage with river basin stakeholders to manage cumulative impacts within a given river basin.

Source: MoFE 2018

4. ARUN RIVER BASIN

4.1 Standards and References

ERM followed the IFC's Good Practice Handbook on CIA and also considered the guidance documents indicated in the consulting services ToR, complemented by other available international good practice guidance, including:

- *Performance Standards on Environmental and Social Sustainability* (IFC 2012)
- *Good Practice Note: Environmental, Health, and Safety Approaches for Hydropower Projects* (IFC 2018a)
- *Good Practice Handbook: Environmental Flows for Hydropower Projects, Guidance for the Private Sector in Emerging Markets* (IFC 2018b)
- *Draft Cumulative Impact Assessment Guidelines for Hydropower Projects in the Lao People's Democratic Republic* (IFC no date)
- *Environmental and Social Framework (ESF). ESS1: Assessment of Management of Environmental and Social Risks and Impact* (World Bank 2018, paragraph 23)
- *Cumulative Effects Assessment Practitioners Guide for the Canadian Environmental Assessment Agency* (Hegmann *et al.* 1999)
- *Strategic Environmental Assessment for Hydropower Sector Planning – Guidance Material* (Annandale *et al.* 2014)
- *Joint Initiative on Rapid Basin-wide Hydropower Sustainability Assessment Tool* (USAID *et al.* 2010)
- *Cumulative Impacts – A Good Practice Guide for the Australian Coal Mining Industry* (Franks *et al.* 2010)

4.2 General Setting

There are nine major river systems in Nepal (i.e., Mahakali, Karnali, Babai, Rapti, Gandaki, Bagmati, Kamala, Koshi, and the Kankai). The Koshi River system (Bharati *et al.* 2019) is the largest and originates from Nepal's four highest Himalayan peaks (Mt. Everest – 8,850 m, Mt. Jannu – 7,710 m, Mt. Makalu – 8,462 m, and Mt. Cho Oyu – 8,201 m). The Koshi is also called the Sapta Koshi for its seven Himalayan tributaries in eastern Nepal: Indrawati, Sun Koshi, Tama Koshi, Dudh Koshi, Liku, Arun, and Tamor (***Figure 4.1***).

Figure 4.1: Koshi Basin including the Arun Catchment

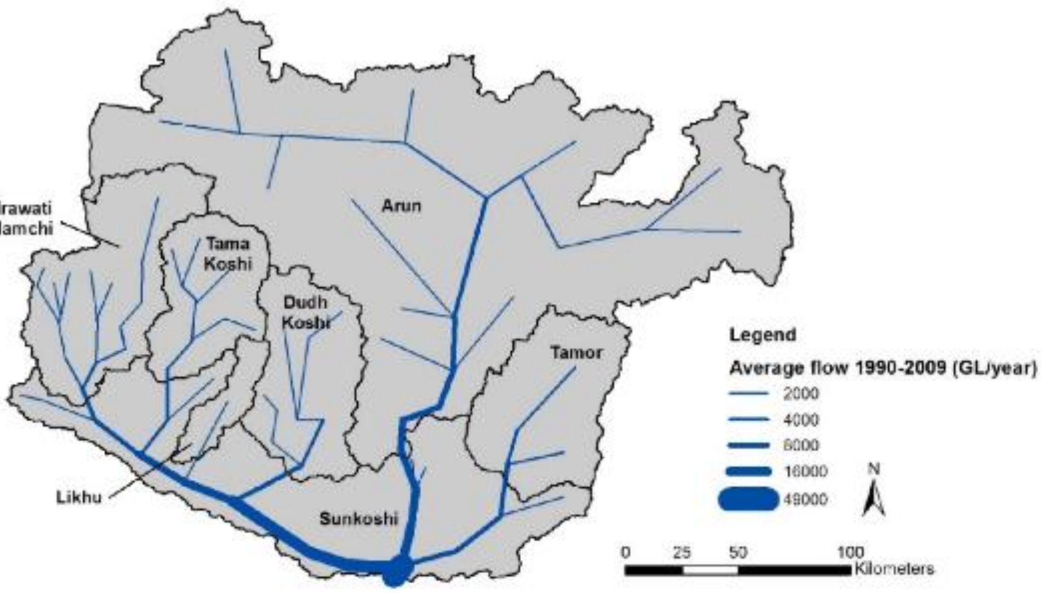
Source: Penton 2017

The Arun River is the largest trans-Himalayan river passing through Nepal and also has the greatest snow and ice-covered area of any Nepalese river basin. The Arun River drains more than half of the area contributing to the Sapta Koshi river system.

In Tibet Autonomous Region, the Arun River is known as Men Qu (Moniqu) in its upper reaches north of Xixabangma and then as the Peng Qu (Pumqu) for most of its course north of the Himalayan crest. After progressing eastward through arid grasslands, the Peng Qu turns south at the confluence with the Yarn Qu (Yeyuzangbu). The Peng Qu crosses the Himalayan crest at an elevation of about 2,175 m and becomes known as the Arun in Nepal. South of the Himalayan crest, the flow volume of the Arun increases rapidly downstream in the seasonally-humid environment of east Nepal. The Nepal portion of the Arun Basin represents only 17% of the total basin area, but it provides more than 70% of the Arun River's total flow at its confluence with the Sapta Koshi (Kattelmann 1990). Over 80% of the annual precipitation of 1,500 mm occurs during the monsoon season (June-September) (Pradhan and Sharma 2017). ***Figure 4.2*** shows the average streamflow in the Koshi Basin of Nepal.

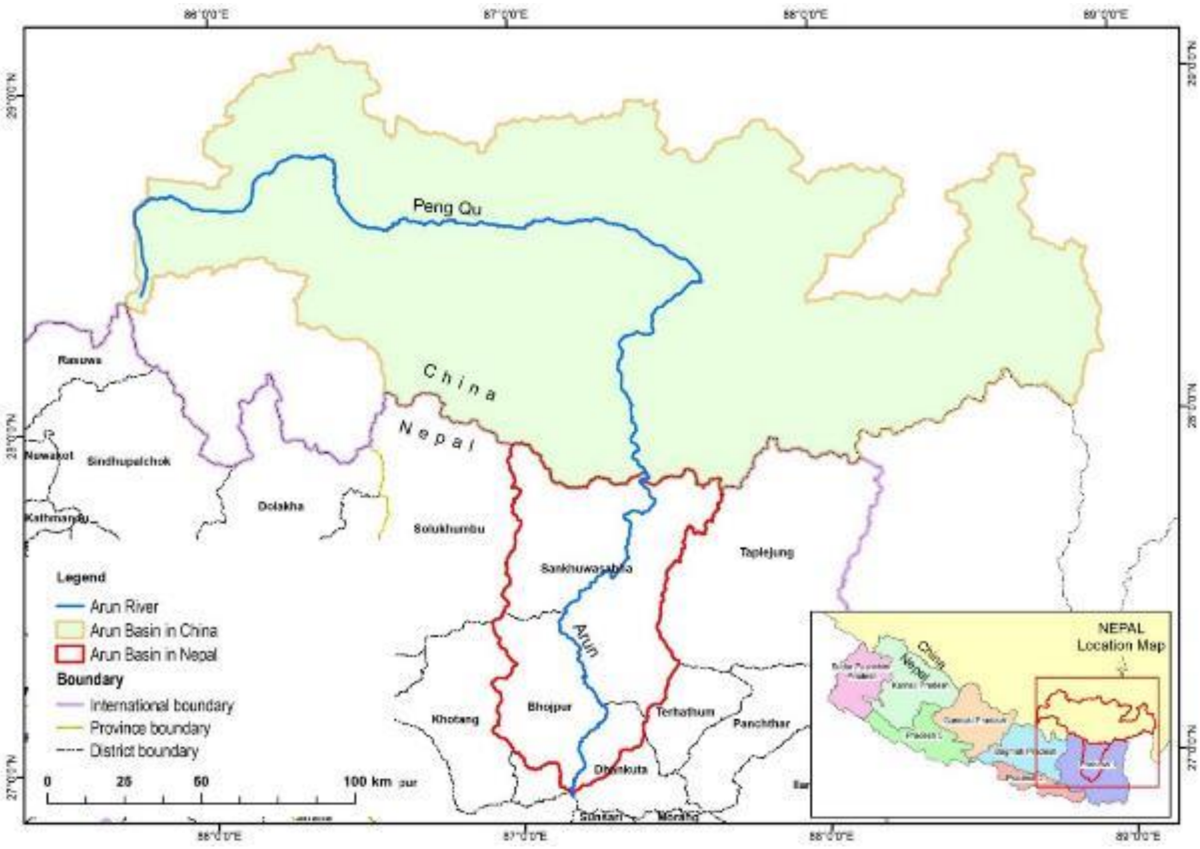
The Arun Basin covers an area of 30,041 km^2, of which 24,888 km^2 (83%) is situated in China and 5,153 km^2 (17%) is in Nepal (***Figure 4.3***). The general demographics and areas of biodiversity significance of the Arun Basin in China and Nepal are summarized below.

Figure 4.2: Average Streamflow in the Nepal Koshi Basin



Source: Penton 2017

Figure 4.3: Arun River Basin



Source: ERM 2020

4.3 Demographic Overview

4.3.1 Arun Basin in Tibet Autonomous Region

The Arun River Basin in Tibet Autonomous Region is encompassed within one prefecture, namely Shigatse (also known as Xigazê). Key demographic data for Shigatse Prefecture is provided in ***Table 4.1.*** Note that data specific to Shigatse is not available for all indicators, for these, data for the entire Tibet Autonomous Region has been provided.

Table 4.1: Key Demographic Data for the Tibet Autonomous Region in the Arun River Basin

	Area in the Arun Basin	TAR
Total land area (km^2)	24,873	-
Total forest area (km^2)	1,136 (4.6%)	-
Population density (people per km^2)	3.9 (for Shigatse Prefecture)	2.6
Total male population	-	50.2%
Total female population	-	49.8%
Total literacy rate	-	43.5
Male literacy rate	-	50.0
Female literacy rate	-	30.1
Poverty rate	-	24.5%
Human Development Index (HDI)	-	0.57

Sources: China National Bureau of Statistics, 2002, 2010; Land Management Bureau of Tibet Autonomous Region, 1992; Tibetan Statistical Yearbook, 2000; UNDP, 2013

4.3.2 Arun Basin in Nepal

In Nepal, the Arun River Basin is situated across three districts of Province No. 1, namely: Sankhuwasabha, Bhojpur, and Dhankuta (***Figure 4.4***). These districts are located within an area often referred to as the "Koshi Hills." Key demographic data for these three districts are provided in ***Table 4.2.*** Statistics and profiles of communities of indigenous people in these districts are provided in **Section 7**.

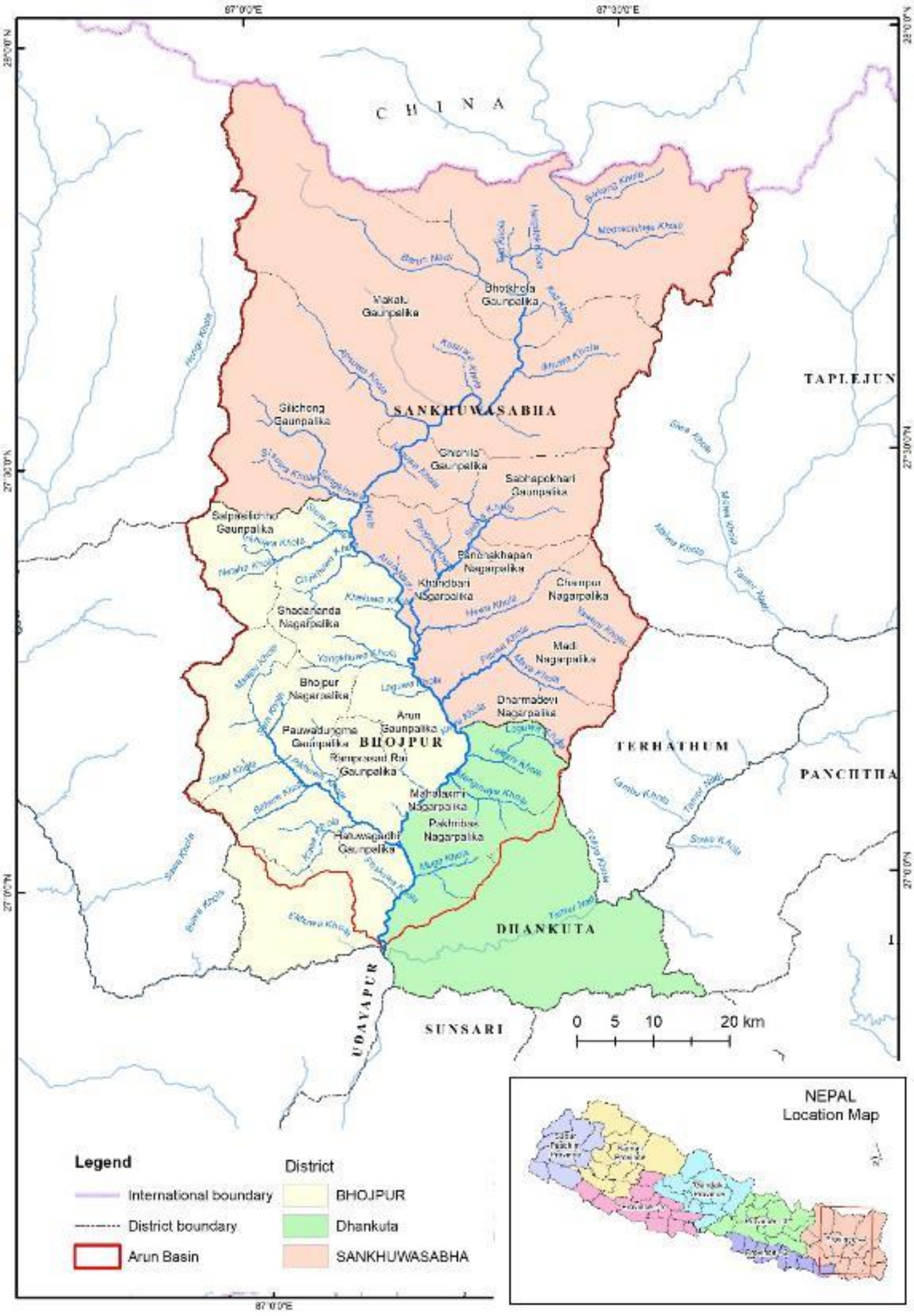
Table 4.2: Key Demographic Data for the Arun River Basin in Nepal

	Sankhuwasabha	Bhojpur	Dhankuta
Total land area (km^2)	3,476.8	1,526.8	901.1
Total forest area (km^2)	1,561.0	728.8	367.8
Total population (people)	158,742	182,459	163,412
Total male population	47.4%	47.2%	46.8%
Total female population	52.6%	52.8%	53.2%
Total households (HHs)	34,624	39,419	37,616
Male headed HH	72.6%	72.6%	70.7%
Female headed HH	27.4%	27.4%	29.3%
Total literacy rate	69.4%	69.3%	74.4%

	Sankhuwasabha	Bhojpur	Dhankuta
Male literacy rate	77.5%	78.4%	82.4%
Female literacy rate	62.2%	61.4%	67.4%
Poverty rate	21.0%	24.4%	15.9%
Human Development Index (HDI)	0.49	0.48	0.52
Income from agriculture, forestry, and fishery (%)	81.92%	87.18%	79.90%

Sources: CBS 2011; Poverty rate: Nepal small area estimate of poverty (CBS); State of Nepal's Forests (DFRS 2015); Nepal Human Development Report (NPC and UNDP 2014)

Figure 4.4: Arun Basin in Nepal



Source: ERM 2020

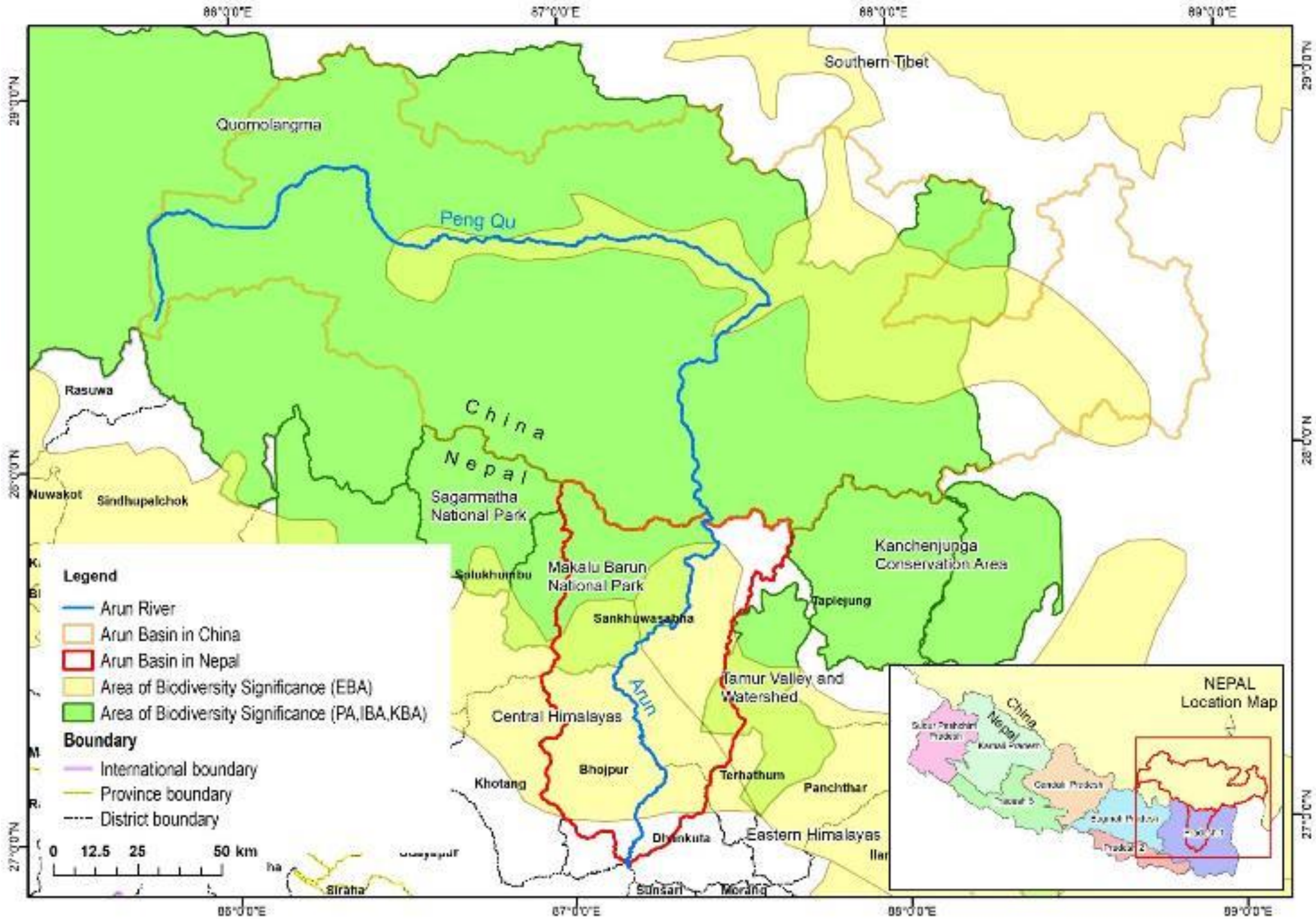
4.4 Area of Biodiversity Significance in the Arun Basin

Areas of biodiversity significance within the Arun River Basin (within Nepal and Tibet Autonomous Region of China) are summarized in ***Table 4.3*** and identified in ***Figure 4.5***, which includes Protected Areas, Key Biodiversity Areas (KBA), Endemic Bird Areas (EBA), and Nature Reserves. Additional details regarding the Makalu Barun National Park (MBNP) are provided in **Section 7.2**.

Table 4.3: Areas of Biodiversity Significance within the Arun Basin

Name	Type	Location	Summary
Makalu Barun National Park (MBNP)	Protected Areas and KBA	Nepal – within the Arun River Basin	The MBNP Core Area and its Buffer Zone is a biodiversity hotspot of international importance. It is the world's only protected area with an elevation gain of more than 8,000 m enclosing tropical forest as well as snow-capped peaks. It covers an area of 1,500 km^2 in Solukhumbu and Sankhuwasabha districts, and is surrounded by a Buffer Zone to the south and southeast with an area of 830 km^2.
Tamur Valley and Watershed	KBA and IBA	Nepal – Tamur River Basin	The Tamur Valley and Watershed KBA and IBA (20,000 ha) has extensive forests of oak *(Quercus spp.)* and chinquapin *(Castanopsis spp.)*, with rich patches of *Rhododendron spp*. A total of 260 bird species have been recorded from this site
Sagarmatha National Park	Protected Area and KBA	Nepal – Koshi Major River Basin	Covers an area of 124,400 ha and includes the highest mountain on Earth, Mt. Sagarmatha (Mt. Everest) at 8,850 m, as well as another seven peaks over 7,000 m. The area is home to several rare species such as the snow leopard and the red panda.
Kanchenjunga Conservation Area	KBA	Nepal – Tamur River Basin	Kanchenjunga Conservation Area was established in 1997, and measures 203,500 ha. Ranging in altitude from 1,200 to 8,586 m, it covers a range of bioclimatic zones, like other conservation areas of the region, with a concomitant rich biodiversity.
Eastern Himalayas	EBA	Several countries – overlapping with the Arun Basin	This EBA follows the Himalayan range east from the Arun-Kosi valley of eastern Nepal, through Bhutan, north-east India, south-east Tibet Autonomous Region (China) and north-east Myanmar to south-west China
Central Himalayas	EBA	Several countries – overlapping with the Arun Basin	This EBA extends through the Himalayas from the extreme east of Nepal to the extreme west, and into adjacent regions of India.
Qomolangma National Park	National Park	China – Shigatse Prefecture, Tibet Autonomous Region, China	Qomolangma National Park (QNNP) is the highest altitude biosphere reserve in the world, protecting approximately 3.4 million ha of the central Himalaya in Tibet Autonomous Region (China). It contains or abuts several of the world's highest peaks, including Qomolangma (Chinese: Zhulangmafeng) or Mt. Everest 8,850 m).

Figure 4.5: Key Biodiversity Areas in the Arun River Basin



Source: ERM 2020

5. SCOPE OF CUMULATIVE IMPACT ASSESSMENT

5.1 Spatial Boundary

The IFC *Cumulative Impact Assessment (CIA) Guidelines* recommend the following rules of thumb to determine the spatial boundary of a CIA:

- Include the area that will be directly affected by the project or activity (in this case, the UAHEP), which is known as the Direct Area of Influence (DAI) in the traditional ESIA sense.
- List the important resources (VECs) within the DAI.
- Define if these VECs occupy a wider area beyond the DAI.
- Consider the distance that an effect can travel, and other impacts that the VEC may be exposed to within its range.

Delineating an appropriate spatial boundary for a hydropower CIA depends on where active change is occurring in a watershed and what the significance of those changes is (Lein 2002). This helps to keep the CIA focused, and give priority to issues of concern (MacDonald 2000). To account for accumulated changes in biophysical parameters of a river system, Squires *et al*. (2010) suggest that a CIA framework considers changes from river headwaters to mouth.

The spatial boundary may vary depending on the VEC assessed. For example, the study area for livelihoods encompasses settlements that are potentially most reliant on the rivers and streams within the Arun Basin (i.e., located near each side of the Arun River and its main tributaries). Moreover, there are certain common economic, social, and cultural features that link upstream, midstream, and downstream river reaches of the Arun River Basin. Likewise, there exist certain similarities and differences in resource utilization patterns (for example, in agriculture, fishing, and other riverine-based livelihoods) and economic conditions (linked to market access, gender, inequality, and other income-related issues).

The CIA study area and the overall Arun River Basin boundary are shown in ***Figure 4.4***. Although the CIA study area focuses on the Upper Arun River reach, the CIA also considers significant impacts in the upstream reach within Tibet Autonomous Region of China, as well as downstream towards its confluence with the Sapta Koshi.

5.2 Temporal Boundary

Temporal delineation for a CIA is a challenge due to the inherent uncertainty about potential future projects and activities. The following are the basic rules of thumb to determine temporal boundaries for the assessment according to the IFC *CIA Guidelines*.

a) Use the time frame expected for the complete life cycle of the proposed development (including construction, operation, and decommissioning).
b) Specify whether the expected time frame of the potential effects of proposed development can extend beyond (a).
c) Use the most conservative time frame between (a) and (b).
d) Use professional judgment to balance between overestimating and underestimating, and make sure to document the justification or rationale.
e) Exclude future actions if (i) they are outside the geographical boundary, (ii) they do not affect VECs, or (iii) their inclusion cannot be supported by technical or scientific evidence.

Most of the projects identified within the spatial boundary are hydropower, transmission line, and transportation projects. A limit of 10 years is adequate to frame the hydropower projects considered (**Section 55.3.1**), as it is assumed that these projects will be at least under construction within this period. The temporal extent of these impacts is longer as HEPs typically have a long life expectancy. Hydropower projects are designed to operate for at least 50 years and expected to operate for 80 or more years, especially if they implement an effective sediment management strategy to minimize sediment deposition in the project reservoir. It is difficult to predict impacts with any certainty that far into the future; as such, the temporal scope of the CIA was established as a maximum 50-year timeframe.

The timeframe for potential hydropower project decommissioning is so far in the future as to make any impact assessment unreliable. Further, the transmission line and transportation projects will be maintained and repaired, but are unlikely to be decommissioned. For these reasons, the decommissioning of these projects was not considered in this CIA.

5.3 Past, Present and Reasonably Foreseeable Future Actions

This section identifies past and present actions that have influenced the current condition of the resources or VECs within the CIA study area, as well as reasonably foreseeable future actions (RFFA). Key past, present, and future actions within the Arun Basin include hydropower, road infrastructure, agriculture, sand and gravel extraction, and mining, as well as other external stressors (e.g., climate change and natural hazards). The actions presented in this section have been compiled from stakeholder consultations and literature reviews. The timeframe for this analysis was determined based upon the construction and operational phases of UAHEP and IKHPP and the RFFAs that could be predicted. As such, a timeframe of 50 years has been established for the analysis. Predictions beyond this timeframe are considered to be unreliable.

5.3.1 Hydropower Development

Within the Arun River Basin there are there are 9 operating HEPs, 22 under construction (i.e., obtained construction license), 12 have applied for a construction license, and 17 have obtained a survey license, all of which total approximately 4,763 megawatt (MW). ***Table 5.1*** summarizes the projects that have been identified to date. The approximate locations of select HEPs are shown in ***Figure 5.1***. ***Table 5.3*** indicates the status of each project.

Given the lack of available data for many of these HEPs, this CIA focuses on under-construction and planned projects located on the main stem (Arun River), including (from north-to-south): Kimathanka Arun, UAHEP, Arun-4, Arun-3, and Lower Arun; and key tributary HEPs including: IKHPP, Upper Ikhuwa Khola Small, and Lower Barun. These hydropower projects also involve access roads and transmission lines, which are discussed in more detail in the following subsections. There is generally little information on the smaller hydropower projects located on tributaries of the Arun River, as many of these are only in the early license stage of development. These projects are included in this CIA, but more qualitatively and on a programmatic basis.

Projects on the downstream Koshi River (i.e., the existing Koshi Barrage and the planned Sapta Koshi High Dam Multipurpose Project) are also considered in this CIA due to the potentially significant impacts of these projects on the identified VECs considered in this CIA.

Hydropower on the Arun River in Tibet Autonomous Region

There are currently no existing or planned hydropower projects on the Bum-chu/Peng Qu River (the Arun River in the TAR) and its tributaries. The majority of operating/planned hydropower projects in TAR operations are located in the western reaches of the region, on the Yarlung Tsanpo and Jinsha rivers.

Main-stem Projects on the Arun River in Nepal

Below are descriptions of the main-stem HEPs on the Arun River in Nepal. A summary of the salient features for these HEPs is provided in ***Table 5.1*** and a schematic diagram of these projects is shown in ***Figure 5.2***.

Kimathanka Arun HEP

The proposed 450 MW Kimathanka Arun Hydropower Project (KAHEP) is a peaking located approximately 8 km upstream from the UAHEP headworks. Located within the Makalu Barun National Park Buffer Zone, the proposed intake is approximately 1.6 km downstream from the border with TAR at Kimathanka Arun Pass and the dam bed elevation is approximately 1,968 masl. The proposed powerhouse is located 1.6 km downstream from the confluence of Chhujan Khola with Arun River, at an elevation of approximately 1,665 masl.

Upper Arun HEP

The UAHEP is a peaking run-of-river (PRoR) type hydroelectric project on the Arun River in Sankhuwasabha District of eastern Nepal, about 15 km south of the international border with TAR and 220 km east of Kathmandu. The proposed dam site is in a narrow gorge about 350 m upstream from the Arun River's confluence with the Chepuwa Khola. The proposed UAHEP power plant site is located approximately 16 km downstream from the dam site, near the Arun River's confluence with the Leksuwa River. The right bank of the Arun River, at the proposed UAHEP site, falls within the MBNP Buffer Zone, which extends, according to park officials, to the middle of the Arun River. The proposed UAHEP dam site is, therefore, located partially within the Buffer Zone. The project has an authorized capacity of 1,063.36 MW, and will operate in a 6-hour daily peaking mode during the dry season.

Arun-4 HEP

Arun-4 HEP is a run-of-river (RoR) project planned approximately 18 km downstream from the UAHEP dam (about 1.5 km downstream from the UAHEP powerhouse) and 14 km upstream from Arun-3 HEP dam, near Gola village, with a total installed capacity of 473 MW. The dam site will be located at an elevation of approximately 1,065 masl, and the tailrace at 835 masl. It is understood that the Nepal Department of Electricity Development (DoED) is developing this project.

Arun-3 HEP

Arun-3 HEP is a 900 MW PRoR project located approximately 32.0 km downstream from the UAHEP dam (about 15.5 km downstream from the UAHEP powerhouse). Construction of the Arun 3-HEP commenced in 2018, and is expected to take seven years according to the project's EIA. The dam site is located near Num Village in Sankhuwasabha District on the Arun River, about 60 km from Tumlingtar. The dam site will be located at an elevation of approximately 790 masl, and the tailrace at 525 masl.

Lower Arun HEP

The Lower Arun HEP was planned as a PRoR (6 hours of daily peaking) project located immediately downstream from the Arun-3 HEP, and will take advantage of some of its infrastructure. Water from the tailrace of Arun-3 HEP will flow directly to the Arun River. Thereafter, the Lower Arun HEP diversion structure will start. The updated supplementary EIA for the project envisages constructing the power plant as a cascade facility to Arun 3 HEP. It will have no dam structure. The installed capacity for cascade operation is expected to be 669 MW. The project is being developed by SJVN, which is also constructing the Arun-3 HEP.[1]

[1] See: https://sjvn.nic.in/businessprojectdetails/28/5/46

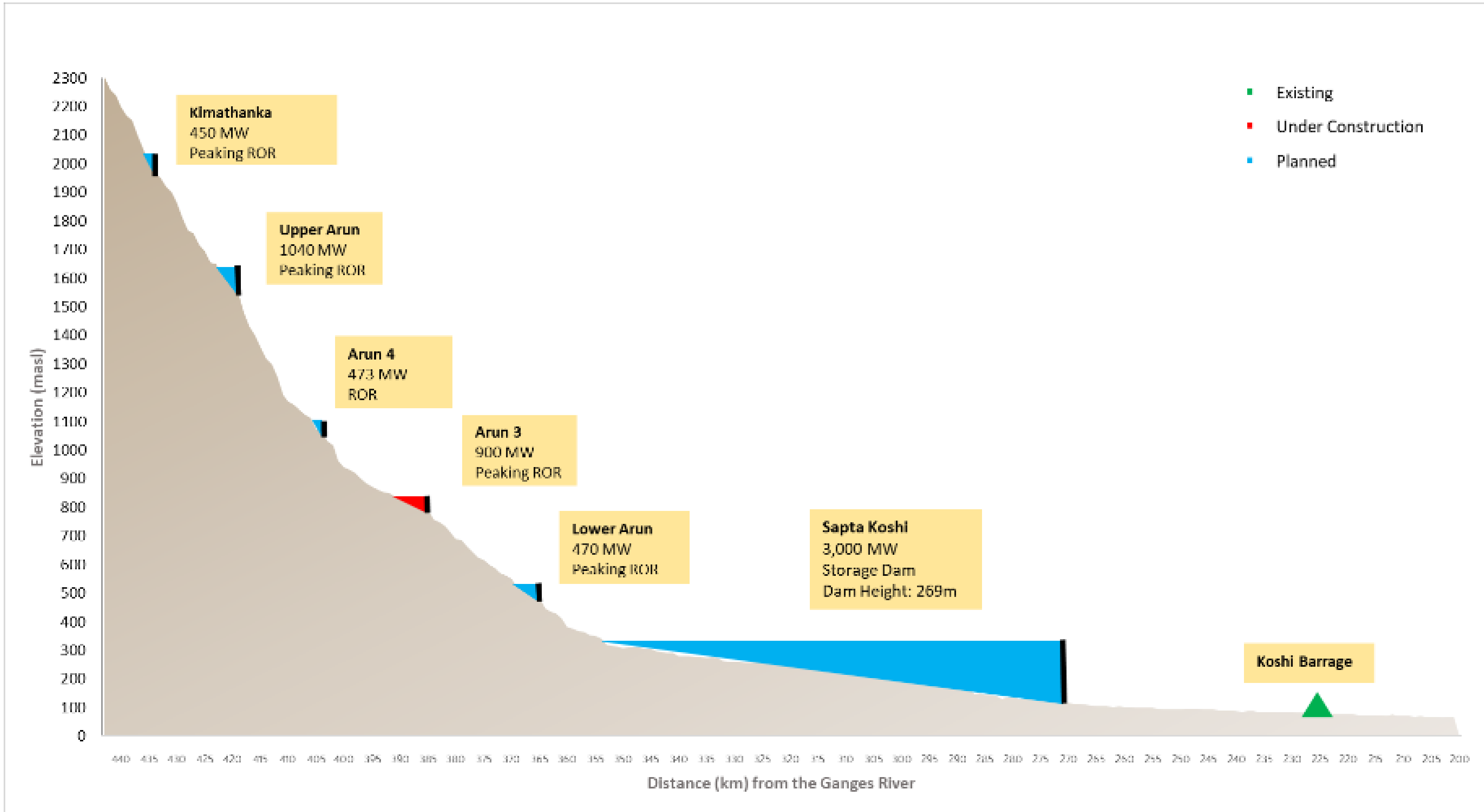
Table 5.1: Salient Features of the Main-stem HEPs

Salient Features	Kimathanka	Upper Arun	Arun 4	Arun 3	Lower Arun[2]
Status	Planned	Planned	Planned	Under construction	Planned
Dam river km	431 km	418 km	400 km	386 km	365 km
Operation	PRoR – 6 hrs	PRoR – 6 hrs	RoR	PRoR	RoR – cascade with Arun 3
MW	450 MW	1040 MW	473 MW	900 MW	669 MW
Dam height	70 m	100 m	13 m	68 m	-
Avg flow	198 m^3/s	217 m^3/s	256 m^3/s	297 m^3/s	-
Design discharge	143 m^3/s	235 m^3/s	253 m^3/s	343 m^3/s	344 m^3/s
Net head	370 m	508 m	216 m	287 m	212 m
EFlow	4.8 m^3/s	5.4 m^3/s	4.3 m^3/s	6.3 m^3/s	From Arun 3 and augmented river flow
Fish passage	Unlikely	No	Unlikely	No	-
FEL	2,035/2,025 m	1,640/1,625 m	1,078 m	845/835 m	-
Total storage volume	10.2 M m^3	5.1 M m^3		13.9 M m^3	-
Reservoir length	3.0 km	2.1 km		4.5	-
Reservoir surface area	33.8 ha	20.1 ha		66.3 ha	-
Diversion reach length	10 km	16.5 km	9 km	18 km	-
Tailwater elevation	1,650 m	1,084 m	~835 m	~525 m	~285 m
Transmission line length	18.5 km	5.8 km	13.5 km	310 km	2 km
Access road	Koshi Hwy	Koshi Hwy	Koshi Hwy	Koshi Hwy	Koshi Hwy
Land take requirement	Uncertain	180 ha	Uncertain	180 ha	184 ha
Elevation impact	2,035–1,650 m	1,640–1,084 m	1,078–835 m	845–525 m	532–285 m

[2] Supplementary EIA of Lower Arun HEP, 2023: https://ibn.gov.np/uploads/files/SEIA%20Lower%20Arun%20HEP%20(669%20MW)%20-upload_1693738160.pdf

Salient Features	Kimathanka	Upper Arun	Arun 4	Arun 3	Lower Arun[2]
Max residence time	59 hours	26 hours	<24 hrs	61 hours	55 hours
Distance from PH to next downstream reservoir	0.8 km	1.2 km	0.5 km	0.1 km	0.0 km

Figure 5.1: HEP Arrangements on the Arun River



Key Tributary Projects

Key tributaries for this CIA include the Ikhuwa Khola and the Barun Khola. Planned HEPs on these tributaries include IKHPP, Upper Ikhuwa Khola Small HEP, and Lower Barun HEP. A summary of the salient features for these HEPs is provided in ***Table 5.2***.

Ikhuwa Khola Hydropower Project

The proposed Ikhuwa Khola (IKHPP) site is located on a tributary of the Arun River approximately 8 km downstream from the proposed UAHEP powerhouse site, and 5 km upstream from the proposed Arun III Hydropower Project headworks. The RoR IKHPP project area is situated within longitude 87°21"16" to 87°25"07" east and latitude 27°35"07" to 27°37"12" north.

Based on the September 2019 IKHPP Feasibility Study, the proposed IKHPP dam (6-meters high) is located in Makalu Rural Municipality, about 588 m upstream from Ikhuwa Khola confluence with Pawa Khola. The powerhouse site is located on the right bank of the Ikhuwa Khola near the confluence of Arun River and Ikhuwa Khola. The diversion dam diverts a design capacity of up to 6.02 cubic meters per second (m^3/s) of water via a headrace tunnel to a powerhouse with a 40 MW capacity, returning the water to the Arun River through a tailrace canal.

Upper Ikhuwa Khola Small HEP

According to the DoED's hydropower license database[3], Khadga Bdr Karkee acquired a survey license for the 9.60 MW Upper Ikhuwa Khola Small HEP. The project area is situated within longitude 87°25"08" to 87°27"07" east and latitude 27°35"50" to 27°37"20" north. Additional information on this project is not currently available.

Lower Barun HEP

Ampik Energy Pvt Ltd has acquired a survey license for the 132 MW RoR Lower Barun HEP on the Barun River. An EIA has been submitted to the DoED for this project, which has not been made available to the CIA team. Based on the developer's salient features document, a weir (with a crest level of 20 m) will be built at Saldim-Barun confluence. An underground powerhouse will be built in Bhotkhola Rural Municipality.

Isuwa Khola HEP

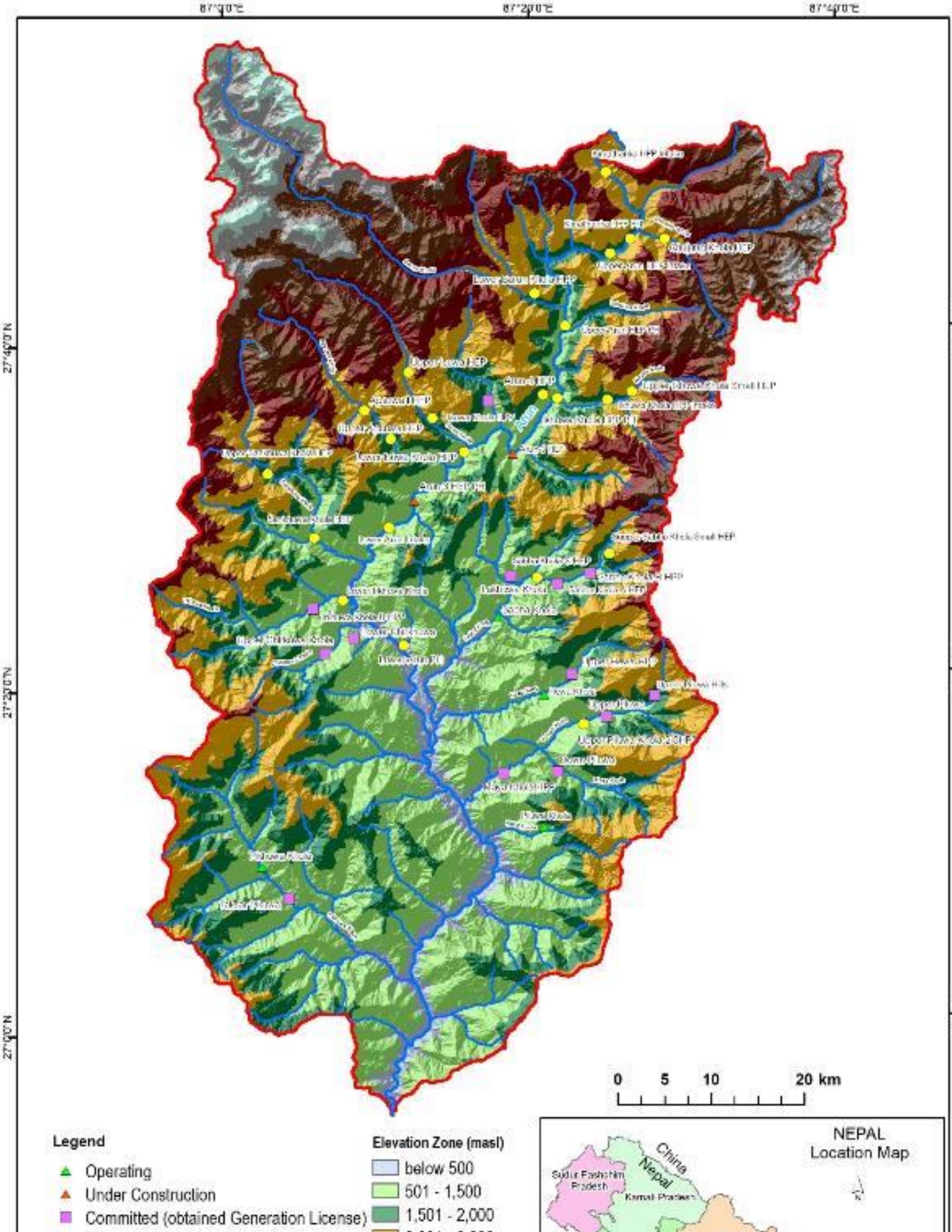
KBNR Isuwa Power Ltd. Is constructing this project in Isuwa river with installed capacity of 97.2 MW. The project area is situated within longitude 87°11"23" to 87°14"30" east and latitude 27°34"03" to 27°37"00" north. Additional information on this project is not currently available. The company is also constructing another 40.1 MW Isuwa Khola PRoR Cascade HEP downstream from Isuwa Khola HEP.

Table 5.2: Select Salient Features of the Key Tributary Projects

Salient Features	IKHPP	Upper Ikhuwa	Lower Barun
Operation	RoR	RoR	RoR
MW	40 MW	9.60 MW	132 MW
Average flow	9.86 m^3/s	N/A	24.37m^3/s
Design discharge	8.03 m^3/s	N/A	18.44 m^3/s
Transmission line length	2 km	N/A	20 km
Substation	Arun Hub	Arun Hub (assumed)	Arun Hub (assumed)
Transmission line capacity	132 kV	N/A	220 kV

[3] https://www.doed.gov.np/license/13

Figure 5.2: Planned HEPs in the Arun River Basin



Source: ERM 2020

Projects on the Koshi River

As all the rivers in Nepal eventually flow towards India and join the Ganges River, developments and water issues related to Nepal's rivers also affect India. As such, surveying of the Koshi River and a project report was prepared in 1946 for the Sapta Koshi High Dam Project. In 1954, India and Nepal signed the Koshi Agreement to regulate the flow of the Koshi River and control flooding, nearly a year later, planning of the Koshi Barrage commenced.

Koshi Barrage

Construction of the Koshi Barrage began near the Nepal/India border, approximately 56 km downstream from the confluence of the Arun and Koshi rivers (***Figure 5.3***), started in 1958 and was completed in 1962. The Koshi Barrage has a fish ladder, but it is reported to be very inefficient in terms of upstream fish migration (Yadav and FAO undated). In 2008, the embankment of the Koshi Barrage collapsed and displaced millions of people in Nepal and India. According to Oza (2014), this was the eighth major breach since the embankment was completed in 1959. Following the 2008 breach, a Nepal-India Commission on Water Resources issued a new strategy to control flooding on the Koshi River, which involved restarting planning of the Sapta Koshi High Dam Project through the creation of the Sapta Koshi Joint Commission Office.

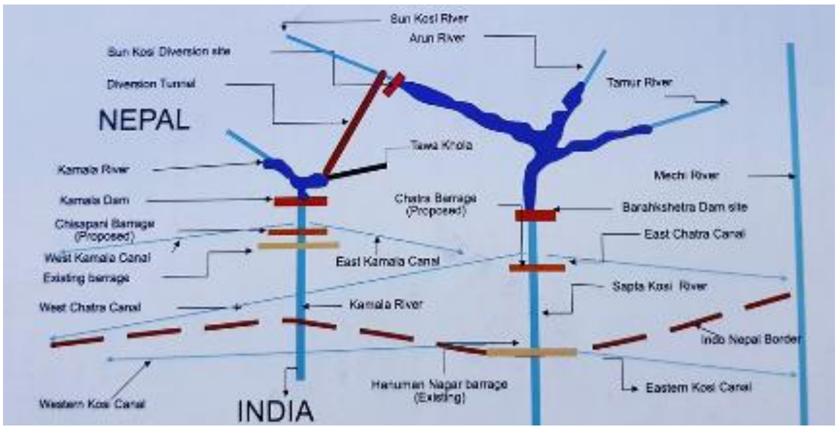
Sapta Koshi High Dam Multipurpose Project

The Sapta Koshi High Dam Multipurpose Project (also called the Sapta Koshi Project), for which investigations works have been underway since 2004, is currently in the Detailed Project Report (DPR) stage. The 269 m high storage dam is planned to be situated across the Sapta Koshi, with the intended purpose to: regulate seasonal river flows; generate hydropower with an installed capacity of 3,000 MW; and provide flood and silt control, and irrigation to the Terai area of Nepal and North Bihar in India.

According to consultations with the Sun Koshi Sapta Koshi Investigation (SKSKI) office, the Sapta Koshi Project is facing key challenges such as bilateral (Nepal/India) issues regarding compensation and resettlement, public concern regarding mitigation for those displaced, and potential impacts from the planned Tamor Storage project (located on the Tamor River upstream from the confluence with the Sapta Koshi River). The Sapta Koshi Project dam height will need to be considered in coordination with the Tamor Storage project. An EIA for the Sapta Koshi Project will be conducted after the project components have been confirmed and the Detailed Feasibility Study is completed.

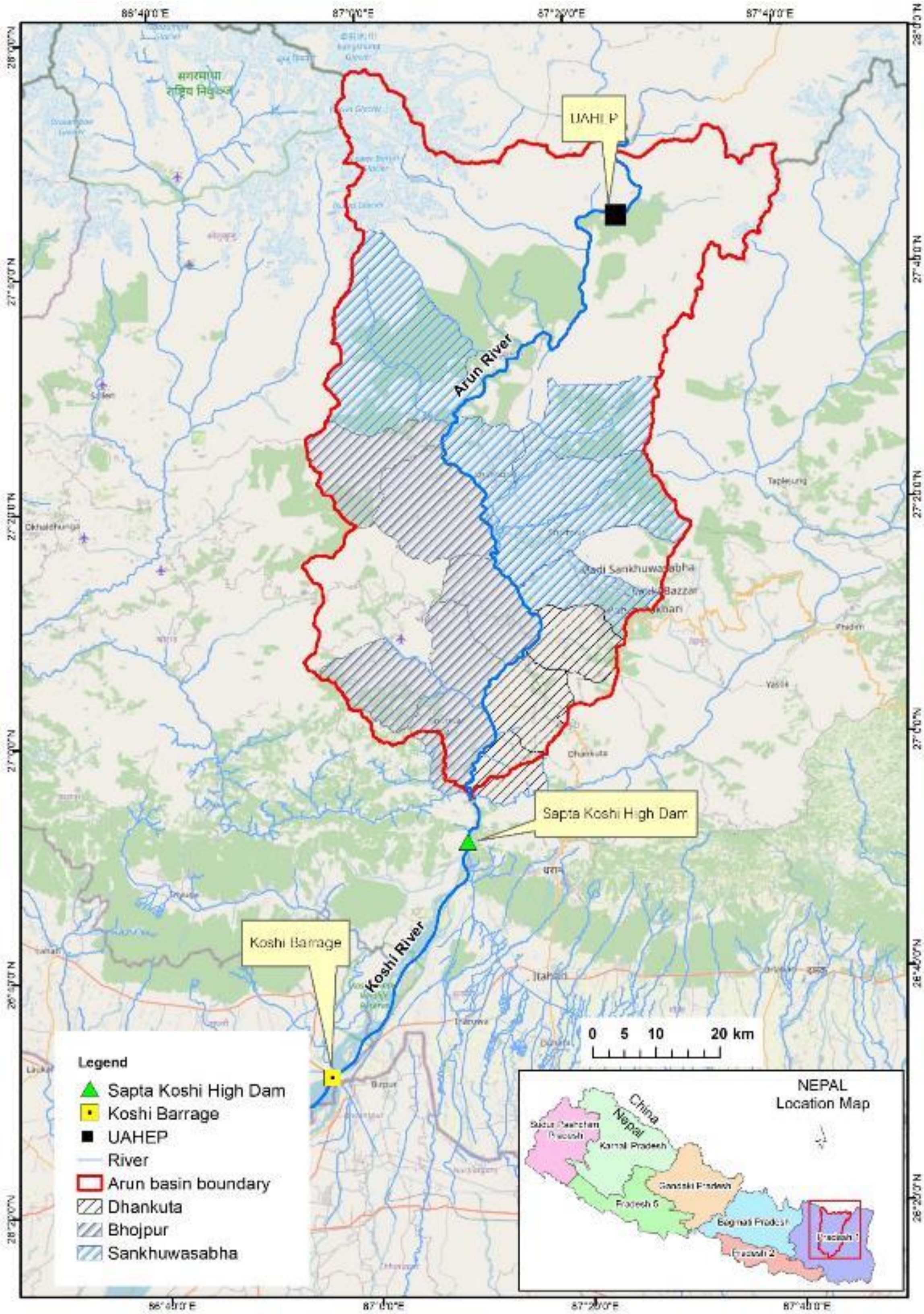
Although the Sapta Koshi Project is not located in the Arun River Basin, it is likely to result in backwater effects on the Arun River (as well as the Tamor and Sun Koshi rivers). Rai (2020) reported that the Sapta Koshi Multipurpose Project would inundate more than 11,777 ha of upstream land, and displace 10,263 people across Bhojpur, Dhankuta, and Sankhuwasabha districts (***Figure 5.4***).

Figure 5.3: Schematic Diagram of the Sapta Koshi Project



Source: SKSKI, Sapta Koshi High Dam Multipurpose Brochure

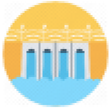
Figure 5.4: Location of the Koshi Barrage and Sapta Koshi High Dam



Source: ERM 2020

Note: The shaded areas represent the municipalities which are likely to be at least partially inundated by the Sapta Koshi High Dam Multipurpose Project according to Rai (2020).

Table 5.3: Hydropower Projects in the Arun River Basin

Status	Hydropower Projects	Capacity (MW)	Promoter
Operating	**9**	**52.865**	
	Piluwa Khola (operation date: 18 September 2003)	3.00	Arun Valley Hydropower Development Company Pvt. Ltd.
	Hewa Khola (operation date: 08 February 2002)	4.45	Barun Hydropower Development Co. Pvt. Ltd
	Sabha Khola (commercial operation date: 20 September 2017)	3.30	Dibyaswari Hydropower P Ltd
	Pikhuwa Khola	5.00	Eastern Hydropower P Ltd
	Lower Piluwa	0.99	Baneshwor Hydropower P Ltd
	Maya Khola Hydropower Project	14.9	Maya Khola Hydropower Company Pvt Ltd
	Taksar Pikhuwa	8	Taksar Pikhuwa Khola Hydropower Pvt Ltd
	Upper Hewa HPP	8.5	Upper Hewa Khola Hydropower Company Pvt Ltd
	Upper Pilwa Khola – 2 SHP	4.72	Menchhiyam Hydropower P Ltd.
Under Construction	**22**	**1,267.24**	
	**Arun-3 (construction began in 2018)**	900.00	SJVN Arun-3 Power Development Company (SAPDC)
	Chujung Khola HEP	48	

Status	Hydropower Projects	Capacity (MW)	Promoter
	Down Piluwa	10.3	
	Irkhuwa Khola-B HPP	15.524	
	Isuwa Khola Hydropower Project	97.2	
	Isuwa Khola PRoR Cascade HEP	37.7	
	Kasuwa Khola HPP	45	
	Lankhuwa Khola	5	
	Lower Chirkhuwa	4.06	
	Lower Hewa Khola-A HPP	7.3	
	Lower Irkhuwa Khola	14.15	
	Phedi Khola (Thumlung) Small HPP	3.52	
	Sabha Khola A	10.4	
	Sabha Khola-B HPP	15.1	
	Shyam Khola HEP	7.25	
	Super Hewa HPP	5	
	Upper Chirkuwa Khola	4.7	
	Upper Irkhuwa HPP	14.5	
	Upper Pikhuwa Khola HEP	4.9	
	Upper Piluwa 3 HPP	4.95	
	Upper Piluwa Hills Small HPP	4.99	
	Upper Piluwa-1 HEP	7.7	
Applied for Construction License	**12**	**821.5**	
	Apsuwa I HEP	23	Ram Janaki Hydropower Pvt. Ltd

Status	Hydropower Projects	Capacity (MW)	Promoter
	Ikhuwa Khola HEP	40	Upper Arun Hydro Electric Limited
	Irkhuwa Khola Ka HEP	15	Eastern Hydropower Pvt.Ltd.
	Kimathanka Arun HEP	454	Vidhyut Utpadan Company Limited
	Lower Apsuwa HEP	54	Mizu Energy Limited
	Lower Barun Khola HPP	132	Ampik Energy Pvt Ltd
	Pikhuwa Pashupati HEP	4.1	Sumnima Hydropower Company Pvt. Ltd.
	Sabha Khola C HEP (Cascade)	6.3	Orbit Energy Private Limited
	Sisuwa Khola HEP	13.5	Matribhumi Hydropower Development Company Pvt. Ltd
	Super Sabha Khola Small HEP	4.1	Sankhuwasabha Power Development Pvt.Ltd
	Upper Apsuwa HEP	35.15	Ram Janaki Hydropower Pvt. Ltd
	Upper Sankhuwa Khola HEP	40	Happy Energy Pvt. Ltd
Planned (Issued Survey License)	**17**	**2,713.74**	
	Arun 4 PRoR HEP	490.2	Nepal Electricity Authority
	Bakan Khola HEP	44	Summit Energy Solution Pvt. Ltd
	Induwa Khola PRoR HEP	24.921	Vision Tesla Power Pvt. Ltd.
	Isuwa Cascade-3	9.95	Magic Arun Hydropower P.Ltd.
	Isuwa PROR Cascade-2 HEP	9.95	Bista Energy House Pvt. Ltd.
	Lower Arun Hydropower Project	679	SJVN Limited India

Status	Hydropower Projects	Capacity (MW)	Promoter
	Mathillo Maya Khola Hydropower Project	5	Waleng Tumhok Hydro Power Pvt. Ltd.
	Pikhuwa Khola HPP	6.7	Aspire Power Company Pvt. Ltd.
	Saldim Khola HEP	45	Ludhiana Holding Energy Nepal Pvt. Ltd
	Sankhuwa Khola HEP	41.061	Guras Hydro Pvt. Ltd
	Super Irkhuwa Khola HEP	5	Bhojpur Siwalaya Power Pvt. Ltd
	Super Sabha Khola A HPP	9.55	Sankhuwa Sabha Development Pvt. Ltd.
	Tejo Thogam Khola HPP	29	Snowfall Hydropower Pvt. Ltd.
	Upper Arun HEP	**1,063.36**	**Upper Arun Hydro Electric Limited**
	Upper Barunkhola HEP	109.5	Great Hydropower Pvt. Ltd
	Upper Chhujung HEP	40.7	White Flower Company Pvt. Ltd
	Upper Ikhuwa Khola Hydropower Project	9.6	Sashi Power Investment Pvt. Ltd.
Total	**39**	**3,739.73**	

Electricity Connectivity

The lack of a North-to-South high voltage transmission line has been a limiting factor for hydropower development in the Arun River Basin. As such, networks of transmission lines are currently under-construction or proposed. Existing and under construction transmission lines in the eastern districts of Nepal (according to the NEA's Power Development Map of Nepal dated July 2019; NEA 2019) are shown in ***Figure 5.5***.

Rastriya Prasaran Grid Co Ltd (RPGCL), which was established by the Government of Nepal in 2015 to transmit and evacuate the power for the development and operation of the hydropower sector, has also proposed future transmission line in the Arun River Basin region in the 2018 Transmission System Development Plan of Nepal. The RPGCL proposed transmission lines include:

- Around 6 km transmission line from Upper Arun substation of Sankhuwasabha district to Arun Hub (Haitar) substation of Sankhuwasabha district is proposed to evacuate power from Upper Arun Region.
- Around 35 km of Quad Moose 400kV double circuit transmission line is proposed between Arun Hub and Sitalpati substation in Sankhuwasabha.[4]
- Around 94 km of Quad Moose 400kV double circuit transmission line is proposed between Sitalpati substation to the Inaruwa substation, which is currently being studied by NEA (NEA 2023).
- Around 75 km of Quad Moose 400kV double circuit transmission line connecting Sitalpati substation to Tingla substation; the line will then be extended from Tingla substation to Dudhkoshi hydropower plant and Dhalkebar substation.

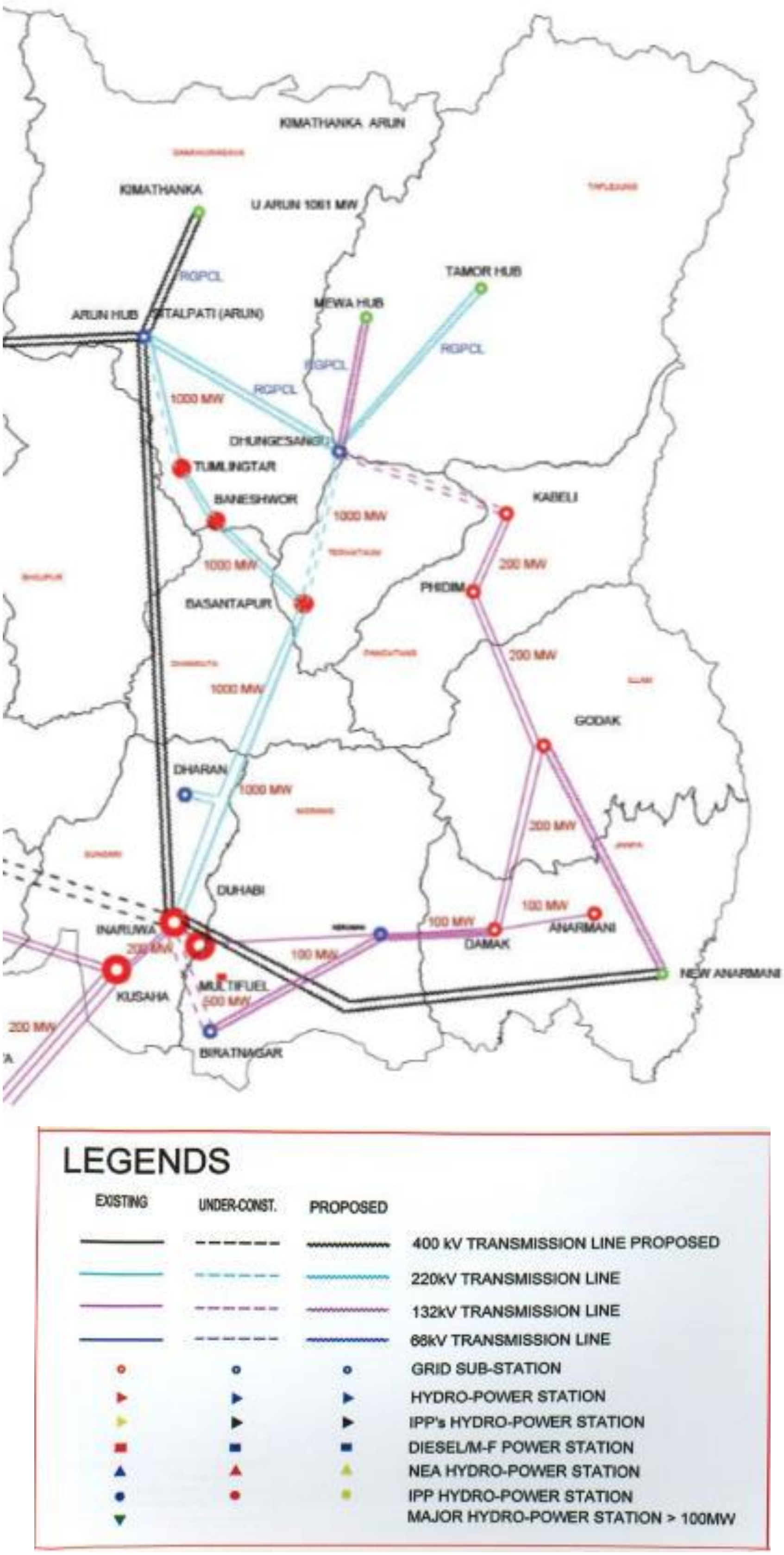
Hydropower projects will require construction of transmission lines to evacuate the electricity generated to the electricity grid. Below is a summary of the transmission lines that would be constructed for select HEPs (according to the HEP's EIA/IEE):

- Kimathanka Arun: A 18.5 km long, 400 kV double circuit transmission line within a 46 m wide right-of-way (RoW) to the proposed Arun Hub substation or a 72 km transmission line to Inaruwa substation
- UAHEP: A 5.9 km long, 400 kV double circuit transmission line within a 46 m wide[5] RoW extending from the UAHEP potyard to the proposed Arun Hub substation at Hitar
- IKHPP: A 2.6 km long, 132kV single circuit transmission line with an 18m RoW to the Arun Hub substation
- Arun-4: A 14 km long, 400 kV double circuit transmission line within a 46 m wide RoW to the Arun Hub substation
- Arun-3: A 310 km long, 400 kV double circuit transmission line within a 46 m wide RoW to Mujaffarpu, India. Only 25 km of the route is situated in the Arun Basin
- Lower Arun: A 2 km long, 400 kV transmission line within a 46 m wide RoW connecting to 400 kV line emerging from Arun 3 HEP substation

[4] https://rpgcl.com/projects/haitar-sitalpati-arun-corridor-400kv-transmission-line-project

[5] The RoW is the area of land that will be used to locate, construct, operate, and maintain the transmission line. Most structures and certain activities are restricted within the RoW to ensure there will be no future incompatible development that will affect transmission line operations and to protect local residents from any adverse health effects from electric and magnetic fields. The standard RoW width for a 400 kV transmission line in Nepal is 46 meters, 23 meters horizontally on each side from the centerline. The transmission line towers will be located along the centerline of the RoW. In Nepal, typically just the land underlying the towers is acquired, while private owners of other land within the RoW receive compensation for the restrictions placed on their land.

Figure 5.5: Power Development Plan in Eastern Nepal



Source: Power Development Map of Nepal (NEA 2019)

Access Roads

Access roads are needed for HEPs to transport required structures and materials during construction and operation. Hydropower projects in the Arun River Basin will typically require either extensions or improvements and the widening of existing roads. For example, below is a description of the access roads which would be required for construction/operation of the following HEPs (according to the HEP's EIA/IEE):

- Upper Arun HEP – Requires completion of the Koshi Highway and building of a dedicated access road of approximately 22 km, including an estimated 2.0 km of road tunnel and a bridge over the Arun River
- Arun-4 HEP – Requires a 23 km extension from the existing road network
- Ikhuwa Khola HPP – Requires an extension of 4 km to connect the powerhouse to the Koshi Road; an additional of 12.5 km of hilly road will be constructed from the powerhouse site to the headwork
- Arun-3-HEP – A total of 88 km of road network needs to be constructed for the proposed project. An IEE has been approved for a stretch of 58.51 km roads and these segments are under construction. The remaining stretch of about 29.09 km will be constructed as a part of Arun-3 HEP.
- Lower Arun – The existing earthen road Tumlingtar-Khandbari-Kheutar would be extended and upgraded for the access to the dam site. For the access to Powerhouse, the existing Tumlingtar-Betini/Chewabesi road is to be upgraded.

In addition to the HEPs, temporary roads may be constructed for access to tower locations during construction of transmission lines in this region.

5.3.2 Road Infrastructure

The Koshi Hills comprises four districts; Sankhuwasabha, Bhojpur, Dhankuta and Terhathum, all belonging to the eastern region of Nepal. The first roads in Koshi Hills were constructed in 1982, by 2007 all four districts headquarters were connected to the road network totaling 934 km. The Koshi Highway, also known as the Dharan-Dhankuta Highway, is the main thoroughfare that connects the Koshi Hills with the Terai region and other major places across the country, as well as the bordering cities of India. Shown in ***Figure 5.6*** is the existing road infrastructure in the Arun River Basin.

There has been a drastic change in road networks in the Koshi Hills over the past 24 years. The average road density was 14.2/100 km^2 in 2010, increasing from the density below 9.1/100 km^2 in 2007. Bhojpur and Sankhuwasabha have a relatively poor road density, below 7.7/100 km^2. However, these two districts are linked by an air service with Kathmandu (national capital city) and Biratnagar (regional city in the eastern Terai region). In areas of Koshi Hills where there are no roads, traditional highways such as trail networks and bridges are crucial. There are about 1,093 km of trails and 231 trail bridges in the Koshi Hills region (Pradhan and Sharma 2017).

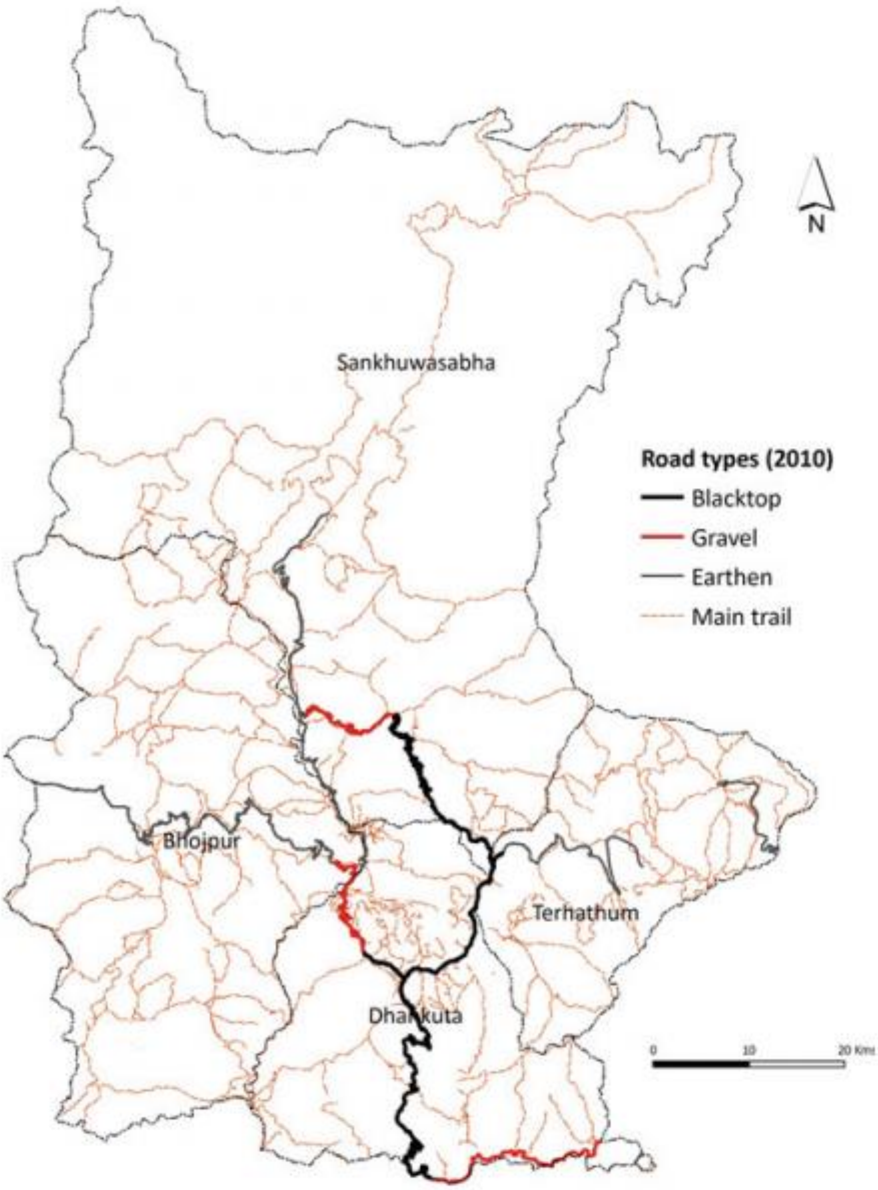
The North-South Highway (Koshi Highway) connects India to China across the Himalayan Mountains in Nepal.[6] The Tumlingtar-Khandbari road was built in 2010, the Khandbari-Num road was completed in 2016, and the track beyond Num was recently opened in 2018 as a part of the Koshi Highway (***Figure 5.7***) and is in the process of being completed. According to the North-South Highway Project Office, approximately 14 km remains to be completed from Chemtang to Ghongghappa, which is expected to be opened in 2022. This section of the Koshi Highway is still not completed.

The 1,776 km Mid Hill Highway is under construction to connect east and west Nepal. As shown in ***Figure 5.8.***, a portion of the highway passes through the Arun Basin. An EIA has been undertaken for the Mid Hill Highway, which was not available to the CIA Team.

Cumulative impacts of the existing road network and the remaining sections of the Koshi Highway to the selected VECs are assessed in **Section 8**.

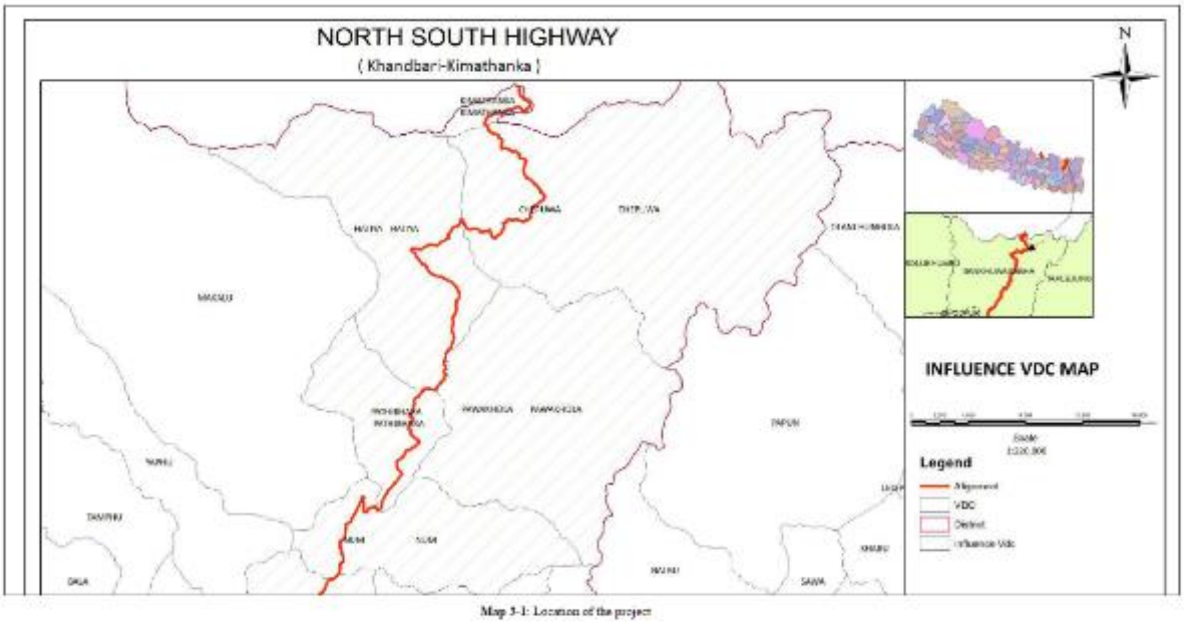
[6] https://thehimalayantimes.com/nepal/biratnagar-kimathanka-trilateral-road-projects-disheartening-progress/

Figure 5.6: Road Infrastructure in the Arun River Basin



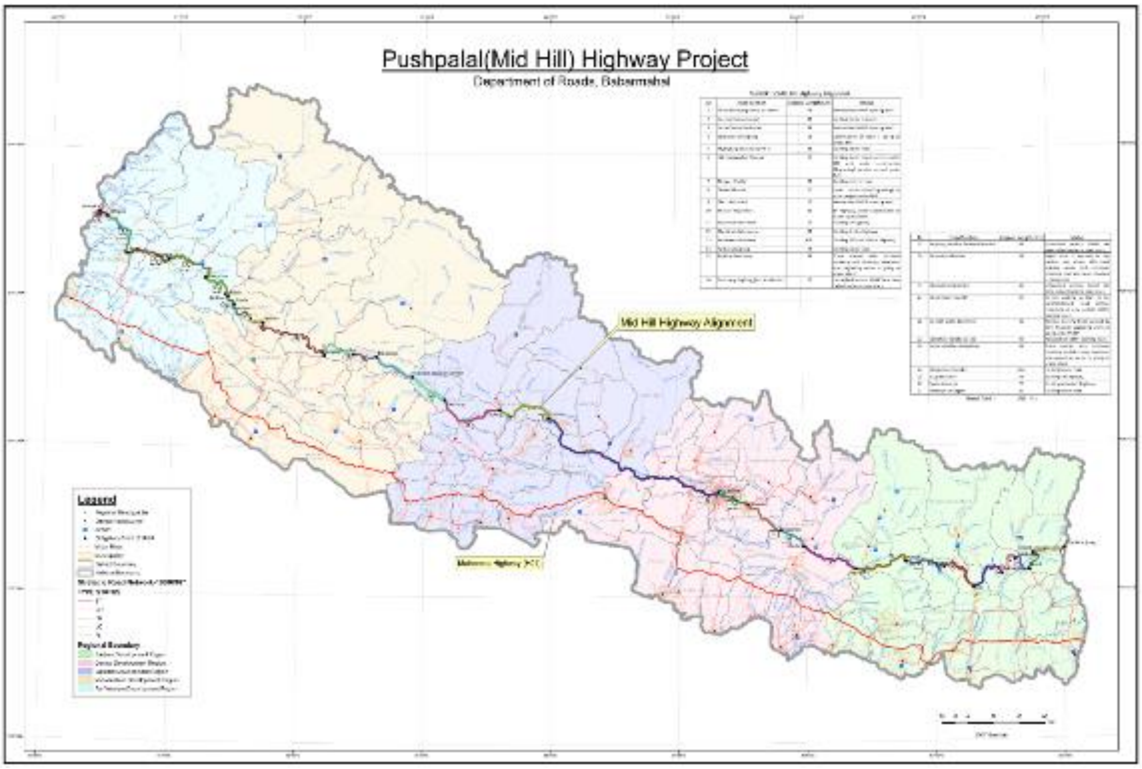
Source: Pradhan & Sharma 2017

Figure 5.7: North-South Highway (Khandbari-Kimathanka)



Source: Num-Kimathanka EIA 2019

Figure 5.8: Schematic of the Mid Hill Highway



Source: Phidim District Department of Roads

5.3.3 Agriculture

Agriculture has been the predominant economic activity in the Koshi Hills (Sankhuwasabha, Bhojpur, Dhankuta, and Terhathum districts), although the population engaged in this sector has decreased from 98% in 1971 to 76% in 2001, which was still far higher than the national average (60% in 2001). The agricultural system is predominantly subsistence in nature, except in few areas accessed by roads where intensive cultivation of vegetables is practiced (Pradhan and Sharma 2017). The development of roads in the region since 1985 has encouraged the substantial increase of commercial farming, however, between 1995 and 2011, changes in commercial agriculture were detected. Changes were observed in the growth in production of high value crops and commercial utilization of forest products. Vegetable production has increased from negligible amounts cultivated for home consumption in the 1970s to over 101,000 metric tons (MT) by 2009/10 (MoAC 2010). Production and cropping areas have risen significantly from 1990 onwards, with cultivation mostly concentrated in Dhankuta, which produced 46% of total vegetables in the region, followed by Terhathum (19%), Bhojpur (18%), and Sankhuwasabha (17%).

Agricultural production has largely been along the road corridors and near the main bazaars and/or towns. Large cardamom production has dramatically increased from seven hectares in 1971 to 3,930 hectares in 2009 (representing a 561-fold increase) (MoAC 2010). In 2009/10, the four districts produced 1,603 MT of the spice (31% of nationwide production), with Sankhuwasabha becoming the third largest producer in the country. Households can earn NPR 60,000 to 90,000 from cardamom cultivation in one season.[7]

The main types of agricultural areas in the basin Ide *bari* (upland irrigated), *khet* (riverine), *pakho* (unirrigated), and floodplain agriculture. Typically, agricultural land closer to the river is given to land users under three types of land tenure arrangements: *adhiya* or sharecropping (predominant upstream and downstream); *bandhagi* or convenience-based use, collateral linked to loan repayment (predominant midstream); and *kut* farming or contract farming (predominant midstream). Paddy is generally grown in *khet* and maize and millet in *bari* land. Similarly, cardamom is grown in *pakho* and *bari* land (Arun-3 EIA).

In line with the CIA consultations with the Water Source and Divisional Irrigation Office and downstream local communities, common agricultural products include paddy, millet, vegetables, maize, wheat, and cash crops (cardamom, chilli, mushroom, etc.). Most farming activities are for household consumption and for sale in the local markets. Few farmers are engaged in large-scale commercial agriculture according to consultation with the Agriculture Knowledge Centre.

5.3.4 Sand and Gravel Extraction

The CIA Downstream Consultations indicate that most gravel, sand and stone are extracted from Shaba Khola, Sishwa Khola, and Nepa Khola and partly from the Arun River. The extracted materials are typically used within the district, for instance, for road construction. This is particularly the case for the North-South Highway, which sources gravel, sand and stones from streams along the road alignment. Crusher plants are not allowed in the Arun River, however, small scale mining for households and other purposes is seen at some locations along the Arun River.

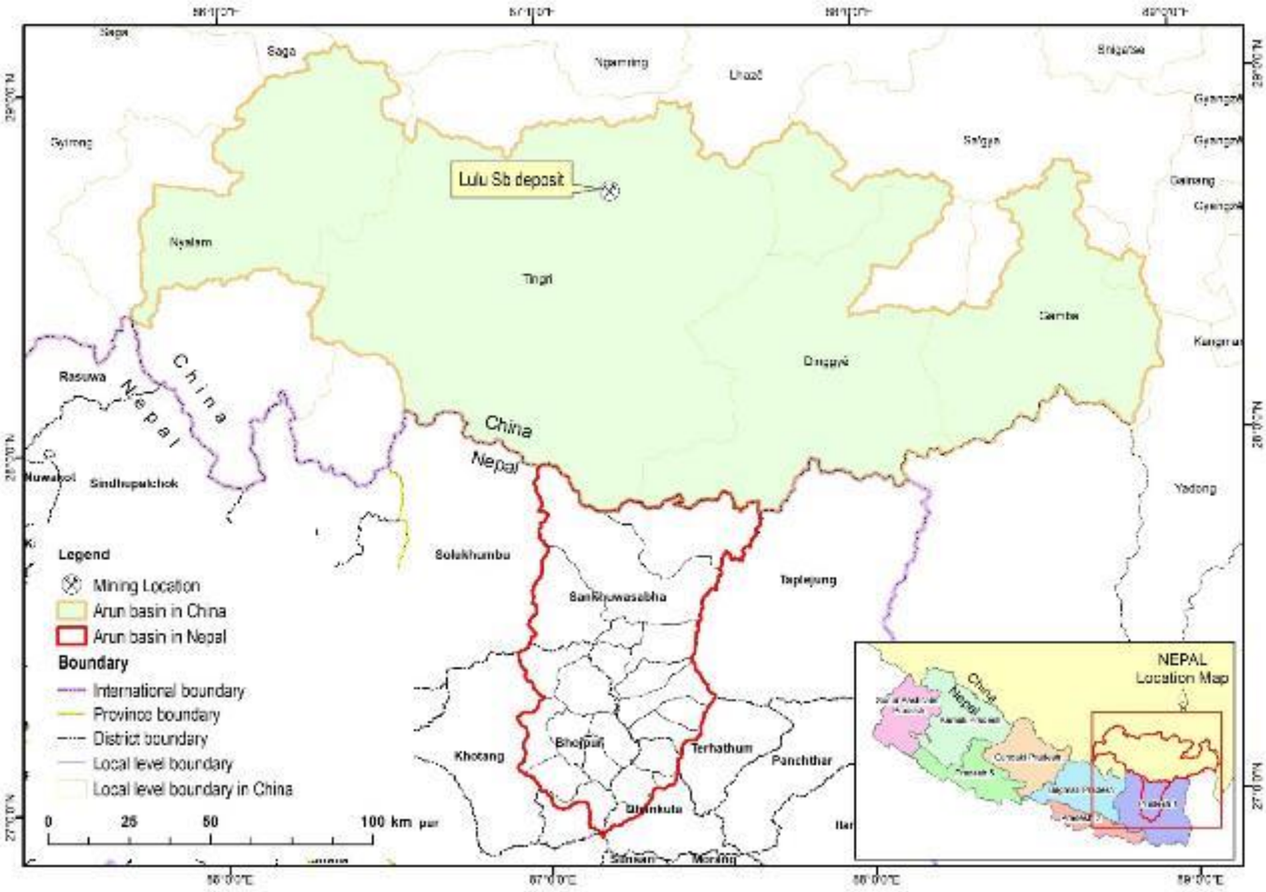
If practiced unsustainably, sand and gravel extraction could increase riverbank erosion and result in negative hydrological and biodiversity impacts. As such, the impacts of sand and gravel extraction activities are considered for selected VECs. Additionally, given that sand and gravel extraction is a livelihood source in the Arun River Basin, cumulative impacts on this income generating activity are considered under VEC: river-based livelihoods.

[7] https://assets.publishing.service.gov.uk/media/57a08a2540f0b652dd0005ae/NPRKH_Final_Summary_Report.pdf

5.3.5 Mining

Shown in ***Figure 5.9*** is the only known mining site (Lulu Sb) in the TAR portion of Arun River Basin. This quartz mine is located over 100 km north of the Nepal/TAR border.

Figure 5.9: Mining Site in the Arun Basin



Source: ERM 2020

5.3.6 Natural Hazards and Climate Risks

Nepal is among the 20 most disaster-prone countries in the world, in terms of both natural and human induced disasters (MoHA 2017). Globally, Nepal ranks 4th and 11th in terms of its relative vulnerability to climate change and earthquakes, respectively (MoHA 2015). More than 80% of the total population of Nepal is at risk of natural hazards such as floods, landslides, windstorms, hailstorms, fires, earthquakes and glacial lake outburst floods (GLOFs). These natural hazard and climate risks have been exacerbated by the warming of the climate. Over the last 30 years, Nepal has experienced an 0.06°C temperature increase, which is higher than the global rate, and has resulted in rapid shrinking of the majority of glaciers in Nepal (Shrestha and Aryal 2011).

The Government of Nepal conducted a climate change vulnerability mapping in 2010. Vulnerability is mapped through different natural hazard indicators like rainfall and temperature vulnerability index, landslide vulnerability index, flood vulnerability index, drought vulnerability index, GLOF vulnerability index, and overall index. Shown in ***Table 5.4*** are the findings of climate vulnerability index for districts in the Arun River Basin. Overall, Sankhuwasabha and Bhojpur districts are ranked as 'high' vulnerability and Dhankuta is ranked as 'moderate'.

Table 5.4: Vulnerability Index for Districts in the Arun Basin

Vulnerability Index	Vulnerability Rank		
	Sankhuwasabha	Bhojpur	Dhankuta
Rainfall and temperature risk	Low	Low	High
Landslide	Moderate	High	Low
Flood	Very Low	Very Low	Very Low
Drought	Very Low	Moderate	Very Low
GLOF	Very High	High	High
Overall	High	High	Moderate

Source: MoE 2010

In addition to the current situation and impacts of climate change, a significant and consistent increase in temperature was projected for Nepal. Various models projected the warming of temperature to be above the baseline average (1977–2000); the temperature will increase by 1.2°C in 2030, 1.7°C in 2050 and 3.0°C in 2100. These models also showed the possible impacts of climate change induced deglaciation on various sectors, such as increase in mean river discharge, GLOFs, landslides, and their eventual effects on agriculture and livelihoods (Agrawala *et al*. 2003).

The following subsections provide additional details regarding floods, landslides, GLOFs and earthquakes in the Arun River Basin. The impacts of these natural hazards to the selected VECs are also considered in **Section 8: Cumulative Impact Assessment**.

Floods

The Koshi River is termed the “sorrow of Bihar”, as frequent floods kill hundreds of people and affect thousands of hectares of agricultural land on an annual basis. The Himalayan foothills in the Arun Basin are subject to intense and prolonged rainfall during summer, which produces locally-high river levels and contributes to downstream flooding. Flood-generating overland flow has even been observed in the cloud forests of the upper Arun. The greatest peak flows in the Himalaya tend to result from sudden releases of water following failure of some natural impoundment. Such dams include glaciers, glacial moraines, and mass movement deposits. Several million m^3 of water may enter the river in just a few hours. Such floods, where they occur, far exceed peak flows resulting from rainfall or snow- and ice-melt in upstream areas. Even though these flash floods are attenuated downstream, the potential for destruction from dense debris flows is likely to be far above that caused by rainfall floods (Kattelmann 1990). ***Table 5.5*** shows impact of floods and landslides in districts of the Arun Basin during the period 2000 to 2009.

Table 5.5: Impact of Floods and Landslides in the Study Districts (2000–2009)

District	Deaths	Affected Families	Animal Loss
Bhojpur	23	504	238
Dhankuta	12	74	28
Sankhuwasabha	31	391	482

Source: (Samir 2013)

Bharati (2019) found that climate change will mean a high likelihood of wetter and stronger monsoons in the future, which will increase risks for monsoon-related disasters, such as landslides and floods. Based on statistical analysis and modelling of climate change impacts on the whole Koshi River Basin, Prasad and Gyawali (2015) also found that annual water discharge will increase due to climate change, particularly during the monsoon season, which could lead to more flood events.

Prasad and Gyawali (2015) found that snow and glacier melt currently contribute approximately 34% of annual discharges in the Koshi River Basin, and that climate change will induce the melting of glaciers and snow in the surrounding area, thus contributing to a 13% increase in annual discharges by 2050.

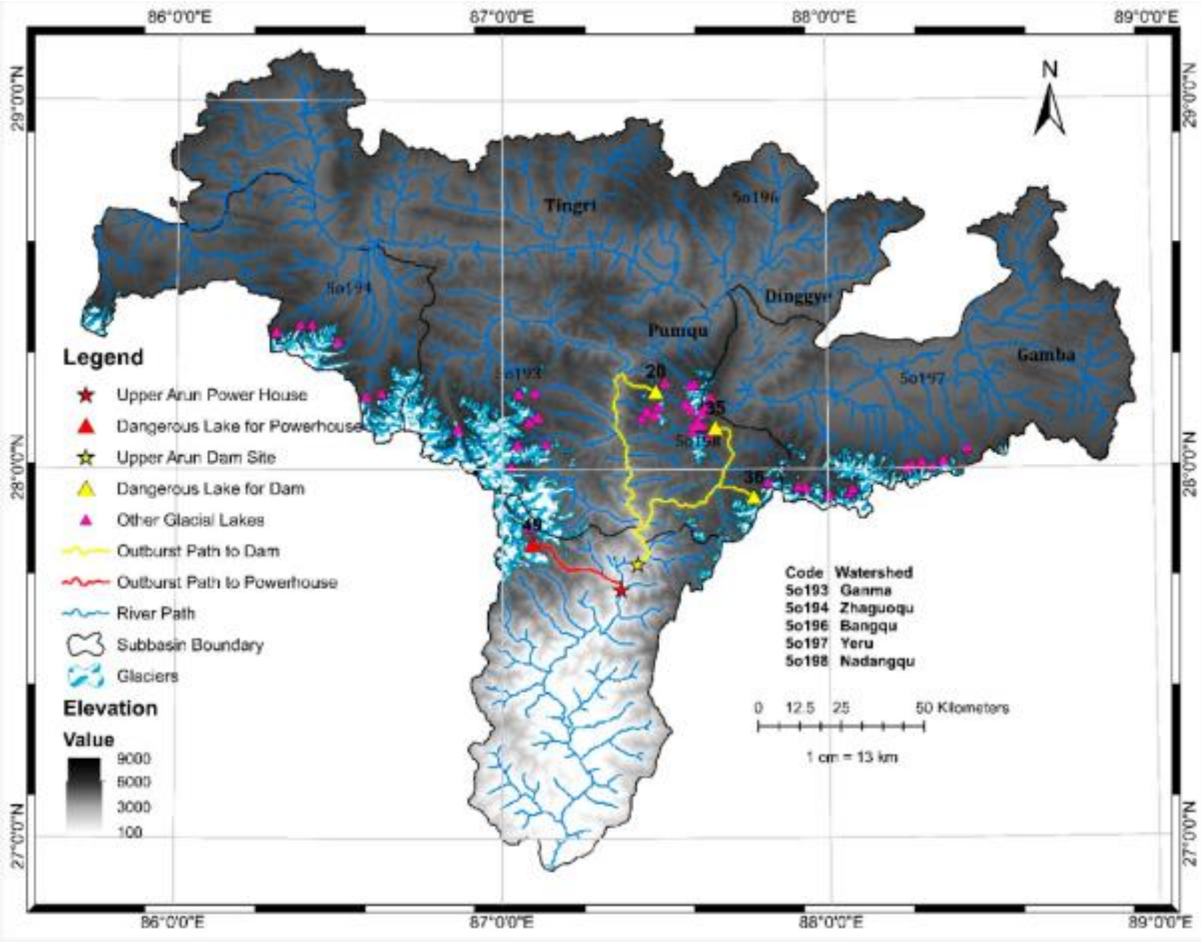
Glacial Lake Outburst Floods (GLOFs)

According to (ICIMOD 2011) one of the more spectacular effects of recent atmospheric warming in the Himalayas is the creation of meltwater lakes on the lower sections of many glaciers. Glacier are retreating quickly in Nepal – ranging from 3 to 6 meters per year (Shrestha and Shrestha 2004) – and are projected to continue or accelerate due to global warming (Agrawal 2008; ICIMOD 2011).

The most active glaciers in Nepal and the adjoining region of Tibet Autonomous Region in China are located in the eastern part of the region. In the Arun Basin, Washakh *et al*. (2019) identified 49 glacial lakes with areas greater than 0.1 km^2 (***Figure 5.10***). These lakes can be potentially hazardous in the event that a GLOF occurs, which suddenly releases the stored water. GLOFs are one of the major natural hazards in Nepal, particularly in Sankhuwasabha District. Since 1964, 10 of the 11 major natural hazards recorded in the Arun River were due to GLOFs (***Table 5.6***). These flood surges can potentially destroy infrastructure and take human lives in the valleys below.

Washakh *et al*. (2019) identified four potentially critical glacial lakes (nos. 20, 35, 36, and 49, ***Figure 5.10***) for the UAHEP powerhouse. Glacial lake no. 49 (Langmale Lake) is located in the Arun Basin, specifically, on the Barun River in the MBNP. On April 20, 2017, a flood from the Barun River formed a 2–3-km-long, 500-m-wide lake at its confluence with the Arun River. Debris had dammed the floodwaters directly above the village of Barun Bazaar, which displaced 10 families from their homes, destroyed fields, and threatened to impact at least 80 families living within the immediate area in the event that the dam suddenly failed The lake also threatened downstream villages, including Phaksinda, Diding, Chetabesi, Lumningtar, and other riverside communities in Bhojpur and Dhankuta districts, as well as UAHEP construction activities, located two km downstream (Byers *et al.* 2019).

Figure 5.10: Glacial Lakes in the Arun Basin



Source: Washakh *et al.* 2019

Table 5.6: Recorded Natural Hazards in the Arun River

SN	Flood in Arun River	Cause of floods	Effects on Infrastructures and Lives
1.	21 September 1964	Gelhaipo lake outburst in TAR; end moraine collapse due to glacier-fall into lake	Damaged road, 12 trucks, etc.
2.	Around 1964	GLOF noticed by local people along the Arun River	Timber, concrete block, and parts of trucks flowing down
3.	NA	GLOF along the Barun Khola. Some traces of past GLOF on the river channel recognized from aerial survey	
4	1968	Ayico lake outburst, TAR	Damaged road and bridge, etc.
5.	1969	Ayico lake outburst, TAR	Damaged road and bridge, etc.
6.	1970	Ayico lake outburst, TAR	Damaged road and bridge, etc.
7.	October 2–6, 1979	Large rainfall in upper Arun Basin and Num	Not stated
8.	August 27, 1982	Jinco lake outburst, TAR	Not stated

SN	Flood in Arun River	Cause of floods	Effects on Infrastructures and Lives
9.	August 27, 1985	Jinco lake outburst, TAR	Damaged eight villages, livestock, farm land, roads, bridges, etc.
10.	April 20, 2017	Langmale glacier lake flood and flood debris deposited by tributary Barun River at Bhotkhola	9 houses inundated by the flood, destroyed dozens of hectares of pasture and forest land, killed 24 yaks and *dzo*
11.	June 22, 2019	Landslides and floods due heavy rainfall	Excavator, loader, tractor, truck, and compressor and more than 200 quintals of iron rod were swept away; property worth 400 million NPR in Phyaksinda

Source: Yamada and Sharma 1993; Shrestha and Shrestha 2004; Chen *et al.* 2013; Byers *et al.* 2019; Himalayan Times 2017

Landslides

The geological characteristics of the Himalayan mountains make them highly vulnerable to landslides and other mass wasting processes from factors such as rainfall, earthquakes, floods, road construction and development works. Nepal suffers from numerous landslides, especially during the late monsoon period when water pressure builds up in the hill-slope mass or catastrophic earthquake happens (Thapa 2015).

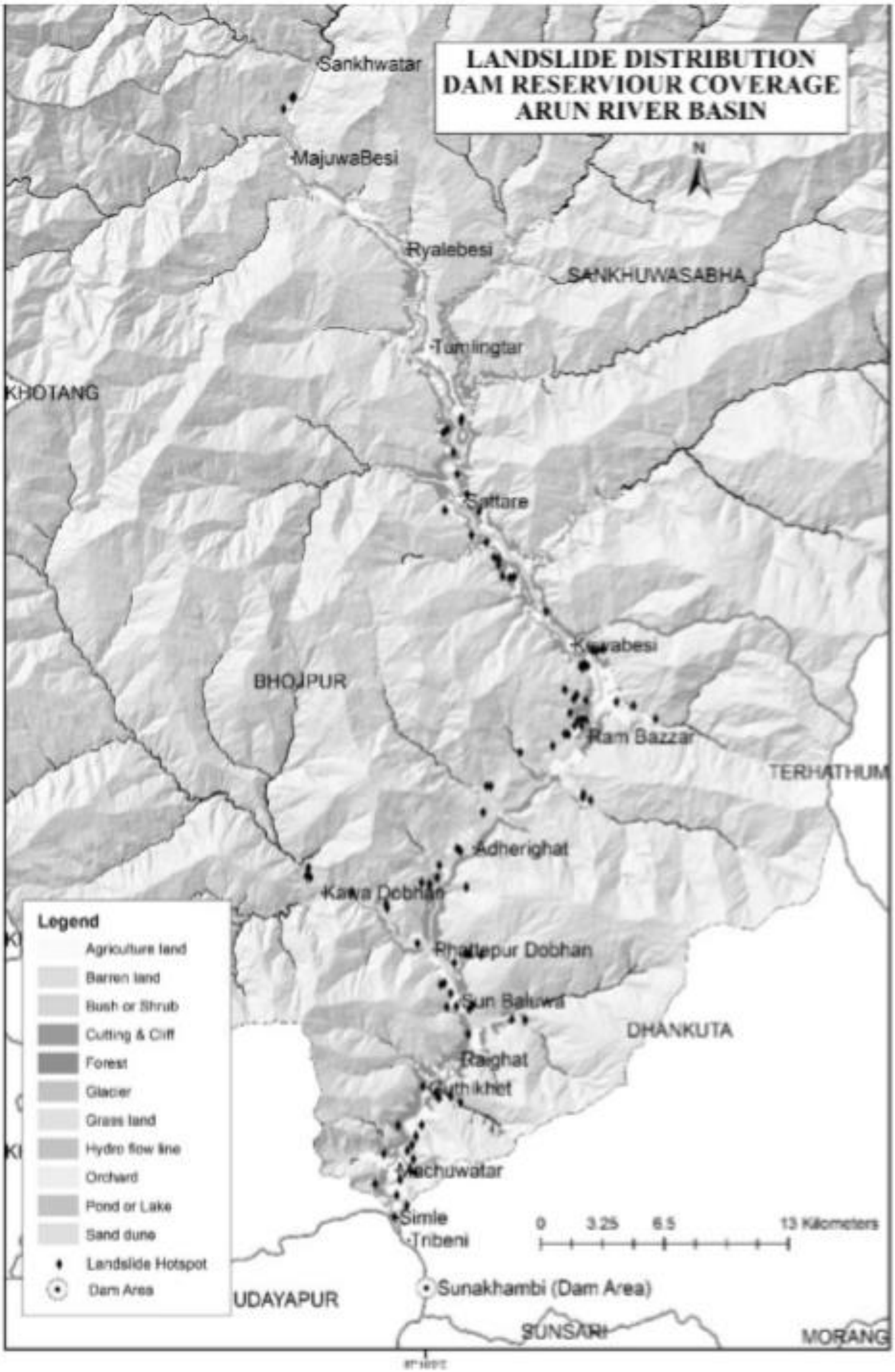
The devastating 2015 earthquake event and its subsequent aftershocks caused over 3,000 landslides across Nepal, including in the Koshi River Basin (ICIMOD 2016).[8] Impacts from landslides include alteration of water height and flow regimes, therefore, affecting the potential for hydropower projects to generate power. There is a risk that alterations are not within the design capacity of a dam's structural integrity, which can lead to the cracking of dam structures or even to dam collapse.

The Eastern region of Nepal accounts for 19% of the total fatalities caused by landslides in Nepal. Available landslide and related hazards database (DesInventar) during the period from 1971 to 2013 shows that average loss of life is about 24 per year in the region. The districts with high occurrence of landslides in the eastern Nepal are Taplejung, Panchthar, Ilam**,** Sankhuwasabha**,** Solukhumbu, Okhaldhunga, and Khotang. The region has significantly high reports of human deaths and other losses, such as buildings destroyed and damaged, because of landslides with high impact in Okhaldhunga (1976), Jhapa (1980), Dhankuta (1987), and Khotang (2002) etc. The high number of affected people in Bhojpur (1996), Sankhuwasabha (2008), Sankhuwasabha (2011) and Terhathum (2011) can be traced Ihe occurrence of severe landslides. The districts with extremely high economic losses are Khotang, Taplejung, Okhaldhunga, and Sankhuwasabha (Chaydhary *et al.* 2015).

Kumar (2020) examined landslide and erosion hotspots within the lower Arun Basin. The study found 103 landslide hotspots (***Figure 5.11***) and explained that characteristics of landslide distribution strongly correlate with slope, land use and land cover and presences of stream and its spatial density.

[8] http://lib.icimod.org/record/31841/files/River_Basin_management.pdf

Figure 5.11: Landslide Hotspots in the Lower Arun Basin



Earthquakes

Shown in ***Table 5.7*** are the recorded earthquakes in the Arun River Basin, according to the Nepal National Seismological Centre website. According to the data, there have been at least 22 light-moderate intensity earthquakes between 1994 and 2018, ranging from a 4.0 to 5.3 magnitude (ML), and no records of strong intensity (above 6.0 ML) of earthquakes in this region.

Table 5.7: Earthquakes Recorded in the Arun River Basin between 1994 and 2018

Date	Time	Latitude	Longitude	Magnitude (ML)	Epicenter
A.D:2018-08-29	Local:23:35	27.79	87.41	4.2	Sankhuwasabha
A.D:2016-02-23	Local:08:45	27.47	87.15	4.5	Sankhuwasabha
A.D:2013-10-28	Local:07:22	27.36	87.37	4.3	Sankhuwasabha
A.D:2011-06-18	Local:11:00	27.83	87.35	4.3	Sankhuwasabha
A.D:2011-02-22	Local:11:00	27.57	87.01	4.2	Sankhuwasabha
A.D:2011-02-13	Local:11:00	27.47	87.01	4.7	Bhojpur-Sankhuwasabha border
A.D:2009-05-14	Local:11:00	27.48	87.36	4.6	Sankhuwasabha
A.D:2009-05-14	Local:11:00	27.43	87.35	4.2	Sankhuwasabha
A.D:2005-08-28	Local:11:00	27.31	87.22	5.3	Sankhuwasabha
A.D:2002-07-16	Local:11:00	27.75	87.36	4.3	Sankhuwasabha
A.D:2000-03-17	Local:11:00	27.76	87.55	4.2	Sankhuwasabha
A.D:2000-03-13	Local:11:00	27.73	87.71	5.1	Sankhuwasabha
A.D:1998-06-27	Local:11:00	27.866	85.812	5	Sankhuwasabha
A.D:1994-09-25	Local:11:00	28.34	87.35	4.8	Sankhuwasabha
A.D:2007-07-30	Local:11:00	27.27	87.02	4.1	Bhojpur
A.D:2015-02-14	Local:01:37	28.85	82.18	5.1	Bhojpur
A.D:2007-08-03	Local:11:00	27.24	87.03	4.5	Bhojpur
A.D:2007-08-03	Local:11:00	27.2	87.04	4.3	Bhojpur
A.D:2007-08-03	Local:11:00	27.24	87.02	4	Bhojpur
A.D:2007-07-30	Local:11:00	27.27	87.02	4.1	Bhojpur
A.D:2013-09-12	Local:10:14	26.96	87.34	4.5	Dhankuta

6. VEC SCREENING AND SELECTION

Valued environmental, social, and ecosystem components (VECs) are defined as fundamental elements of the physical, biological or socio-economic environment that are likely to be the most sensitive receptors to the cumulative impacts of other projects and stressors in combination with the proposed project.

A set of preliminary VECs were identified through stakeholder engagement, as summarized in **Section 2.2.2.** A VEC screening process was conducted to determine which of the preliminary VECs would be included in the CIA. As shown in ***Figure 6.1***, to be selected for this the CIA, a VEC must first be confirmed to be valued by an identifiable stakeholder group and/or the scientific community. Second, the VEC must be reasonably expected to be affected by some combination of other projects and/or external stressors. Findings from the VEC screening process are presented in ***Table 6.1***, and the selected VECs and assessment approach are summarized in ***Table 6.2***.

Figure 6.1: VEC screening process

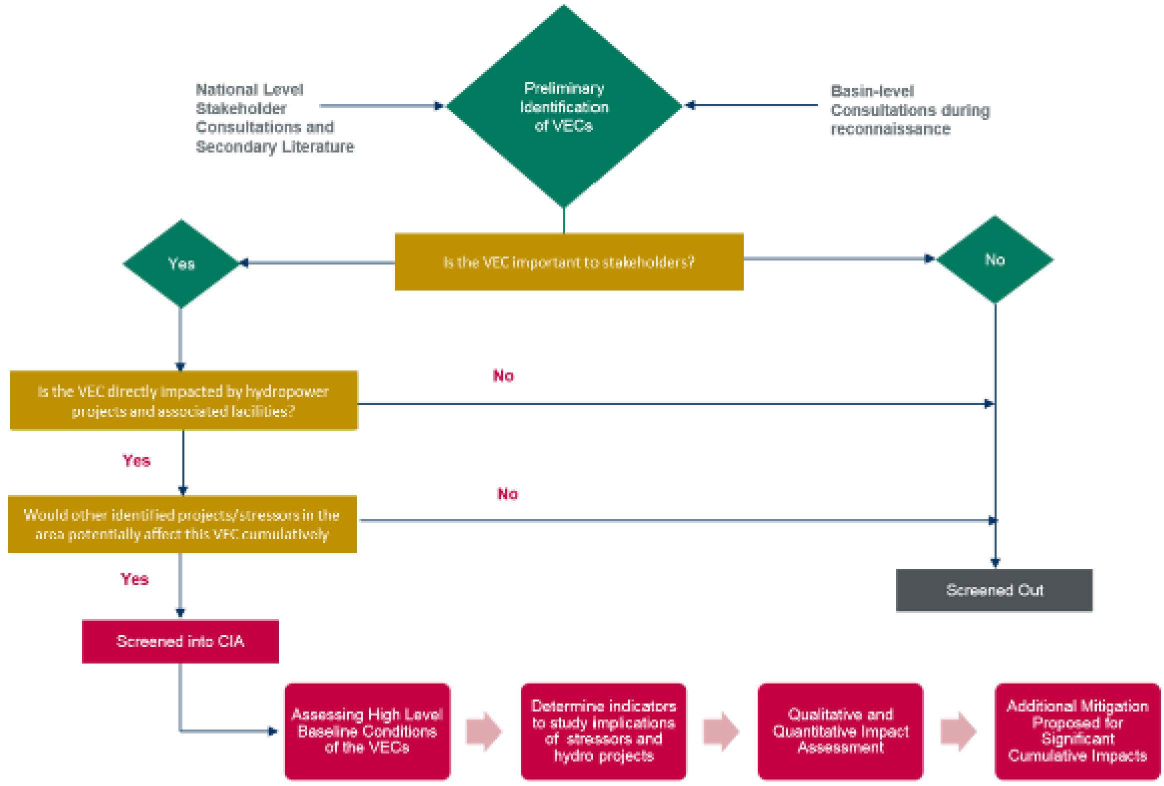


Table 6.1: VEC Screening and Selection

Potential VEC	Valued by Stakeholders	Impacted by UAHEP	Impacted by Other Projects and Stressors	Selected for CIA	Justification, Comments
Air quality	Yes, according to consultations	Yes	No potential for cumulative impacts	No	This VEC has not been selected for the CIA because there is negligible potential for significant cumulative air quality impacts (e.g., from fugitive dust) from HEP developments, as the impact from a HEP on air quality is temporary and unlikely to extend far enough to result in cumulative impacts with other source of air emissions.
Noise	Yes, according to consultations	Yes	No potential for cumulative impacts	No	This VEC has not been selected for the CIA because there is negligible potential for significant cumulative noise impacts from HEP developments. Noise impacts from HEPs are typically temporary, limited to the construction phase.
Water resources	Yes, according to consultations	Yes	Yes	Yes	Cumulative impacts on including water quality, geomorphology, and sediment transport are considered in this CIA.
Natural forest integrity	Yes, according to consultations	Yes	Yes	Yes	Natural forest loss and fragmentation from hydropower projects, other developments, and climate change-related risks are considered in this CIA. In addition, natural forests serve as habitats for several important species, therefore, assessing the impacts on natural forest is an indicator for impacts on diversity of species.
Makalu Barun National Park	Yes, according to consultations	Yes	Yes	Yes	Impact to critical terrestrial species and habitat in the MBNP from hydropower projects and other developments (particularly roads) are considered in this CIA.
Fish and aquatic habitat	Yes, according to consultations	Yes, potentially significant	Yes, potentially significant	Yes	Cumulative impacts on fish and aquatic habitat from barrier effects, changes in hydraulic/hydrological regimes, and climate related impacts are considered in this CIA.

Potential VEC	Valued by Stakeholders	Impacted by UAHEP	Impacted by Other Projects and Stressors	Selected for CIA	Justification, Comments
River-based livelihoods	Yes, according to consultations	Yes	Yes	Yes	Cumulative impacts from hydropower projects, other developments and climate change, on river-based livelihoods (i.e., irrigation, rafting and sport fishing outfitters, artisanal fishing, and river mining are considered in this CIA.
Settlement	Yes, according to consultations	Yes	Yes	Yes	Cumulative impacts from hydropower projects, other developments and climate change, on settlement patterns and associated effects are considered in this CIA.
Social cohesion	Yes, according to consultations	Yes	Yes	Yes	Cumulative impacts from hydropower projects, other developments (including roads) and climate change, on social cohesion components are considered in this CIA.

Using the results of stakeholder consultations, field surveys, data analysis, and the literature review, the following seven VECs were selected for the CIA study: natural forest integrity, Makalu Barun National Park, water resources, fish and aquatic habitat, river-based livelihoods, settlement, and social cohesion. The key basin-level impacts and CIA assessment approach for each of selected VECs are summarized in ***Table 6.2***.

The following sections of this CIA study will present the baseline status, potential cumulative impacts, and mitigation and monitoring framework to manage impacts on the selected VECs.

Table 6.2: Final VECs and Assessment Approach

VEC	Key Basin-level Impacts to Consider	Assessment Metrics
Physical Components		
VEC: Natural forest integrity	Forest loss and fragmentation from hydropower projects, other developments, and climate change-related risks	■ Forest land gain/transfer ■ Loss of ecosystem services values from forest clearance
VEC: Water resources	Changes to the physical characteristics of a river, including water quality, geomorphology, and sediment transport	■ Qualitative assessment of the level of impact to water quality and flow
Biological Componets		
VEC: Fish and aquatic habitat	Barrier effects (fragmentation) and changes in flows that lead to degradation of ecosystem integrity and fish habitat	■ Seven native species including golden mahseer and common snow trout used at indicators ■ River segments subject to flow alterations ■ Aquatic habitat fragmentation and losses
VEC: Makalu Barun National Park	Impact on critical terrestrial species and habitat in the MBNP from hydropower projects and other developments (particularly roads)	■ Forest land gain/transfer ■ Loss of ecosystem services values from forest clearance
Social Components		
VEC: River-based livelihoods	Impact of hydropower projects, other developments, and climate change, on sources of livelihoods, including: ■ Irrigation ■ Rafting and sport fishing outfitters ■ Artisanal fishing ■ River mining	Qualitative assessment of the level of impact to the livelihood components
VEC: Settlement	Impact of hydropower projects, other developments, and climate change on settlement patterns and associated effects such as:	Qualitative assessment of the level of impact resulting from changes in settlement patterns

VEC		Key Basin-level Impacts to Consider	Assessment Metrics
		■ Changes in settlement demographics resulting in possible conflict ■ Changes in intangible cultural heritage resources resulting from changes in settlement demographics	
	**VEC: Social cohesion**	Impact from hydropower projects, other developments (including roads), and climate change, on social cohesion components: ■ Social safety nets ■ Gender and social exclusion ■ Social tension ■ Access to culturally significant places/practices	Qualitative assessment of the level of impact on the components of social cohesion

7. BASELINE STATUS OF SELECTED VECS

7.1 VEC: Natural Forest Integrity

Natural forest integrity was selected as a VEC for this CIA considering the importance of forested land to communities, biodiversity, and ecological processes and ecosystem services. Moreover, the cumulative impacts of hydropower projects, road developments (specifically the Koshi Highway), and climate change to forest lands may be significant over the 10 years.

7.1.1 Types of Forests in the Arun Basin

The forest of eastern Nepal is categorized into eight broad types (Stainton 1972). ***Table 7.1*** describes these forest types.

Table 7.1: Forest Types within Eastern Nepal

Forest Type	Elevation
Tropical forests	<1,000 m
Sub-tropical broadleaved forest	1,000–2,000 m
Sub-tropical pine forest	1,000–2,200 m
Upper temperate broadleaved forest	2,200–3,000 m
Upper temperate mixed broadleaved forest	2,500–3,500 m
Temperate coniferous forest	2,000–3,000 m
Sub-alpine forest	3,000–4,100 m
Alpine scrub	above 4,100 m
Source: Stainton 1972	

7.1.2 Land Use/Land Cover Assessment

Historical forest land and other land use and land cover (LULC) in the Arun River Basin were analyzed[9] using remote sensing to determine the dynamic change between forest land and other land covers from year 2009 to 2018. The assessed LULC classes fall into six key categories: agricultural land, settlement land, forest, waterbody, grassland/shrubland, barren land,[10] and snow. A graphical representation of these LULC classes within the CIA Study Area in Nepal for years 2009 and 2018 is presented in ***Figure 7.1.***

As shown in ***Table 7.2*** and ***Figure 7.1*** forested areas comprised the greatest amount of land in the CIA study area in both years, occupying almost 66% of the total basin area (5,171 km^2) in 2018. Forested land was mostly concentrated in the northern part of the CIA study area in Sankhuwasabha District.

[9] Key limitations of the LULC study: 1) six broad land classes were assessed, land classes in between or a mixture of land classes were not captured in the study; 2) LULC classification assumptions were for ambiguous Landsat satellite sensing images – e.g., shadows and blurred LULC boundaries; 3) these findings have not been verified by field surveys or consultations with personnel representing the districts in the study area.

[10] Barren land is defined as areas covered by sand, rock (e.g., scree), in which less than one third of the area has vegetation.

Figure 7.1: Arun Basin Land Cover in 2008 and 2018

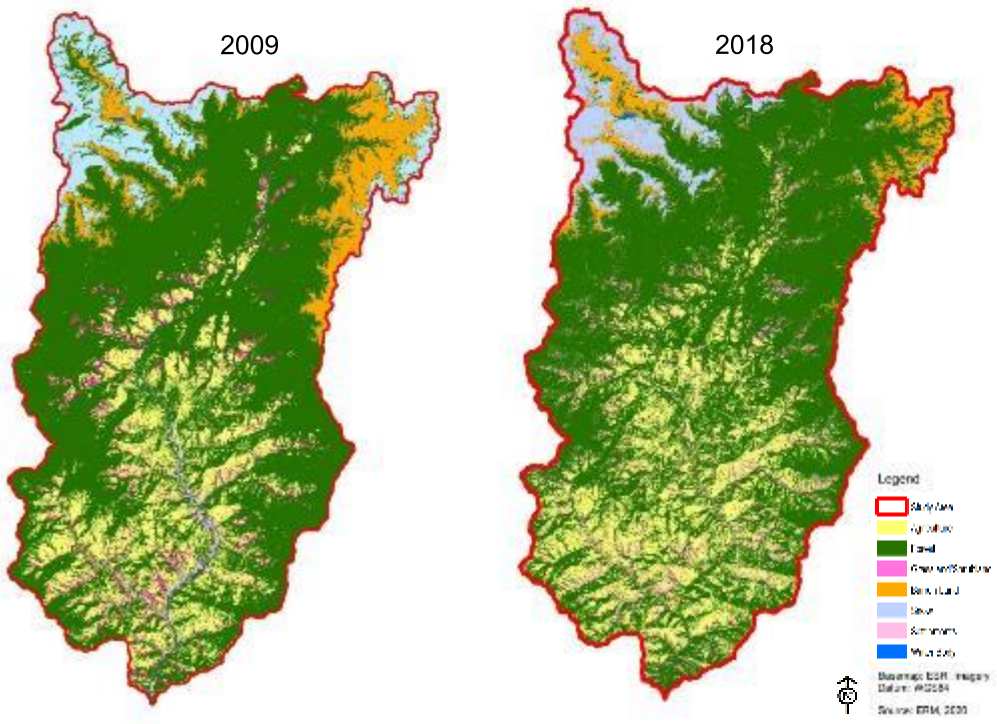


Table 7.2: LULC Dataset

Dataset	Date	Resolution	Azimuth	Elevation Angle
Landsat 8 OLI/TRIS (Path/Row:139/41,140/41)	November 11, 2018	30	155.59	35.09
			156.39	36.05
Landsat 5 TM (Path/Row:139/41,140/41)	October 15, 2009	30	152.23	37.33
			152.45	35.93

Agricultural land was the second largest LULC class, covering an area of 878 km^2 (17%) in 2018. Agricultural lands were primarily located in the southern part of the basin in Bhojpur and Dhankuta districts. In Sankhuwasabha District, agricultural land scattered along the river valley and in the lower elevation mountains the south of the district. The remaining study area comprised grassland/shrublands (166 km^2, 3%); barren land (266 km^2, 5%); settlements (116 km^2, 2%); and waterbodies (17 km^2, 0.3%) in 2018.

This is mostly in line with a study of land use change in the Koshi Hills region (covering Sankhuwasabha, Bhojpur, Dhankuta, and Terhathum districts) by Pradhan and Sharma (2017). The study found that in 2010, Sankhuwasabha and Bhojpur had a forest coverage of 51% and 46%, respectively, while Dhankuta, and Terhathum had over 46% agricultural land coverage. ***Table 7.3*** compares land use/land cover in 2009 and 2018.

Table 7.3: Proportion of LULC Classes in 2009 and 2018

	2009		2018		Change from 2009 to 2018	
Land Class	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**	**Area (km^2)**	**Area (%)**
Agriculture	823	16	878	17	55	6
Settlements	47	1	116	2	69	60
Snow/clouded area	361	7	322	6	-39	-12
Forest	3,376	66	3,377	66	39	<1
Grassland/shrubland	152	3	166	3	14	8
Barren land	363	7	266	5	-97	-37
Waterbodies	18	<1	17	<1	<1	-6
Total	5,141		5,141		0.00	

Source: ERM 2020

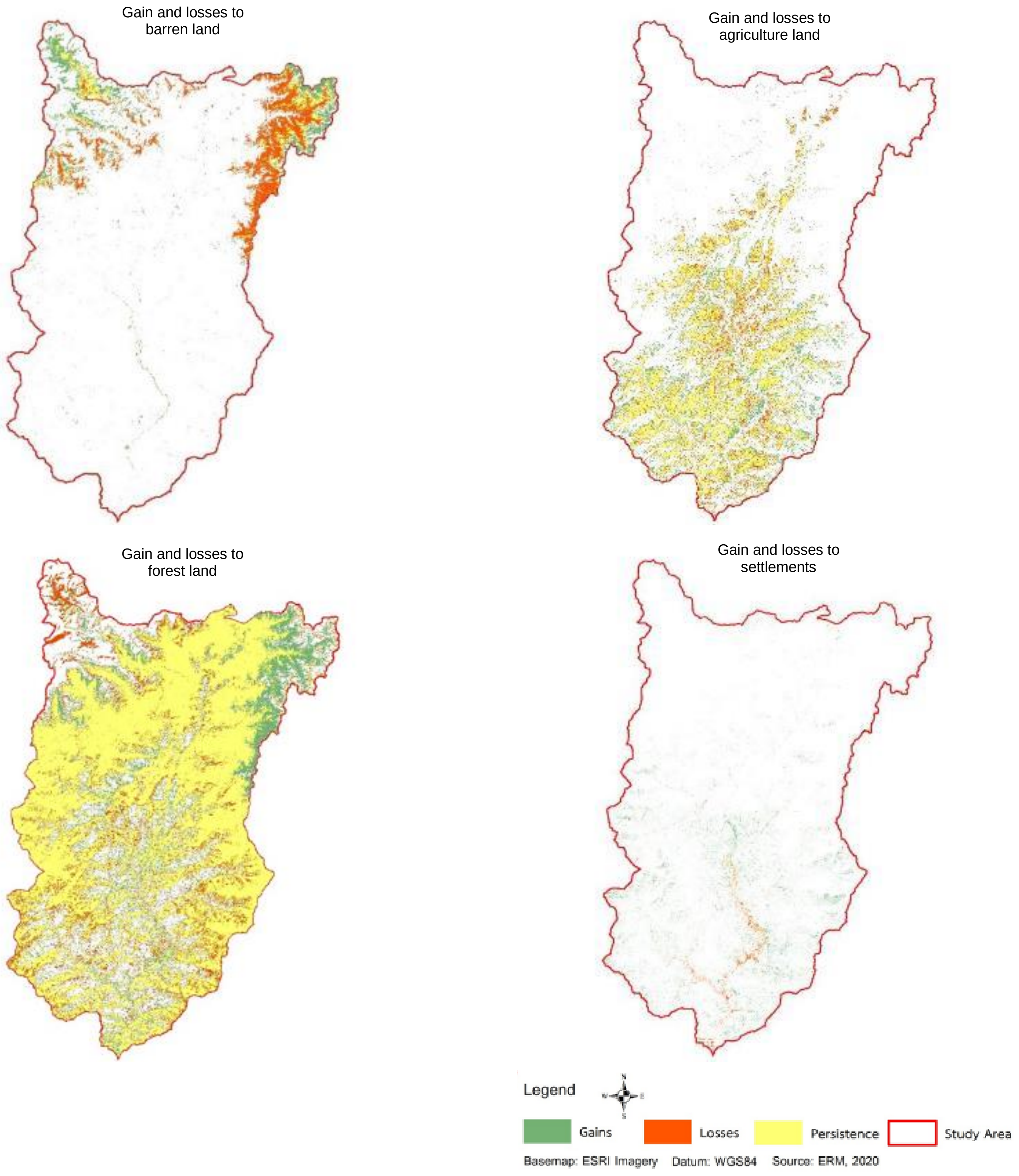
Increases (gains) and decreases (losses) for each land use class between 2009 and 2018 are illustrated in ***Figure 7.2.*** Shown in ***Table 7.4*** is the statistical representational of the net changes in the LULC classes between 2009 and 2018. There was a minor increase of 0.01% of forested land in the Arun Basin. The significant gain of forest land was from the conversion of 266 km^2 of agricultural land, and 67 km^2 of barren land and 65 km^2 of settlement land to forest land. However, 188 km^2 of forest land was lost due to conversion to agricultural land. In comparison, the Global Forest Watch[11] results for the greater Koshi Region (Eastern Region of Nepal) found that the region has lost 0.4% of its tree coverage between 2009 and 2018.

Agriculture land had a slight gain of 6% between 2009 and 2019 (from 823 km^2 to 878 km^2), as shown in ***Table 7.5***. It is noteworthy that the gain was particularly in the southern reach of the Arun Basin. The settlement areas increased (60%) from 47 km^2 to 116 km^2 between 2009 and 2018. However, settlements still accounted for only for 2% of the total study area in 2018.

Pradhan and Sharma (2017) support this pattern of land areas transfer in LULC classes. Their study indicated that, during the past two decades (1986–2010), forest land appears to be increasing by encroaching upon shrubland/grassland and agricultural land. An increase in “other land” use (comprising waterbodies, snow land, bare land, rock and ice, built up land, and road), mainly due to encroachment upon forest, agricultural land, and grassland, might be due to the construction of roads, expansion of settlement clusters, and institution buildings, etc.

[11] https://www.globalforestwatch.org/dashboards/country/NPL/2/1/

Figure 7.2: Gains and Losses in LULC between 2009 and 2018



A summary of the land use dynamic changes in the CIA study area between 2009 and 2018 is shown in ***Table 7.5***. Settlement was the fastest changing land class during this period, with a rate of change of 30 $km^2.a^{-1}$ (square kilometers per annum), followed by barren land at 10 $km^2.a^{-1}$. Settlement land also had the highest gain rate of 22 $km^2.a^{-1}$, followed by waterbodies and grassland/shrubland at 5 $km^2.a^{-1}$ and 4 $km^2.a^{-1}$, respectively.

Forest underwent the lowest change between 2009 and 2018, namely, 3 $km^2.a^{-1}$. As discussed above, the overall net gain in this LULC class was 0.10%. The transfer rate and gain rates were both at 1 $km^2.a^{-1}$. Change rates for agriculture land were relatively modest, namely, 6 $km^2.a^{-1}$. The transfer rate and gain rates were 3 $km^2.a^{-1}$ each. The change rate of grassland/shrubland is also considered relatively modest (8 $km^2.a^{-1}$). The transfer rate and gain rates were 3.5 $km^2.a^{-1}$ and 4.3 $km^2.a^{-1}$, respectively.

Table 7.4: Area Transfers in LULC Classes from 2009–2018 (km^2)

Land Class		2018							
		Agriculture	Settlements	Snow/Clouded Area	Forest	Grassland/Shrubland	Barren Land	Waterbodies	Total
2009	Agriculture	588	43	-	188	-	4	<1	823
	Settlements	23	4	-	15	4	1	<1	47
	Snow/clouded area	0.1	0.06	238	35	0.07	84	4	361
	Forest	266	65	57	2,849	68	67	3	3,376
	Grassland/shrubland	-	3.5	-	54	94	1	0	152
	Barren land	0.4	0.09	26	227	0.22	108	1	363
	Waterbodies	0.04	0.11	0.08	8	0.01	1	8	18
	Total	878	116	321	3,377	166	266	17	5,140

Source: ERM 2020

Table 7.5: Rate of Change in LULC Classes from 1992–2017

Land Class	Unchanged Area			Transfer		Gain		Rate of Change/(km^2 per year)	Dynamic Degree (%)
		2008	2019	Area/km^2	Rate/(km^2 per year)	Area/km^2	Rate/(km^2 per year)		
Agriculture	588	823	878	235	2.6	289	3.2	5.8	2.6
Settlements	4	47	116	43	8.3	112	21.8	30.1	8.3
Snow/clouded area	238	361	322	123	3.1	83	2.1	5.2	3.1
Forest	2,849	3,376	3,377	527	1.4	528	1.4	2.8	1.4
Grassland/shrubland	94	152	166	59	3.5	72	4.3	7.8	3.5
Barren land	108	363	266	255	6.4	158	3.9	10.3	6.4
Waterbodies	8	18	17	10	5.1	9	4.6	9.7	5.1
Total		5,141	5,141		30.4		41.4	71.7	30.4

Source: ERM 2020

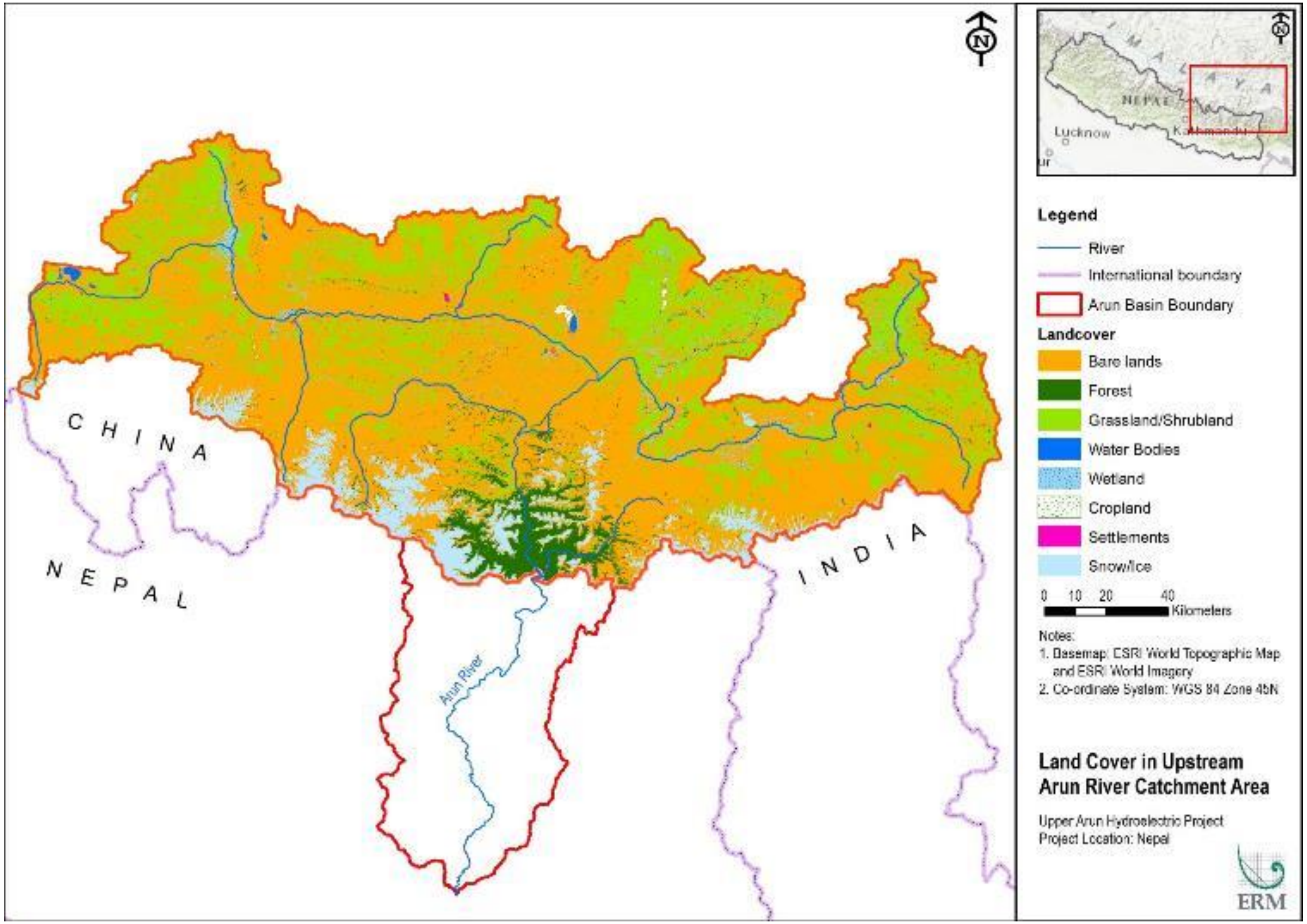
7.1.3 LULC of the Arun Basin in Tibet Autonomous Region

The LULC of the portion of the Arun Basin within TAR was analyzed using remote sensing. As shown in ***Table 7.6*** and ***Figure 7.3***, bare land covers approximately 61% of the 24,878 km^2 area, followed by 26% of grassland/shrubland.

Table 7.6: LULC in the Arun Basin within Tibet Autonomous Region

Land Cover in the Arun Basin within TAR	Area (km^2)	% of Total Area
Cropland	44	<1
Barren (bare) land	15,162	61
Wetlands	546	2
Forest	1,136	5
Grasslands/shrubland	6,359	26
Permanent snow/ice	1,553	6
Settlements	15	<1
Waterbodies	73	<1
Total	**24,873**	**100**

Figure 7.3: LULC in the Arun Basin in Tibet Autonomous Region



7.1.4 Ecosystem Services from Forests

Forest Resources

Inhabitants of the Arun Basin are highly dependent on ecosystem services from the forest. They primarily harvest poles, fuelwood, and timber from community and private forest (ICIMOD 2012) The incidence of poverty is high in rural areas of the Koshi Hills. Those with limited resources of their own, locals particularly rely on community forests to sustain their livelihoods. In addition, forests also provide employment opportunities through small scale forest enterprises.

In the Koshi Hills, nearly 1,400 community forest user groups (CFUGs) have been formed. More than 85% of total households in Sankhuwasabha, Bhojpur, Terhathum and Dhankuta districts are involved in these CFUGs, and together they manage 82% of local forest areas. Out of the total households involved in CFUGs, about 49% are categorized as relatively poor, based on participatory well-being criteria.

CFUG income generation from forest products have been steadily increasing over the years. This has been the result of a devolution of power of forest resource management to local forest users. Chapagain (2009) claim that 46% of “poor” community forest users have crossed the relative poverty line, largely due to engagement in CFUG livelihoods improvement related activities and capacity building events. Likewise, 35% of “very poor” households have moved to the poor category.

In eastern Nepal, CFUGs have invested US$327,000 over ten years in formal school education, informal literacy programs for women and the poor, and scholarships for poor students. Some CFUGs have contributed to construction and maintenance of roads, schools, irrigation canals, and health posts, etc. Furthermore, community forests have had supportive influences on agriculture production, income and employment generation, biodiversity conservation, democratic governance, social unity, and literacy in society.

Through the CIA consultations with the members of Federation of Community Forest Users Nepal (FECOFUN), Sankhuwasabha, 50% of the income from community forests in the district is invested in income generating activities, education, and capacity building. Communities collect firewood and house-building materials from the community forests. Forest resource collection complements agriculture activities for farmers, as they collect fodder for livestock, and tree wastage to make compost manure to cultivate crops. Traditional healers also depend on non-timber forest products (NTFPs) from the community forests. Generally, vulnerable and disadvantaged groups are highly dependent on the community forests for collection of food and herbs for medicinal purposes and for sale. Concerns were raised during the downstream CIA consultations regarding the impacts of hydropower projects and road developments on community forests. For instance, the Arun-3 HEP has impacted on community forests by causing landslides and the expansion of Koshi highway is also negatively impacting on community forests.

Value of Ecosystem Services from Forests

Pant *et al.* (2012) estimated the monetary value of the goods and services provided by the forest ecosystems of three districts of eastern Nepal. The total economic value includes select provisioning, regulating and supporting services as shown in ***Table 7.7***. Based on the study, the total economic value of the forest-based ecosystem services in the districts is NPR 8,905 million per year, which is equivalent to approximately NPR 30,000 per ha per year (***Table 7.8*)**.

Table 7.7: Ecosystem Services Valuation Methods Used

Type of ecosystem service	Major services	Main users	Valuation methods
Provisioning	Timber and wood (poles, fuelwood) Medicinal plants (chiraita, Himalayan yew, valerian, prickly ash, asparagus) Biomass for animal husbandry (fodder, grass, leaf litter) Farming (vegetables) Subsidiary food (mushrooms, bamboo shoots, other vegetables, edible fruit, honey)	Local people, contribute to livelihoods	Market price method used to estimate the village level price or its equivalent
	Fresh water	Downstream populations	Not included in the study
	Genetic resources of flora and fauna	Researchers and future generations	Not included in the study
Regulating	Carbon sequestration	Global community	Benefit transfer method
	Air quality regulation, climatic regulation, natural hazard regulation, water regulation and purification, soil erosion control, pollination, pest control	Local, regional, and global	Not included in the study
Supporting	Soil formation and nutrient recycling for farmland	Local farmers, contributes to livelihoods	Change in crop productivity
Cultural	Aesthetic and recreational for ecotourism Spiritual and religious	Visitors and local tribal populations	Not included in the study

Source: Pant *et al.* 2012

Table 7.8: Total Value of Ecosystem Services from Forest Ecosystems

Source of value	Value (million NPR)	Percentage of total
Value of provisioning services		
Timber and other wood	1,396.00	15.7
Biomass for animal husbandry	5,206.10	58.5
NTFPs	13.05	0.1
Wild edibles	25.81	0.3
Medicinal plants	371.01	4.2
Value of regulating services		
Carbon sequestration	1,654.82	18.6
Value of supporting services		
Increase in crop income	238.13	2.7
Total	8,904.92	100.00

Source: Pant *et al.* 2012

7.2 VEC: Makalu Barun National Park

The Makalu Barun National Park has been identified as a VEC due to its high biodiversity and community value and potentially significant level of impacts from planned developments (including the UAHEP and Num-Kimathanka Road). This section provides an overview of the historical and current management approach, land cover, and baseline biodiversity and socio-economic setting.

7.2.1 Overview

The MBNP is an internationally recognized IUCN Management Category II protected area. MBNP was established in 1992 as an eastern extension of the Sagarmatha National Park (under the National Parks and Wildlife Conservation Act, 1973). It is one the world's few protected area with an elevation gain of more than 8,000 m which encloses tropical forest as well as snow-capped peaks. The MBNP encompasses a total area of 2,330 km^2 (approximately 45% of the total Arun Basin) with 1,500 km^2 of the core area in Solukhumbu and Sankhuwasabha districts, with the surrounding Buffer Zone (as declared in 1999) covering an area of 830 km^2 to the south and southeast.

7.2.2 Management Approach

The MBNP is managed using a people-oriented approach, as per the Himalayan National Park Regulation 2036 BS (1979 AD). According to this regulation, people living within the MBNP and its Buffer Zone are entitled legal access to subsistence harvesting within those areas. However, it was later realized that this arrangement was not sufficient to manage the biodiversity and ecological integrity of the MBNP Core Area and Buffer Zone (Chapagain 2009). As a result, the National Park Management Plan was designed in 1990 to recognize the legitimacy of traditional economic and subsistence activities such as gathering medical herbs and economically useful plants such as *Daphne malingo* (bamboo). The plan also emphasized the importance of “bottom-up” decision-making structure that incorporates local knowledge. The Management Plan stipulates special use areas, such as Strict Nature Reserves to protect places of exceptional ecological significance, and Special Sites and Trails designated to accommodate tourism or traditional cultural activities (Carpenter and Zomer 1996).

7.2.3 Land Use and Land Cover

According to Kari *et al.* (2018), in 2002, 45% of the area was covered with rock, ice and snow, whereas forest together with shrubland and grassland occupied almost half of the MBNP Core Area. More than half of the Buffer Zone was covered with forest (58%), 16% by agricultural land, 20% by scrubland and grassland altogether, and only 6% by rock, ice, and snow.

The LULC analysis conducted by ERM show that in 2018, 57% of the Core Area was covered with rock, ice and snow, and the rest of the area comprised mainly forest (42%). For the Buffer Zone, the land use pattern comprised 80% forest coverage, 10% agricultural land, 3.5% grassland, and the rest was made up of rock and snow coverage. The significant increase in forest area could be a result of the park management approach discussed in **Section 7.2.2** and **Section 7.2.6.**

The traditional and subsistence use of forest resources is allowed in Buffer Zone areas of the MBNP, such as cattle grazing, collecting fuelwood, timber and non-timber forest products, with the permission of the chief conservation officer of MBNP.

Massive quantities of water are stored in snow and glacier ice in the upper elevations of the MBNP, which are released continuously, forming seven major river tributaries. These tributaries which pour southward into Arun and Dudh Koshi rivers. Solukhumbu and Sankhuwasabha districts comprise about 580 glacial lakes, of which 121 of these glacial lakes lie inside the MBNP. Groups of alpine, sub-alpine lakes exist in the upper elevations of the MBNP; these high altitude wetlands include Bahula Pokhari, Yekle Pokhari, Tin Pokhari, Jhale Pokhari, Panch Pokhar (bigger), Dudh Pokhari, Tama Pokhari, Panch Pokhari (smaller), Thulo Pokhari and Sano Pokhari (Karki 2002).

7.2.4 Socio-economic

The MBNP Buffer Zone covers an area with a total population of 34,467 individuals. People within the Buffer Zone are mainly from Rai communities (64%) followed by Bhote (18%), Sherpa (8%), and Tamang, Gurung, Newar, Chhetri, Brahmin and other castes (10%).

Most of the households are subsistence farmers engaged in agriculture and livestock herding. Rotational slash and burn farming and animal husbandry are the main economic activities of the local communities. Local households also depend upon the diverse national resources from the Buffer Zone.

The MBNP is an attractive tourism destination for trekking and mountaineering due to its landscape, lakes, richness of flora and fauna and Mount Makalu, Buruntse, and Sherpin Col. However, there has been limited tourism due to its difficult terrain and limited accessibility. A total of 1,000–1,500 tourists visit the MBNP and its Buffer Zone annually (Sherpa 2002), and a total income of USD 43,000 (NPR 4.3 million) was generated for the park during 2016/17, which is considerably lower than other popular areas like Chitwan National Park, which had a total earnings of USD 2.01 million (NPR 201 billion) during the same period (DNPWC 2017).

7.2.5 Biodiversity

The MBNP protects a broad range of Eastern Himalayan forest types, ranging from near-tropical dipterocarp monsoon forest (400 m) to subalpine conifer stands (4,000 m). Forests span over five bioclimatic zones (tropical, subtropical, lower and upper temperate, and subalpine), but ecotones are poorly defined. Below 2,000 m forests are strongly affected by subsistence agriculture, although some ecologically significant stands remain at those elevations. Above 2,000 m, a cool, humid climate suppresses agricultural activity and forests are usually extensive (Carpenter and Zomer 1996).

Table 7.9 shows the number of species types recorded in the Makalu-Barun National Park (Karki *et al.* 2018), which are further detailed below.

Table 7.9: Number of Species Types Recorded in the MBNP

Mammals	Reptiles	Amphibians	Birds	Fish	Butterfly	Endemic Plants	Plants
86	43	13	421	78	315	7	3,073

Source: Buffer Zone Management Plan, MBNP (2005)

Flora and Fauna

More than 3,000 species of flowering plants are found in the MBNP, among which 56 species are rare and endangered. Almost two hundred (199) species of flowering plants have been recorded from the park (TMI and IUCN 1995). Seven (7) species of endemic flowering plants have been recorded in the MBNP, which includes *Desideria nepalensis, Pedicularis pseudoregeliana, Carex himalaica, Kobresia gandakiensis, Kobresia, fissiglumis, Ranunculus himalaicus*, and *Ranunculus makaulensis*. Panchaunle (*Dactylorhiza hatagirea*) and kutki (*Neopicrorhiza scrophulariiflolia)* are plant species protected by the Government of Nepal that are also found in the MBNP. Similarly, over 86 species of mammals, including the threatened snow leopard (*Pantherauncia*), musk deer (*Muschus chrysogaster*), red panda (*Ailurus fulgens*), clouded leopard (*Neofelis nebulosa*), spotted linsang (*Prionodon pardicolor*) and Assamese monkey (*Macaca assamensis*), are found in this park.

Birds

A total of 421 bird species have been recorded within the park and its Buffer Zone. The park is especially important for the globally threatened wood snipe, and the near threated satyr tragopan and yellow-rumped honeyguide, which are resident and likely breed in the park region. The MBNP is also of importance to seven (7) restricted-range species from the Central and Eastern Himalayas EBAs that are likely resident in the area, namely: the yellow-vented warbler, broad-billed warbler, Nepal wren babbler, rufous-throated wren babbler, spiny babbler, hoary-throated barwing, and white-naped yuhina (TMI and IUCN 1995). In addition, the spiny babbler (*Turdoides nipalensis*) (Nepal's endemic bird species), and the green cochoa (*Cochoa viridis*) (classified as extinct in Nepal), were sighted in the MBNP in 1990 (Bhuju 2007).

For this reason, the MBNP is identified as an Important Bird and Biodiversity Area (IBA), according to several criteria: A1 (globally threatened species), A2 (restricted range), and A3 (biome-restricted species) (BirdLife International 2020). As the MBNP triggers IBA criterion A2 (restricted range species), it has been classified as an Endemic Bird Area. EBAs are regions that represent natural areas of bird endemism where the distribution of two or more restricted-range bird species overlap, where restricted-range refers to a breeding range of no more than 50,000 km^2 (BirdLife International 2018). Details of the bird species that meet IBA criterion A2 found in the CIA study area are presented in ***Table 7.10.***

Table 7.10: Bird Species that Meet IBA Criterion A2 Found in the CIA Study Area

Common Name	Scientific Name	IUCN Red List Category
Spiny babbler	*Turdoides nipalensis*	LC
Hoary-throated barwing	*Sibia nipalensis*	LC
Rufous-throated wren-babbler	*Spelaeornis caudatus*	NT
Yellow-vented warbler	*Phylloscopus cantator*	LC
Broad-billed warbler	*Tickellia hodgsoni*	LC
Nepal wren babbler	*Pnoepyga immaculata*	LC
White-naped yuhina	*Yuhina bakeri*	LC

Notes: LC = Least concern; NT = Near Threatened

Source: Birdlife International 2020

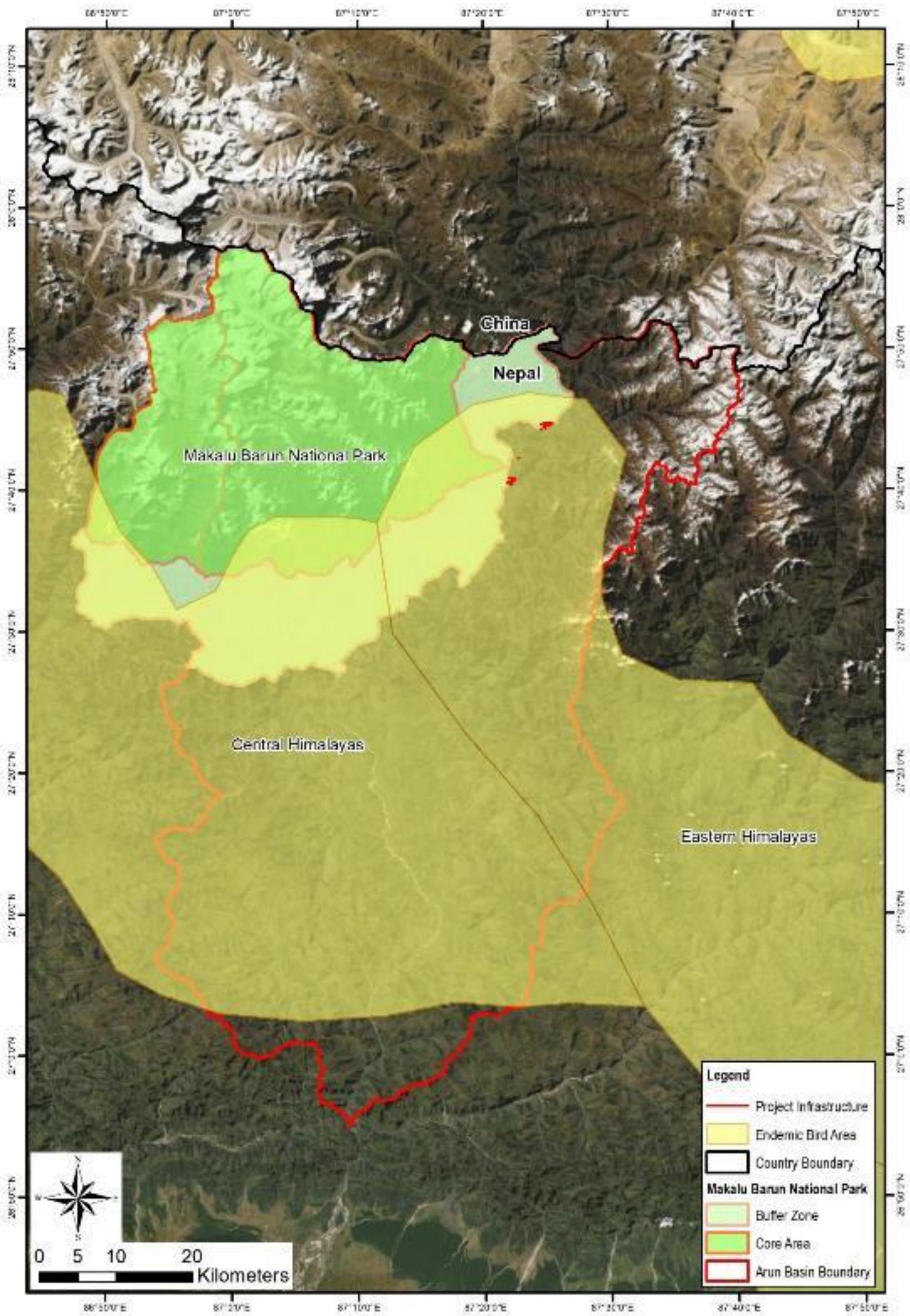
The EBAs overlapping the Arun Basin are provided in ***Figure 7.4*** with a description of each EBA and the A2 trigger species are provided in ***Table 7.11*****.**

Table 7.11: EBAs Overlapping the Arun Basin

Endemic Bird Area	Location	Diversity
Eastern Himalayas	This EBA follows the Himalayan range east from the Arun-Kosi valley of eastern Nepal, through Bhutan, north-east India (Sikkim, northern West Bengal and Arunachal Pradesh), south-east Tibet Autonomous Region and north-east Myanmar to south-west China (north-west Yunnan province).	As they lie further to the south, the mountains of this region have a distinctly different climate (and, hence, vegetation) from the rest of the Himalayas: they experience warmer mean temperatures and fewer days with frost, and generally have a much higher rainfall. Two evergreen forest types appear to be particularly important breeding habitats for the EBA's restricted-range birds, both of which reach their western limit in eastern Nepal: subtropical wet hill forest is found at altitudes between approximately 1,000 and 2,000 m, and wet temperate forest at altitudes of about 1,800-3,000 m. This part of the Himalayas is particularly rich in restricted-range birds, and the genus *Sphenocichla* is endemic to the EBA.
Central Himalayas	This EBA extends through the Himalayas from the extreme east of Nepal to the extreme west, and possibly into adjacent regions of India.	Two of the three restricted-range birds, *Pnoepyga immaculata* and *Sibia nipalensis*, breed in Himalayan moist temperate forest between about 1,800 and 3,300 m, and *Turdoides nipalensis* occupies dense scrub and secondary growth at slightly lower altitudes. The newly described *P. immaculata* is apparently an altitudinal migrant, as it has been recorded in the lowlands of southern Nepal outside the breeding season; it has only been recorded in Nepal so far, but may prove to be present elsewhere in the Himalayas

Source: BirdLife International 2019

Figure 7.4: EBAs Overlapping the Arun Basin and MBNP



Source: ERM 2020

Threatened Species and Critical Habitat

Threatened Species

The Integrated Biodiversity Assessment Tool (IBAT) was used to determine the potential critical habitat species (Critically Endangered/Endangered) within the study area. For the IBAT search, a 50 km radius from the UAHEP project location was used, which included the Makalu-Barun National Park, the Tamor Valley and Watershed, and the Kanchenjunga Conservation Area.

Threatened species that have been identified within the study area – according to the IBAT results, IUCN Red List of Threatened Species, and the National Red List for Nepal – are listed in ***Table 7.12*.** The Red List provides the conservation status of these listed species as being Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). CR, EN and VU species are considered to be at a heightened risk of extinction and are awarded an elevated level of consideration under IFC PS6. Species identified as endemic, restricted range, migratory and/or congregatory according to the relevant IUCN species profiles are also listed in order to assess against the thresholds for critical habitat criterion 2 (endemic and/or restricted-range species) and/or criterion 3 (migratory and/or congregatory species). Where species have not yet been evaluated by IUCN, the protection status has been considered.

Critical Habitat

As detailed in the UAHEP ESIA (Section 6.2 Terrestrial and Aquatic Biodiversity), the terrestrial areas of the MBNP qualify as critical habitat (CH), as they are likely to maintain populations of six CH-qualifying terrestrial species (Himalayan red panda, black musk deer, Chinese pangolin, clouded leopard, spotted linsang, and Himalayan black bear). A section of the Arun River is located within the MBNP Buffer Zone area, which could contain potentially suitable habitat for the golden mahseer. However, the targeted electrofishing surveys did not indicate the presence of golden mahseer in the UAHEP project area. The Arun River in the project area is not considered critical habitat. However, the terrestrial areas of the MBNP are considered critical habitat and must achieve net gain of these biodiversity values. Additonal study on the critical habitat assesemnt has been carried out to confirm that Himalayan red panda, clouded leopard, spotted linsang, and Himalayan black bear qualified as critical habitat species; and mitigation plans have been developed and budgeted. This net gain has been demonstrated in the ESIA and in the report by Red Panda Network Nepal (2023) *Critical Habitat Assessment of the Upper Arun Hydro-electric Project* and its Biodiversity Management Plan (BMP).

Table 7.12: Terrestrial Species of Conservation Significance

S/N	Class	Scientific Name	Common Name	Migratory	Endemic/ Restricted Range	IUCN Listing	National Red List for Nepal[1]	CITES[2]
1.	Birds	*Aythya baeri*	Baer's pochard	Yes	No	CR	CR	-
2.	Birds	*Emberiza aureola*	Yellow-breasted bunting	Yes	No	CR	CR	-
3.	Birds	*Gyps bengalensis*	White-rumped vulture	No	No	CR	CR	II
4.	Birds	*Gyps tenuirostris*	Slender-billed vulture	No	No	CR	CR	II
5.	Birds	*Sarcogyps calvus*	Red-headed vulture	No	No	CR	EN	II
6.	Mammals	*Manis pentadactyla*	Chinese pangolin	No	No	CR	EN	I
7.	Birds	*Aquila nipalensis*	Steppe eagle	Yes	No	EN	VU	II
8.	Birds	*Falco cherrug*	Saker falcon	Yes	No	EN	EN	II
9.	Birds	*Haliaeetus leucoryphus*	Pallas's fish-eagle	Yes	No	EN	CR	II
10.	Birds	*Leptoptilos dubius*	Greater adjutant	Yes	No	EN	CR	-
11.	Birds	*Neophron percnopterus*	Egyptian vulture	Yes	No	EN	VU	II
12.	Birds	*Sterna acuticauda*	Black-bellied tern	No	No	EN	CR	-
13.	Fish	*Tor putitora*	Golden mahseer	No	No	EN	-	-
14.	Mammals	*Ailurus fulgens*	Red panda	No	No	EN	EN	I
15.	Mammals	*Cuon alpinus*	Dhole	No	No	EN	EN	II
16.	Mammals	*Caprolagus hispidus*	Hispid hare	No	No	EN	EN	I
17.	Mammals	*Elephas maximus*	Asian elephant	No	No	EN	EN	I

S/N	Class	Scientific Name	Common Name	Migratory	Endemic/ Restricted Range	IUCN Listing	National Red List for Nepal[1]	CITES[2]
18.	Mammals	*Moschus chrysogaster*	Alpine musk deer	No	No	EN	EN	I/II/NC
19.	Mammals	*Moschus fuscus*	Black musk deer	No	No	EN	DD	I/II
20.	Mammals	*Moschus leucogaster*	Himalayan musk deer	No	No	EN	DD	I
21.	Birds	*Antigone*	Sarus crane	Yes	No	VU	VU	II
22.	Birds	*Aquila heliacal*	Eastern imperial eagle	Yes	No	VU	CR	I
23.	Birds	*Aquila rapax*	Tawny eagle	No	No	VU	-	II
24.	Birds	*Aythya farina*	Common pochard	Yes	No	VU	NT	-
25.	Birds	*Gallinago nemoricola*	Wood snipe	Yes	No	VU	VU	-
26.	Birds	*Grus nigricollis*	Black-necked crane	Yes	No	VU	DD	I
27.	Birds	*Leptoptilos javanicus*	Lesser adjutant	Yes	No	VU	VU	-
28.	Birds	*Mulleripicus pulverulentus*	Great slaty woodpecker	No	No	VU	EN	-
29.	Birds	*Ploceus megarhynchus*	Finn's weaver	No	No	VU	CR	-
30.	Birds	*Prinia cinereocapilla*	Grey-crowned prinia	No	No	VU	CR	-
31.	Birds	*Saxicola insignis*	White-throated bushchat	Yes	No	VU	EN	-
32.	Mammals	*Aonyx cinereus*	Asian small-clawed otter	No	No	VU	-	II

S/N	Class	Scientific Name	Common Name	Migratory	Endemic/ Restricted Range	IUCN Listing	National Red List for Nepal[1]	CITES[2]
33.	Mammals	*Arctictis binturong*	Binturong	No	No	VU	-	III
34.	Mammals	*Bos gaurus*	Guar	No	No	VU	VU	I
35.	Mammals	*Lutrogale perspicillata*	Smooth-coated otter	No	No	VU	EN	I
36.	Mammals	*Myotis sicarius*	Mandelli's mouse-eared myotis	No	No	VU	VU	-
37.	Mammals	*Neofelis nebulosa*	Clouded leopard	No	No	VU	EN	I
38.	Mammals	*Panthera pardus*	Leopard	No	No	VU	VU	I
39.	Mammals	*Panthera uncia*	Snow leopard	Yes	No	VU	EN	-
40.	Mammals	*Rhinoceros unicornis*	Greater one-horned rhino	No	No	VU	P	I
41.	Mammals	*Rusa unicolor*	Sambar	No	No	VU	VU	-
42.	Mammals	*Ursus thibetanus*	Asiatic black bear	No	No	VU	EN	I
43.	Mollusc	*Tricula mahadevensis*	-	No	No	VU	-	-
44.	Reptiles	*Crocodylus palustris*	Mugger	No	No	VU	-	I
45.	Reptiles	*Python bivittatus*	Burmese python	No	No	VU	-	II
46.	Flowering plants	*Anacyclus pyrethrum*	Atlas daisy	No	No	VU	-	-
47.	Birds	*Falco severus*	Oriental hobby	Yes	No	LC	CR	II
48.	Birds	*Halcyon coromanda*	Ruddy kingfisher	Yes	No	LC	CR	-
49.	Birds	*Haliaeetus albicilla*	White-tailed sea-eagle	Yes	No	LC	CR	I

S/N	Class	Scientific Name	Common Name	Migratory	Endemic/ Restricted Range	IUCN Listing	National Red List for Nepal[1]	CITES[2]
50.	Birds	*Loriculus vernalis*	Vernal hanging-parrot	Yes	No	LC	CR	II
51.	Birds	*Numenius arquata*	Eurasian curlew	Yes	No	NT	CR	-
52.	Birds	*Pelecanus philippensis*	Spot-billed pelican	Yes	No	NT	CR	-
53.	Birds	*Aegypius monachus*	Cinereous vulture	Yes	No	NT	EN	II
54.	Birds	*Botaurus stellaris*	Eurasian bittern	Yes	No	LC	EN	-
55.	Birds	*Rallina eurizonoides*	Slaty-legged crake	Yes	No	LC	EN	-
56.	Birds	*Asio flammeus*	Short-eared owl	Yes	No	LC	VU	II
57.	Birds	*Aythya nyroca*	Ferruginous duck	Yes	No	NT	VU	-
58.	Birds	*Ciconia nigra*	Black stork	Yes	No	LC	VU	II
59.	Birds	*Circus aeruginosus*	Western marsh-harrier	Yes	No	LC	VU	II
60.	Birds	*Circus cyaneus*	Hen harrier	Yes	No	LC	VU	II
61.	Birds	*Clamator coromandus*	Chestnut-winged cuckoo	Yes	No	LC	VU	-
62.	Birds	*Falco naumanni*	Lesser kestrel	Yes	No	LC	VU	II
63.	Birds	*Ficedula hodgsoni*	Pygmy blue-flycatcher	Yes	No	LC	VU	-
64.	Birds	*Ficedula sapphira*	Sapphire flycatcher	Yes	No	LC	VU	-
65.	Birds	*Galerida cristata*	Crested lark	Yes	No	LC	VU	-
66.	Birds	*Gallicrex cinerea*	Watercock	Yes	No	LC	VU	-
67.	Birds	*Gyps himalayensis*	Himalayan griffon	Yes	No	NT	VU	II

S/N	Class	Scientific Name	Common Name	Migratory	Endemic/ Restricted Range	IUCN Listing	National Red List for Nepal[1]	CITES[2]
68.	Birds	*Hydrophasianus chirurgus*	Pheasant-tailed jacana	Yes	No	LC	VU	-
69.	Birds	*Limosa*	Black-tailed godwit	Yes	No	NT	VU	-
70.	Birds	*Macropygia unchall*	Barred cuckoo-dove	Yes	No	LC	VU	-
71.	Birds	*Nettapus coromandelianus*	Cotton pygmy-goose	Yes	No	LC	VU	-
72.	Birds	*Pitta sordida*	Western hooded pitta	Yes	No	LC	VU	-

[1] Nepal Red List of Birds and Mammals, 2011

[2] Convention on International Trade in Endangered Species of Wild Fauna and Flora:

- Annex I includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances.
- Annex II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.
- Annex III contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade.

Notes: LC = Least Concern; VU = Vulnerable; EN = Endangered; NT = Near Threatened; CR = Critically Endangered; DD = Data Deficient; NT = Not Listed; P = Protected – = No; X = Yes

7.2.6 MBNP Conservation Projects

The Makalu-Barun Conservation Area Project was initiated in 1988 as a joint endeavor of the Department of National Parks and Wildlife Conservation (DNPWC), an INGO called The Mountain Institute (TMI), and local organizations and committees, with the aim of promoting a participatory approach towards sustaining biodiversity conversation and management for long-term benefits. The activities initiated since 1992 include:

- Community development: eco-tourism development and income-generation programs (off-farm activities and market development for local products)
- Local culture conservation
- Natural resource management:
  - Community forestry programs
  - Grazing area management: prepared grazing area management plan and its operation

The outcomes of the Partnership Project[12] for improving local livelihoods and biodiversity conservation include:

- Over 97 CFUGs have been formed, which are managing over 11,500 ha of natural forests, covering over 90% of households in the MBNP area.
- Six Grazing Area Management User Groups were formed and four Operational Plans for grazing areas were realized.
- Eight forest nurseries have been established and are owned and operated by local farmers in the MBNP area, covering 37 ha of degraded community and private land.
- There has been significant forest recovery and improved forest conditions in the MBNP Buffer Zone areas through voluntary conservation by local communities.
- Wildlife poaching and hunting are under control; the local communities help arrest hunters and poachers.
- The Project has supported over 250 small-scale infrastructure development projects, such as providing a drinking water supply system and improving trails and school facilities.
- An agreement was made for managing natural resources and eco-tourism across the Himalayan boundary between Nepal and Tibet Autonomous Region of China (Jha 2003).
- The Project has improved the livelihoods of over 3,000 people through the provision of livelihood improvement training programs such as weaving and knitting, trekking, cooking and managing lodges, carpentry, and bamboo craft, among other things. Furthermore, the Project has also supported the conservation of local culture by constructing and maintaining temples, gompas, and sacred places, etc.

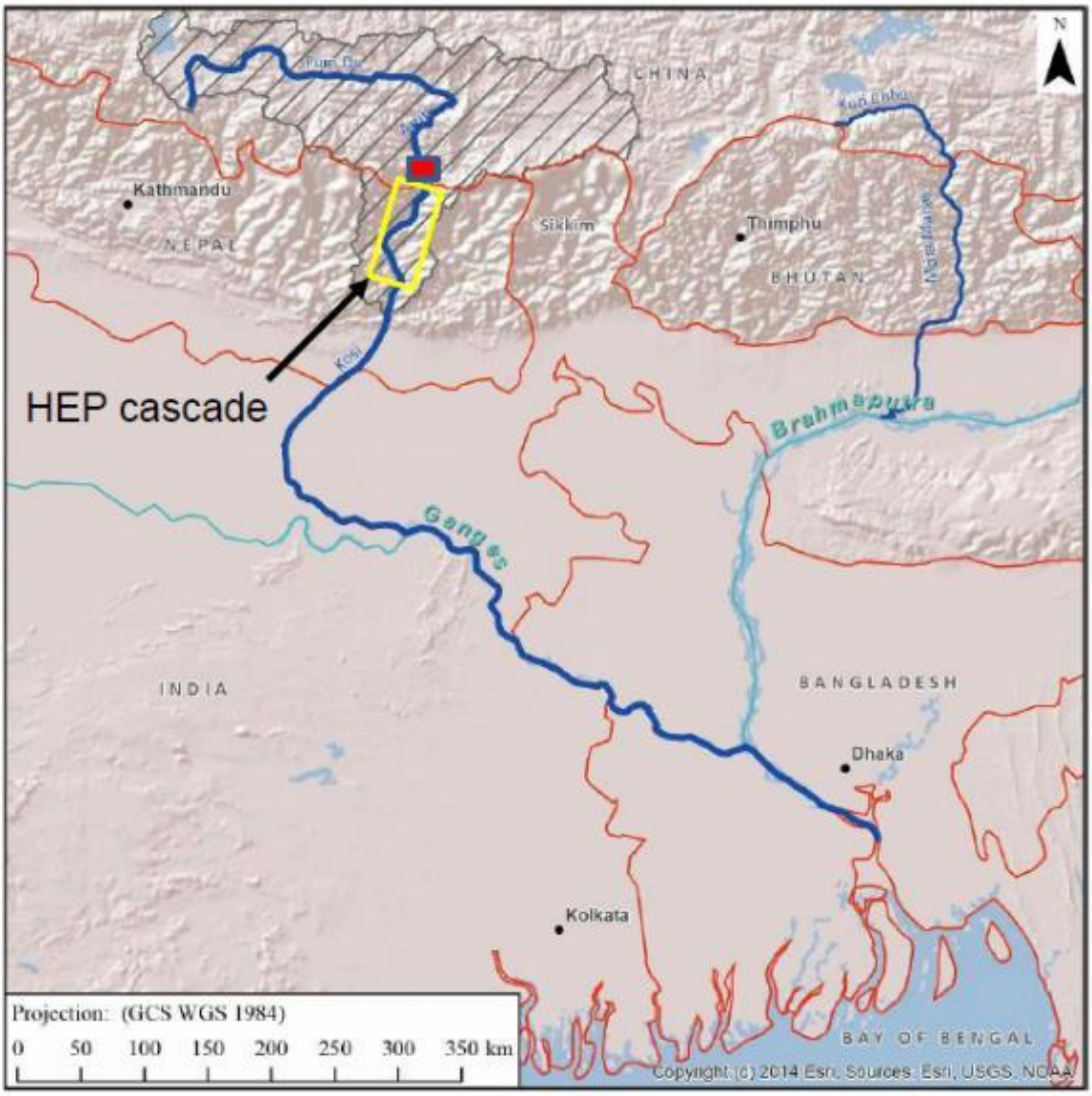
7.3 VEC: Water Resources

7.3.1 Arun River Basin

The Arun River is a tributary of the Sapta Koshi River, which in turn is a tributary of the Ganges River in India, which ultimately discharges into the Indian Ocean in the Bay of Bengal (see ***Figure 7.5***). The river originates from a glacier on the north slope of Mount Xixabangma (elevation 8,012 m) and the southern part of the Tibetan highlands in the Tibet Autonomous Region of China.

[12] The Partnership Project is the collaborative efforts of the Government of Nepal, The Mountain Institute, and local communities in promoting participatory approaches towards sustaining the conservation of the MBNP and its Buffer Zone, as well as improving the livelihoods of local people (Jha 2003).

Figure 7.5: Arun River Drainage

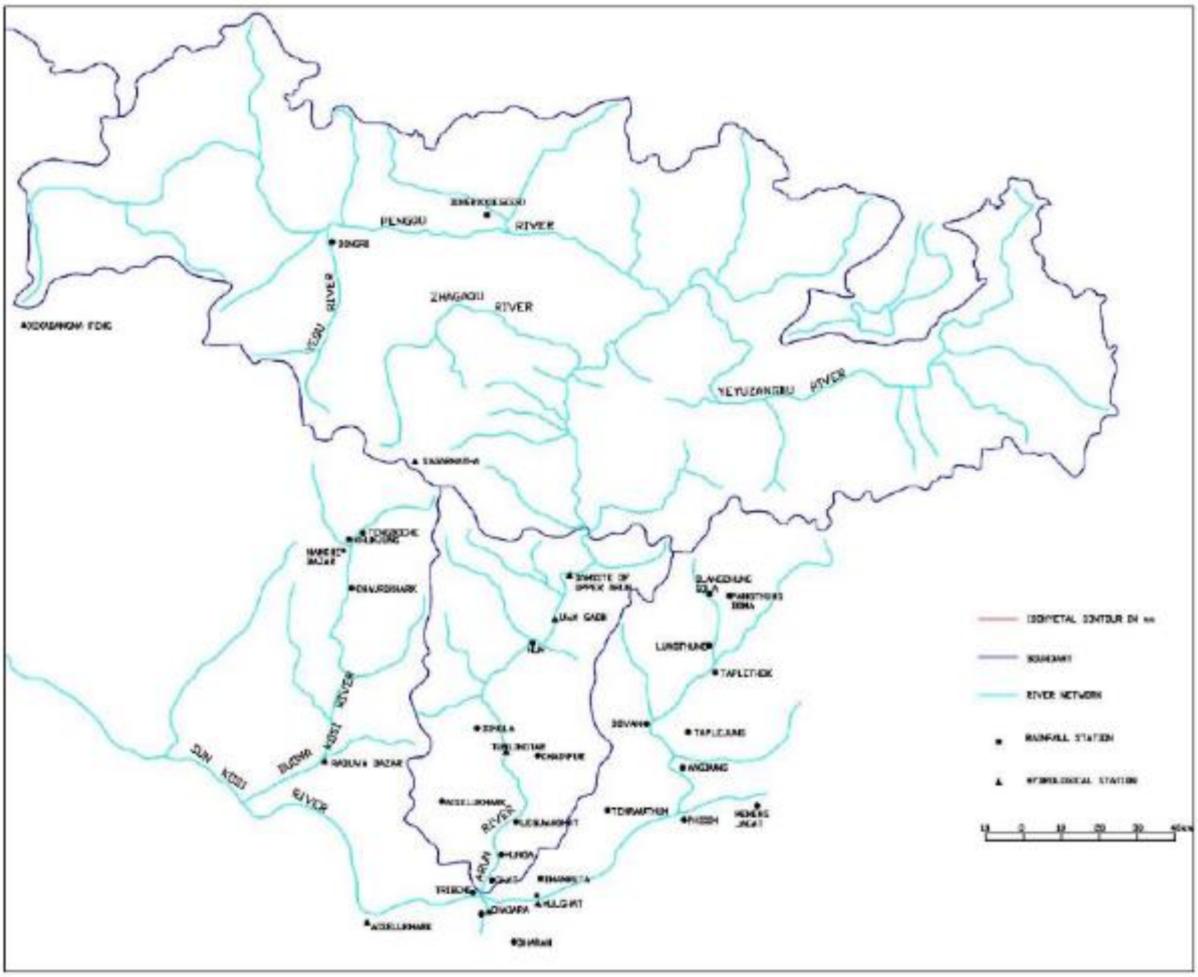


Source: Reynolds 2020

The Arun River has a total drainage area of approximately 30,400 km^2, with approximately 83% of that draining from China (***Figure 7.6***). The Arun River drainage areas at key locations are listed below:

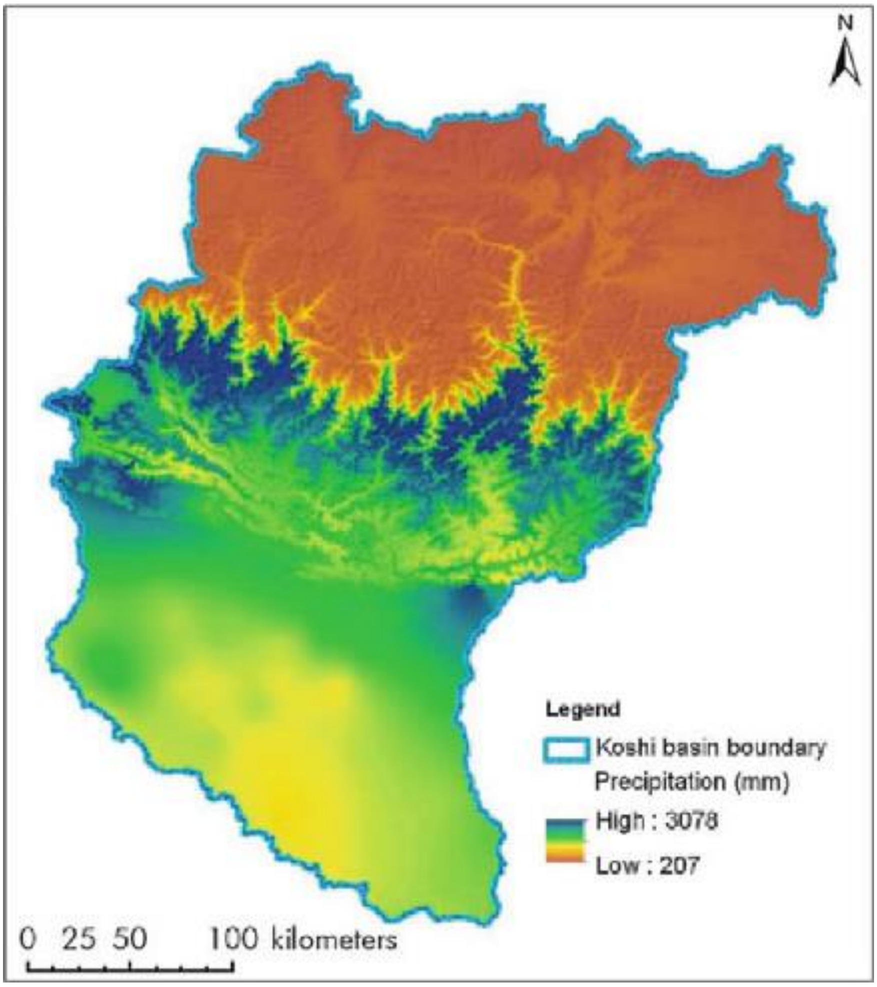
- Drainage area at China border – 25,307 km^2
- Drainage area at UAHEP dam – 25,700 km^2
- Drainage area at UAHEP powerhouse – 26,300 km^2
- Drainage area near Tumlingtar – 28,150 km^2
- Drainage area at confluence with Sapta Koshi River – 30,400 km^2

Figure 7.6: Arun River Basin



The Arun River is the largest trans-Himalayan river passing through Nepal and has the greatest snow and ice covered area of any Nepali river basin (Kattelmann 1990). The Arun River drains more than half of the Sapta Koshi River Basin, but provides only about a quarter of the total flow, which is attributable to the fact that more than 80% of the Arun's drainage area is within the Himalaya rain shadow in Tibet Autonomous Region, where average annual precipitation is less than about 300 mm, as compared to about 2,400 mm in the Nepal portion (***Figure 7.7***).

Figure 7.7: Average Annual Rainfall in the Koshi Basin



Source: Neupane *et al*. 2014

7.3.2 Arun River Flow Characteristics

The Arun River is a relatively high volume, high gradient/high velocity, glacier-fed (i.e., cold with high sediment load) river. In terms of flow, there are five Nepal Department of Hydrology and Meteorology (DHM) gauging stations along the Arun River, as summarized in ***Table 7.13***. The Uwa Gaon gauging station, which is located just downstream from the UAHEP powerhouse, is the closest gauge to the Project Area and provides about 25 years of consecutive flow data. Three staff gauges were installed in April 2018 at the confluence of the Arun River with Chepuwa Khola, the powerhouse site, and Leksuwa Khola; and an automatic gauging station was installed at the dam site in June 2018.

Table 7.13: Nepal DHM Flow Gauging Stations along the Arun River

Station No.	Location	Longitude	Latitude	Catchment Area (km^2)	Flow Series
600.1	Uwa Gaon	27°35’21”	27°35’21”	26,620	1985–2010
604.5	Turkeghat	87°11’30”	87°11’30”	28,200	1975–2014
606	Simle	26°55’42”	26°55’42”	30,380	1986–2010, 2012–2016
602	Tumlingtar	87°12’45–	87°12’45”	409	1974–2016
602.5	Pipletar	87°17’45”	87°17’45”	148.5	1974–1976, 1976, 1984–2016

The flow in the Arun River is subject to strong seasonal effect as evidenced in average monthly flows:

- December to February – The lowest flows occur during the winter when the little precipitation that occurs is as snow.
- March to early June – Still the dry season, but flows slowly begin to increase as warming temperatures slowly start to melt accumulated snow and ice.
- Mid-June to mid-September – The monsoon season has the highest flows, due to heavy rainfall combined with snow and ice melt.
- Late September to November – Gradually decreasing flows, as the monsoons end and temperatures begin to cool.

The Arun River is currently free flowing for its entire length with no existing hydropower, irrigation, or other dams along its course. This will change in the near future, as Arun-3 HEP is already under construction and several other main stem hydropower projects are proposed, including Kimathanka Arun, Upper Arun, Arun-4, Arun-3, Lower Arun, and the Sapta Koshi High Dam, which, although proposed to be located on the downstream Sapta Koshi River, will inundate the lower portion of the Arun River.

The Arun River is used for multiple purposes along its length, including subsistence, recreational, and commercial fishing; recreational boating; cultural practices (e.g., cremations); and irrigation (discussed in more detail in **Section 7.4** VEC: Fish and Aquatic Habitat and **Section 7.5** VEC: River-based Livelihoods).

7.4 VEC: Fish and Aquatic Habitat

7.4.1 Fish Diversity in the Arun River Basin

There is currently no available full fish data survey indicating species diversity and gradient along the Arun River. As such, this section has been developed based on the following sources:

- Arun-3 HP EIA, (WAPCOS Limited 2015)
- FAO Technical Paper 431 (Petr *et al*. 2002)
- Species list prepared by K.J. Rajbanshi (Rajbanshi 2002)
- CIA of Tamor (ERM 2019), which is the neighboring river just east of Arun
- EIA of the Dudhkoshi Storage Hydropower Project (EIA of DKSHEP, 2020, ELC in prep), which is located in an adjacent river to the west of Arun River
- ESIA of the Upper Arun Hydropower project (ERM, forthcoming)

According to FAO's Technical Paper 431 (Petr *et al*. 2002), the part of the Koshi River system downstream from Arun has 31 registered fish species, the neighboring Dudhkoshi River west of Arun has 31 registered species in the lower part of the river, and the Middle Tamor east of Arun has 50 registered species. In 2002 Rajbanshi listed 31 species in the Arun River, and the EIA for the Arun-3 HEP (2015) lists 22 registered species. Sampling in the Upper Arun area collected 5 species, while local people reported 21 species including the river section downstream from the Arun-3 HEP.

By compiling the available data from the aforementioned sources and qualifying the data against the IUCN (www.iucnredlist.org) and Fishbase (http://www.fishbase.org) databases, the list of species that are reasonably found in the Arun River Basin constitutes 44 species, as presented in **Annex D.**

7.4.2 Target Fish Species

When selecting target species as a tool to understand the impacts and mitigating strategies, it is important that the target species are also present in the CIA area, and that the species will potentially be affected by the proposed Project. In addition, the species should meet the following criteria:

- Single species that cover the ecological needs for a larger group of species (representatively)
- IUCN red listed species, and endemic species
- Long and medium range migratory species
- Locally valuable species

Guided by the aforementioned criteria, the fish species shown in ***Table 7.14*** have been selected based on expert opinions, field surveys, and consultations with local people. ***Table 7.15*** shows the migration and spawning seasons for selected key fish species

Table 7.14: Target Fish Species

Species	English name	Local name	Comments
Anguilla bengalensis (bam)	Eel	Raj bam	Long migrant
Tor putitora (mahseer)	Golden mahseer	Sahar	Long migrant
Schizothorax richardsonii	Common snow trout	Butche asala	Mid migrant
Neolissocheilus hexagonolepis	Copper mahseer	Katle	Mid migrant
Labeo dero	River rohu	Gardi	Mid migrant
Glyptosternum blythi	Dwarf catfish	Tilkabre	Strong climber, up to 3,000 masl
Psilorhynchoides pseudecheneis (titae)	Stone carp	Titae	Endemic, strong climber

Box 7.1: Description of Target Species

Freshwater Eel (*Anguilla bengalensis*)

Nepali name: *Rajabam* or *bam*

Physical features:

The body of this freshwater eel appears naked, but small cycloid scales are embedded in the skin. The body is covered by mucus, which makes it slippery, giving rise to the expression “slippery as eel”. It is an excellent game fish.

Fresh water eel (*rajabam*)

Feeding: It lives in deep stone crevices feeding actively on young fish and molluscs.

Spawning and migration: It lives in freshwater, but also occurs in estuaries and in the sea during early life and near maturity in the bay of Bengal (www.fishbase.org). It is believed to begin life in the ocean and then migrate to freshwater as an immature eel; they spent most of their life in freshwater and return to the ocean to spawn and die. They are a long migrant species and are known to migrate upstream during the monsoon floods from May to August.

Economic importance: Highly valued for food. Highest price range.

Distribution: Asia: Pakistan, India, Sri Lanka, Burma, and the East Indies, Nepal and Bangladesh (www.fishbase.org). Endangered status in India (Arunachalam and Sankaranarayanan 2000).

Conservation status: IUCN: Vulnerable

Golden mahseer *(Tor pitutora)*

Nepali name: *Sahar*

Physical features:

The golden mahseer is a beautiful freshwater game fish. The snout of this fish is long and pointed. It is noted for its large 9 predorsal scales, which is not possessed by any other fishes inhabiting the mountain streams. General body colour is silvery green to olive green above, belly silvery white pinkish on sides, and fins are yellowish.

Golden mahseer (*sahar*)

Feeding: It mainly feeds on macroinvertebtares and fish.

Spawning and migration: The golden mahseer is a long range migrant fish, which migrates upstream for spawning. The ideal time for the spawning is from July to September, when the river has a high water level. A mature golden mahseer of 45 cm yields 6,300 to 28,000 eggs.

Generally, spawning of the golden mahseer starts at the confluence of warm tributaries or in the lower parts of these tributaries, where water is highly oxygenated and has moderate velocity. The suitable water depth for spawning is 2 to 5 m.

Economic importance: Highly valued for food. Highest price range.

Distribution: It occurs in high mountain streams, up to 1,200 masl, although this varies depending on water temperatures and other factors. It is found in the Koshi river sytem and in several of the large tributaries of Tamor, Arun and Dudhkoshi, as well as in the Trishuli, Gandaki, Karnali, and Mahakali river systems, and feeder streams. This fish is also found in India, Pakistan, Myanmar, Sri Lanka and Bangladesh.

Conservation status IUCN: Endangerd

Common snow trout *(Schizothorax richardsonii)*

Nepali name: *Buche asala* or *asala*

Physical feature:

The snout of the common snow trout is rather blunt and its body is trout like, but more cylindrical. The mouth is inferior. Its general body colour is silvery with golden yellow spangles on the sides. The paired fin is often tinged with red.

Common snow trout (*buche asala*)

Feeding: The snow trout feeds on almost any aquatic algae and organic matter, mainly in the early morning and evening.

Spawning and migration: This is a midrange migrant fish. It generally becomes sexually mature after 2 years and female produces about 33,000 to 55,000 eggs. The species has two breeding seasons; September/October and Spring March/April.

Economic importance: Highly valued for food. Highest price range.

Distribution: It occurs in high mountain streams and in most of the river systems in Nepal.

Conservation staus: IUCN: Vulnerable. See **Annex E** for an esimated distribution of this species in the Arun Basin.

Copper mahseer (*Neolissochilus hexagonolepis)*

Nepali name: *Katle*

Physical features:

The lower lip is separated from the jaw with a horny covering. Further, it has a osseous dorsal spine, two pairs of barbells, large scales, a olive-green colour on the dorsal side, and a silvery white colour below.

Copper mahseer (*katle*)

Feeding: Copper mahseer is an omnivorous fish.

Spawning and migration: The spawning behaviour is similar to the golden mahseen and it spawns in June-September when the river has high water levels. The copper mahseer is a mid range migratory fish. Their migration is limited to 5–10 km.

Economic importance: Highly valued for food. Highest price range.

Distribution: Mountain rivers up to more than 1,000 masl.

Conservation status: IUCN: Vulnerable. See **Annex E** for an esimated distribution of this species in the Arun Basin.

River rohu *(Labeo dero)*

Nepali name: *Gardi*

Physical features:

The river rohu has a medium-sized, snout with many horny tubercles. It is bluish black above, with silver sides and yellowish ventral fins. The whole body of the fish is covered by large scales.

River rohu (*gardi*)

Feeding: Its main food is algae, fish, crustaceans and frogs.

Spawning and migration: This fish is a resident or a short range migrant species. It ascends hill-streams for spawning during May-June in shallow water over plants and gravel.

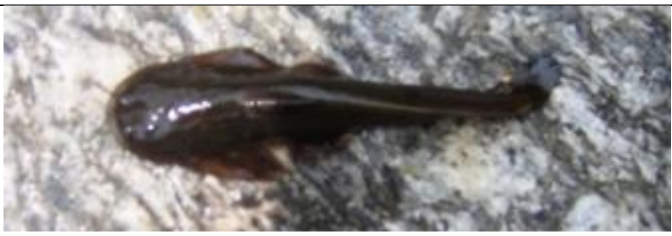
Economic importance: Highly valued for food. Highest price range.

Distribution: Mountian rivers up to more tha 1,000 masl.

Conservation status: IUCN: Not Threatened

Dwarf catfish (*Glyptosternum blythi*)
Nepali name: *Tilkabre* and *telkabre*

Physical features: The dwarf catfish's head is depressed with a broad snout. Its lips are broad and continuous and its mouth is round with papillation, which helps the fish adhere to rocks. Its body colour is yellowish brown and its dorsal and caudal fins are tinged with black.



Dwarf catfish (*tilkabe* or *telkabre*)

Feeding: The dwarf catfish is omnivorous, feeding on aquatic insects, tadpoles, and earthworms.

Spawning and migration: A resident fish that breed in May and June.

Economic importance: None. Not used as food.

Distribution: Asia, endemic to Nepal (www.fishbase.org).

Conservation status: Not evaluated by IUCN

Stone carp (*Psilorhynchus pseudecheneis*)

Nepali name: *Titae*

Stone carp (*titae*)

Physical features: Its body is elongated, depressed and flattened with 3 to 5 distinct transverse folds on the ventral side. Generally, its body colour is dark with greenish spangles on the dorsal sides. A few dark blotches and bands are present in front of the dorsal fin as well as behind. Its scales are pigmented with black. The length of a full mature fish is around 18 cm.

Feeding: Its food consist of algae, small aquatic insects, tiny molluscs, and crustaceans.

Spawning and migration: The stone carp is a resident and a short range migrant fish. Its main spawning period is August. It enters to small tributaries for spawning. Spawning takes place in shallow riffles of streams.

Economic importance: This fish has a bitter taste and has medicinal value for abdominal diseases.

Distribution: Endemic to eastern Nepal (www.fishbase.org).

Conservation tatus: Endemic and IUCN: Least Concern

Table 7.15: Migration and Spawning Patterns for some Selected Species

Species	Migratory Pattern by Month												Spawning
Long-distance migratory fish	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	
Anguilla bengalensis (bam)		↑	↑	↑	↑	↓	↓	↓					Jun–Jul
Tor putitora (sahar or golden mahseer)					↑	↑	↑	↑	↑ ↓	↓	↓	↓	July, Oct
Tor tor (putitor mahseer)						↑	↑	↑	↑ ↓	↓	↓	↓	Aug–Oct
Short/medium-distance migratory fish	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	
Neolissochelius hexagonolrpis (katle)			↑	↑	↑	↑	↑ ↓	↓	↓				
Labeo dero (gardi)			↑	↑	↑	↑	↑	↓	↓				Varies*
Schizothorax richardsonii (butche asala)		↑	↑	↑	↑					↓	↓	↓	Varies*
Schizothorax progastus (chuche asala)		↑	↑	↑	↑					↓	↓	↓	Varies*
Resident fish													
Psilorhynchoides pseudecheneis (titae)							↑	↑	↓	↓			August
Glyptosternum blythi (tilkabre)					↑	↑	↓	↓					May–Jun**

Notes: * Varies with the local thermal regime and flooding conditions. ** Low level knowledge about the species ecology.

7.4.3 Aquatic Habitats

Assessing the basin for fish diversity will require an understanding of temperature variations, and species composition and distribution; therefore, ERM has used existing EIAs of projects in the basin and other studies carried out by ERM to create a digital elevation model (DEM) of the basin that specifies the elevation across the basin. Temperatures of river reaches at varying elevations, obtained from other basins, were used to delineate three zones in the basin (***Figure 7.8***):

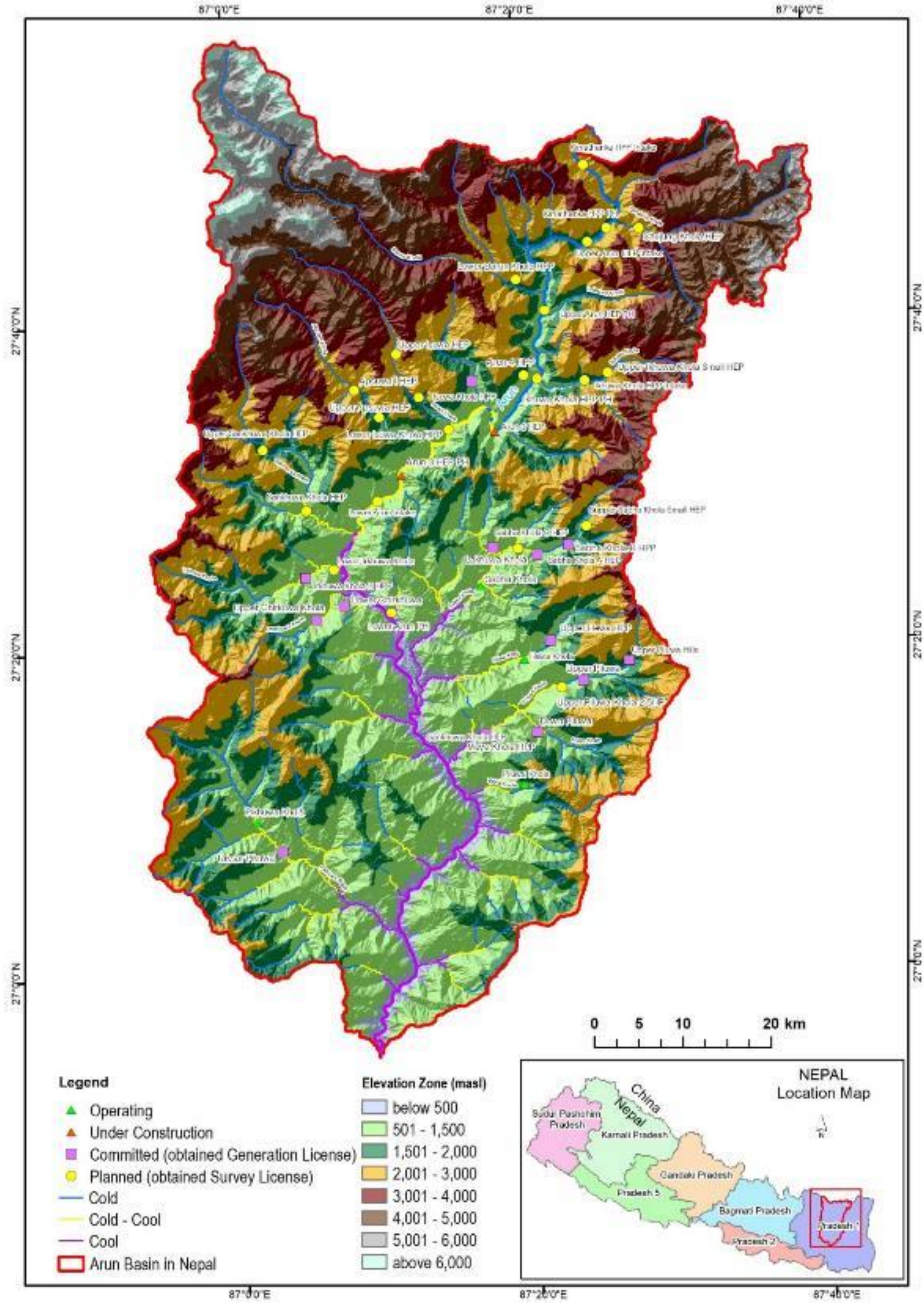
- Cold – upstream of ~800 masl, this is specific for the glacier fed Arun River
- Cold-cool (~800 to ~400 masl)
- Cool (downstream of ~400 masl)

Table 7.16 lists the physical characteristics of key Arun River tributaries.

Table 7.16: Physical Characteristics of Tributaries along the Arun River

Tributary	Physical Characteristics	Zone
Chujung Khola – Left bank	Snow and glacier fed, high sediment load	Cold at confluence (upstream from UAHEP)
Barun river – Right bank	Steep gradient, high sediment load, glacier fed	Cold at confluence
Lexuwa Khola – Left bank	Clear water river during winter and spring, not snow fed, dominated by boulders	Cold-cool at confluence
Ikhuwa Khola – Left bank	Clear water during winter and spring, steep gradient, dominated by boulders and stones	Cold-cool at confluence
Induwa Khola – Left bank	Clear, steep gradient	Cold-cool at confluence
Hingsa Khola – Right bank	Clear river, steep gradient	Cold-cool at confluence
Isuwa Khola – Right bank	Glacier and snow fed, turbid/clear, steep gradient, no temperture	Cold at confluence
Apsuwa Khola – Right bank	Snow and glasier fed, turbid/clear, steep gradient, no temperature	Cold at confluence
Sangkhuwa Khola – Right bank	Clear, low level snow fed	Cool at confluence
All tributaries further downstream	Clear during winter and spring, ecological value depend on the year cycle flow conditions, but usually good habitats	Cool at confluence

Figure 7.8: Three River Temperature Zones in the Arun Basin



7.5 VEC: River-based Livelihoods

For this CIA, livelihoods encompass income and activities required to secure the necessities of life for people in the Arun River Basin. Emphasis is placed on river-based livelihoods, as they would be most impacted by planned hydropower projects in the basin.

7.5.1 River-based Sources of Income

Fishing

There is a lack of temporally and spatially comparable data on fishing within the Arun River Basin. The following is general fishing livelihood information that has been obtained from available hydropower project EIAs/IEEs and the CIA consultations in the Arun River Basin.

Fishing has long been a livelihood source in Nepal, given the importance of fish and other aquatic products due to their nutritional, religious, and cultural value in Nepalese society (Gurung and Sah 2016). Fishing communities were consulted during the CIA downstream consultations in Khandbari Urban Municipality and Shaba Pokhari Rural Municipality of Sankhuwasabha District (***Figure 7.9***). The consulted communities included ethnic groups (Bhahmin/Chhetri, Newar, Dalits, janajatis) in Katle Bhanjyang settlement; the Kumul and Majhi communities in Tumlingtar; and mixed ethnic groups in Barhabishe Bazar; as well as local fish markets.

According to the consultations, fishing is not a sole source of income and is typically conducted only six months of the year (from April to November). Local residents rely on other economic activities for income, including agriculture (growing crops, vegetables, maize, lentils, cash crops, etc.), running hotels, tea stalls, teaching, and office work; some have migrated for foreign employment or are self-employed (driving vehicles and tractor). For these communities, fishing is generally for household consumption, and their surplus catch may be sold at local fish markets (e.g., Tumlingtar market and Hat Bazar in Khandbari) to supplement their income. Fish is valued as special food for family consumption as it is considered nutritious; dried fish is also valued as a gift to relatives and friends. Moreover, fish is essential for various spiritual practices, for example, fish are used to perform death rituals of the Majhi and the Limbu, and fish is used during Kul Puja (an annual ritual to worship God specific to their community) by the Rai, Kumal, and Majhi.

The fishermen consulted typically engage in fishing activities twice a week, depending on fish availability in the river. Fishing activities usually take place all year round, although are more common before the monsoon (February/March/April) and after the monsoon season (late September, October/November). Communities typically use traditional fishing gear, such as cast nets, gill nets, lift nets and various other nets with indigenous names; different types of traps and baskets; as well as rods and lines for subsistence fishing. Some community members of the Kumal community in Tumlingtar also make fishing gear and bamboo fish storage containers for sale. However, destructive fishing approaches, such as the use of explosive materials and electric fishing, were reported in the basin. During the consultations, various communities expressed concern that these approaches are negatively impacting fish habitats and spawning grounds.

On average, fishermen catch 1–3 kg of fish per day; the volume can be higher depending on river conditions. The use of explosives and electric fishing can sometimes result in 8–10 kg of fish being caught per day. According to consultations with communities in Boharatar, Barhabishe Bazar, Tumlingtar, and the DCC Officer, popular sites for fishing in the area include Arun River, Shabha River, Hewa River, Sankhuwa River, Sisuwa River, Khangluwa, Newa River, Pilwa Khola, and Sankhuwa Khola. Common fish species caught in the Arun River Basin are asala, buduna, singe, gunj, katle, sahar, thed, bam tikhe, and titae (***Figure 7.10***).

Men and young boys generally undertake fishing activities. Women, however, are responsible for drying fish and selling them in local markets. Dried fish is commonly sold in more volume than fresh fish, because fish is easily perishable, therefore, it is preserved for long time marketing. The fishermen generally earn an average of NPR 1,200 per day, according to a key informant interview from the Majhi community. Market prices for fish are dependent on fish species and size, with small fish selling for NPR 600 per kg and large fish selling for NPR 1,000 per kg, while dried fish may sell for NPR 5,000 per kg.

The consulted communities expressed concern that the local fish population has reduced significantly over the past five to ten years. They further explained that frequent landslides/flood in the Shaba Khola and Arun River, the use of electrofishing and explosives for fishing, the development of hydropower projects, and mining gravel and sand from the river were major factors responsible for the reduction in fish population in the Arun River Basin.

Figure 7.9: CIA Consultations with Fishing Communities

Community members engaged in fishing activities in Boharatar and Tumlingtar

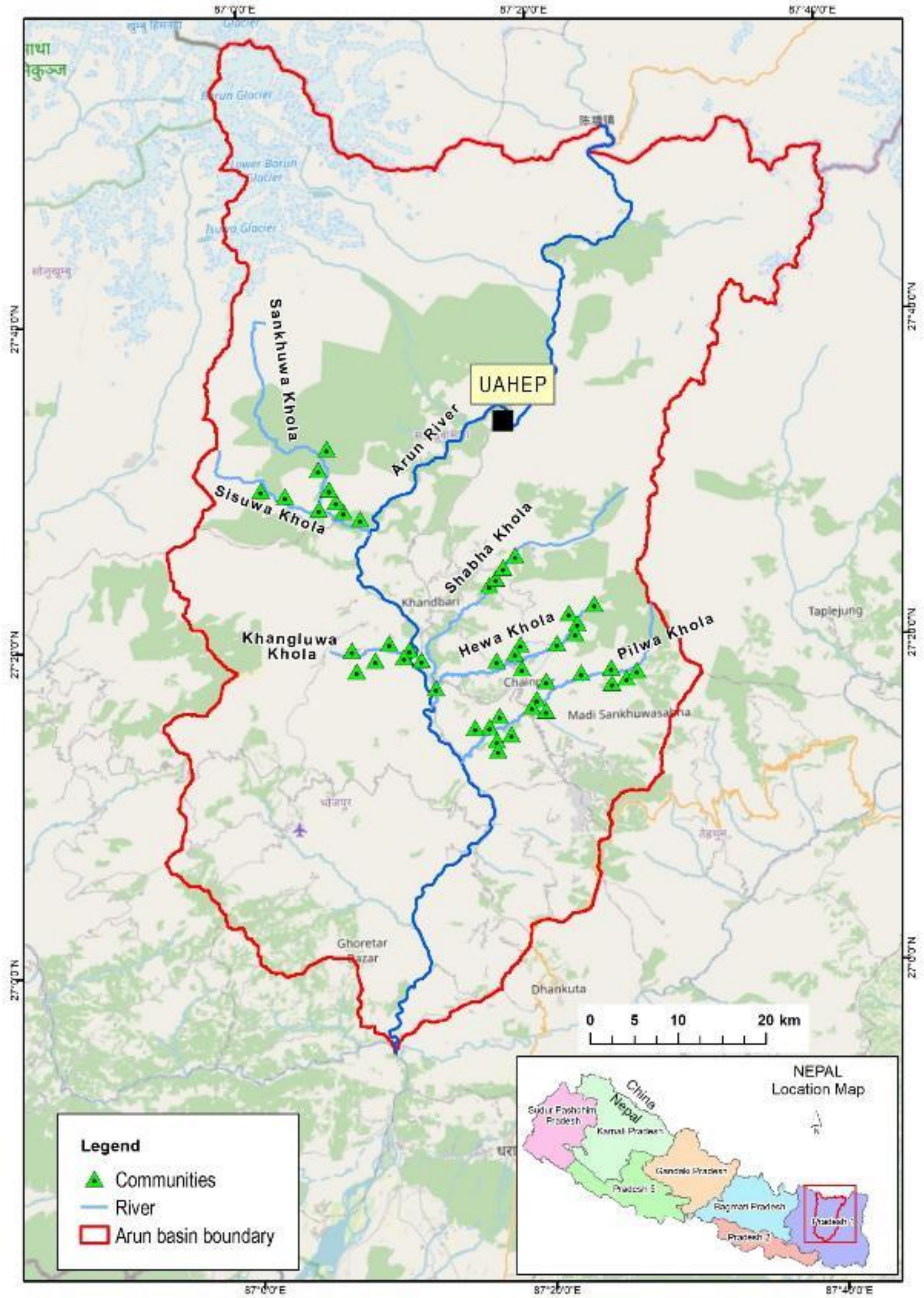
Women selling fish in Hat Bazar, Khandbari

Consultation with fishing community in Kumal

A fisherman in Kumal making a fishing net for sale

Source: ERM 2020

Figure 7.10: Key Fishing Rivers and Nearby Communities



Sport Fishing

Sport fishing has gained popularity in Nepal in recent years. Golden mahseer is the most commonly sought sport-fish in Nepal. Sport fishermen also target copper mahseer, river catfish, mountain stream trout, freshwater eel, mud eel, giant murrel, knife fish, feather back, and common and grass carp. In Nepal, the best months for sport fishing are October to December and February to May.[13] Nepal currently does not have any "catch and release" regulations.

A few sport fishing outfitters operate along the Koshi River and its tributaries, such as Nepal River Runner, Nature Trail, and Adrift Adventures. According to the Nepal River Runner website, the outfitter organizes a 5-day fishing trip in combination with rafting along Sunkoshi River, covering a distance of over 270 km through the confluence of Arun and Tamor rivers.[14] Adrift Adventure offers a combination of rafting and trekking on the Arun River, in which participants can bring along a fishing rod or try local methods of bamboo pole or a crude fish trap.[15]

River Rafting

At least four outfitters are currently providing rafting services on the Arun River: Nature Trail, Makalu Adventure, Adventure Hub Nepal (AHN), and Swissa Rafting & Trekking Expeditions. According to the website of Nature Trail,[16] this outfitter organizes a trek and rafting trip starting from Tumlingtar in Sankhuwasabha. They offer a six-day rafting and kayaking, and claim that the lower Arun River is one of the best rafting routes in Nepal, because of its turbulent water current and huge water volume, and this route ends at Biratnagar. Adventure Hub Nepal provides a 16-day journey of a combination of trekking and rafting with a total distance of 116 km. The trek starts from Tumlingtar and ends at Chatra with the take-out point in Arun and Sun Koshi Rivers.[17]

During the CIA consultations, key informant interviews with members of the Majhi community revealed that people like to do rafting, swimming, and other recreational activities in the Arun River near Tumlingtar. This community used to provide boating services for the communities on both sides of the river. However, since bridges have been constructed across the Arun River, the need for boating services has stopped, and the community switched to fishing on a part time basis for income.

Sand and Gravel Extraction

CIA consultations with the Deputy Mayor, Khandbari Urban Municipality and the Coordinator of the DCC, Sankhuwasabha, indicated that the crushing industry can take around 35 trucks of sand, stone, and gravel per day from Shaba Khola, according to the agreement with the Khandbari Urban Municipality. Crusher plants are not allowed in the Arun River, however, small scale mining for households and other purposes is seen at some locations along the Arun River. While larger operations require an IEE, small scale mining operations do not require any clearances, but are required to pay royalty (fees assessed per truck) to the municipality.

Most gravel, sand and stone are extracted from Shaba Khola, Sishwa Khola, and Nepa Khola and partly from Arun River. Materials extracted are usually used within the district, for instance, for road construction.

During the CIA consultations, community members recognized that the extraction of sand, stone, gravel has resulted in degradation and deterioration of fish habitat; consequently, there has been a significant reduction in the fish population in the past 10 years.

[13] https://www.fishinginnepal.com/fishing-in-nepal.php

[14] https://www.nepalriverrunner.com/river/fishing-trip-sunkoshi-5-days/

[15] https://www.adriftadventure.com/fishing-nepal/

[16] https://www.naturetrail.com/arun-river-rafting/

[17] https://adventurehubnepal.com/nepal/rafting-kayaking/rafting-kayaking-at-arun-gorges

7.5.2 River Use for Domestic Purposes

The CIA consultations with the downstream communities found that the Arun River is an important resource for communities in the Arun River Basin; for some, their livelihoods significantly depend on it. The Lower Arun River is commonly used for irrigation purposes. A Solar Lift Drinking Water Scheme provides drinking and irrigation water for communities in Boharatar, Katle Bhanjyang, and communities in Tumlingtar by lifting water from Arun River and Shaba River. This scheme is particularly vital for water-stressed communities for irrigation purposes and it has enabled an increase in agricultural activities in dry areas, according to consultations with the community in Boharatar and Katle Bhanjhyang.

The situation is different in the Upper Arun River, where relatively few people use the river for potable water, fishing, or irrigation because of difficulties in accessing the river as a result of the difficult terrain, but many (87%) use it for religious and other purposes.

7.5.3 Irrigation

Irrigated land comprises 47% of the agricultural land in the mountains of Sankhuwasabha District, and 28% in the hill district of Dhankuta (ICIMOD 2009) The irrigation sources for these districts tend to be perennial and seasonal streams, rather than the Arun River (***Table 7.17***).

Table 7.17: Irrigation Sources

District	Irrigated Land of Total Agriculture Land (%)	Land Irrigated by Sources (%)				
		Tube Well	Perennial	Seasonal	Pond/Well	Other
Dhankuta	28	0.7	45	49	0.7	2.8
Sankhuwasabha	47	0.3	15	74	2.6	6.5

According to the CIA consultation with the Water Source and Divisional Irrigation Officer of Sankhuwasabha, the organization is providing surface irrigation to 821 ha of farmland from Malta Khola, Hewa Khola, Hanchuwa Khola, Pantha Khola, and Neguwa Khola, which are tributaries of the Shaba Khola and Arun River. Irrigation and drinking water are also provided by modern irrigation schemes from Shaba Khola and Arun River. Modern irrigation schemes cover 106.5 ha of land in the district. Farmers are using irrigation to cultivate crops (paddy, maize, white, potato) and vegetables. Surface irrigation is specifically used to grow mustard, wheat, potato (winter crops), paddy, millet, and maize (summer crops). In the Upper Arun River valley, most of the farmers grow cardamom in wet land, which typically requires irrigation.

7.6 VEC: Settlement

7.6.1 Overview

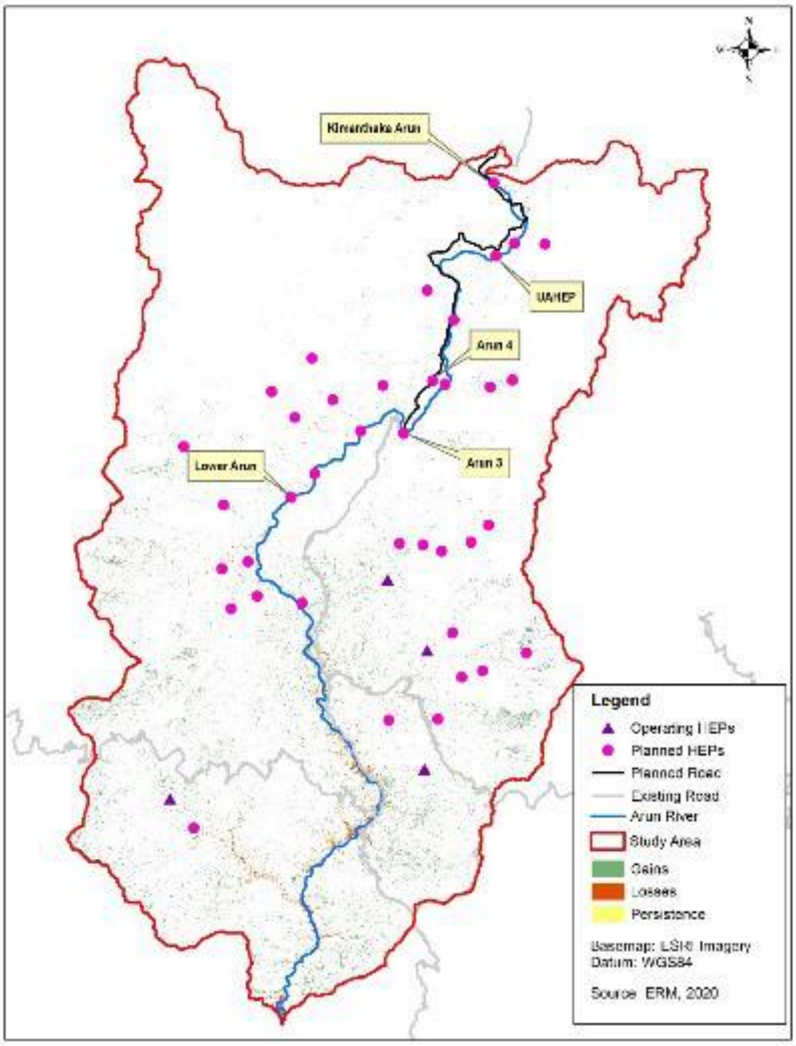
The settlement VEC examines settlement patterns within the Nepal portion of the Arun River Basin. As such, this section summarizes the historical settlement patterns based on the 2009–2018 LULC assessment of the Arun River Basin, and discusses associated drivers/effects of these movements including commerce and industry, land ownership and housing, and public infrastructure.

7.6.2 Settlement Patterns in the Arun River Basin

Settlements in the Nepal portion of the Arun River Basin increased by 60% (from 47 km^2 to 116 km^2) between 2009 and 2018 – although settlement land accounts for only for 2% of the Arun River Basin in 2018. Settlement was the fastest changing land class during this period, which had a gain rate of 22 km^2 per year. As shown in ***Figure 7.11***, settlement clusters have grown along rivers and roads, particularly within the lower elevated regions of the Arun River Basin, between 2009 and 2018.

There is a historical trend of people in the eastern region migrating from the hills to the Terai. There are scattered settlements in the upper region of the Arun River Basin which have not been connected to the region's road network, which is changing due to construction of the North-South Highway.

Figure 7.11: Settlement LULC Change in the Arun River Basin from 2009–2018



Source ERM 2020

7.6.3 Historical Migration

The most fundamental changes to the Koshi Hill's demography took place in the late 1950s, when there was a significant movement of people from the eastern hills to the Terai after the eradication of malaria and the expansion of farmlands and employment opportunities. The Census shows that migration steadily rose until 2001, after which there was a dramatic acceleration within the Koshi Hills and nationally. In 1981, the absent population in the Koshi Hills totaled about 20,100 (3.7% of total population); by 2011, it had sharply increased to 51,318 (8.4% of total population), with the highest portion recorded in Terhathum (9.5%) followed by Dhankuta (8.8%), Bhojpur (8.2%), and Sankhuwasabha (7.6%) (CBS 2011). As shown in ***Table 7.18***, the population in the three districts within the Arun Basin (Sankhuwasabha, Bhojpur, and Dhankuta) increased between 1991 and 2001, and decreased between 2001 and 2011.

Men (93%) are the main migrants from the Koshi Hills (CBS 2011), although, since 2001, there has been a slight increase in the number of female migrants from 5.6% in 2001 to 7.0% in 2011. Historically, a key feature of labour migration in Koshi Hills has been the spatial and social recruitment of young Rai and Limbu ethnic groups into British and Indian regiments. The significantly higher salaries and pensions earned by recruits, coupled with the high degree of continuity in recruitment from specific villages and families, have led to the creation of 'new elites' in the villages (Caplan 1995). This, also has historical association with the flow of development assistance, primarily British aid, in the Koshi Hills, such as the Dharan-Dhankuta Road, Pakhribas Agriculture Centre, Koshi Hill Area Rural Development Project, and Nepal UK Community Forestry Project (Nickson 1992). However, recent years have seen a rise in labour migration in the region, most particularly to Gulf countries, and a decline in recruitment into the British and Indian army.

The destinations for labour migrants from Koshi Hills have expanded beyond the Terai and northern Indian states, which were always the main destinations, to the Persian Gulf and South Asia. In 1991, only 2% of the migrants from the Koshi Hills migrated to Persian Gulf, however, by 2001, this figure has skyrocketed to 38% (CBS 1991; CBS 2001). This trend occurred in three of the Koshi Hills districts, except Bhojpur where over 70% continued to go to India. The CIA downstream consultations with the Kumul in Tumlingtar verified this fact, as one of community member stated that some of the young boys in their community have migrated to Arabian countries or Malaysia for foreign employment.

This large scale labour migration has led to significant remittance flows back to the Koshi Hills. In 1971, just over NRP 1 million in remittances entered the region; since then, remittances increased steadily, reaching NPR 30 million by 1990 and nearly NPR 80 million by 1995. By 2005, the total value of remittances back to the Koshi Hills had surpassed NPR 1 billion, having increased more than 10-fold in just a decade.

The people that out-migrated were generally considered very poor, having fewer livelihood resources. Gulf countries such as Saudi Arabia, Qatar, United Arab Emirates, and Malaysia are the major destinations for foreign employment. Engagement in the Indian and British Army and Singapore Police are popular especially among the aadibasi/janajati groups (particularly Rai and Limbu) in these districts. The income derived from the salary and pension from the armed forces plays a significant role in the local economy of these districts (KEL SA 2011).

Table 7.18: District Population in 1991, 2001, and 2011

District	Area (km^2)	Population (persons)			Population Density (person per km^2)		
		1991	2001	2011	1991	2001	2011
Sankhuwasabha	3,480	141,903	159,203	158,742	40.8	46.0	46.0
Bhojpur	1,507	198,784	203,018	182,459	131.9	135.0	121.0
Dhankuta	891	146,386	166,479	163,412	164.3	187.0	183.0

Source: CBS

7.6.4 Commerce and Industry

Off-farm Income Sources

Agriculture is, and has long been, the primary source of livelihood and income for households in the Arun Basin (see **Section 5.3.3**). However, there has been a changing trend in the last decades as off-farm (e.g., services, businesses, industries) earnings have gained importance in the region. The sources of this growth in non-agricultural gross domestic product (GDP) are associated both with private enterprise and the public sector, as well as development program growth. The trade and service sectors in the Koshi Hills have also increased at an annual rate of 3.9% from 1971 to 2010. Moreover, trades and services, as a percentage of total GDP, have risen from 22.6% in 1971 to 29.8% in 2010.

There has also been a significant increase in the number of cottage industries (economic activities carried out in a person's home) within the Koshi Hills (although the total number remains very low) from a handful in 1975 to over 1,700 by 2011. In 1975, families were only selling or bartering surplus products at *hāts* (local makeshift market). This scenario has changed significantly due to the proliferation of cottage and small enterprises and commercialized production. The utilization of family labour has, however, remained dominant. Studies also indicate a gendered dimension to the cottage industries, as production was, and continues to be, generally undertaken by women, the majority of whom are from aadibasi/janajati communities.

The majority of the industries within the Koshi Hills are in textiles (47%), paper products (27%), and food and beverages (20%), with most specializing in products that are chiefly based on local materials, and crops that are indigenous to the districts. For example, tea estates are concentrated in Dhankuta district, namely, Guranse Tea Estate, Kuwapani Tea Plantation, and Narayani Tea Plantation, while the industries in Terhathum are focused on producing dhaka, a traditionally handloom-woven fabric that is distinctive in its pattern and design. In Sankhuwasabha, the industries are based on fabric woven from nettles (allo or *Girardinia diversifolia*) and handmade paper, while those in Bhojpur engage mainly in paper production (CBS 2007).

The Arun-3 Hydropower Project EIA identified off-farm activities in the project area, such as the trading of cardamom, hotel/lodges, trekking, and transportation based services. People also participate in *hāts* for the trading of local produce and other goods for daily needs.

Findings from the CIA downstream consultations with communities in Khandbari Municipality and Shaba Pokheri Rural Municipality were similar. Non-agricultural activities identified by the locals include running hotels, tea stalls, jobs (such as teaching, office assistant), self-employment (driving vehicles and tractors), or migration for foreign employment.

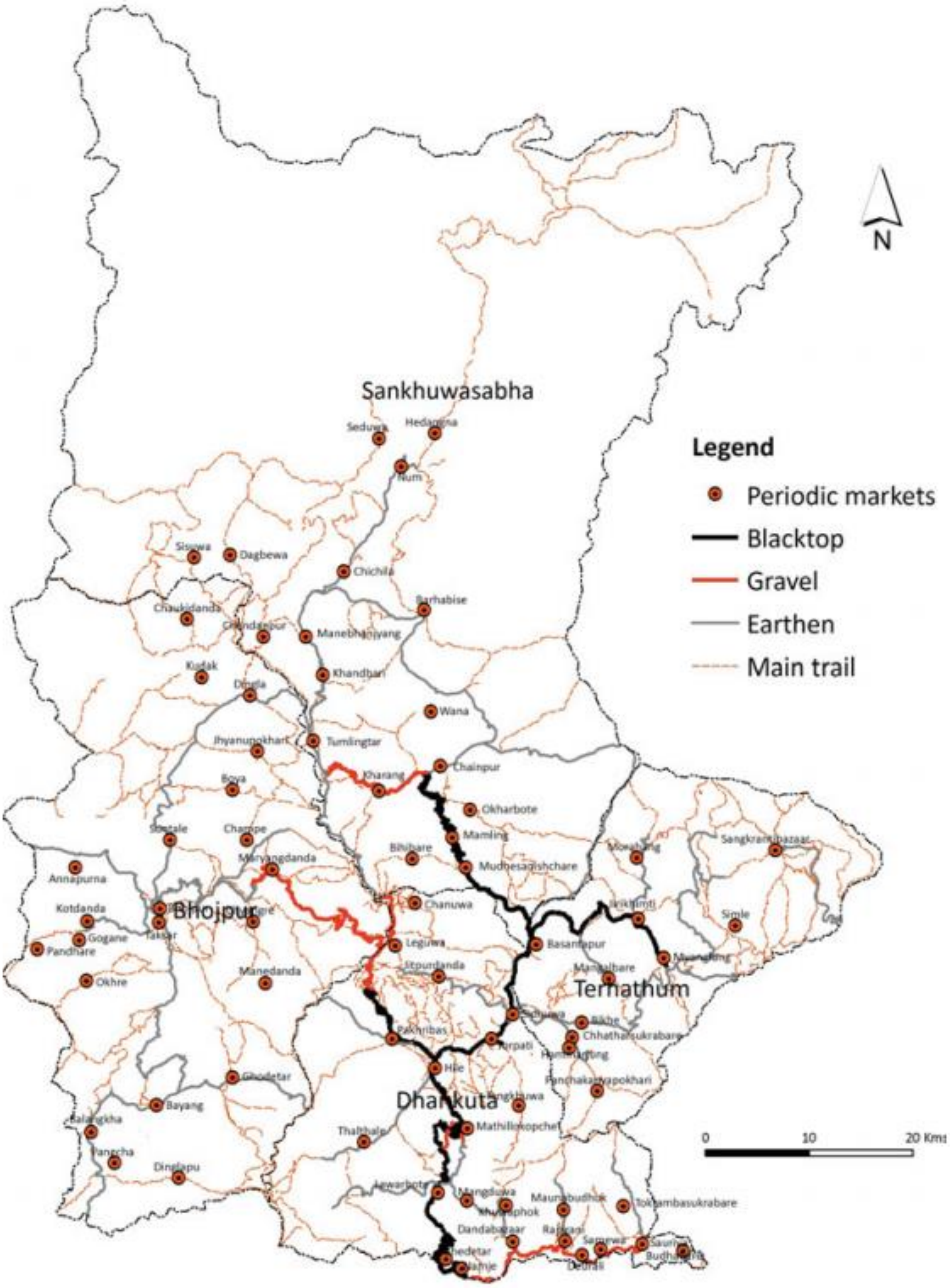
Market Centers

Trading is conducted through two types of markets in the Koshi Hills: (i) permanent market centers; and (ii) local bazars known as *hāts.* There are permanent market centres with various hierarchical levels, ranging from district headquarters to small centres in the Arun River Basin, of which most are connected by roads. *Hāt*s are crucial markets for rural villages, which are open all days of the week, selling local products as well as imported goods. *Hāts* are by far the most important markets in terms of volume of trade. The distribution of *hāts* exhibits a spatio-temporal pattern: they are held at different places, as well as on different days of the week. There are 66 *hāts* across the Koshi Hills, approximately 1 *hāt* for every 100 km^2 (***Figure 7.12***). This density is changing due to improvements in roads and transport, the commercialization of agricultural production, and increases in population density (Pradhan and Sharma 2017).

7.6.5 Land and Housing

In the Koshi Hills (Sankhuwasabha, Bhojpur, Dhankuta and Terhathum districts), approximately 88% of the residents live in housing that they own, 8% live in rented accommodation, 3% live in “other” housing, and 1% live in institutional housing (CBS 2011). There has been an increase in the number of people residing in relatively “better housing” in the last two decades. More people are residing in *pakki* houses (permanent house), although over half of the population continued to live in semi-*pakki* houses (semi-permanent house with walls or roofs constructed using permanent materials), and just fewer than 50% live in poor quality *kachchi* housing (built with temporary materials such as wooden flakes, mud, straw, unbaked bricks, or bamboo).

Figure 7.12: Market Centres in the Arun River Basin



Source: Pradhan and Sharma 2017

7.6.6 Public Infrastructure

Roads

As discussed in **Section 5.3.2**, there are over 934 km of built roads in the Koshi Hills, which have influenced settlement patterns within the Arun River Basin. Improved road connectivity is facilitating trade in *hāts* and local permanent market centres. Highways have also opened up links for local produce to be traded in larger cities of Dharan and Biratnagar in the Terai, as well as with other places across the country, and also with India. There has been an increase in commercial agriculture and along the roadsides.

Electricity

Although the number of households with access to grid electricity in the Koshi Hills is increasing (from 39% of households in 2001 to 53% in 2011), it is still much lower than the national average of 67% (NPC and DFID 2013). There are small micro hydropower projects within the Project footprint. Electricity is sourced from the micro-hydro projects in Sibrung, Namase, Hema, Rukma, and Chepuwa, among others. These plants require regular maintenance and, thus, the use of solar home systems is also prevalent in the region an alternative source. In areas where there are no such micro-hydro plants, the use of solar is more prevalent. The major cooking fuel source is fuelwood, with 92.7% of households depending on it (CBS 2011).

In the Koshi region, there has been very little hydropower energy development over the last decades. The currently under-construction Arun-3 HEP was proposed in the 1990s. The project stalled due to controversy regarding its environmental sustainability and economic viability, as well as equitable benefit sharing of the local people. As of today, the four districts in the Koshi Hills only have a few small scale and micro hydropower projects, which together provide energy to only a small proportion of the population. The available electricity derives from the national grid and is generated elsewhere, and it is largely confined to towns and larger settlement (NPC and DFID 2013).

Water Supply

In the Koshi Hills, about 72% of the households have access to tap and piped water. However, important regional variations were detected: tap/piped water was available to over 80% of the population in Dhankuta, but only about 67% of those in Sankhuwasabha and Bhojpur (CBS 2011). The sanitation conditions have also improved considerably in the Koshi Hills, with Sankhuwasabha and Dhankuta having approximately 77% of households with toilets, and Bhojpur with only 63% (CBS 2011).

Health Facilities

Health facilities in the Koshi Hills include hospitals, primary health care centers, health posts, and sub-health posts. In 2004, the life expectancy of Koshi Hills residents was 65, showing an improvement from 63 in 1998. Despite a higher average life expectancy compared to the national average (55 years), health services are considered poor in the Koshi Hills, due to the limited number of health personnel and lack of convenient access to healthcare facilities (Pradhan and Sharma 2017).

7.6.7 Local Governance

Through the Constitution of Nepal (2015), Nepal restructured its governance system into three levels of government: national, provincial, and local. The local government comprises municipalities and rural municipalities. In Sankhuwasabha District, there are 10 municipalities/rural municipalities and 76 wards, out of which 5 are rural municipalities (*gaunpalika*) and 5 are municipalities (*nagarpalika*).[18] The ward is the lowest administrative unit. Khandbari is Sankhuwasabha District's headquarters and Hatiya is Bhotkhola Rural Municipality's headquarters. DCCs coordinate between the federal government offices, provincial government offices, village bodies, and municipalities/rural municipalities within a district;

[18] https://cbs.gov.np/wp-content/upLoads/2018/12/Population_Ward_Level_753_Local_Unit.pdf

monitor development and construction work; manage natural disaster resilience; and issue working procedures, directives, and standards within their jurisdiction.

The Constitution underpins the Government's vision of protecting, promoting and using water resources effectively. Water resources management and conservation are the jurisdiction of national government as well as provincial governments. Watershed management, drinking water, and small hydro projects fall within the purview of local governments.

In addition, there are a number of donor and multi-lateral agencies. Furthermore, each district has a chamber of commerce and industry (CCI) that looks after business and industrial activities. Most of the NGOs are working in forestry, drinking water and sanitation, women's empowerment, and savings, credit, and group mobilization. The NGOs working in these sectors have received support from different national, foreign, and international agencies. Many decades ago user groups existed, which played a role in local development in the Koshi Hills (Pradhan and Sharma 2017).

7.7 VEC: Social Cohesion

The World Bank defines social cohesion "as the glue that bonds society together, promoting harmony, a sense of community, and a degree of commitment to promoting the common good. Beyond the social relations that bridge ethnic and religious groups, vertical linkages in which state and market institutions interact with communities and peoples can further cement the cohesiveness of a society if they are inclusive, transparent, and accountable" (Colletta *et al.* 2001). As such, this VEC considers social capital, social inclusion (vulnerable groups, indigenous communities and women), sense of place, and cultural practices within the Nepal portion of the Arun River Basin, which are discussed below.

7.7.1 Social Capital

Social capital is understood as "the goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action" (McDougall and Banjade 2015). Given the limited size of the villages, with approximately 20–30 households within each village, community dependency is high and, thus, social capital plays a significant role. Through consultations, several incidences of close community networks and interdependence were observed. As an example, when there is a death in a family, the entire village participates in the final ritual. During the harvest season, communities take turns to help each other with the fieldwork. Borrowing from close relatives and neighbors is one of the common ways of borrowing within these villages.

7.7.2 Sense of Place and Cultural Practices

The natural environment is of significant cultural and spiritual importance to inhabitants of the Arun River Basin. Forests and rivers are of particular importance to many indigenous communities in the basin. Several communities (including Limbu, Magar, Gurung, Sherpa, and Rai) perform spiritual rituals along the Arun River and its tributaries, according to the CIA consultations. The Deputy Mayor of Khandbari Urban Municipality identified that different communities perform rituals by the river and in the forests, mostly on the banks of Sabha Khola and Hewa Khola, and in Banduke, Maanebhanjyang, and Mankamana Rivers. Community people from any caste and ethnicity make offerings to the gods during, Naya Puja, Jangali Puja and Udhauali/Ubhauli (local festival), which are performed on the banks of rivers or near their own houses. For instances, the Kumal, Rai, and Majhi used fish to offer/worship God during Kul Puja (a yearly ritual specific to their community). Religious activities and festival celebrations often take place at the confluence of Shaba Khola and Arun River, as well as at the confluence with the Barun River at Maghi Mela in Triveni.

According to the CIA consultations, cremations are performed at many locations along the banks of the Barun, Sabha, and Arun rivers by different communities, including the Kumal, Majhi, and Rai – for example, at the confluence of the Barun and Upper Arun rivers, in Triveni (confluence of Sabha and Arun rivers), and near the Manakamana Temple on the bank of the Arun River in Tumlingtar. The Rai community have burial grounds in the hills.

Moreover, a number of shrines, temples, and sacred places, which are common to all of the religions and various ethnic groups, are situated along the riverbanks. The most important is Manakamana Mai, on the left bank of the Arun immediately north of Tumlingtar. Every year during the winter month of Magh (Jan-Feb), local people and others from surrounding districts, gather here to worship and participate in the Mela, which is a continuation of the larger annual Barun Mela held upstream at the Barun/Arun confluence.[19]

In addition, these communities usually have cultural and traditional practices that are both related and non-related to their religions. According to the UAHEP ESIA social baseline survey, the main cultural practices of the Rai ethnic group include traditional singing, wood craft, sewing, and the use of *dhami* and *jhakri* (religious doctors). The Rai also celebrate the festivals of Dashain, Tihar, and Losar. The Gurung ethnic group's main cultural practices include traditional songs and dancing, wood craft, sewing, and carpet making. Other customary and religious traditions practiced by Gurung include Bhumi Puja, Dashain, and Tihar.

Detailed information about the tangible and intangible cultural heritage of ethnic groups in the Arun River Basin, particularly in the UAHEP Project affected area, can be found in Section of the UAHEP EIA.

7.7.3 Social Inclusion

Ensuring the inclusion of communities from different ethnic backgrounds, genders, and vulnerable groups (both social and economic), as well as indigenous communities, is a critical element of social cohesion.

Vulnerable Groups

Vulnerable groups are defined as disadvantaged people who are marginalized socially, economically, or politically. This section provides an overview of the vulnerable groups in the Arun River Basin (Dalits, women, and indigenous peoples).

Dalits

The National Dalit Commission in Nepal defines Dalits as "those communities who, by virtue of atrocities of caste-based discrimination and untouchability, are most backward in social, economic, educational, political and religious fields, and deprived of human dignity and social justice" (NDC 2008). The Dalit community faces daily discrimination, with Action Aid Nepal estimating that Dalits face 205 forms of discriminatory practices in their daily lives (KAHEP SA). These range from the denial of access to public places, such as drinking water from public wells and entering sacred religious sites, to exclusion from participating in democratic processes and leadership positions in organizations. While discrimination and the untouchability system was abolished by the Constitution of 1963, and caste-based discrimination was outlawed by the Caste Based Discrimination and Untouchability Act in 2011, implementation, especially in rural and remote areas, continues to be a challenge.[20] While communities are not vocal about such discrimination, it was clearly evident in interactions with the communities across several instances. One such example emerged from a consultation with the Dalit community in Sibrung, where the consultation had to be conducted outside the residence, as Dalits were not allowed inside.

Different development indicators show that Dalits are still lagging behind compared to other communities in Nepal. While poverty has decreased among the Dalit population, the poverty rate is still 41%, against the national average of 25%. The literacy rate of Dalits is 34%, in contrast to the national average of 54%. Their life expectancy is 50.8 years, whereas the national average is 59 years. This

[19] https://www.eia.nl/docs/mer/diversen/pos_010-03_nepal_arun_iii_hydroelectric_project_environmental_assessment_summary.pdf

[20] https://idsn.org/wp-content/uploads/2018/07/CERD-Nepal-2018-alternative-report-Dalit-situation-.pdf

gap has widened in 2011, compared to the 2001 census. The under-five mortality rate for Dalits is 90 per thousand, which is 32% higher than the national average of 68 per thousand.[21]

The Dalit population in Nepal is estimated at 13–14%, based on the 2011 census, although some Dalit groups have estimated this number to be as high as 20–25%, taking into account that some Dalits may be reluctant to identify themselves as Dalits for fear of persecution (IDSN 2008). While there have been several methods to group Dalits, the National Dalit Commission has listed 671 Dalit surnames belonging to 21 distinct Dalit sub-castes.

Within the Arun River Basin Districts, Dalit groups make up approximately 10% of the total population (***Table 7.19***). Their primary sources of livelihood are wage labour work and some crafts and artisanal work. While they practice similar religious observances as other Hindu groups, these are held in separate areas. Additionally, unlike other ethnic groups, such as the Limbu and Rai, no natural resources are specifically associated with Dalit communities (Kabeli Corridor Project Social Impact and Management Report). Dalit land holdings are typically small and landlessness among Dalits is extreme. The Arun-3 HEP Resettlement Action Plan indicates that Dalits own less than 0.5% of the land holdings in the project area.

Compared with other vulnerable groups (indigenous people and women), Dalits are considered to be the most marginalized group in the area. This is due in part to low literacy, landlessness, and historical caste-discrimination (untouchability).

Women

The marginalization and vulnerability of women and girls is deeply engrained in traditional caste society. Women in Nepali society continue to face obstacles to participate in the formal economy and gain political representation. Even as they participate in the labour force, they are often not compensated for the labour they expend in both farm and non-farm activities. Women have less access to public services such as education and sanitation, and are more vulnerable to violence and abuse. While the female literacy rate has increased, it is still behind men (44.5% female literacy rate vs. 71.6% male literacy).

Women account for approximately 53% of the population in all of the Arun River Basin districts. Women-headed households[22] account for an average of 28% in the area (which is higher than the national average of 25.73%). Women also play a significant role in the livelihood pursuits of their families. When the primary source of income is not agriculture and livestock – as in the case where there is income from the foreign employment of male family members – they provide secondary sources. Women pursue various forms of livelihood, such as daily wage labour, fishing, cattle rearing, government service, small businesses (e.g., shops, tea stalls, and eateries), tea plantation work, other cash cropping, and making/selling handicrafts made from bamboo. Women are also engaged in making dried fish and selling them in the local markets and collecting wild vegetables, wild fruits, and herbs for livelihoods. This was confirmed by the CIA consultations.

The prevalence of traditional gender roles was observed during consultations with the communities in Barhabishe Bazar, Boharatar, and Kumal Gaun. For example, fishing is considered a traditionally male profession, in which women do not partake. The Deputy Mayor of Khandbari Urban Municipality strengthened the fact that Nepal remains a male-dominated society by explaining that women's opinions and experiences are not valued in the households nor in the workplace. Gender roles were found to be similar across different ethnic communities where women are primarily engaged in household work and agriculture, and men are engaged in daily wage work and salaried jobs as well as agriculture. Moreover, girls are also reported to fall victim to gender-based violence (GBV) and victimizing by their own family members. Despite this, consultation with police officials in Hatiya suggests that the reporting of gender-based violence is low among communities, undermining the significance of the issue.

Dalit women are also especially vulnerable and prone to social marginalization. Nepali law prohibits marriage before the 20 years of age, and arranged marriage is practiced among different ethnicities

[21] https://pdfs.semanticscholar.org/218f/61b06cec01333744bd4b4a312ea8121a86d9.pdf

[22] A women/female-headed household is a household in which an adult female is the sole or main income provider.

and communities. Arranged child marriage, which expose young girls and women to abuse, is still common among Dalit communities. Dalit women commonly experience reproductive health issues, such as prolapsed uterus, a result of young childbearing and poor nutrition. Consultations in Gadi suggest that labor influx may increase the incidence of GBV if not managed properly. There were reports of road contractors (from outside of the rural municipality/districts) marrying women from the local communities, suggesting that such cases may result in trafficking in persons (TIP) cases if not monitored carefully.

In addition, verbal abuse by contractors, including eve-teasing,[23] was reported in the open bathing areas near the road construction sites. A contractor management plan designed to minimize such impacts will need to be implemented.

Indigenous People (Aadibasi/Janajatis)

There are 22 indigenous peoples (aadibasi/janajatis) groups present in the districts in the Arun River Basin, according to the 2011 Census (CBS 2011). These include 9 "highly marginalized", 11 "marginalized", 1 "endangered", and 1 "advantaged" groups, according to NEFIN's aadibasi/janajati classification (***Table 7.19***). The classification is based on development indicators including literacy and education, income, wealth, land holding and other assets.[24]

Table 7.19: Populations of Vulnerable Group in the Arun River Basin, by District

Category	Classification	Sankhuwasabha (%)	Bhojpur (%)	Dhankuta (%)
Dalit	Highly marginalized	10.34	9.86	7.40
Women				
Women population (% of total population)		65.52	52.84	53.18
Dalit women (% of total Dalit population)		5.61	5.33	3.96
Indigenous women (% of total indigenous population)		43.45	33.17	34.86
Indigenous people (Aadibasi/Janajati) Groups				
Rai	Marginalized	19.54	54.21	32.96
Tamang	Marginalized	19.13	16.02	10.79
Sherpa	Marginalized	10.68	2.81	0.44
Limbu	Marginalized	10.02	0.21	21.86
Gurung	Marginalized	9.95	0.80	1.23
Newar	Advanced	8.70	13.63	7.83
Yakkha	Marginalized	8.30	0.23	5.10
Magar	Marginalized	6.12	7.98	16.30
Bhote	Highly marginalized	4.03	-	0.05
Kumal	Marginalized	1.03	0.27	0.03
Lhomi	Highly marginalized	1.00	0.02	-
Bhujel	Marginalized	0.98	2.94	1.97
Majhi	Highly marginalized	0.19	0.32	0.96
Tharu	Marginalized	0.12	0.14	0.32
Topkegola	Highly marginalized	0.08	-	-

[23] Eve-teasing refers to physical contact or harassment by a man to a woman in a public place.

[24] https://www.ifad.org/documents/38714170/40224860/nepal_ctn.pdf/63df5831-28f8-4d0c-8338-ac2062c7fa24

Category	Classification	Sankhuwasabha (%)	Bhojpur (%)	Dhankuta (%)
Sunuwar	Marginalized	0.06	0.21	0.09
Bote	Highly marginalized	0.04	-	0.01
Dhanuk	Highly marginalized	0.02	0.01	0.04
Danuwar	Highly marginalized	0.01	-	-
Hayu	Endangered	-	0.01	-
Thami	Highly marginalized	-	0.18	-
Dhimal	Highly marginalized	-	-	0.02
Total indigenous population (% of total population)		86,639 **(68.13%)**	107,612 **(58.98%)**	97,448 **(59.63%)**
Total population		127,461	182,459	163,412 7

Source: Census (CBS 2011)

8. CUMULATIVE IMPACT ASSESSMENT

The focus of this cumulative impact assessment is to predict to what extent HEPs may contribute, in combination with the other proposed projects and activities selected for this assessment, to cumulative impacts on the selected VECs.

The significance of cumulative impacts is considered for each VEC – the significance is not evaluated in terms of the magnitude of change, but in terms of VEC response and the resulting condition and sustainability. The cumulative impact significance definitions used in this CIA are:

- **Negligible** – VEC would not experience noticeable changes
- **Moderate** – VEC would experience noticeable changes, but within natural variations
- **Substantial** – VEC would experience changes beyond natural variation, but within its range of tolerance/resilience
- **High** – VEC would experience changes that would likely exceed its range of tolerance/resilience and the viability of the VEC would be threatened

8.1 Overview of HEP Impacts

There are three primary categories of hydropower operating modes: run-of-river, peaking, and storage. The important distinctions between the three modes are the amount of water stored, outflow, and downstream flow effects, as summarized in ***Table 8.1*.**

Table 8.1: Hydropower Operating Modes

Operating Modes	Relative Reservoir Size	Outflow	Downstream Flow Effects
Run-of-river	Small	Outflow = inflow	Negligible
Peaking run-of-river	Medium	Large daily variation	Potentially major negative
Peaking/Storage	Large	Relatively steady	Positive and negative

Strict run-of-river projects do not regulate a river's flows. Given that these projects do not store water, they are typically considered to have fewer adverse impacts than peaking or diversion RoR projects.

PRoR projects (shown in ***Figure 8.1***) provide daily or weekly regulation of flows by storing water in small reservoirs behind the dam. Water is passed through dam turbines to maximize power generation during times of peak energy demand. As such, peaking projects can result in sudden changes to a river's flow. By releasing large quantities of flows within the span of a few hours, peaking projects create daily fluctuations between flood and drought that can wash away or disrupt fish breeding grounds and aquatic biota. Unexpected dam releases can have detrimental impacts on people living downstream. This is particularly the case when no advance warnings are issued prior to a release.

In a diversion RoR project, a portion of the river is diverted through surface or underground tunnels (penstock) that connect to a downstream powerhouse. A small dam, or weir, is typically constructed to ensure that enough water enters the penstock. Water from the penstock is run through turbines then returned to the river. Long stretches of the river are often dewatered due to these types of projects, turning the river into a series of pools and tunnels throughout the year. River diversions can also result in changes in water temperature, velocity, and depth.

The development of several projects, even strict RoR projects, in a series (or cascade) breaks a river's connectivity. Such cascades can result in impenetrable barriers to migratory fish or block sediment from traveling downstream. The blocking of sediment flow can negatively impact ecosystems and the fertility of downstream floodplains. A schematic of a typical hydropower project and key environmental and social impacts is shown in ***Figure 8.2*.**

Figure 8.1: General Characteristics of Peaking HEPs

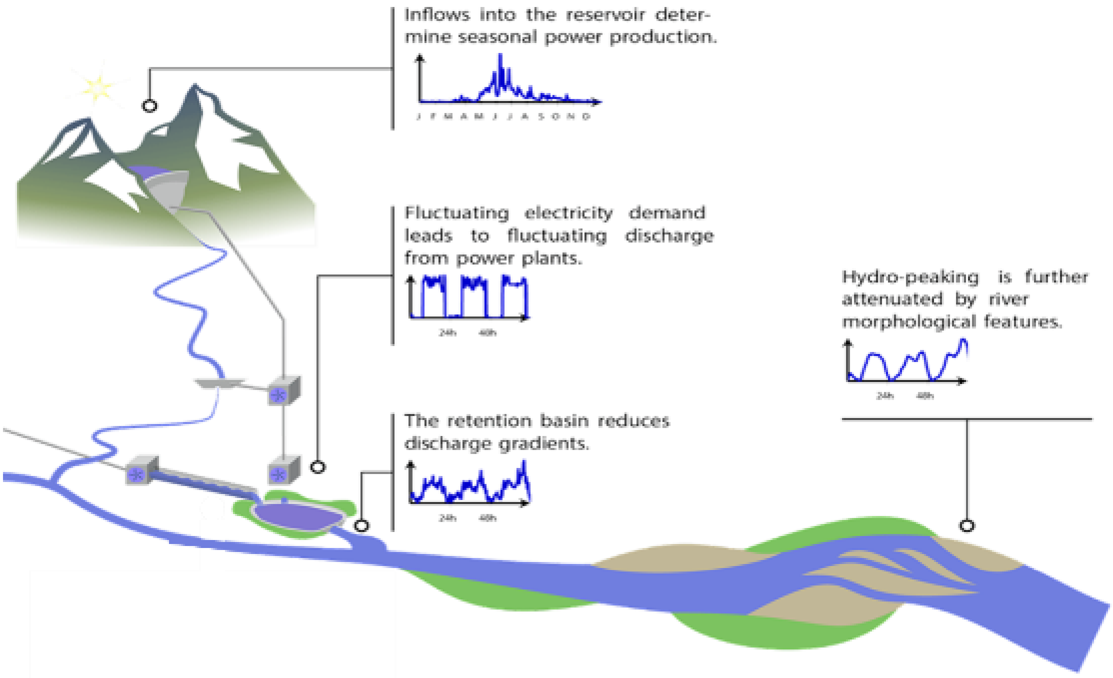
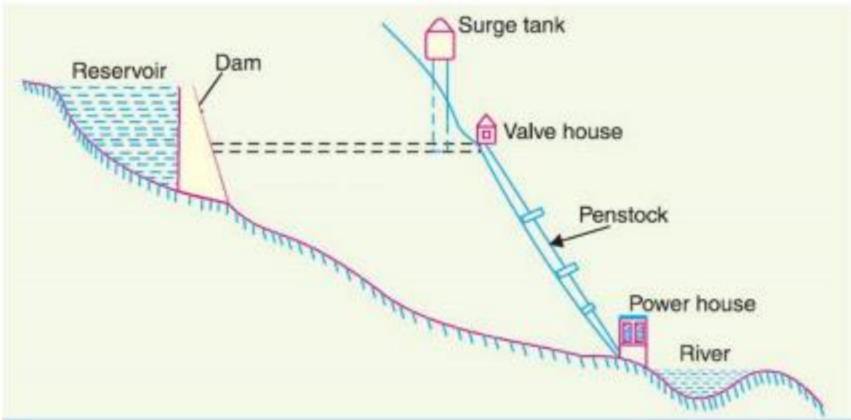


Figure 8.2: Schematic of a Typical HEP and Key Environmental and Social Impacts



- **Reservoir:** typically displaces people, floods forested and agricultural land, converts river to lake habitat
- **Weir/dam:** can block migratory fish and sediment transport
- **Diversion reach:** reduces flows, affects water users/uses, impacts aquatic habitat
- **Powerhouse:** land acquisition, often kills fish that pass through turbines
- **Transmission lines:** land acquisition and risk of bird collisions/electrocution
- **Tailrace** – areas downstream of powerhouse subject to changes in flow if HEP is peaking or peaking ROR

8.2 Cumulative Impacts on VEC: Natural Forest Integrity

Approximately 66% of the Arun Basin is covered by forest land (**Section 7.1.12**) – which is of high importance to maintain ecosystem services and to communities and species and which depend on the natural habitat.

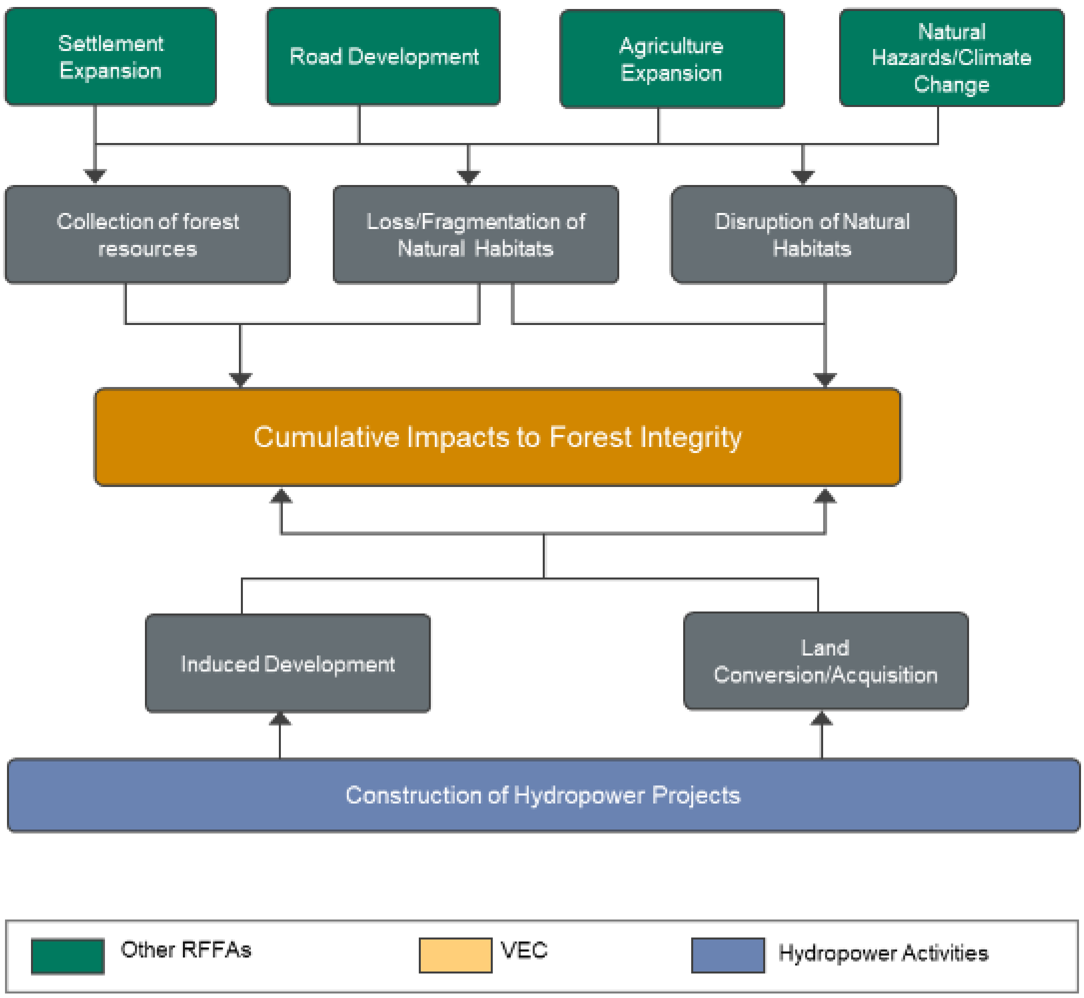
8.2.1 Key Stressors and Impacts

Key stressors that result in forest loss and fragmentation in the Arun River Basin include:

- *Hydropower development:* Conversion of forest land for construction of HEP components and associated facilities
- *Road development:* Conversion of forest land to construct new and expand existing roads and increased access to forests
- *Agriculture and settlement expansion:* Conversion of forest land to develop and expand upon existing agricultural land and settlements. Loss of forest cover will result in increased dependency on the remaining forests for, e.g., NTFPs, building materials, and other ecosystem services.
- *Climate change and natural hazards:* Increased climate related disasters such as landslides and floods in the future

The impact pathway schematic in ***Figure 8.3*** summarizes how the aforementioned stressors, plus other RFFAs, may affect natural forest integrity in the basin.

Figure 8.3: Cumulative Impact Pathway for VEC: Natural Forest Integrity



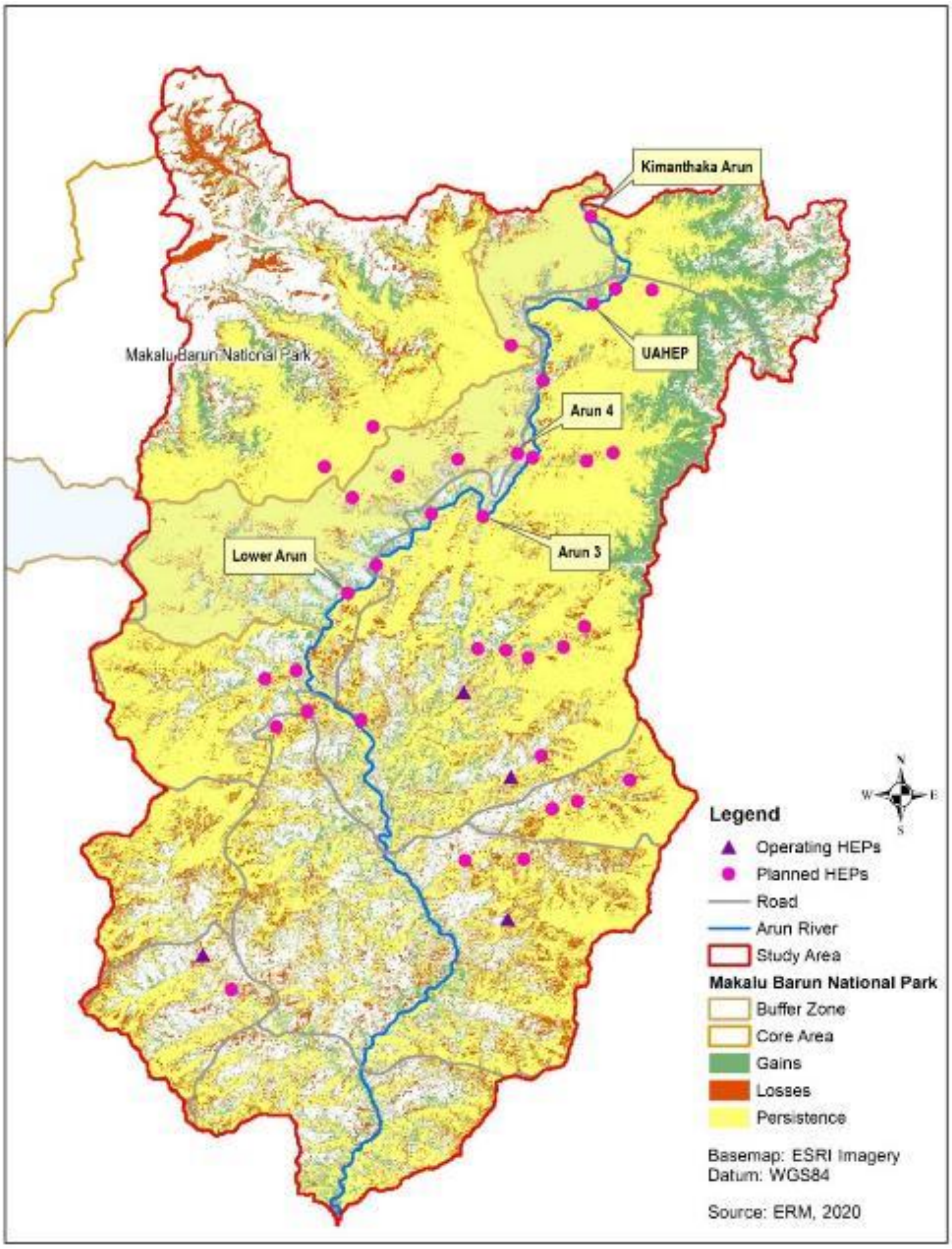
8.2.2 Cumulative Impacts

Historical Forest Gain

According to LULC analysis conducted for this CIA, the forest land in the Arun Basin has marginally increased (0.10%) between 2009 (3,376.23 ha) and 2018 (3,376.62 ha) (***Figure 8.4***). Gains to forest land was observed in the mountainous north-eastern area of the basin adjacent to Taplejung District, whereas the main loss of forest land was in the mountainous north-western area of Sankhuwasabha District (in the MBNP) and in the southern reaches of the Arun Basin.

The conversion of barren land and agricultural land were the main contributors to forest land gains. The increase in forest land is likely primarily due to the forest conversation efforts of community forestry, leasehold forestry, and private forestry programs over barren land and grassland/shrubland.

Figure 8.4: Gains and Losses to Forest Land between 2009 and 2018



Future Forest Loss

Forest clearance for the construction of RoR projects is relatively small, compared to projects with larger physical footprints (such as those with large dams and reservoirs). For example, the 1,040 MW UAHEP, 473 MW Arun-4 HEP and 40 MW IKHPP would result in forest clearance of approximately 153,258 ha and 11 ha, respectively.

In addition to the hydropower components, forest clearance is typically required for associated transmission lines and access roads. In the case of the UAHEP, less than 6 km of transmission lines would be needed to connect the project to the Arun Hub. In comparison, 310 km of transmission lines (400 kV double-circuit) to connect Arun-3 HEP to the Muzaffarpur substation in India. Of the total length of 310 km, 26 km of the line is situated in the Arun Basin – which results in approximately 97 ha of forest clearance.

Of all the identified future developments in the Arun Basin, the most significant forest clearance would result from the construction of the Sapta Koshi Project. The Sapta Koshi Project would inundate approximately 4,618 ha of forest land across Bhojpur, Dhankuta, and Sankhuwasabha districts – representing approximately 1.4% of the total forested area of the Arun Basin. Moreover, according to Rai and Linkha (2020), the high-dammed reservoir over the steep and rugged topography would pose risks of landslide and erosion, which could further exacerbate forest loss in the area.

For road developments, the direct impact area comprises a typical 30 m RoW. As such, the direct impact of the 120 km North-South Koshi Highway RoW comprises 92 ha of forest land. Of the 120 km route, 108 km is situated in the MBNP (**Section 8.3.2**). Moreover, about 24 km of new roads would be needed for each of the planned HEPs on the Arun River to enable access to the projects from existing roads – which would result in an approximately 72 ha RoW (based on a 30 m RoW) per HEP.

In addition to direct land take, HEPs, transmission lines and access roads result in habitat fragmentation. Such fragmentation can negatively impact fauna and flora populations and often exacerbates existing ecological impacts. Edge effects also occur when two dissimilar areas or habitat types are temporarily or permanently located immediately adjacent to one another. This phenomenon commonly occurs in cleared areas adjacent to natural habitats, where changed moisture differentials can cause impacts such as increased predator and hunter access, microclimate changes, and increased erosion. Similar edge effects can also occur adjacent to reservoirs where standing water environments occur adjacent to forested habitats. This can lead to temporary inundation and drying out of the lake shores, impacting vegetation distribution and abundance.

Natural habitat adjacent to infrastructure, including access roads and transmission lines, will likely be exposed to edge effects during construction and continue into operation. Edge effects will occur along reservoir margins during operation, caused by submersion and temporary emergence and drying, as a result of water releases to meet power generation requirements. This is likely to lead to a bare, un-vegetated reservoir margin area between short- and longer-term high and low water levels.

Climate change further exacerbates the aforementioned impacts on forested areas, as the high likelihood of stronger monsoons will increase the risk and impact of monsoon related disasters such as landslides and floods in the future (Bharati 2019).

Shown in ***Table 8.2*** are land clearance approximations per type of development in the Arun River Basin. The following RoW assumptions have been applied: 46 m for 400 kV transmission lines, 34 m for 220 kV transmissions lines, 30 m for access roads, and 50 m for the Num-Kimathanka Road. As land clearance details (e.g., size and land type) are not currently available for all of the planned hydropower developments, certain assumptions were applied: i.e., for Arun-4 and Lower Arun HEPs – 0.55 ha of forest clearance per MW has been assumed, and for Kimathanka Arun HEP a 24 km access road has been assumed.

Table 8.2: Forest Land Clearance per Development in the Arun Basin

Development	Land Required per Development in the Arun Basin (ha)			
	HEP Components	Transmission Lines RoW	Roads RoW	Total
Hydropower projects in Arun Basin (under-construction and planned)				
Kimathanka Arun	490	67	50**	607
UAHEP	153	20	30	203
Arun-4	258*	49	49	356
Arun-3	94	97	56	247
Lower Arun	257*	11	50	318
IKHPP	11	3	17	31
Sub-total	**1,263**	**247**	**252**	**1,762**
Sapta Koshi Project	4,618	Not available	Not available	4,618
Num-Kimathanka Road (North-South Highway)			92	92
Total estimated forest clearance	5,881	247	344	6,472
% of total forest area in the Arun Basin	1.8%	0.1%	0.1%	1.7%

Notes: * Assumed 0.55 ha of forest clearance per MW; ** Assumed 24 km access road

Source: ERM 2019

8.2.3 Summary of Cumulative Impacts

Cumulatively, the impacts of the planned HEPs, road developments, transmission lines, and other anthropogenic activities within the next 10 years on forest loss and fragmentation in the middle Arun Basin are considered to be of **Moderate Significance**. A road network already exists in this area and forest cover has remained fairly consistent between 2009 and 2018. However, there are a number of planned HEPs that would result in forest loss and fragmentation, particularly for the construction of access roads and transmission lines.

Due to the high number of planned large HEPs and the development of the Num-Kimathanka Road, the cumulative impacts on forest loss and fragmentation in the upper Arun Basin are of **High Significance**. The cumulative impacts on the MBNP, which is situated in the northwest of the Arun Bain and covering approximately 45% of the Basin, is examined separately in **Section 8.4**.

The cumulative impacts on forest loss and fragmentation in the lower Arun Basin are of **High Significance**. The most significant impact would be from the Sapta Koshi Project, which would inundate 4,618 ha of forest land near the lower Arun River.

8.3 Cumulative Impacts on VEC: Makalu Barun National Park

As discussed in **Section 7.2**, the MBNP is a nationally and internationally recognized protected area classified as an IBA. In addition to being a key biodiversity area, local households greatly depend upon the diverse national resources within the park's Buffer Zone to maintain livelihoods and household sustenance.

8.3.1 Key Stressors and Impacts

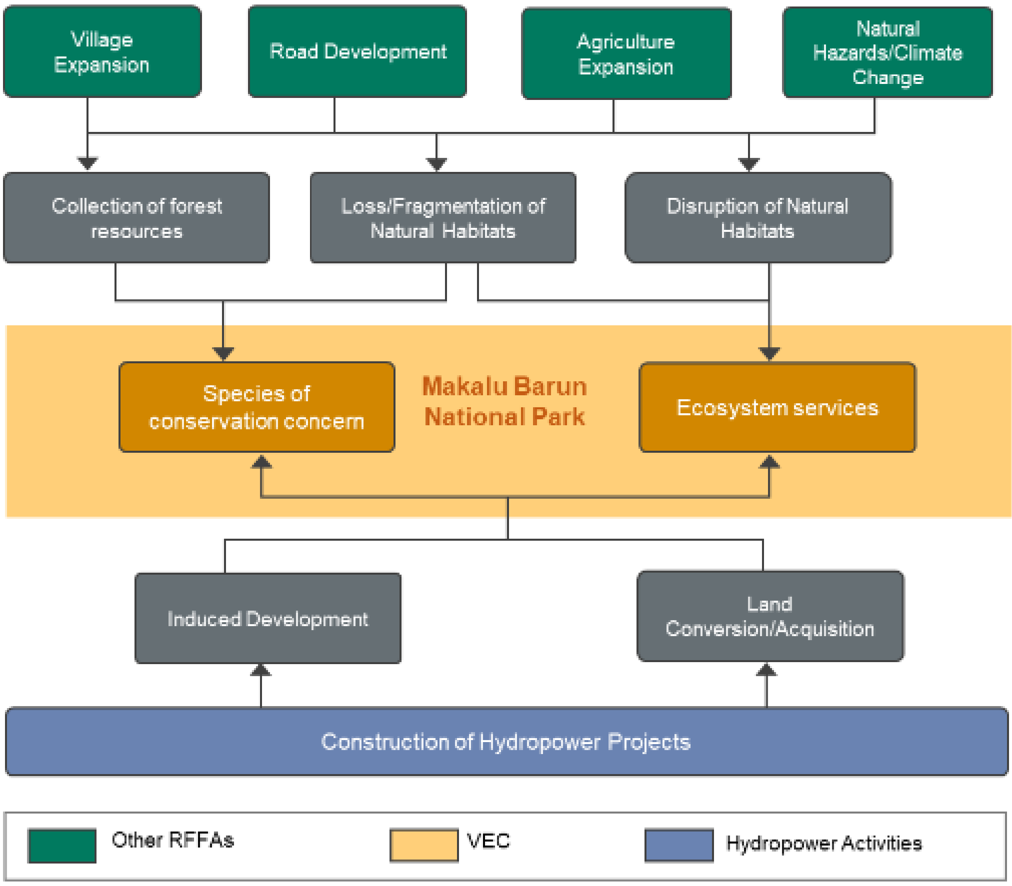
Key stressors and impacts on the MBNP include:

- *Hydropower developments*: Loss of habitat associated with land clearing for infrastructure development (including habitat inundated by creation of the reservoir following impoundment), disturbance and/or displacement of fauna, barrier creation, fragmentation and edge effects, habitat degradation, transmission strikes and other mortality events

- *Forest resource collection and agricultural practices*: There is a high dependency on forest resources from local and slash and burn cultivation and overgrazing further threatens forest land.
- *Road developments*: Increased access will exacerbate pressure on the forest resources, mortality events associated with vehicle strikes, land clearing, and increased hunting and poaching.
- *Climate change and natural hazards*, *particularly GLOFs*: Mortality events and loss of habitat, resulting in impacts on taxa supported by those habitats and associated ecosystem services

The impact pathway schematic in ***Figure 8.5*** summarizes how the aforementioned stressors affect biodiversity and ecosystem services in the MBNP.

Figure 8.5: Cumulative Impact Pathway for VEC: Makalu Barun National Park



Source: ERM 2020

8.3.2 Cumulative Impacts

Hydropower Projects

There are several HEPs planned on the main stem along and tributaries within the MBNP. It is impossible for any hydropower project on the main Upper Arun River to avoid impacting on the MBNP, as the park boundary extends along the centerline of the river from below the Arun-3 HEP, all the way to the border with China.

As summarized in ***Table 8.3***, there are five HEPs planned on the Upper Arun River in the MBNP: Kimathanka Arun, UAHEP, Arun-3, Arun-4, and Lower Arun. These projects will directly impact only on the MBNP Buffer Zone, not the Core Area. On the tributaries within the MBNP Core Area three HEPs are planned: Apsuwa I, Upper Isuwa, and Lower Barun, and six planned HEPs within the MBNP Buffer Zone: Upper Apsuwa, Isuwa, Lower Isuwa, Kasuwa, Upper Sankhuwa Khola, and Sankhuwa Khola.

These hydropower schemes will result in barriers to the movement of fauna species; disturbance to fauna behaviors; habitat degradation, fragmentation, and loss; bird strikes from transmission lines; fauna mortality from vegetation clearing activities; and induced impacts from increased access. The main stem projects on the Upper Arun River (main stem) would result in an estimated 327–490 ha of land conversion in the MBNP Buffer Zone. The tributary projects in the MBNP Core Area would require an estimated 267–397 ha, and the tributary projects in the MBNP Buffer Zone would require an estimated 208–312 ha.

Table 8.3: HEPs planned in the MBNP

Hydropower Project	Upper Arun River in MBNP Buffer Zone	Tributaries in MBNP Core Area	Tributaries in MBNP Buffer Zone
Kimathanka Arun	450 MW PRoR		
UAHEP	1,040 MW PRoR		
Arun-3	900 MW PRoR		
Arun-4	473 MW RoR		
Lower Arun	470 MW PRoR		
Apsuwa I		400 MW	
Upper Isuwa		24.3 MW	
Lower Barun		132 MW	
Upper Apsuwa			24.6 MW
Isuwa			97.3 MW
Lower Isuwa			37.7 MW
Kasuwa			9.2 MW
Upper Sankhuwa Khola			24 MW
Sankhuwa Khola			41.06 MW

Road Developments

Road developments (specifically the Num-Kimathanka Road and access roads to reach the planned HEPs) would result in similar habitat degradation, fragmentation, and loss. New access can also result in indirect impacts such as illegal logging, clearing, hunting, poaching, and collection of animal and plant species, as well as vehicle strikes. A total of 108 km of the Num-Kimathanka Road passes through the MBNP, requiring a 540 ha RoW and a 5,400 ha Zone of Influence. Moreover, the development of roads to access the main stem HEPs would require approximately 32–47 ha of land for the RoWs, and the tributary HEPs access road RoWs would require approximately 190–285 ha.

Electricity Connectivity

To support the planned HEPs on the Upper Arun River a total of approximately 86–130 ha RoW would be required for transmission lines in the MBNP Core Area and 81–122 ha would be required in the MBNP Buffer Zone. In addition to habitat degradation, fragmentation, and loss, transmission line projects would result in an increased frequency of bird-line collisions and electrocution.

The Arun Valley is a well-known migratory route for birds migrating through the Himalayas. The MBNP in this regard could be a significant migration corridor for birds. Large bodied water birds perform north-south migrations and are known to use this corridor. Also, important to note is that many large bodied raptors not only migrate north-south, but also move east-west. Hence, north-south transmission lines could also be a significant threat to these birds.

Other Anthropogenic Activities

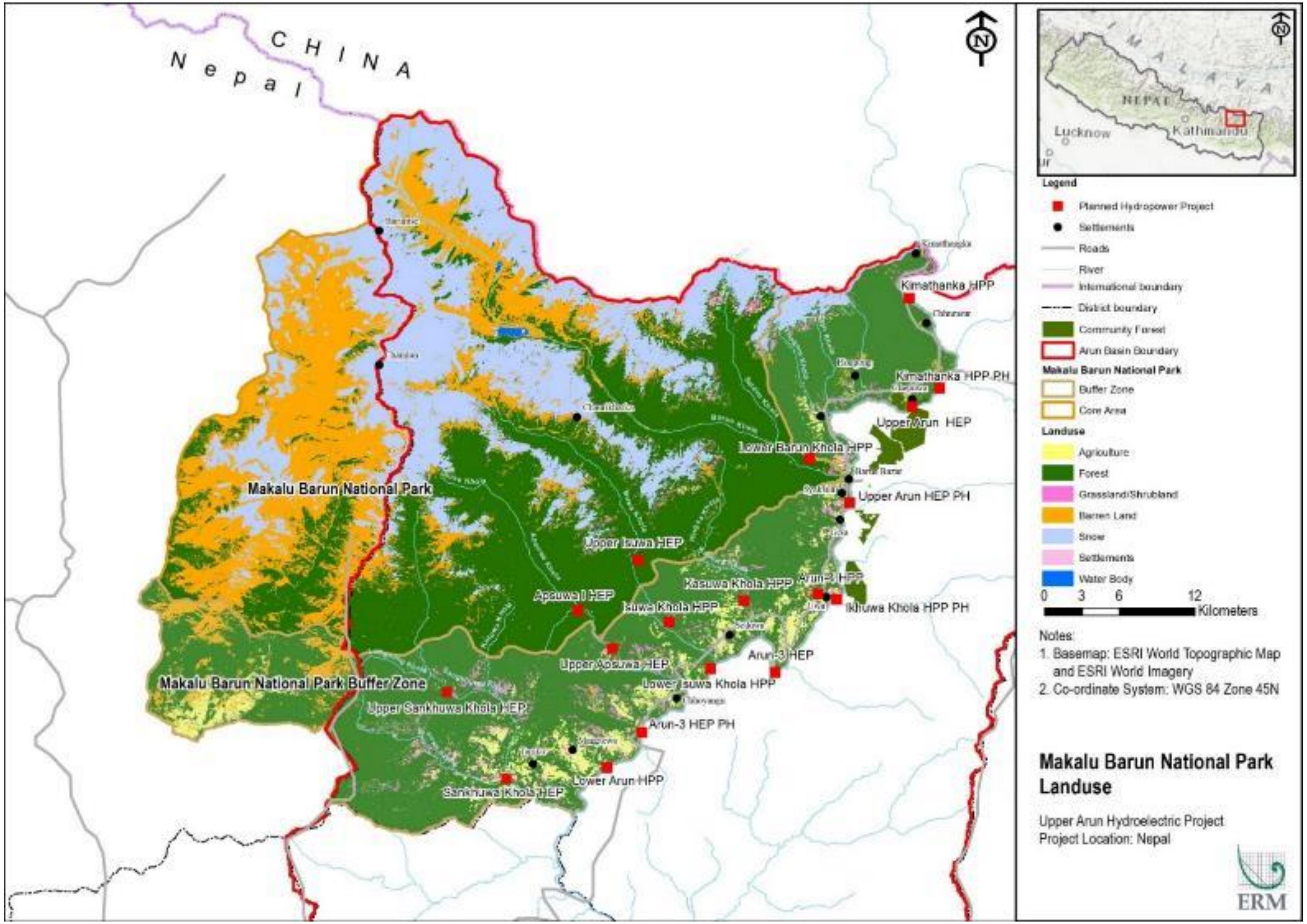
Historically, agricultural practices such as slash and burn cultivation and overgrazing have resulted in significant impacts on natural habitat in the MBNP and its Buffer Zone. Other anthropogenic activities that may have a significant impact on forest land and species of conservation significance include those that would convert or disrupt larger areas of natural habitat to other land uses (e.g., forest encroachment for agricultural land and settlement expansion). As shown in *Figure 8.6***,** there are 13 settlements located in the MBNP Buffer Zone, at which agricultural land has encroached upon forested areas. Such habitat loss and fragmentation poses threats to threatened and endemic species in the basin. Moreover, the collection of forest resources is likely to intensify as population and settlement expansions increase upon opening of the Num-Kimathanka Road and HEP access roads in the study. ***Table 8.4*** summarizes estimated land clearance within the MBNP.

Table 8.4: Estimated Land Clearance in the MBNP

Development	Land Required per Development			
	HEP Components	Transmission Lines RoW	Roads RoW	Total
Hydropower projects and associated facilities – on Upper Arun River in the MBNP Buffer Zone				
Kimathanka Arun UAHEP Arun-4 HEP* Arun-3 Lower Arun HEP*	327–490 ha	28–42 ha	32–47 ha	356–580 ha
Hydropower projects and associated facilities – on tributaries within the MBNP Core Area				
Apsuwa I Upper Isuwa* Lower Barun	265–397 ha	86–130 ha	115–173 ha	466–700 ha
Hydropower projects and associated facilities – on tributaries within the MBNP Buffer Zone				
Upper Apsuwa* Isuwa Khola* Lower Isuwa Khola* Kasuwa Khola* Upper Sankhuwa Khola* Sankhuwa Khola Num-Kimathanka Road	208–312 ha	53–80 ha	75–112 ha	336–504 ha

Total estimated clearance	800–1,200 ha	167–251 ha	762–873 ha	1,729–2,324 ha

Figure 8.6: Developments Planned in the MBNP

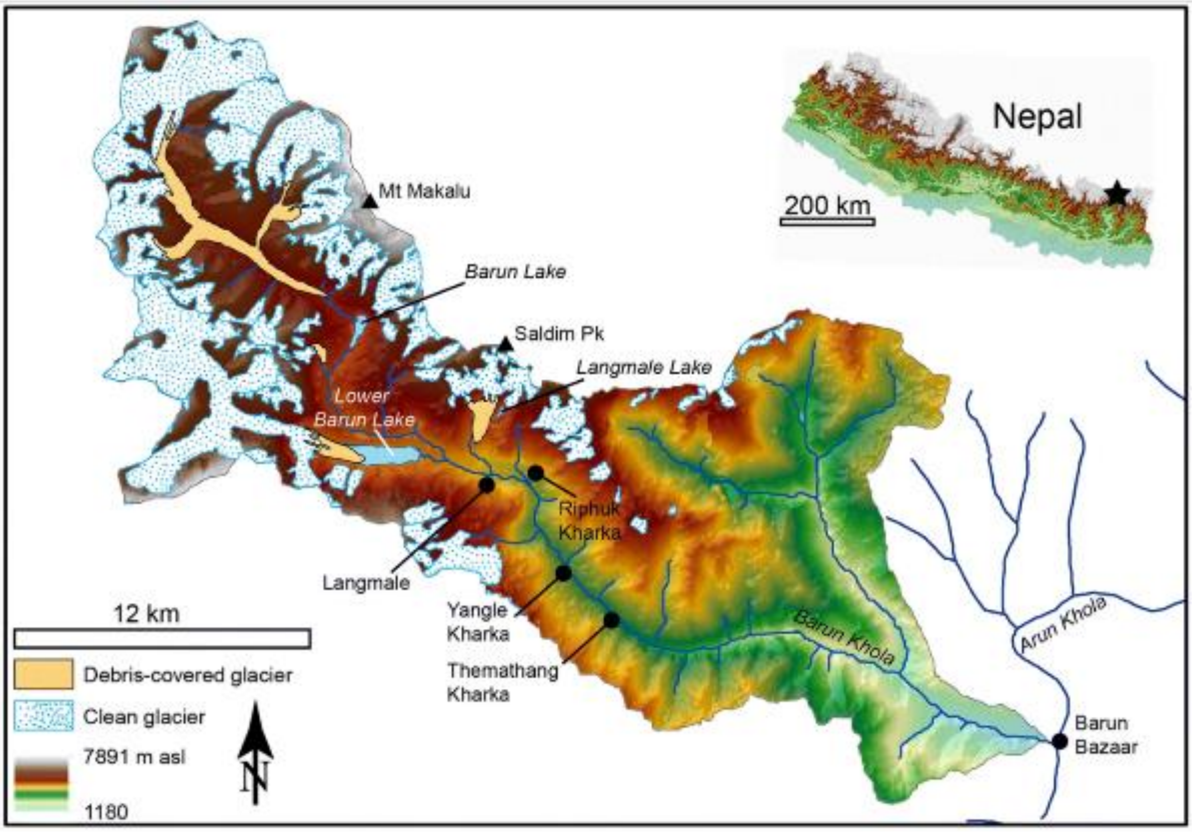


GLOFs

The MBNP is also at risk of climate change associated natural hazards including flooding, GLOF, wildfires, and landslides. GLOF events may increase over the coming years as the trends of temperature and precipitation in the region are predicted to increase in the future. There are three glacial lakes located in the MBNP: Langmale, Barun, and Lower Barun (***Figure 8.7***). As discussed in **Section 5.3.3**, the Langmale is a high volume moraine-dammed lake, which has a high outburst probability.

Should an outburst occur on one of these lakes, UAHEP would likely be impacted, grazing areas (*kharka*) would also be flooded, and bridges, trails and homes would be destroyed – as was the case on April 20, 2017 when a Langmale GLOF impacted 0.76 km^2 of agricultural land, 33 buildings, and four bridges.

Figure 8.7: Glacial Lakes in the MBNP



Source: Byers *et al.* 2019

Ecosystem Services

Traditional and subsistence use of forest resources are allowed in Buffer Zone areas of the MBNP, such as cattle grazing and collecting fuelwood, timber, and non-timber forest products, with the permission of the chief conservation officer of MBNP. As such, in addition to the loss of biodiversity value, developments in the MBNP will result in the loss of aforementioned forest resource use (also referred to as provisioning ecosystem services). Using the total economic value of forest ecosystem services (**Section 7.1.4**), the loss of these resources are estimated at NPR 52–70 million (US$441,000–594,000) per year.

8.3.3 Summary of Cumulative Impacts

Cumulatively, the impacts from the planned HEPs, road developments, transmission lines and other anthropogenic activities within the next 10 years – coupled with an increase in natural hazards such as GLOFs – to the MBNP are considered to be of **High Significance**.

8.4 Cumulative Impacts on VEC: Water Resources

8.4.1 Key Stressors and Impacts

Key stressors and impacts on water quality and flows in the Arun River Basin include:

- *Existing and planned HEPs*: Could result in flow regime changes and unmanaged domestic waste due to the presence of workforce could affect water quality
- *Sand and gravel mining*: Could impact upon water quality from increased turbidity and suspended soils, and oil spills or leakages from the excavation machinery
- *Village and settlement development*: Could negatively impact on water quality from increased litter and surface pollution
- *Road developments*: Could cause erosion and sedimentation, resulting in water quality degradation
- *Forestry and agricultural development*: Could result in land clearance and agricultural runoff
- *Climate change and natural hazards* (e.g., landslides): Could affect water flows

8.4.2 Cumulative Impacts

The Arun River is currently free flowing along its entire length, however, within Nepal, the Arun-3 HEP is under construction, four other main stem dams are proposed along its length, and the Sapta Koshi High Dam multi-purpose project is located downstream, but would flood the lower portion of the Arun River. These projects would substantially transform the Arun River from a natural free flowing river to a series of dams and river sections subject to flooding (reservoir), reduced flows (diversion reaches), or water level fluctuations (as a result of peaking operations at four of the hydropower projects). As **Figure 5.1** indicates, flow in essentially the entire length of the Arun River in Nepal will be affected.

Of the approximately 175 km of river from the border with China to the proposed location of the Sapta Koshi Dam, the entire Arun River within Nepal (and a small portion of the Sapta Koshi River) would be converted as follows:

- Flooded river segment (i.e., reservoir) – ~98 km
- Reduce flow river segment (i.e., diversion reach) – ~73 km
- River segment subject to water level/flow fluctuations (i.e., due to peaking) – ~4 km
- Free-flowing river segment – 0 km

Further, as indicated in ***Table 6.3***, there are several existing and many proposed hydropower projects on tributaries of the Arun River. Most of these are small and true RoR operations. Nevertheless, on a smaller scale, many of the tributaries to the Arun River would also be modified into a series of reservoirs and reduced flow diversion reaches.

The overall cumulative effect of the proposed hydropower projects on natural flow in the Arun River will be of **High Significance**.

These changes in flow conditions will affect the physical characteristics, biological conditions, and social uses of the river. These effects are discussed below.

Physical Characteristics

The effects of hydropower projects on flow can, in turn, affect the physical characteristics of a river, including water quality, geomorphology, and sediment transport.

River Water Quality

In terms of water quality, the major concerns typically relate to temperature, thermal stratification, dissolved oxygen, and the potential for reservoir eutrophication. For the Arun River, these risks are low for the following reasons

- *Reservoir water temperature and potential for stratification* – The proposed main stem dams all have relatively small reservoirs (with the exception of the downstream Sapta Koshi High Dam), which, combined with the river's relatively high flow even during the dry season, results in a very short residence time for all of these reservoirs (maximum worst case residence time of approximately 60 hours during the annual low flow month [January] at the Arun-3 HEP), which poses little risk of reservoir thermal stratification.
- *Dissolved oxygen* – Colder water can absorb more oxygen, and the Arun River's high gradient combines to result in naturally high dissolved oxygen concentrations in the river. Further, the very short residence time for all of these reservoirs results in little risk of low dissolved oxygen conditions.
- *Reservoir eutrophication* – As indicated above, the relatively short residence time in all of the main stem reservoirs, and relatively low nutrient concentrations in the river because of the low population density within the river basin, result in little risk of reservoir stratification or associated eutrophication.

The provision of environmental flows can help to mitigate these impacts to some extent. The overall cumulative effect on river water quality is considered to be of **Moderate Significance**, with the more significant impacts likely occurring in the large Sapta Koshi reservoir.

Geomorphology

Hydropower projects create different geomorphology risks in the reservoir, diversion reach, and reach downstream from peaking powerhouses, as well as for road and transmission line construction.

- *Reservoir area* – Reservoir inundation can destabilize slopes along the reservoir margins, especially for the four main stem hydropower projects that are proposed as having PRoR operations, where reservoir water levels fluctuate by 10 to 15 m. These water level fluctuations can destabilize adjoining slopes and increase the risk of landslides. All of these hydropower projects, but especially the four PRoR projects, should carefully evaluate slope stability along the reservoir margins and, if appropriate, establish maximum drawdown rates to manage slope stability risk.
- *Diversion reach* – In the diversion reach, the reduction in flow for most of the year will likely result in the narrowing of the river channel, as the rivers adjusts to a new flow equilibrium, and woody vegetation will start encroaching on the margins of the channel.
- *Downstream reach* – The reaches downstream from PRoR operation mode powerhouses will be subject to fluctuation in water levels, velocities, and wetted area as the projects alternate between peaking and non-peaking operations. This will reduce the ecological value of the portion of the stream channel that is subject to the alternating wet and dry periods.
- *Road and transmission line construction* – Much of the Nepal portion of the river basin, but especially the portion upstream from Khandbari, has very rugged terrain and steep slopes. The construction of roads and transmission lines can destabilize these slopes across a large area. Appropriate siting of these facilities, prohibiting side casting, and maintaining vegetation within the transmission line RoW can all help to minimize the risk of landslides from these facilities.

The provision of environmental flows can help to mitigate these impacts to some extent. The overall cumulative effect on geomorphology is considered to be of **Moderate Significance**.

Sediment Transport

The Arun River transports a naturally large sediment load, as a result of the glaciers in the river's headwaters. Management of this sediment is critical, both to maintain the life expectancy and sustainability of the hydropower projects, as well as to minimize impacts on stream channel geomorphology and aquatic habitat.

The multiple hydropower projects along the mainstem of the Arun River will affect natural sediment transport, with more coarse sediments settling out in the project reservoirs. Details of the sediment management strategy for several of the proposed mainstem hydropower projects is not available, but the five most upstream mainstem projects all have quite short reservoirs (0.5–5 km in length) and should be able to maintain a relatively natural sediment transport system with monsoon season sediment flushing. The Sapta Koshi HEP would have a much longer reservoir (~70 km), which would likely result in significant sediment deposition and much more significant sediment management challenges.

The overall cumulative impact on sediment transport is considered **Moderate** in the Upper Arun River and **High** in the Lower Arun River.

Biological Conditions

The impacts of changes in hydrological regimes on fish and aquatic habitat are discussed in detail in **Section 8.5.**

Social Uses of the River

At various locations along the Arun River, the river is used for subsistence, recreational, and commercial fishing; irrigation; recreational boating; and cultural practices (e.g., cremations). The river is not used in any meaningful way for water supply or navigation purposes and it is unlikely that the proposed development activities would have any adverse effect on future use of the river for these purposes. The potential cumulative impacts on fishing, irrigation, and recreational boating along the Arun River are discussed in **Section 8.6**.

8.5 Cumulative Impacts on VEC: Fish and Aquatic Habitat

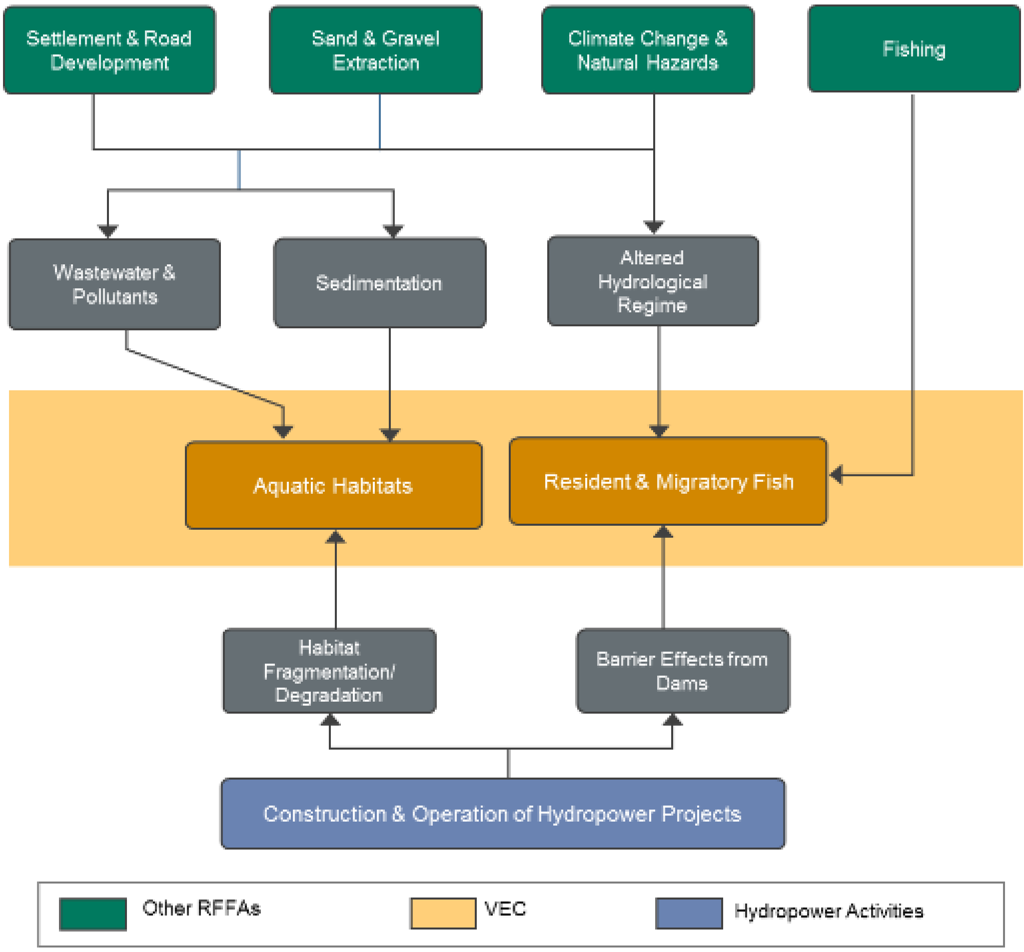
8.5.1 Key Stressors and Impacts

Key stressors and impacts on fish species and habitat in the Arun River Basin include:

- *Hydropower projects*: Could result in altered hydrological regimes, water quality degradation, loss of aquatic habitat from reservoir development and water diversion, and barrier effects
- *Road development*: Could result in soil erosion into rivers, which could then likely result in a significant increase in total dissolved solid levels which degrades aquatic habitats
- *Climate change:* Could lead to changing patterns of rainfall (both higher and lower) within and between seasons, thereby affecting river flow

The impact pathway schematic in ***Figure 8.8*** summarizes how the aforementioned stressors affect aquatic species and habitats in the basin.

Figure 8.8: Cumulative Impact Pathway for VEC: Aquatic Species and Habitat



8.5.2 Cumulative Impacts

Hydropower projects will change several characteristics of aquatic habitats in the basin – including water depth, channel width, flow velocity, substrate/sediment characteristics, and potentially habitat connectivity. Each of these changes will have effects on aquatic community composition and diversity within the basin, as summarized in this section.

Species gradient along a river section is an important issue when assessing the impacts of hydropower projects in Nepal. Usually when moving upstream in a river the number of species decrease as a function of the physical properties of the river. Exact species gradients for the Arun River Basin are currently not available, as such, environmental monitoring connected to Arun-3 and UAHEP show a decreasing species diversity when moving upstream from 700 masl (downstream Arun-3 dam site) and up to 1,600 masl (dam site of UAHEP). Other documents describing the fish biodiversity in Arun show high fish biodiversity in lower parts of the river. Based on this knowledge the species list of 45 species are prepared and seven target species were selected according to the target species criteria: *Anguilla bengalensis* (bam), *Tor putitora* (golden mahseer), *Labeo dero* (gardi), *Neolissochilus hexagonolepis* (katle), *Glyptosternum blythi* (telkabre), *Schizothorax richardsonii* (asala) and *Psilorhynchoides pseudecheneis* (titae).

It is to be noted that the maps presented in this CIA showing the target species distribution are indicative, reliant on limited survey data and the review of secondary information. Distributions are likely to change with comprehensive surveys.

Generally, many long distance migratory fish (e.g., *Tor sp.*) use the tributaries of the Arun River and its confluence points with tributaries for spawning, as well as rearing of fries and fingerlings. Mid-migratory fish, specifically *Labeo dero* (gardi*), Schizothorax progastus* and *richardsonii* (chuche and butche asala)*,* and *Neolissocheilus hexagonolepis* (katle) migrate to the tributaries during the spring and monsoon season*.*

As detailed in **Section 7.4.3**, a DEM of the basin was used to predict migratory fish species distributions, based on predicted temperature tolerance for migratory species. For each zone and from their accompanying ecological attributes for fish life-histories, the cumulative impacts were then assessed, as described below.

Barrier Effects

The most significant cumulative impacts arise from the barrier effect of additional dams. Dams without fish passages will impede the migration of fish attempting to access foraging sites and spawning sites, and stop seasonal movements due to changes in water temperature and flow. Most of the mainstem Arun River dams will likely be quite high (e.g., Arun-3 HEP is 68 m and UAHEP will be 91 m), which limit the potential effectiveness of fish passage facilities.

There are likely more than 20 tributaries that might offer spawning habitats. The non-snow or glacier fed tributaries (i.e., cool water tributaries) usually show higher water temperatures than the main stem of the Arun River (i.e., cold water). When water temperatures are too low for spawning in the main river, the warmer tributaries offer better habitat for spawning and bio-production, which is a function of temperature and of sediment load. An example is the common snow trout, which spawns naturally in clear water on gravelly/stony grounds or on fine pebbles at 1–3 m depth, and these conditions are often likely in tributaries (Shrestha and Khanna 1976).

Several of the large main-stem hydropower projects along the Arun River are proposed with PRoR operations. When peaking, these projects have the potential for interrupting habitat connectivity between the Arun River and tributaries. Peaking operations will likely occur for most of these projects during the dry season from October to May, which includes the spring spawning migration period, and have the potential to disrupt fish access to spawning areas in tributaries. Fish connectivity between the Arun River and the tributaries must be maintained, especially during the spawning season, to support fish access to important spawning grounds. Ikhuwa Khola and Leksuwa Khola are two key spawning tributaries that may be affected by the UAHEP PRoR operations. Maintaining this habitat connectivity is critical in the segment of the Arun River between the Arun-3 and UAHEP dams to maintain a naturally reproducing native fish population.

A good productive substratum Is composed of gravel and stones that give good shelter for the fish. Another important quality of the tributaries is the flow conditions during the dry season. Temporary dry out or very low flow give also limited ecological value.

Dams will impede access to these tributaries by either being in the main stem and impeding entry into the upstream tributaries or, if in tributaries, impeding access to desirable habitats further upstream in the tributaries.

Facilitating downstream migration for both adult fish and fry is just as important as for upstream migration. Fish passing through hydropower turbines usually have high mortality, and the mortality increases when the body length of the fish increases.

The dam for the Arun-3 HEP is under construction and blocks the river at approximately 800 masl. There is no fish passage planned and with a head race tunnel of 11.7 km the dewatered section in Arun river is approximately 20 km.

There is insufficient data on what mid- and long-distance migrating fish species are passing through the Arun-3 dam site, but the dam is situated at an elevation that usually still has several species present, potentially including the golden mahseer, although there is only one 15-year old record of golden mahseer being observed upstream from the Arun-3 dam site. The Arun-3 HPP will prevent any long migrating and mid distance migrating fish species from reaching spawning areas upstream from the dam site, and also probably change the possible utilization of the river and tributaries between the dam and the tail race entry in the river due to low flow.

The general impacts of these type of dams lead to loss of spawning and nursing areas upstream from the dam that will affect the recruitment by fish fry to the ecosystem downstream from the dam. This blockage of the ecosystem services may have a long-term effect on the species composition, population sizes, and biomass production in the river system.

It is not possible to mitigate these losses of upstream migrating biomass by establishing hatcheries, as hatcheries will typically result in the loss of genetic vigor and diversity within the native fish stocks. The only possibility is to establish a fish population that can utilize the local bio-production by using stocking by fry from hatcheries as mitigating measure upstream from the dam. If fish from a hatchery are to be part of the mitigating strategy to strengthen the downstream fish populations, species selected, size of fish fry, and when stocking shall be done are important factors.

Flow in dewatered sections is crucial for fish to migrate. Small fish, such as stone carp (titae) and common snow trout (asala), need less flow than larger fish, such as golden mahseer. Flow may favor some species and stop other species.

Table 8.5 provides the spawning potential for each of the zones in terms of number of suitable tributaries. Suitability is assessed based on its potential for offering more favorable conditions. ***Table 8.5*** also provides the rationale for suitability based on where information was available from secondary literature sources. Given the lack of fish passage, at most, if not all, of the proposed main stem hydropower dams, these projects will result in segmented populations of native fish, including mid-range migrants who can tolerate cold water lentic (i.e., reservoir) conditions. In order to maintain genetic vigor and naturally reproducing populations, preservation of important tributary spawning streams, such as Ikhwua Khola located between Arun-3 HEP and Arun-4 dams, is critical.

Table 8.5: Suitability of Spawning Potential for Tributaries in Temperature Zones

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
Cold **Down to 800 masl**	**Negligible** in snow-and glacier fed rivers and **Moderate** if warmer than main stem and in clear water tributaries	Tributaries such as the Chujung Khola upstream from UAHEP dam site in high elevation (confluence above 1,700 masl) are snow fed and cold as the Arun River, and the spawning potential is low. The Barun River is snow and glacier fed and has also a waterfall close to the confluence with the Arun River. The fish species diversity is low with low population size. Tributaries such as Leksuwa Khola and Ikhuwa Khola (**High**) (confluence 1,090 and 900 masl) are warmer than the main stem and with long periods of clear water. These kind of rivers are highly valuable as spawning and nursing habitats for several species that might include golden mahseer. It only a few of these kind of "warm" rivers in the upper section of Arun river.	Monitoring results, stakeholder consultations, maps and Google Earth pictures, expert consultations	**Main Stem** **Kimathanka** No fish passage, stop fish migration, low bio-production Small fish population, mostly resident Impacts: **Moderate** **UAHEP** No fish passage, stop fish migration, low bio-production Small fish population, mostly resident Impacts: **Moderate** **Arun-4 HPP** No fish passage, fragmentation of river habitat Block local fish migrations, IUCN listed fish species With Arun-3 in operation the impacts are: **Moderate** **Arun-3 HEP** No fish passage IUCN endangered and vulnerable species, good fish species diversity Blockage of fish migrations Under construction without fish passage, so preventing upstream migration of long-range migrants and some mid-range migrants

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
				Regional effects Impacts: **High** **Tributaries** Cold tributaries as Chujung and Barun Khola probably will have **Negligible** impacts from downstream barriers due to low productivity and restricted accessibility, small fish populations. Barriers within these cold tributaries probably also have **Negligible** ecological impacts. Leksuwa Khola, Ikhuwa Khola and Induwa Khola are “warm” tributaries serving as spawning and nursing habitats for the upper Arun river section. Impeding access to these tributaries by Arun-3 HEP will lead to impacts on local, mid distance and long-distance migrating fish species, and will probably affect fish population far downstream in the Arun River. Impacts: **High** **Lower Barun Khola HEP** Natural waterfall stops fish migration (except stone carp). Glacier fed and cold river. Impacts: **Negligible** **Ikhuwa Khola HPP** Dam and low minimum flow impede fish migration and affect the fish fry production,

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
				both for the in-river and the downstream (Arun River) fish populations. Effect will depend on fish passage and on EFlow (10% not enough). With 10% EFlow the impacts will be: **High** **Upper Ikhuwa Khola Small HEP**, High elevation, probably small fish population. Predicted impacts: **Negligible**
Cold-Cool **800–400 masl**	**Negligible** in snow-and glacier fed rivers and **Moderate** and **High** if warmer tributaries and in clear water perennial tributaries. This zone has high fish species diversity, including IUCN listed species.	Rivers like **Hingsa Khola (Kasuwa Khola)** are not glacier and snow fed, but a landslide may give high temporary sediment load in the lower section. If accessible for fish, these tributaries with minimum flow of > 1.5 m^3/s might be a good spawning site for a nursing biotope. In the upper part of the Cold-Cool Zone, assumed **High** value. **Isuwa Khola** is glacier and snow fed and might be cold and with **Negligible-Moderate** value as a spawning habitat. **Apsuwa Khola** is also glacier fed, but with less ice than the Isuwa Khola, the river might be a clear water river and with a slightly higher temperature than the main stem.	Monitoring results, stakeholder and expert consultations, maps and Google Earth pictures	**Main Stem** **The Arun-3 dam** blocks fish migration and the minimum flow might alter the species diversity along the 20 km long dewatered section. The golden mahseer population and several other species will be strongly affected. Impacts: **High** If peaking operations, the bio-production and species diversity downstream from the tailrace will be heavily affected. Impacts: **High** The Lower Arun dam and the dewatered section, without upstream and downstream effective fish passages, might led to **High** level damage to the total fish population including loss of species diversity and fish production, as well as fragmentation of the fish community. This includes the IUCN

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
		High value as spawning and nursing habitat. **Sangkhuwa Khola** has a large catchment in lower altitudes and a relatively small part of the catchment is covered by ice and snow, which means a warm clearwater river with **High** value as spawning and nursing habitat, and with high fish species diversity.		listed golden mahseer. The river in this section is highly productive. Impacts: **High** **Tributaries** **Kashuw Khola HEP** in lower part of Hingsa Khola might led to barrier effects for migrating fish. Low EFlow (10%) might have the same effect. This river confluence might be valuable for golden mahseer. Impacts: **High** **Isuwa Khola**, is a cold or semi-cold river and the **Upper Isuwa HEP** probably has a **Negligible** effect on the fish population in the downstream river system, while the local fish population might suffer. The Isuwa Khola HEP in lower part of the river might impede fish migration and if there is an effect on the confluence area with the Arun River the project might affect the golden mahseer, thereby resulting in **High** impacts, while if not disturbing the confluence area, the impacts are: **Moderate**. **Apsuwa I HEP** High elevation and probably low fish species diversity and low fish production. Predicted impacts: **Negligible**

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
				Upper Apsuwa HEP seems also to be in high elevation, but the downstream dewatered section might impede fish migration and affect fish fry production, both for in-river and downstream (Arun River) fish populations. Effect depends on fish passage and EFlow (10% not enough). With 10% EFlow, impacts will be: **Moderate**.
Cool **Downstream of 400 masl to the confluence with the Koshi river**	The tributaries in this section are all warm clearwater tributaries, which have **High** value as spawning habitats. The natural bottleneck for fish production is the flow during the dry season. In warm areas high temperatures and water quality might also play important roles in defining the species composition. Low flows as 1 to 2 m^3/s give high bio-production/m^2, but these rivers are easy to harvest and the fish populations are often decimated during low flow seasons by local fishermen, who in addition to traditional equipment are using both poison and electricity to catch and kill fish. This is also a	Rivers such as the Chirkhuwa Khola, Sabha Khola, Hewa Khola, Nankuwa Khola, Piluwa Khola, and Pikhuwa Khola have good natural conditions that may serve ecodynamic year-cycle processes, as well as high productivity and **High** value as spawning areas and nursing rivers for a high number of species including the golden mahseer. These rivers have catchments large enough to have perineal flows. Some of the smaller rivers might have very low flow during April due to no meltwater from the mountains. These rivers offer unstable ecological conditions, but during monsoon and late autumn might provide spawning and short time nursing facilities for species that can	Monitoring results, stakeholder and expert consultations, maps and Google Earth pictures	**Main Stem** The Lower Arun PH indicates a long-dewatered section in this lower temperature zone. Fish migration in this section depends on the EFlow during dry season. During monsoon, the flow will probably be high enough to serve the big fish species, such as golden mahseer. Conditions with sufficient EFlow result in impacts: **Moderate**. During peaking operations, the bio-production and species diversity in section downstream the tailrace will be heavily affected. Impacts: **High** The Sapta Koshi Project will inundate a long section of the Arun River, likely resulting in the loss of a significant amount of spawning habitat. **Tributaries** Several of the tributaries that have an assessed high ecological value due to

Zone	Tributary Suitability for Spawning	Rationale	Reference	Likely Cumulative Impacts from Barrier Effects
	serious problem along EFlow sections in regulated rivers in Nepal, and this anthropogenic activity makes the regulated rivers less suitable as spawning and nursing biotopes than rivers with natural flow.	leave the rivers before low flow season. The suitability for spawning might be **High**, while the service as a nursing river might be **Moderate**.		sufficient flows throughout the years cycle have one or more hydropower projects planned in the productive sections of the rivers. Projects above water falls and in altitudes above 1,800 masl in this warm area have lower impacts than projects at lower altitudes. Impacts: **Moderate** Most of these tributary hydropower projects in lower altitudes may impede fish migration and, if peaking operations are planned, the total impact might be serious for the Arun River catchment fish populations and species diversity. If upstream and downstream effective fish passages are not built, a high number of spawning areas and nursing areas may be affected. Together, the power projects at lower altitudes will probably have a **High** impact. But, depending on EFlow and fish passages, the impacts might be classified as **Moderate**.

Changes in Hydraulic/Hydrological Regimes by Reservoirs

The inundation of river segments for reservoirs could result in significant impacts on aquatic habitat. These effects will be more significant for larger reservoirs and ones located in the lower portions of the river basin (i.e., Sapta Koshi and Lower Arun), as warmer water temperatures and longer residence times can result in reservoir stratification and reductions in dissolved oxygen. Species that needs fast flowing well oxygenated waters (lotic species) will be impacted by inundation for reservoirs. Some common species in the Arun River (e.g., common snow trout), however, can acclimate to reservoirs.

Fish that cannot tolerate reservoir conditions may move further upstream into tributaries and other lotic habitats, which may result in increased competition and predation by individuals already occupying that habitat. This is usually a short-term effect, until a new equilibrium is established. The reduction in lotic habitats will likely result in a reduction in lotic bio-production.

Reservoirs can also provide habitat for exotic species, like the Chinese carp, which can proliferate and may outcompete native species and become dominant in these altered natural habitats.

The loss of spawning habitats is especially crucial, although many fish in the Upper Arun River spawn in the clear water tributaries rather than the cold, turbid, and high velocity Arun River. Hydropower projects proposed on these clear water tributaries may have a disproportionate impact on fish in the Arun River.

The main energy force in a river ecosystem is the input of organic matter. Both autochthonous and allochthonous organic matter is relevant, where the allochthonous matter is usually the most important source for bio-production. Construction of a reservoir reduces water velocity and both inorganic and organic matter will be trapped in the reservoir. Entrapment of organic matter will result in considerably increased potential for bio-production, compared to the average bio-production before the impoundment. The section downstream from the reservoir will receive less organic energy for ecosystem dynamic processes, which will suffer from the missing energy input.

If local fish species are able to utilize the positive bio-production qualities developed by the impoundment, the fish production may increase substantially in the reservoir area. This is a function of organic matter influx, temperature, water quality, and sediment load.

The glacier fed Arun River and its glacier fed tributaries carry a high sediment load and will likely have a high sedimentation rate in the reservoir, which will result in depressed bio-production in the impounded area compared to the bio-production in the free-flowing river section.

Table 8.6 provides the likely cumulative impacts of impoundment in the three zones.

Table 8.6: Likely Cumulative Impacts from Impoundment in the Three Zones

Zone	Suitability of Main Stem and Tributaries for Lotic Species	Rationale	Reference	Likely Cumulative impacts From Impoundment
Cold Down to 800 masl	High	This section of this river system is dominated by species developed to live in torrent fast flowing rivers. *Schizothorax sp.* (snow trout), *Psilorhynchoides pseudecheneis* (stone carp), and some species of cat fish (such as *Euchiloglanis hodgarti*) dominate, and are all very strong climbers. No species developed for lentic environment are present.	Aquatic biodiversity surveys conducted for this report, expert consultations	**Main Stem** Relatively **Negligible** for each of the projects due to impoundments only to do short peaking operations. Four HEP's planned on the main stem: – Kimathanka Arun HEP – Upper Arun HEP – Arun-4 – Arun-3 (under construction) The loss of the lotic bio-production area represents relative low value due to small reservoirs (wetted area) and low water temperatures. More important in this glacier fed river is the effect on the supply of allochthonous matter that will be trapped in the reservoir and among the sediment. If not trapped among sediments, the organic matter might bypass the dewatered section. This organic matter is the key energy for the river ecosystem. Due to relatively small reservoirs and low temperatures each of the reservoirs do not lead to substantial negative effects, but from four projects in this upper section of Arun river the total impoundment cumulative impact is assessed as **High**, because of the little free-flowing river remaining between the dams. In periods with low level sediment load, the effect on bio-production in the reservoir will be **Moderately** positive from a fish production perspective.

Zone	Suitability of Main Stem and Tributaries for Lotic Species	Rationale	Reference	Likely Cumulative impacts From Impoundment
				Tributaries The impacts will be **Negligible**, as most projects in this zone are typical run of the river projects with minimal impoundment. The organic matter effect is also assessed as Negligible in the reservoirs.
Cold-Cool 800–400 masl	High	In addition to the very strong climbers in the cold zone, there is a high number of lotic and oxygen demanding species as *Tor putitora*, *Neolissochilus hexagonolepis, Labeo dero*, and *Angilla bengalesis.* All these are strong climbers and the only species also adapted to life in lentic waters is *Anguilla bengalensis*. The dams without a fish passage might prevent the eel from reaching the impoundments. In the lower part of this zone there might be increasing number of species, probably more than 20. But most of them adapted to fast flowing rivers.	Aquatic biodiversity surveys conducted for this report and available literature, expert consultations	**Main Stem** Relatively **Negligible** as the project, Lower Arun HEP, has a relatively small impoundment area. The loss of lotic bio-production area represents **Low** to **Moderate** impacts. More important, in this glacier fed river is the effect on supply of allochthonous matter that will be trapped in the reservoir and among the sediment. If not trapped among sediments, the organic matter might bypass the dewatered section. This organic matter is the key energy to the river ecosystem. In periods with low level sediment load, the effect on bio-production in the reservoir will be **Moderately** positive, from a fish production perspective. **Tributaries** Impacts **Negligible** as most projects in this zone are typical run of the river projects with minimal impoundment, with some projects at high elevation and some in a glacier fed tributary. The organic matter effect is also assessed as Negligible.

Zone	Suitability of Main Stem and Tributaries for Lotic Species	Rationale	Reference	Likely Cumulative impacts From Impoundment
Cool **400 masl and downstream**	Moderate	In this zone the river slows down a bit, but still has a high magnitude of stony river biotopes and high velocity waters. The fish population in this zone consists of a high number of species, probably more than 40, with a mixture between species adapted to life in fast flowing rivers, as well as generalists able to live in different kinds of biotopes and also species adapted to more lentic river conditions.	Aquatic biodiversity surveys conducted for this report, available literature, expert consultations	**Main Stem** The Sapta Koshi would be by far the largest of the main stem reservoirs and will result in a significant loss of spawning and lotic habitat, and a significant reduction in the supply of allochthonous matter, which will be trapped in the reservoir and among the sediment. If not trapped among sediment, the organic matter might bypass the dewatered section. This organic matter is the key energy to the river ecosystem. **Tributaries** At least 20 hydropower projects are planned in 7 of the tributaries, which means a total massive hydropower regulation in the watershed that even with small impoundments and RoR power stations might give a high cumulative effect especially concerning the impacts on organic matter for the ecosystem budget.

Low Flows in Dewatered Reaches

The Arun watercourse has a high number of planned hydropower projects in different ecological zones. Depending on the decided EFlows for each HEP, the impacts may differ substantially in the dewatered sections (***Table 8.7***). This amount of EFlow (as a percentage of river flow) required to maintain aquatic habitat integrity varies based on several factors, including length of the sections, tributary inflow, gradient, river geomorphology and cross-section, riverbed transect compositions, river substratum (boulders, stones and gravel) and water temperatures. In the Upper Arun River, where the river is deeply incised, less flow is required to maintain aquatic integrity. Farther downstream, where the river cross-section widens, more flow is required to maintain aquatic integrity (e.g., water depths and velocities).

Table 8.7: Likely Cumulative Impacts from Low Flow in the Three Zones

Zone	Likely cumulative impacts of low flow	Rationale
Cold Down to 800 masl	**Main Stem** ■ **Negligible** for Kimathanka HEP and Upper Arun HEP ■ Arun-3 – **High** impacts on fish species migrating upstream before monsoon ■ Arun-3 – **Moderate** impacts on species migrating upstream during monsoon **Tributaries** ■ **Negligible** for Chujung Khola HEP, Lower Barun and Upper Ikhuwa Khola HEP ■ **High** for IKHPP	**Main Stem** The upper reaches of the Arun River connected to Kimathanka Arun HEP and Upper Arun HEP are situated in the cold, glacier fed river with high sediment load. The river has low bio-production and a small fish population and a narrow relatively deeply incised river channel. The impacts here are less. **Arun-3** has an EFlow of 10% of minimum monthly flow. The river has a steep gradient and low flow might impede upstream migration before monsoon. In this zone, the water temperatures give good bio-production conditions, with fish species diversity of 20 or more species, including valuable species such as golden mahseer, copper mahseer, and different species of snow trout. During low flow season, wetted productive area will decrease and so will bio-production and the fish production. Due to low flow, the harvesting of fish will be far easier than in the natural river. This might lead to decimation of the fish population, especially if illegal fishing methods are being used such as use of explosives, poison and electricity. These methods are regularly used in other rivers in Nepal with dramatic effects. Information from local experts indicate that this illegal fishing is a widespread problem. During the monsoon season the flow will likely be sufficient for all species to migrate upstream from the dewatered section. **Tributaries** The Chujung Khola HEP and Lower Barun Khola HEP are snow- and glacier fed cold and muddy rivers with low bio-production and if fish a small population. Upper Ikhuwa Khola HEP at high altitude is a "warm" river, but has a small fish population. Ikhuwa Khola HEP is a "cool-water" river, important as spawning area for several fish species. This probably also represents the upper spawning habitat for golden mahseer (IUCN-EN), and is important for the local and regional population of snow trout and stone carp (endemic). Minimum flow (10%) is not sufficient for migration, especially considering the wider stream channel.

Zone	Likely cumulative impacts of low flow	Rationale
Cold-Cool 800–400 masl	**Main Stem** ■ **Negligible** for Lower Arun HEP **Tributaries** ■ **High** for Kasuwa Khola HEP ■ **Negligible** for Upper Ishuwa HEP ■ **Negligible** for Isuwa Khola HEP ■ **Moderate** for Apsuwa HEP	**Lower Arun** The gradient in the Lower Arun River is less steep than further upstream, and it is a warm and productive river. A minimum flow (10%) might be enough for several species migrating upstream during. No specific evaluation available. **Tributaries** Kasuwa Khola HEP is a warm river with a steep gradient and is potentially productive for *Tor putitora* as well as several other fish species. Compared to the assessment of Ikhuwa Khola, the 10% flow in this project will not be sufficient to serve the fish population. A landslide makes the river muddy, but that might be a temporary condition. Kashuwa Khola is the only river along the upper part of the dewatered section that might provide vital biotopes for several fish species. Isuwa Khola is a cold snow fed tributary, with Upper Ishuwa HEP and Isuwa Khola HEP at high altitudes. The ecological value of this river is evaluated as low compared to the warmer tributaries in tis zone. Apsuwa I HEP is located at high elevation, with steep gradient cold water and if there are fish, probably a small population. Upper Apsuwa HEP is located at high elevation, but the downstream dewatered section might impede fish migration and affect fish fry production, for both in-river and downstream (Arun River) fish populations. With a 10% minimum monthly flow as EFlow, the impacts are assessed as moderate.
Cool From 400 masl and downwards	**Main stem** ■ **Moderate** for Lower Arun end its dewatered section in this zone **Tributaries** ■ **High** – 20 hydropower projects planned in 7 tributaries	**Lower Arun** Several tributaries add flow to the main stem, which will reduce the critical impacts of a low EFlow. Sangkhuwa Khola is a major contributor with no planed hydropower projects. Fish migration in the Arun River may reach Sangkhuwa Khola, which will provide these fish populations with spawning and nursing habitats. If this connection can be sustained, the impacts of a 10% minimum monthly flow could be reduced and still be a Moderate cumulative impact. **Tributaries** All tributaries are warm rivers with high bio productivity. Altogether, 20 hydropower projects are planned in 7 of the tributaries, which mean a total massive hydropower regulation in the watershed. All projects will have a dewatered section with varying gradients and river profiles. Compared to the effects in the tributaries in the cold zone, this minimum flows will have high impacts, both due to the reduction of bio-production in low flow season and due to the low flow probably in several rivers, which will impede fish migration and led to a dramatic reduction in the total fish population in both Arun and Sun Koshi systems. High and dramatic cumulative ecological effect.

Peaking

Peaking projects provide daily or weekly regulation of flows by storing water in reservoirs behind the dam. Water is passed through dam turbines to maximize power generation during times of peak energy demand. As such, peaking projects can result in drastic changes to a river's flow – even on an hourly basis. By releasing large quantities of flows within the span of a few hours, peaking projects create daily fluctuations between flood and drought that can wash away or disrupt fish breeding grounds and aquatic biota. Peaking projects could also result in rapid water level fluctuations and wetting and drying of banks increases susceptibility to bank erosion and seepage erosion (piping) processes. Furthermore, peaking projects increase shear stress during flow changes and thereby erosion and bed incision, causing changes in bed habitat and water quality.

As a possible consequence of peaking it has been found that the biodiversity of macroinvertebrate assemblages (measured with Shannon-Wiener diversity index) decreased at dams and downstream locations from dams associated with hydropower plants in comparison to diversity in reference sites (Armanini *et al.* 2014; Vaikasas *et al.* 2013). It was concluded that hydropower plants not only induce cardinal changes in macroinvertebrate assemblage composition, but also in water quality in the riparian ecosystem.

Peaking may also highly affect young and small fish living close to the shoreline. The effect is most dramatic close to the tailrace outlet in the river, and the death rate due to stranding of fish depending on how fast the water level drop after a peaking episode. Other important factors are the shoreline slope and the substratum composition. How far downstream from the tailrace the peaking effect will be of negative character depends on the operating procedures, the riverbed conditions and the added flow from the tributaries, but the effects may occur some kilometers downstream. If the peaking operations are heavy, it might also force large fish to leave the area with the unpleasant flow regulations. Daily peaking may, if not operated in an environmentally adapted manner, lead to high mortality in the area downstream from the tailrace outlet and result in depletion of the river ecosystem and a degraded ecological condition. Upstream migrating fish might also be disturbed by these fast water level drops.

If all of the proposed mainstem hydropower projects are constructed, the effects of peaking on downstream flows will be minor because the distance from each of the project's powerhouses to the next downstream reservoir is very short (often ~1 km or less). Peaking operations, and associated water level fluctuations, can be significant in the interim for the Kimathanka, Upper Arun, Arun-3, and Lower Arun projects, depending on the timing of construction of their next downstream project (***Table 8.8***).

Table 8.8: Likely Cumulative Impacts from Peaking in the Three Zones

Zone	Likely Cumulative Impacts of Peaking	Rationale
Cold	**Main stem** **Significance variations** depending on sequence and timing of project construction, but generally low in Upper Arun River, because of deeply incised river channel and low fish abundance **Tributaries** **Low** – no peaking projects planned	Depending on the operating procedures and the riverbed conditions, there may be stranding effects in this vulnerable cold environment. Fish fry are living close to the shoreline and will be easily impacted if the shoreline slopes are low. If the shoreline is steep, the impacts will be less, but overall the cumulative impacts are considered **Medium** in this segment because of the number of dams and because nearly all of the remaining riverine segments will be subject to at least seasonal peaking operations.

Zone	Likely Cumulative Impacts of Peaking	Rationale
Cold-Cool	**Main stem** **Potentially High** – due to the Arun-3 PRoR **Tributaries** **Negligible** – no available information about peaking projects	The river section has high biodiversity and likely more than 20 fish species which are vulnerable to stranding. The effects depend on the operating procedures and the riverbed morphology. Without an environmentally adapted peaking procedure, the stranding and depletion effects might be substantial, hitting most of the species, such as the fry of *Tor putitora*, snow trout, copper mahseer and all other fish species that have fish fry living in this river section.
Cool	**Main stem** **Potentially High** – due to the Lower Arun PRoR **Tributaries** **Negligible** – no available information about peaking projects	Without an environmentally adapted peaking procedure, the stranding and depletion effects might be substantial and will impact on the fry of *Tor putitora*, snow trout, copper mahseer and all other fish species that have fish fry living in this river section. The rivers in this area are wider with shallower shore lines and, thereby, have a higher probability for stranding mortality.

Changes in Sediment Transport

The impacts of sediment flushing are most evident in low flow situations and in sections where the river bed is dominated by rocks and boulders. In fine sand areas sediment flushing is not a problem. As the main stem and tributaries in much of the three zones are dominated by stones and boulders impacts, cumulative impact of sediment flushing can be considered to be **High**.

Climate Related Impacts

Climate change predictions for the Himalayan region of Nepal vary, but generally slightly warmer temperatures are expected, which should result in slightly higher average river flows in the near to mid-term as glaciers slowly melt, and then possibly slightly lower average river flows in the mid to long term as glacier melt is reduced. It is difficult to definitively determine the effects of these changes on fish and aquatic habitat. In the absence of project dams, slightly warmer air and water temperatures could extend habitat suitability upstream along the Arun River for some species (e.g., golden mahseer), although proposed dams will prevent golden mahseer and possibly other native fish species from accessing potentially new suitable upstream habitat.

8.5.3 Summary of Cumulative Impacts

Table 8.9 provides a scheme for categorizing baseline ecological integrity (Kleynhans1996), which is used to determine the significance of cumulative impacts on fish and aquatic habitat in the Arun River Basin. From the cumulative assessment of impacts carried out above, the changes in ecological integrity are predicted in the Arun Basin for each of the three zones and separately for the main stem and tributaries (***Table 8.10***). The rationales for these changes are also provided.

As summarized in ***Table 8.10***, the cumulative impacts of planned/under-construction HEPs, in combination with climate change and other stressors, are predicted to result in a **Largely Modified** ecological integrity in the main stems and tributary in each of the temperature zones – aside from the cold zone main stem, which is predicted to be **Moderately Modified**.

Compared to the cool zone, the cold and cold-cool zones are expected to have more significant cumulative impacts, as the baseline ecological integrity is less modified. As such, the following is a summary of the cumulative impact significance to fish and aquatic habitat per zone:

- Cold Zone main stem and tributaries: **High** cumulative impact significance
- Cold-Cool Zone main stem and tributaries: **High** cumulative impact significance

- Cool Zone Main stem and tributaries: **Moderate** cumulative impact significance

Table 8.9: Categories for Baseline Ecological Status

Ecological Category	Description of Habitat Condition
A	Unmodified: Still in a natural condition.
B	Slightly modified: A small change in natural habitats and biota has taken place, but ecosystem functions are essentially unchanged.
C	Moderately modified: Loss and change of natural habitat and biota has occurred, but the basic ecosystem functions are still predominantly unchanged.
D	Largely modified: A large loss of natural habitat, biota and basic ecosystem functions has occurred.
E	Seriously modified: The loss of natural habitat, biota and basic ecosystem functions is extensive.
F	Critically/extremely modified: The system has been critically modified with an almost complete loss of natural habitat and biota. In the worst instances, basic ecosystem functions have been changed and the changes are irreversible.

Source: After Kleynhans 1996

Table 8.10: Changes in Ecological Integrity for the Three Zones

Temperature Zone	Main Stem or Tributary	Baseline Ecological Integrity	Predicted Ecological Integrity	Cumulative Impact Significance and Rationale
Cold	Main stem	Unmodified	Moderately Modified	**High Significance** No HEPs so far and anthropogenic pressures are low. The HEPs in the main stem will have limited impact on aquatic diversity, which is low due to cold conditions, but none of the proposed dams will have fish passage facilities, representing a barrier to migration for key species, like the common snow trout, and resulting in fragmented and segmented fish populations. The four proposed HEPs in this segment would convert the Arun River to a series of dams, reservoirs, diversion reaches, and segments subject to flow fluctuations from peaking operations. HEPs on tributaries could have significant impact depending on EFlow.
	Tributary	Unmodified	Largely Modified	
Cold-Cool	Main stem	Moderately Modified	Largely Modified	**High Significance** Baseline aquatic diversity is high in this zone, although modified by the presence of several settlements, some sand and gravel mining and overfishing. The main stem will be impacted by barrier effects on migratory fish, as well as some peaking and sediment transport.
	Tributary	Moderately Modified	Largely Modified	**High Significance** Baseline aquatic diversity is high in this zone, although modified by the presence of several settlements, some sand and gravel mining and overfishing. Tributaries will be impacted by barrier effects on migratory fish and sediment transport.

Temperature Zone	Main Stem or Tributary	Baseline Ecological Integrity	Predicted Ecological Integrity	Cumulative Impact Significance and Rationale
Cool	Main stem	Largely Modified	Largely Modified	**Moderate Significance** Baseline conditions have been modified by over-fishing and use of destructive techniques for fishing, as well as some sand and gravel mining. However, given the absence of peaking projects and the dominance of run habitats, unlikely to be impacted by low flows, there is unlikely to be a major changes in ecological integrity.
	Tributary	Largely Modified	Largely Modified	**Moderate Significance** Baseline conditions have been modified by over-fishing and use of destructive techniques for fishing, as well as some sand and gravel mining. Due to barrier effects on fish species as well as the impacts of low flows and sediment flushing, ecological integrity will further deteriorate.

8.6 Cumulative Impact on VEC: River-based Livelihoods

8.6.1 Key Stressors and Impacts

Shown in ***Table 8.11*** are the primary stressors and impacts on river-based livelihoods from planned hydropower projects, road developments, and climate change in the Arun River Basin.

Table 8.11: Stressors and Cumulative Impacts on Livelihoods

Stressors	Potential Cumulative Impacts on Livelihoods
■ Hydropower developments ■ Electricity development ■ Road development ■ Climate change and natural hazards	■ Effects on irrigation ■ Effects on rafting outfitters ■ Effects on artisanal fishing ■ Effects on river mining

8.6.2 Cumulative Impacts

It is expected that there will be improved quality of life for people living in settlements to which the generated electricity will be distributed. However, improved living conditions in these settlements will likely lead to population increases, which will in turn lead to social cohesion impacts (**Section 8.8**) and increased pressure on the ecosystem services of the surrounding areas, as people will look to gather resources from CFUGs and surrounding forest areas.

Considering a high-level baseline vulnerability, the cumulative impacts from hydropower, road and transmission line developments will be even more significant for vulnerable groups (e.g., women, Dalits and indigenous people). This is particularly the case for those whose livelihoods depend on river resources, perform spiritual rituals in the rivers, or live near hydropower, road, and electricity development projects.

Irrigation

Agriculture is the sector that contributes the most to Nepal's GDP; however, raising productivity through irrigation is constrained by the lack of electricity (Bharati 2019). The national grid has not reached all rural areas, and where it has reached, farmers have not always been able to access the subsidized farm power connection. Where farm power is available, the electricity supply is often intermittent and unreliable (Neupane 2019*).*

In the hills and mountains, the main restrictions on water access are geophysical, with water mostly accessible in the valleys below the steep slopes, with rocky subsoil limiting the possibility of storage. Thus, rain fed agriculture is still the method of choice in most of this area (Neupane 2019*).*

Hydropower Projects

Well-planned multipurpose hydropower projects have the potential to provide co-benefits such as irrigation to support local livelihoods and improve food security. For example, the Sapta Koshi Project would create a large reservoir at Chattara in Nepal which would supply year-round irrigation in the downstream areas. The proposed dam could irrigate more than 1.5 million ha – 546,000 ha in Nepal (Mahattari, Chanusha, Siraha, Saptari, Sunsari, Morang, and Jhapa) and 1,053,000 ha in Bihar, State India. However, the Sapta Koshi Project would inundate 3,764 ha of agricultural land within 15 local levels in Sankhuwasabha, Dhankhuta, and Bhojpur districts. River valley farming systems (which are considered to be of high production capacity) would be most affected by this inundation. As there are limited agricultural land in the hills and mountains, inundation of large amounts of agricultural land may cause severe impacts on production (Rai and Linkha 2020).

Peaking projects provide daily or weekly regulation of flows by storing water in reservoirs behind the dam. As such, peaking projects can result in drastic changes to a river's flow – even on an hourly basis – which can impact on the availability of irrigation. This is more of an issue in the middle and lower Arun River Basin where slopes are gentler and land suitable for agriculture use are found along the river.

Reduced flows in the diversion reaches of the HEPs may result in significant livelihood impacts on those who rely on the affected stretch for irrigation and fishing. Such impacts have been reported in the diversion reaches of other recently commenced HEPs in eastern Nepal.

Road Developments

Communities in Khandbari Urban Municipality have witnessed road construction activities destroy irrigation tunnels. As a result, the community has demanded additional budget for the repair and maintenance of the affected irrigation tunnels.

Climate Change

Climate change is likely to have a great impact on agricultural water security in the future. Pre-monsoon precipitation is projected to decrease and extreme precipitation events to increase (Neupane 2019). There is also a high likelihood of stronger monsoons in the future, which will increase impacts and the risk of related disasters such as landslides and floods (Bharati 2019). Moreover, increasing erosion, landslides, and sediment will complicate repair and maintenance, making it more costly and reducing the command area for surface irrigation.

Summary of Impacts on Irrigation

In summary, considering the predominant reliance on rain-fed irrigation, the impacts on irrigation are considered to be of **Moderate Significance** to communities upstream from the Lower Arun HEP powerhouse. If the Sapta Koshi Project is built, as planned, the impact on irrigation and agriculture is considered to be of **High Significance**, due to the large areas of agricultural lands that would be inundated.

Artisanal Fishing

Fishing is a supplementary source of livelihood for people in the basin, complementing other existing income and nutrition sources. Fish is also considered an important part of various cultures, rituals, and traditions. For example, in Rai community, fish is an important food item for *Kul Puja*, which is celebrated every year. Whereas among the Majhis, it is used during death rituals.

Sabha Khola (which meets the Arun River approximately 10 km downstream from Khandbari) is the most popular fishing area in the basin. Fish from Sabha are considered to be of higher quality and fetch a higher price at market, up to NPR 1,200/kg. Fishing activities on the Sabha contribute to subsistence livelihoods in some communities.

Accounts from consultations suggest decreases in fish catch over the last decade resulting in a decline in artisanal fishing as a livelihood (capture fishing, small-scale commercial fishing, subsistence fishing, and recreational fishing). The plummeting number of fish is primarily owing to a general increase in resource dependence, haphazard infrastructure development (e.g., dumping of road debris into the river during road construction), an increase in electrofishing, increased incidents of floods and landslides, river mining, and lack of regulation, among other things. Sabha is steeper than the Arun River and has seen more flooding incidents in the last decade, which has impacted upon the fish population in the river. This has resulted in communities shifting to other forms of livelihood, such as construction work, daily wage labour, and small businesses. However, some communities are more dependent on fishing than others. For example, approximately 50% of Kumal households near Tumlingtar and 75% of households in Barhabise (Sabha Pokhari Rural Municipality) are dependent on fishing for at least 6 months in a year and may bear higher livelihood impacts.

Any additional infrastructure development, therefore, is likely to add stress to the existing impacts. In addition, road construction and the disposal of road debris in the river (e.g., access roads) may increase the incidence of landslides resulting in impact on fish populations. HEPs will result in barrier effects and changes in hydraulic and hydrological regimes as discussed in **Section 8.6**.

Reduced flows in the diversion reaches of the HEPs may result in significant livelihood impacts on those who rely on the affected stretch of river for fishing. Hydropower structures may also block the migration of important fish species which could severely impact Kumul and Barhabise communities, and other households that rely on fishing as a primary source of livelihood.

In summary, given that fishing is not a major source of income, and as most of the fishing activities are on the Sabha Khola or lower Arun River, cumulative impacts on small scale commercial fishing is considered to be of overall **Negligible Significance** for the basin and of **High Significance** for fishing livelihoods on the Sabha Khola.

River Mining

The local government restricts commercial river mining in the Arun River. However, households use raw materials from Arun River for household purposes (e.g., construction of houses). River mining is most popular in the Sabha River, where it contributes approximately NPR 2.2 million to the Khandbari Municipality and is used to build local infrastructure such as hydropower projects and roads.

River mining is a regular source of income for communities around the crusher plant at Sabha Khola, which is located 12 km downstream from the Lower Arun Powerhouse. On a given day, groups of 5–7 people make 35 trips of gravel, sand, and stone collection from the riverbank. Sedimentation flushing from upstream hydropower projects is not likely to have an impact on these crusher plants. However, if the downstream Sapta Koshi Project was to be built as currently proposed, sand dunes along the riverbank will be inundated, which would impact on the livelihoods of river miners and affect local government revenue. The Sapta Koshi Project would likely impact downstream river mining, because its large reservoir is likely to trap much sediment.

Agricultural activity and road development will potentially increase erosion and, subsequently, the sediment transport in various reaches of the basin, but the coarser grain sizes will still be trapped within the various impoundments. It should also be noted that, if practiced unsustainably, sand and gravel extraction could increase riverbank erosion and result in negative hydrological and biodiversity impacts.

In the absence of the Sapta Koshi Project, cumulative impacts on river mining-based livelihoods are considered to be of **Negligible Significance**, because of the upstream flushing of sediments, which should maintain a quasi-natural sediment transport. If the Sapta Koshi Project were to be built, the cumulative impacts on river mining-based livelihoods would considered to be of **High Significance**, as much of the sand deposits along the Sabha River would be inundated.

Rafting Outfitters

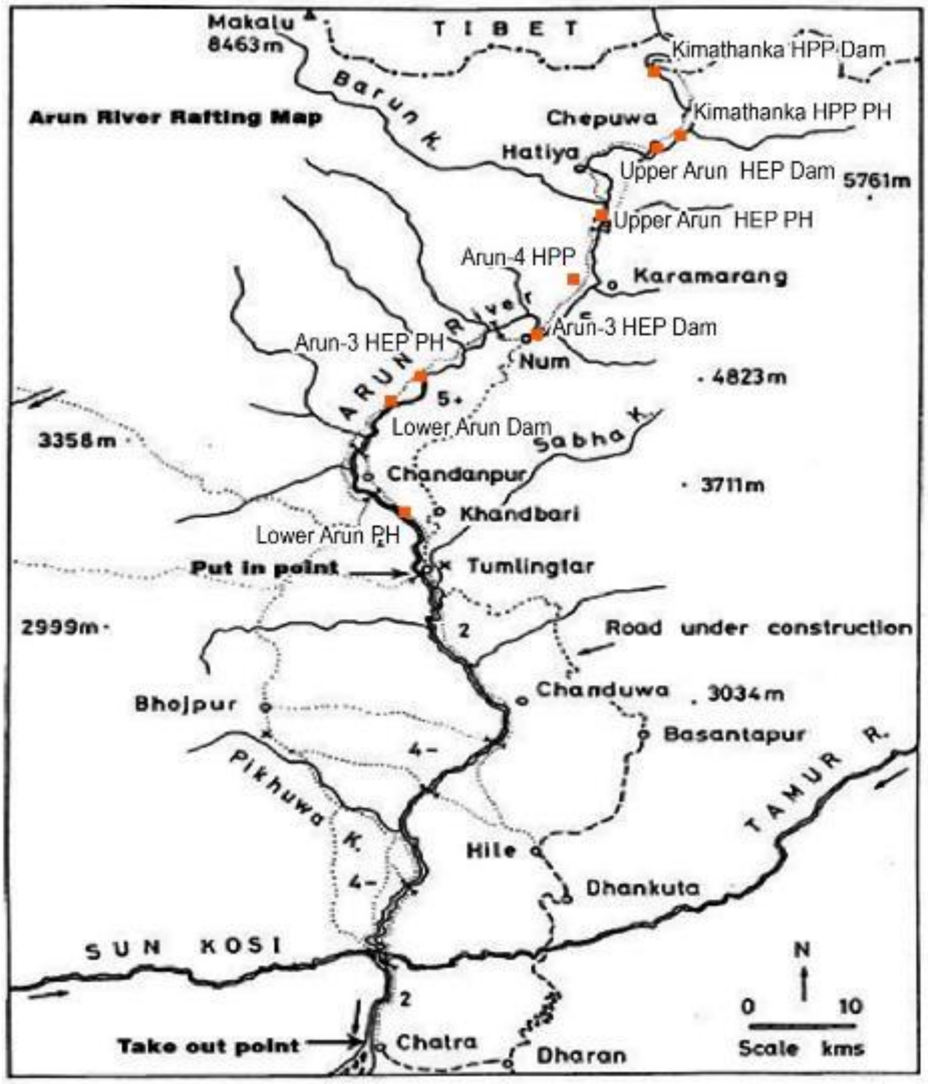
The lower Arun River is used for recreational boating by several rafting outfitters. Although the exact rafting put in and take out points vary by outfitter, most generally put in just upstream from Tumlingtar and take out just downstream from the confluence with the Sapta Koshi River (***Figure 8.9***). Moreover, the opening of the Koshi Highway (including the Num-Kimathanka Road) and access roads will improve accessibility to previously isolated locations – which could benefit rafting outfitters and tourism activities In the basin.

The put in location for rafting is downstream from the Lower Arun HEP tailwaters, so would not be affected by any of the upstream hydropower facilities. The Lower Arun HEP, however, is a PRoR operation, which would control flows for most of the rafting river segment. Depending on the timing of the Lower Arun HEP peaking, the PRoR operation could have either a beneficial or adverse impact on rafting. If peaking occurs during morning or early afternoon hours, the peaking flow of 253 m^3/s would likely provide reliable high-quality flow, which would support rafting. If the peaking occurs during late afternoon or evening, then the outfitters and their customers would likely only have the project's proposed EFlow (i.e., 10% of the average monthly flow) plus any tributary inflow, which would likely be insufficient to provide a quality recreational experience.

If the Sapta Koshi High Dam Project was to be built as currently proposed, it would flood the entire section of the Arun River used for rafting and the current rafting take out point would be downstream from the Sapta Koshi Dam. This project would eliminate the appeal of the lower Arun River for rafting, although it could potentially create other water-based recreational opportunities within the reservoir.

Moreover, the opening of the Koshi Highway (including the Num-Kimathanka Road) and access roads will improve accessibility to previously isolated locations, which could benefit rafting outfitters and tourism activities in the basin. In summary, the cumulative impacts on rafting outfitters in the Upper Arun River would be considered of Low Significance as very little rafting is occurring, but the effects of the Sapta Koshi and, to a much lesser extent, the Lower Arun HEP would be considered of **Moderate Significance**, as they would have a significant impact, but on a relatively low number of outfitters.

Figure 8.9 Arun River Rafting Map



8.7 Cumulative Impacts on VEC: Settlement

8.7.1 Key Stressors and Impacts

Shown in ***Table 8.12*** are the primary stressors and impacts on settlements in the Arun River Basin.

Table 8.12: Settlement Stressors and Impacts

Stressor	Potential Impact on Settlement
■ Hydropower development ■ Electricity development ■ Road development ■ Climate change and natural hazards	■ Change in settlement demographics ■ Improved public infrastructure ■ Change in livelihood sources and income generation ■ Governance impacts ■ Potential increase in trafficking in persons and gender based violence

8.7.2 Cumulative Impact

Overall, in the short term (1–5 years), it is anticipated that improved roads will increase opportunities for people to bring their agricultural products to market and improve access to healthcare and education facilities. Hydropower construction will result in an influx of labour, which will likely generate more local business, particularly at tea stalls and eateries, with a possible shift from traditional sources of livelihood. However, this can also result in increased gender-based violence near these establishments and other significant impacts in less densely populated areas (**Section 8.8**). An Increase in infrastructure development in the area may also increase the responsibilities for the local government including an increase in monitoring and security requirements for individual projects, and an increase in security needs for communities to manage increased influx.

There is a potential that, in the medium term (5–10 years), improved transport and electricity infrastructure may result in increased migration into the basin. This could further increase the pressure on agricultural lands and non-timber forest products.

Change in Settlement Demographics/Patterns

A change in settlement demographics is likely to be one of the major impacts of infrastructure development in the region. Given that villages in the region are a cluster of a limited number of households, increased access and influx may result in a change in settlement demographics. For example, Namase, Rukma, and Chepuwa are primarily Bhote communities with a distinct culture and language, and a change in settlement patterns will potentially have additional impacts on cultural identity. In addition, climate change impacts may have additional impacts on settlements, with accounts of landslides, floods, and the drying up of springs posing a threat of relocation.

Overall, the cumulative impacts on change in settlement demographics to previously remote villages is considered to be of **High Significance**. Descriptions of the impacts on settlement demographics from hydropower projects, improved road connectivity and climate change are discussed below.

Public Infrastructure

Infrastructure development in the region is expected to result in improved public infrastructure as discussed below.

Road Connectivity

Road connectivity is a recent phenomenon in the region. The Tumlingtar-Khandbari road was built in 2010, the Khandbari–Num road was completed in 2016, and the track beyond Num was recently opened in 2018 as a part of the Koshi Highway and is in the process of being completed. While the road from Tumlingtar to Khandbari is black topped, the one from Khandbari to Num is currently being upgraded, and the one beyond Num is only a track opening and is non-operational during the monsoon season. As a result, communities closer to this highway are already seeing changes in demographics, as well traditional sources of livelihood.

Through the CIA consultations with downstream communities, the benefits and negative impacts of road construction were widely recognized. The consultees shared that road construction enables farmers to transport their agricultural products to markets and promote local economic activities; however, they also explained that the construction of roads has destroyed farmlands, forests/community forests, and water sources (e.g., due to associated landslides and dumping of soil into the river).

Access to Healthcare

Communities will have better access to healthcare facilities, with an increase in road connectivity. As an example, the road opening to Gola has reduced travel time for local residents from a day’s walk to few hours of ride to Num, where there is a better health facility.

Electrification

An increase in hydropower development in the region will also result in reliable access to electricity in the region. While some areas are connected to the national grid, the majority of the villages are reliant on micro/mini hydro schemes or solar energy, which is not often reliable. Increased access to electricity may also result in productive end use of electricity, including an increase in small businesses reliant on electricity source.

Livelihood Sources and Income Generation

The Koshi Highway development is changing the face of traditional agriculture in the region; subsistence farming is being replaced by commercial farming, and the effect is seen greater along the roadsides. Although road developments impact on traditional livelihoods and social cohesion (**Section 8.8**), the increased connectivity often results in improved economic activities. Pande (2017) observed a 21% reduction in poverty in Ramechhap, Rasuwa, and Taplejung districts after introduction of access roads through projects funded by the Asian Development Bank (ADB). The observed poverty reduction was in part a result of increased access to markets, which reduced travel time from farm to market and improved agricultural productivity.

Moreover, studies show that a lack of proper transport facilities and road linkages results in a considerable proportion of wasted agriculture products in rural Nepal. These studies indicate that Nepalese farmers lose about 25–30% of their product before reaching the market.

The recent urbanization of Num has also seen an increase in hotels and small businesses, a major shift from agriculture.

The migration of some men to urban centers and abroad has increased the number of women engaged in agriculture, as well as contributed to an increase in female-head households. However, women are less likely to have land registered in their name or obtain documentation to prove entitlement, which further magnifies the impact of land acquisition for the development of hydropower, roads, and transmission lines.

Governance Impacts

Increases in infrastructure development may add stress to the existing human resources available within the local and district government, as they bear the responsibility for monitoring, as well as facilitating coordination between the project and the communities. There may be an increase in demand for security personnel, in addition to clearances that may be required for various purposes, e.g., the divisional forest office will be responsible for any clearances required for community forests.

Trafficking In Persons/Gender Based Violence

The underlying causes of trafficking include poverty, limited socio-economic opportunities, and the lack of sustainable livelihoods. Women and girls are especially vulnerable due to gender discrimination, illiteracy or low education, and low socioeconomic status. In Nepal, those most targeted tend to be from traditionally excluded and socially marginalized groups, such as members of formerly 'enslavable' aadibasi/janajati ethnic groups, as understood from consultations with the local community.[25]

It is understood that personal aspirations play a major part when offenders are not from the known social circle of the victims. Juvenile and adolescent victims especially fall prey to the false promises made by strangers not only for an economically stable life, but also for exposure to different geographies, cultures, traditions, and what they believe would be a better way of life. In rural areas, Internet connectivity and smart phones have brought greater exposure, leading to new aspirations among the youth, some of whom choose to leave home. The aspiration for a better life leads some people to be trafficked, as they place their trust in unknown persons who turn out to be traffickers.

Given this context, the influx of labor and other development activities related to the project may contribute to an increase in the risk of trafficking in persons, especially during project construction, which warrants appropriate mitigation measures to address such risks.

8.8 Cumulative Impacts on VEC: Social Cohesion

8.8.1 Key Stressors and Impacts

Shown in ***Table 8.13*** are the primary stressors and impacts on social cohesion from planned hydropower projects, road developments, and climate change and natural hazards in the Arun River Basin.

Table 8.13: Social Cohesion Stressors and Impacts

Stressor	Potential Impact on Social Cohesion
■ Hydropower developments ■ Electricity development ■ Road development ■ Climate change and natural hazards	■ Impacts on social capital ■ Impacts on sense of place ■ Impacts on cultural Identity ■ Impacts on social inclusion

8.8.2 Cumulative Impact

Communities and individuals near hydropower and road developments in the basin may experience diminished social cohesion and cultural identity due to direct and induced impacts, including land acquisition and resettlement, workforce mobilization, and population influx.

Resettlement has the potential to disturb currently cohesive communities – both those that are resettled, and those that act as hosts to relocated populations. Social cohesion, or the quality of a group collaboration or unity, may be disturbed, as communities (particularly aadibasi/janajati groups), which observe unique norms, mores, and languages, are combined, as the partial resettlement of formerly whole communities potentially takes place, and as local power dynamics and structures are disturbed. Additionally, through the process of resettlement, relocated people will be separated, either temporarily or permanently, from spaces that hold community and cultural significance, including cemeteries, gathering spaces and ancestral lands. These separations can diminish social cohesiveness, as well as connection to cultural identity.

[25] KII with Shakti Samuha at Sindhupalchowk, Chautara 5

The mobilization of the hydropower project workforce, as well as HEP induced influx or in-migration, will create demographic changes that may further diminish social cohesion and cultural identity. For instance, during the construction of the UAHEP, a peak workforce estimated at 4,500, with about 60% likely to be foreign nationals, will enter the Project area. The presence of foreign nationals and other 'outsiders' in local communities with unique cultural norms, mores, and languages, may disrupt the cohesiveness of existing communities located near work camps, and in communities where workers spend leisure time and make organized trips to purchase personal items.

The on-going construction of the Koshi Highway and access roads to be built for hydropower projects will greatly benefit the communities by connecting them to basic services such as healthcare, and education, among other things. However, it will also increase intra-district mobility of various ethnic groups, haphazard urbanization, and, if unmanaged, may disrupt the social cohesion, cultural norms, and the identify of communities.

The cumulative impact on social cohesion is, therefore, considered to be of **Moderate Significance** for the lower Arun Basin (from Tumlingtar to Num/Dovan at the Arun-3 headworks location) and **High Significance** for the upper region from Arun-3 headworks site to Kimathanka.

Social Capital

Local power dynamics and structures may be disturbed through resettlement activities, both for resettled communities that are absorbed by new host communities, and for host communities which incorporate new populations. This disturbance may lead to a reduced or lost access to local power structures and social capital for some members of these communities. As discussed earlier, there is a high interdependence among communities in the area. The *Kiduk Samaj*, which plays a central role in decision-making on village matters mostly, related to birth and death rituals, is prevalent in the UAHEP area. Such local structures may be potentially impacted by demographic changes resulting from displacement, influx and urbanization.

With changes in community membership resulting from resettlement activities, or the dilution of a community with new entrants through project induced influx, existing social safety nets may be weakened or lost. Social safety nets include informal, but established, patterns of caring for elders, impoverished, or otherwise socioeconomically vulnerable individuals who may not have the means to meet their basic needs independent of community support. This is more significant among indigenous communities, which are more communal. Communities reported relying on neighbors during health emergencies, or for financial advice, among other things. Vulnerable households without land ownership often rely on someone else's land for their livelihood (land users). Losing land access will potentially result in increased vulnerability for such households.

This impact is likely to be more significant in the upper region with no current road connectivity, higher level of community dependency, and the presence of local structures such as *Kiduk Samaj*, than the lower region, which has already seen some of these changes with the development of the Koshi Highway as well as Arun-3 HEP. Hence, the cumulative impact on access to lower power structures and social capital is considered to be of **High Significance** in the upper region of the Arun River Basin and **Moderate Significance** in middle and lower regions of the basin.

Sense of Place

The concept of "sense of place" is interactional and psychological, which makes it very difficult to move away from a place that one consider home. Infrastructure development often impacts on a multitude of place related values, including land, traditional forms of livelihood, access to natural resources, such as resources from community forests, access and use of rivers, cultural heritage resources, and social capital, among other things, which will be potentially impacted by the UAHEP as well all other infrastructure development in the Arun Basin. Such impacts are likely to be more significant among indigenous communities with a high dependency on natural resources. Furthermore, impacts are likely to be higher for the elderly population, than for younger people.

Land acquisition resulting in physical displacement is one of the most critical impacts on communities' sense of place. In addition, given the limited availability of replacement land in the area, the likelihood of having to move to a different community is higher, which adds to the impact.

Accounts from communities suggest that they have a spiritual connection to their land, as well as their surroundings. As an example, communities in Namase reported that they feel protected by the hills around them that they revere as God, while those in Limbutar shared their connection with trees that they grew up with.

Irrespective of road connectivity, there will be significant impacts on sense of place in the lower region as well as the higher region of the Arun Basin from infrastructure development and the UAHEP, respectively. As such, the cumulative impacts on sense of place are considered **High Significance.**

Changed Cultural Identity

Demographic changes in local communities generated by resettlement activities and hydropower and road development induced influx, including workforce, workforce families, and other economic opportunity seekers, will contribute to impacts on cultural identity. The influx of non-nationals will impact on the cultural fabric of the local communities in the places where they work, reside, or spend leisure time, diluting local norms and language. In addition, homogenous communities such as the Bhote community in Namase may see an increase in population from other communities of different ethnic backgrounds, influencing the intangible cultural resources, such as languages, festivals, and Bhote scripts.

Traditional artefacts may see a decline resulting from a change in livelihood patterns and increased connectivity to markets. Communities in this region have a spiritual connection to the river and perform several rituals around the riverbanks, including Kul Puja and cremations. A decrease in EFlow with the several hydropower projects that are planned and under construction may have severe impacts on access to the river for cultural purposes.

Haphazard development resulting from road connectivity and population influx may impact on the traditional architecture of the place. This is evident from new non-traditional structures in Num and Khandbari.

This impact is likely to be more severe in the upper region with no current road connectivity, than the lower region, which has already seen some of these changes with the development of the Koshi Highway as well as Arun-3 HEP. Hence, the cumulative impact on cultural identify is considered to be of **High Significance** in the upper region of the Arun River Basin and **Moderate Significance** in the middle and lower regions of the basin.

Generation of Social Tension (including TIP and GBV)

Social tensions may be produced by a variety of project activities and induced impacts, which may create a number of unique schisms and affect a range of communities and individuals. With the entrance of project induced influx, competing cultural norms, mores, language, and customs, and pressure on limited social and environmental resources and public services, social tensions can arise between receiving communities and new entrants. These tensions can be enhanced, particularly when due to the size or economic power of the incoming population, local communities experience or perceive themselves as experiencing economic or cultural marginalization, or when the impacts of increased crime and delinquency arise with the influx.

In situations where there is not widespread public consent to development, social tensions may arise between project opponents and proponents. These divisions may occur along the lines of stakeholders or community members who perceive themselves to be beneficiaries of project development (employment opportunities, supply opportunities, or other economic benefits or compensation for losses that are considered fair and advantageous), and those who do not. Differences in lifestyle and levels of development present within the project area may increase as certain members of communities secure work or supply opportunities with the project, while others do not; this can also contributing to tension and intra-community divisions. These divisions also can occur between generations, ultimately leading to a deterioration of social cohesion within communities.

Incidents of potential trafficking and sexual violence may increase with population influx, as often reported in other infrastructure development, if not carefully monitored. These impacts are likely to be more significant in the upper region, with the concentration of laborers and other small businesses, which has already seen some of these changes with the development of the Koshi Highway as well as Arun-3 HEP. In summary, the cumulative impact from the generation of social tension is considered to be of **High Significance**.

8.9 Summary of Cumulative Impacts on Selected VECs

Overall, a full development scenario (with over 30 hydropower projects) in the Arun River Basin will have significant adverse cumulative impacts on the river and communities. These impacts would be further exacerbated by road and transmission line development, climate change, and natural hazards. And these impacts will be even more significant for vulnerable groups. A summary of the cumulative impact significance for each selected VEC is shown in ***Table 8.14.***

Table 8.14: Summary of Cumulative Impact Significance for each VEC

VEC	Metric	Cumulative Impact Significance
Natural forest integrity	Forest loss and fragmentation	Upper Arun River Basin: **High**
		Middle Arun River Basin: **Moderate**
		Lower Arun River Basin: **High**
Makalu Barun National Park	Forest loss and fragmentation	MBNP: **High**
Water resources	River flow	**High**
	River water quality	**Moderate**
	Geomorphology	**Moderate**
	Sediment transport	Upper Arun River: **Moderate**
		Lower Arun River - High
Fish and aquatic habitat	Changes in ecological integrity	Cold Zone: **High**
		Cold-Cool Zone: **High**
		Cool Zone: **Moderate**
River-based livelihoods	Impacts on irrigation	Upper Arun River Basin: **Negligible**
		Lower Arun River Basin: **High**
	Impacts on artisanal fishing	Overall basin: **Negligible**
		Sabha Khola: **High**
	Impacts on rafting outfitters	If Sapta Koshi Project is built: **Moderate**
Settlement	Changes in settlement demographics patterns	Upper Arun River Basin: **High**
Social cohesion	Impacts on sense of place	Upper Arun River Basin: **High**
	Deterioration or loss of social safety nets	Upper Arun River Basin: **High**
		Mid/lower Arun River Basin: **Moderate**
	Access to local power structures / social capital	Upper Arun River Basin: **High**
		Mid/lower Arun River Basin: **Moderate**
	Generation of social tension	Upper Arun River Basin: **High**
		Mid/lower Arun Basin: **Moderate**

9. PROPOSED CUMULATIVE IMPACT MANAGEMENT STRATEGY

9.1 Overview

Effective application of the mitigation hierarchy (avoid, reduce, mitigate, and compensate) to manage individual contributions to cumulative impacts is recommended as best practice. The UAHEP and other sponsors of other hydropower projects in the basin should incorporate project design features that include physical and procedural controls to avoid and reduce possible impacts, that are planned as part of the projects.

The responsibility for the management of cumulative impacts ought to be collective, requiring individual actions to eliminate or minimize each individual development’s contributions. Project sponsors should be responsible for mitigating their own contribution to cumulative impacts, as well as participating in collaborative watershed management efforts. Moreover, management measures recommended during the CIA process may ultimately be effective only if the Nepal government becomes actively involved (IFC 2013).

The project sponsors should foster collaboration by participating, to the extent feasible and practicable, in working groups and/or government initiatives. The collaboration should be aimed at addressing the management of potential impacts on regional resources to which the projects could incrementally contribute with respect to cumulative impacts. An example of a collaborative cumulative impact management strategy, as recommended in the Upper Trishuli-1 Hydropower Project CIA, is shown in ***Box 9.1***.

Box 9.1: High Management Approach

The Upper Trishuli-1 Hydropower Project CIA study identifies VEC-specific potential cumulative impacts in the Trishuli River Basin, and proposed mitigation and monitoring measures at three different stakeholder levels: individual hydropower developers; government authorities; and local communities. Additional management actions at a higher level, such as a High Management Approach, are also suggested to address the significant cumulative impacts that are predicted to affect the Trishuli River Basin.

The High Management Approach involves a combination of quasi-regulatory, incentive-based, and technical measures, in this example aimed at: managing fish populations; regulating sediment mining; and applying general watershed management measures. Together, these measures contribute to the improvement of habitats and consequently reduce cumulative impacts on the identified VECs. This High Management Approach suggests measures to be cooperatively implemented by hydropower developers, governmental authorities, and local communities.

Source: ERM 2019. *Upper Trishuli-1 Hydropower Project Updated Non-Technical ESIA Addenda*.

9.2 Possible Mitigation and Management Measures

Shown in ***Table 9.1*** are possible mitigation and management measures to avoid/minimize/restore potential cumulative impacts on the selected VECs.

Table 9.1: Possible Mitigation and Management Measures

VEC	Possible Mitigation and Management Measures	
	Government-led Measures	**Project Sponsor-led Measures**
Water resources	■ Nepal's default guideline for EFlows, which requires EFlows to be 10% of the minimum average monthly flow unless the EIA recommends a higher flow, should be re-evaluated to include the evaluation and management of the impacts of flow modifications on biodiversity. IFC Guidelines on the selection of EFlow methods could be adopted as a model (IFC 2018a). The EFlow required to maintain aquatic integrity in the Arun River Basin is strongly linked to the river cross-section and geomorphology, with narrow incised river channels requiring less EFlow to maintain aquatic integrity while broader river channels require more EFlow. ■ Further research is needed on the habitat requirements of fish and other aquatic species in relation to river flow rate, water depth, and so forth, in order to provide the data needed for EFlows assessments and an underlying rationale for the selection of EFlows. ■ Compliance monitoring should be increased to ensure that EFlows, as approved in the EIA, are actually provided.	■ Attention should be given to management of EFlows in cascades where there should be consistency in operating rules for the powerhouses, and operation of power plants should be coordinated to maintain EFlows in the cascade.
Natural forest integrity	■ Develop a transmission master plan for the Arun and neighboring river basins so as to optimize/share transmission lines among hydropower projects. ■ Improve forest restoration achieved through appropriate research into the propagation of broader range of locally indigenous tree species, improve available horticultural facilities, provide training for horticulturalists, support the restoration of faunal species that play an important role in forest ecosystems (e.g., monkeys for seed dispersal), facilitate research by universities into wholistic forest ecosystem functioning and management, equipping, and provide training for forestry staff, support allocation of forestry and other budgets for restoration activities, collaborate with and learn lessons from the UN Decade of Ecosystem Restoration initiative, etc.	■ Develop a Workers' Code of Conduct specifying prohibited activities (such as killing of wildlife and consuming game meat, setting fires) and enforce punishments when the code is violated. ■ Avoid development of access roads for hydropower projects through KBAs and protected areas to the extent possible. ■ If there are no alternatives, use commonly constructed access roads on a shared basis between hydropower projects. ■ For transmission lines, use bird diverters spaced across conductors in an appropriate manner to enhance visibility and with the ability to glow at night for nocturnal migrants; ■ Establish a reporting scheme in coordination with the local environment agency and forestry authority.

VEC	Possible Mitigation and Management Measures	
	Government-led Measures	Project Sponsor-led Measures
		■ Coordinate closely with qualified partners, e.g., NGOs/government working group on forest and watershed conservation.
MBNP	■ A mechanism needs to be developed at the level of the Nepal Ministry of Finance to retain funds generated from hydropower to be allocated for MBNP management purposes. ■ Support to the MBNP should be considered by the large financial institutions such as World Bank, Global Environment Facility (GEF), etc.	■ Support the management initiatives of the MBNP conservation authorities and Community Conservation Programmes, so that they are better able to cope with the increased pressure from influx and other impacts. Support should be towards improved park facilities (e.g., offices, communications, vehicles, and maintenance capacity), infrastructure to access areas for easier management, boundary demarcation, staff training and equipment, and revision of management plans, among other things.
Livelihoods	■ Implement a monitoring and evaluation scheme to track agriculture land and land use conversion and assess livelihood activities related to fishing and those that depend on terrestrial biodiversity and forest land (e.g., hunting, forest product extraction). ■ Implement monitoring and evaluating to understand changes/impacts (if any) on livelihood activities that depend on water resources quality and quantity (such as agriculture, livestock rearing and domestic use).	■ Identify the exact number of households affected by the loss of community forests acquired by the project. Consult affected communities to discuss ways in which their loss of access to community forests can be compensated. ■ Carry out agricultural intensification schemes to make upland land more productive (through irrigation) so that the impact on overall productivity in the basin is mitigated; ■ Consider women's crucial role in the management of agriculture and forest resources. The distinct impacts of land (and forest) acquisition on women should be documented and addressed properly to make sure women's status does not deteriorate further. ■ Establish a reporting scheme commitment in coordination with the local forestry and agriculture agencies. ■ Adopt sustainable fishing techniques under programs that have already seen success in Nepal, such as One Village One Pond.

<table>
<tr><th rowspan="2">VEC</th><th colspan="2">Possible Mitigation and Management Measures</th></tr>
<tr><th>Government-led Measures</th><th>Project Sponsor-led Measures</th></tr>
<tr><td></td><td></td><td>■ Cold-water aquaculture schemes focused on specific communities, such as the Majhi and the Magar.
■ Establish a reporting scheme commitment in coordination with the local water resource agency.
■ Coordinate closely to implement interventions, if necessary with a qualified NGO/government working group related to water resource management and irrigation.</td></tr>
<tr><td>Settlement and social cohesion</td><td>■ Raise awareness among local communities and other stakeholder groups (including hydropower developers and sand and gravel mining entities) upstream for the proper management of waste along with specific zones being declared for muck/spoil disposal etc. – including excess borrow and inert waste.</td><td>■ Respect and fulfil human rights obligations enshrined in ILO Convention 169 and UNDRIP for protecting the rights of indigenous peoples.
■ Follow due process of FPIC.
■ Ensure meaningful participation of project-affected indigenous and local communities in all phases of the project – planning, implementing, monitoring and evaluation.
■ Provide required information on the project to the affected communities.
■ Ensure both quantity and quality with respect to the representation of women in project-related consultations and decision-making processes. Women's concerns should be clearly reflected in the mitigation plans/measures.
■ Develop a Workers' Code of Conduct for proper waste management – which specifies which activities are allowed (and which areas can be used for muck/spoil disposal etc.) and impose penalties if the conduct is breached.</td></tr>
<tr><td>Fish and aquatic species</td><td>■ Research is needed to understand fish behavior for upstream and downstream migrations across dams, to support design of fish passage systems that are effective, especially for the Sapta Koshi and Lower Arun HEPs, which will impact upstream migration of several species, including the endangered golden mahseer.
■ Guidelines should be prepared for the design of fish passes specifically suited for indigenous species (IFC 2018b). Continuous</td><td>■ Successful fish passage systems in the Himalayas should be used as examples of fish passage design and operation for the fish species of interest in the basin, namely snow trout and golden mahseer.
■ Fish ladders are not possible on all dams, especially high dams, so other fish passage techniques should be considered beyond the provision of fish hatcheries (see discussion</td></tr>
</table>

VEC	Possible Mitigation and Management Measures	
	Government-led Measures	**Project Sponsor-led Measures**
	research, guided by monitoring, is needed to improve the design of passages and to identify technologies that are suited for particular conditions. ■ Development of a robust methodology for monitoring the effectiveness of fish passages (e.g. counting the number of fish that pass through the ladder) is needed for all HEPs with a fish passage. ■ Capacity building is needed for hydropower project environmental staff, as well as for government employees who work with fish passages, in order to ensure that they are able to monitor and assess the efficacy of the passages. ■ There is a need for strengthened monitoring and enforcement to ensure required EFlows are actually released, as recent studies in Nepal have found that nearly all hydropower projects do not actually release the required EFlow. ■ A basin-level strategy should be developed for collaboratively designing power plants in the basin to avoid peaking designs where possible, and to minimize impacts of peaking when not. ■ For any hydropower projects considering peaking operation, a robust EFlows assessment should be conducted to evaluate a range of peaking scenarios in order to reach a balance between power generation and environmental protection – enforcement of EFlow requirements via monitoring and fines is needed by the Nepal Government and lenders. ■ Regulation of fishing by communities should be explored. ■ Subsistence fishing should be allowed where sustainable, but fishing methods should be controlled and use of destructive practices such as electrocution and fishing with nets of fine mesh sizes should be prohibited. ■ Use of chemicals to catch fish should be strongly prohibited. By using chemicals or biocides, both macroinvertebrates and fish and their fry are killed. The use of these chemicals not only poisons the fish, but they are also dangerous for people who eat the fish.	below). Alternatives include trap and trucking fish around the dams, nature-like fishway, and habitat enhancements to help maintain fish populations between dams. All low dams on rivers/streams with migrating fish should include a functioning fish passage facility. ■ Downstream fish passage facilities should also be provided to maintain fish populations. ■ Environmental Flows (EFlows) should be designed within the framework of sustainable development to balance the conservation of aquatic ecosystems with loss in power generation as EFlow is increased. EFlow management plans should be developed in accordance with best practice and should thoroughly understand aquatic biodiversity within proposed diversion reaches (IFC 2018b). The appropriate EFlow should be determined based on an assessment of native fish flow requirements and should not be based on an arbitrary flow statistic (e.g., 10% of the lowest monthly flow). ■ Peaking operations should consider options for regulating peaking impacts such through a cascade or with a regulating dam downstream. ■ EFlow should take into consideration the potential for peaking operations to disrupt connectivity between the Arun River and important spawning tributaries. Maintaining fish connectivity with important tributaries, especially during the spring fish migration, is critical for maintaining a naturally-reproducing native fish population. ■ Each HEP should develop a sediment flushing strategy that guides the timing of flushing during the monsoon, when silt loads are high and flushing is unlikely to cause alteration of habitats.

VEC	Possible Mitigation and Management Measures	
	Government-led Measures	Project Sponsor-led Measures
	■ There is a need for the development of a robust methodology per international standards for establishing baselines for aquatic biodiversity during ESIA process, as well as methodologies for the long-term monitoring of aquatic habitats and biodiversity. A good understanding of river ecosystems is required for management of the impacts of hydropower on fish populations. This will include aquatic biodiversity, composition and distribution of fish species, and the importance of connectivity between the main river and tributaries (IFC 2018b). ■ Novel and new survey and monitoring methodologies should be explored and tested (e.g., eDNA) and training provided to hydropower project environmental staff and government staff. ■ Capacity building is needed for hydropower project environmental staff, as well as for government employees who work with fish passages in order to ensure that they are able to monitor and assess the efficacy of the passages. ■ The government should review and update regulations for aquatic habitat protection. ■ Hatcheries should not be considered a primary mitigation option as they are unlikely to help in maintaining wild fish populations. More research is needed to understand under what conditions hatcheries can help. Until then, other mitigation options that are proven to work should be investigated, and research should be carried out on how to supplement fish populations in the wild through hatcheries. ■ A basin wide survey should be carried out with detailed sampling methodology and community consultations to identify important fish spawning areas, which are primarily found along the clear water tributaries of the Arun River, and measures should be taken to protect these important spawning areas to maintain a naturally-reproducing native fish population.	■ Sustainable sediment mining plans should be formulated on a scientific basis, to balance the economic benefits of mining with impacts of mining on aquatic ecosystems and to achieve a win-win for the economy and environment – sand mining sites must be selected to avoid sensitive aquatic habitats (e.g., spawning sites) and must be monitored. ■ Establish a reporting commitment in coordination with the local fishery and agriculture agency, river management agency.

9.3 Key Management Recommendations

This section provides some key recommendations regarding managing cumulative impacts within the Arun River Basin. These represent an action plan for UAHEL to pursue.

- *River Basin Planning:* Even with the adoption and effective implementation of recommended mitigation and management measures listed in ***Table 9.1***, construction and operation of the over 30 HEPs currently proposed within the Arun River Basin will exceed the carrying capacity of the river basin and inevitably result in significant adverse cumulative environmental and social impacts. Over 30 HEPs within this relatively small basin is simply not sustainable. The Government of Nepal should develop a River Basin Management Plan, which protects key fish spawning tributaries, minimizes social impacts, and establishes guidelines relative to fish passage, sediment management, and water quality. There is guidance available for preparing river basin management plans, such as hydropower by design approach recommended by The Nature Conservancy (Opperman *et al.* 2017). This Management Plan should critically review the need for this many projects and prioritize the most important and most sustainable ones. HEPs with the features listed in ***Table 9.2*** are not preferred and should be carefully considered before approving.

Table 9.2: Non-Preferred HEP Features

Non-preferred HEP Features	Example HEPs in the Arun Basin
HEPs located in the MBNP Core Area and other protected areas and key biodiversity areas (KBAs)	Apsuwa I, Upper Apsuwa, Upper Isuwa, and Lower Barun
HEPs requiring long access roads and/or transmission lines that result in significant habitat fragmentation and/or physical displacement	Additional field studies need to confirm access and transmission line routes, but potentially including Lower Barun, Chujung Khola, Upper Ikhuwa Khola Small, Super Sabha Khola Small, Sabha Khola-B, Sabha Khola A, Apsuwa I, Upper Apsuwa, Upper Isuwa
HEPs with long diversion reaches	To be determined based on feasibility studies documenting the proposed length of the diversion reach
HEPs located along important fish migratory routes without effective fish passage plans	To be determined, but effective fish passage at Sapta Koshi High Dam and Lower Arun are very important
HEPs located on clear water tributaries that are important for fish spawning	Additional field studies need to confirm, but potentially including Chujung Khola, Ikhuwa Khola, Ikhuwa Khola Small, Sankhuwa Khola, Lower and Upper Chirkhuwa Khola, Hewa Khola, Sabha Khola C, Lakhuwa Khola, Maya Khola, Piluwa Khola
HEPs requiring significant physical resettlement	Sapta Koshi High Dam Multipurpose Project, possibly others based on site-specific field studies
HEPs impacting areas providing important ecosystem services	To be determined based on site specific field studies

- *Cumulative Impact Assessments* – Consider requiring the use of development scenarios in future hydropower CIAs in Nepal for analyzing future consequences and management options, similar to what was done in the Kuri Kongri Basin in Bhutan and the Trishuli Basin in Nepal.
- *MBNP:* There are five HEPs planned on the Upper Arun River along the edge of MBNP Buffer Zone (Kimathanka Arun, UAHEP, Arun-3, Arun-4, and Lower Arun), three planned on tributaries in the MBNP Core Area (Lower Barun, Apsuwa I, and Upper Isuwa), and four planned on tributaries within the MBNP Buffer Zone (Upper Apsuwa, Isuwa, Lower Isuwa, and Kasuwa). The need for these

HEPs within the Core Area and those within the Buffer Zone, but with lower capacity, should be carefully balanced with their environmental and social impacts, including the construction of project access roads and transmission lines that contribute to fragmentation.

Support the management initiatives of the MBNP conservation authorities and Community Conservation Programmes, so that they are better able to cope with the increased pressure from influx and other impacts. Support should be towards improved park facilities (e.g., offices, communications, vehicles, and maintenance capacity), infrastructure to access areas for easier management, boundary demarcation, staff training and equipment, and revision of management plans, among other things. A mechanism needs to be developed at the level of the Nepal Ministry of Finance to retain funds generated from hydropower to be allocated to MBNP management purposes.

- *Natural forest integrity (impact of transmission lines on birds*): Transmission lines pose a key risk to birds and all of these HEPs will require the construction of new transmission lines. To minimize the risk to birds within MBNP and other KBAs, projects should minimize transmission line crossings of rivers/important bird flyways, be required to share transmission lines corridors, and transmission line voltages should be designed to accommodate future planned hydropower projects, and all projects should adopt bird friendly transmission line design to minimize bird collision and electrocution risk.
- *Migratory fish:* Golden mahseer and other migratory fish species are found within the Arun River Basin. It is important that fish passage is provided along their migratory routes at proposed HEPs to maintain their access to critical spawning grounds. It is especially important for the lower main stem projects to provide effective fish passage, as they could block migratory fish access to a significant number of spawning areas. This is specifically the case for the Sapta Koshi and Lower Arun HEPs, as there is documented important spawning habitat upstream from these dams. The Sapta Koshi, as currently proposed (over 200 m high), is too high for a fish ladder, but other fish passage options should be explored like trap and trucking or even the creation of a nature-like fishway, as the topography at this project is more suitable for this option than farther upstream on the Arun River. The Arun-3 HEP is currently approved without fish passage, which will prevent mid-range migrants (e.g., common snow trout) from reaching potential habitat upstream. This project is already under construction, so it is likely too late to retrofit a fish ladder, but options like trap and trucking should be considered, at least as an adaptive management measure, if monitoring indicates that the population of common snow trout upstream from Arun-3 HEP is not sustainable. The approved fish hatchery will likely contribute to the loss of native fish stocks. Tributary streams important for fish spawning (e.g., Ikhuwa Khola) should be protected (e.g., remain free of hydropower projects).
- *Fish and aquatic habitat* – The provision of a scientifically-based environmental flow (EFlow) within the diversion reaches of the proposed HEPs is critical to maintain the ecological integrity of the Arun River and its tributaries and the ecosystem services they provide. The goal should be to maintain naturally reproducing populations of all native fish species in each segment of the Arun River between the main stem hydropower projects. This will require protecting key clear water tributaries, which are used by common snow trout and golden mahseer for spawning. In the case of Upper Arun, this would mean protecting Ikhuwa Khola from hydropower development;
- *River-based livelihoods:* Conduct regular socialization, consultation, and monitoring activities with relevant stakeholders; ensure that the HEP grievance mechanism is well socialized; and develop relevant community development programs for the HEP-affected people in coordination with government authorities. Provide livelihood restoration for residents that are affected by conversion of the Arun River into a series of reservoirs, diversion reaches, and modified flow reaches.
- *Social cohesion*: Develop a strategic plan and provide funding to help local indigenous peoples (especially upstream from Num) to retain their social identify, cohesion, and heritage in response to both significant improvements in access to this area and labour influx.

- *Cultural heritage:* A cultural heritage management plan should be developed to manage impacts on tangible and intangible cultural heritage resources. In addition, a chance finds procedure should be developed and implemented for all tangible heritage resources that may be uncovered during the construction period. The procedure should be disclosed to the EPC, contractors, and community. HEPs must also consult local leaders before construction activities to discuss cultural heritage sites and understand when planned ceremonies/rituals take place within/near the construction area.
- *Settlement*: Maximize the recruitment of local workers where feasible and provide training to increase the capacity of eligible local people; establish a grievance mechanism (including a gender based violence [GBV] reporting and management system) accessible for all community groups (and workers) to report concerns associated with workers; and conduct investigations into the grievances and address them in a timely manner.
- *Sediment management (related to water resources):* All proposed HEPs must include an effective strategy for managing sediment, both to sustain their own operations, as well as to maintain downstream river geomorphic functioning and to minimize the river's erosion potential. Sediment flushing during the monsoon season should be considered as part of the sediment management strategy, but project developers must demonstrate that this sediment will not silt up the project's diversion reaches.
- *Capacity building, regulatory review, monitoring, and enforcement:* There is a need for more capacity building within the key hydropower regulatory agencies in Nepal in terms of evaluating project impacts, cumulative impacts, and compliance monitoring and enforcement.
  - The DoED and MoFE need to carefully review proposed HEPs to ensure they are properly managing key environmental and social impacts, including physical and economic displacement, EFlows, fish passage, sediment management, and habitat fragmentation.
  - The Ministry of Energy and the MoFE both need capacity building in terms of the assessment and management of cumulative impacts on VECs such as those caused by UAHEP in combination with other projects, activities, and stressors.
  - There is also a need for effective construction and operation phase monitoring and enforcement. A recent review of hydropower projects in Nepal (Dangol and Uprety 2019) found that many that hydropower construction contractors were unaware of required mitigation measures and that many HEPs were not complying with EIA approval conditions. Recent studies have found little compliance with required EFlows and required fish ladders are not designed for the native fish, thereby undermining their likely effectiveness. Further, little government compliance monitoring or enforcement is occurring, and there are no efforts at adaptive management. A much more robust compliance monitoring, enforcement program, and adaptive management is needed to achieve sustainable hydropower in Nepal. The DoED and MoFE should consider more use of participatory monitoring by local communities of HEP construction and operation, especially the Arun River Basin which is far from agency headquarters in Kathmandu and more difficult to monitor because of distance and cost, and stronger enforcement measures.

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ANNEX A CIA WORKSHOP MINUTES

CIA Consultation Workshop of Upper Arun Hydroelectric Project

11 November, 2019

Workshop Minutes

Background

A Cumulative Impact Assessment (CIA) is being undertaken for the Upper Arun Hydroelectric Project (UAHEP) in conjunction with the project's Environmental and Social Impact Assessment. ERM, in partnership with NESS and TMS, are conducting the UAHEP CIA with a particular focus on:

- Cumulative effect of hydropower development in the Arun River basin;
- Cumulative effect on the riverine fishery of Arun River basin including rare and endangered species; and
- Cumulative effect on culture and well-being of ethnic minorities whose life is dependent on natural resources and eco-system services.

UAHEP CIA Workshop Objectives

The purpose of the workshop is to facilitate an open discussion on the potential cumulative impacts of hydropower projects of the UAHEP and other hydropower projects in the Arun River Basin.

Workshop Summary

A two hour consultation workshop of the UAHEP CIA was held on 11 November, 2019 in Hotel Annapurna, Kathmandu. Representatives from UAHEP, DOED, WECS, NARC, and Makalu Barun National Park were in attendance. The list of the participants is annexed at the end of this workshop summary report.

Mr. Ram Chandra Poudel, Project Manager of Upper Arun Hydroelectric Project gave the welcome speech. He gave brief description on the ongoing project activities, environmental and social impact of the project, recommended measures, CIA strategy, assessment and management.

Ms. Christine Bryant from ERM presented a brief overview of the CIA process (according to IFC's 6-step CIA process) and requested input from the participants for each of the 6 steps as summarized below:

- Step 1a: **Preliminary VECs:**
  - Water resources, especially changes in the flow regime;
  - Fish and aquatic habitat, especially the common snow trout, which is the most abundant migratory fish found in the Upper Arun River;
  - Forest loss and fragmentation, including effects on birds and wildlife species;
  - Livelihoods – impacts on traditional and river dependent livelihoods;
  - Social Cohesion - changes in traditional lifestyles, use of natural resources, ecosystem services, cultural practices, differential effects on women; and
  - Makalu Barun National Park (MBNP – effects on MBNP core and buffer areas).
- Step 1b: **Spatial boundary** for the UAHEP CIA: encompasses the Arun River Basin from the Nepal/Tibet border to the confluence of the Arun River and Sabha Khola. The CIA study area is situated in Sankhuwasabha District.
- Step 1c: **Temporal Boundary** for the UAHEP CIA: The temporal boundary for CIA analysis is typically related to the life expectancy of the identified project, in this case UAHEP. For other projects, we typically include those which will reasonably happen within the next 10-15 years
- Step 2: Identifying **hydropower developments** and stressors in the UAHEP CIA Study Area:
  - Apsuwa, Arun III, Chujung Khola, Ikhuwa Khola, Kimathanka Arun, Lower Arun, Lower Barun Khola, Lower Isuwa Khola, Sabha Khola A, Upper Ikhuwa Khola
- Step 3: Establishing the VEC Baseline
- Steps 4,5 and 6: Assessing cumulative impacts and mitigation measures

Key questions and issues raised by the participants:

- It was pointed out that Arun IV project was missing under CIA study area.
- Project licensed within the recent 2 months of Barun Khola project should be included as well.
- It was suggested to update the capacity table and include Arun IV and Barun Projects
- It was suggested to give official letter to DoED in order to request of any type of information.
- It was highlighted that Makalu Barun Conservation Area is a buffer zone area, focus should be given to the conservation of the critical species of that area.
- ERM described that help from relevant department for hydrological data will be very helpful.
- Impact on Transmission line and Koshi Highway corridor should be included in CIA
- It was questioned on who monitors/ address the issues of obstruction in dewater zone, best management practice and the uncertainty.
- It was suggested to include impact from other projects and identify the mitigation measures.
- It was recommended for the formation of basin level committee since Upper Arun cannot take the responsibility of the whole other impacts, same was done in case of Upper Trishuli Project.
- It was suggested to considered Water conservation act of Nepal in CIA.
- It was recommended to have Basin level plan to mitigate cumulative impacts .
- It was pointed out that the scale of operation has significant impact on the CIA process.
- Queries were made whether CIA is mandatory or not and whether CIA is mentioned in any legal reference in Nepal or not?
- It was elaborated that CIA is mentioned in WECS draft.

- Queries were made on the legal requirement of CIA.
- It was questioned whether EIA is required even after CIA or not.
- Discussion on the need of fish ladder and fish hatchery as an appropriate fish impact mitigation measures by all the projects.
- It was suggested that for the legalization of the project document, one should request for recommendation from the conservation area.
- It was suggested to have consensus of local government in the CIA process

The questions and queries made by the participants were responded by the team of experts from ERM. Similarly the comments and suggestions received from the participants were well taken by the team which will be incorporated in the UAHEP CIA.

In his closing remark, Mr. Ram Chandra Poudel expressed appreciation to the participants of the workshop for their active participation and contributions by providing valuable comments and suggestions.

ANNEX B DOWNSTREAM CIA CONSULTATIONS FIELD REPORT

Upper Arun HEP

Cumulative Impact Assessment Workshop

Kathmandu, Nepal
11 November, 2019

ERM

in association with:

NESS

TOTAL MANAGEMENT SERVICES
Engineering & Management Total Consulting Firm

The business of sustainability

ERM

Agenda

Time	Agenda
10:30 – 10:45am	**Welcome and Introductions**
10:45 am – 12:15 pm	**UAHEP CIA** • Overview of the CIA Process • Discussion of the Valued Environmental and Social Components for the UAHEP CIA
12:15 – 12:30 pm	**Closing Note**

Introductions

Cumulative Impacts Assessment Overview

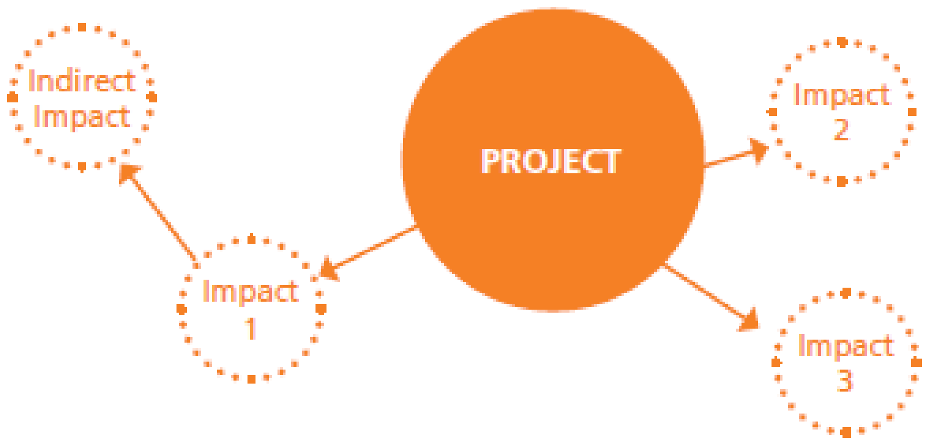
- The objectives of a CIA are to:
  - analyze the potential impacts and risks of proposed projects in the context of the potential effects of other human activities and external stressors on VECs (Valued Environmental and Social Components) over time, and
  - propose measures to avoid, reduce, or mitigate such cumulative impacts and risk, to the extent possible

- For practical reasons, the identification, assessment, 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 – VECs

- CIA is another environmental and social **risk management tool**, like a Environmental and Social Impact Assessment (ESIA), but they are different….

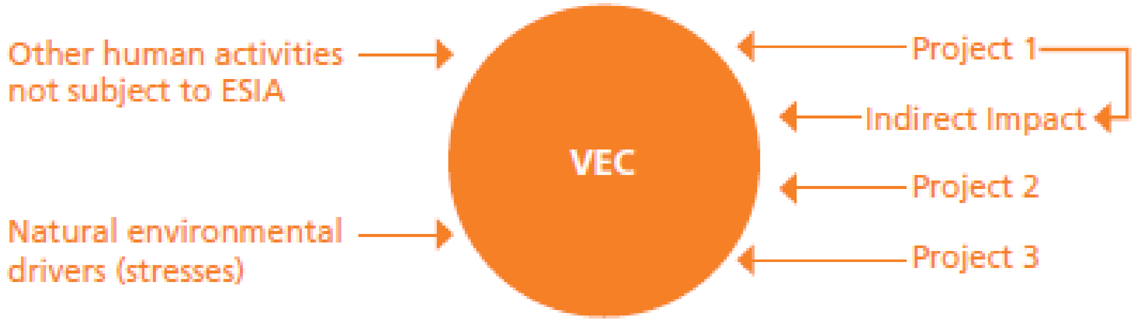
ESIA vs. CIA

ESIA



An ESIA describes the setting, impacts, and mitigation actions for a **specific project**. Focused in the project’s area of influence.

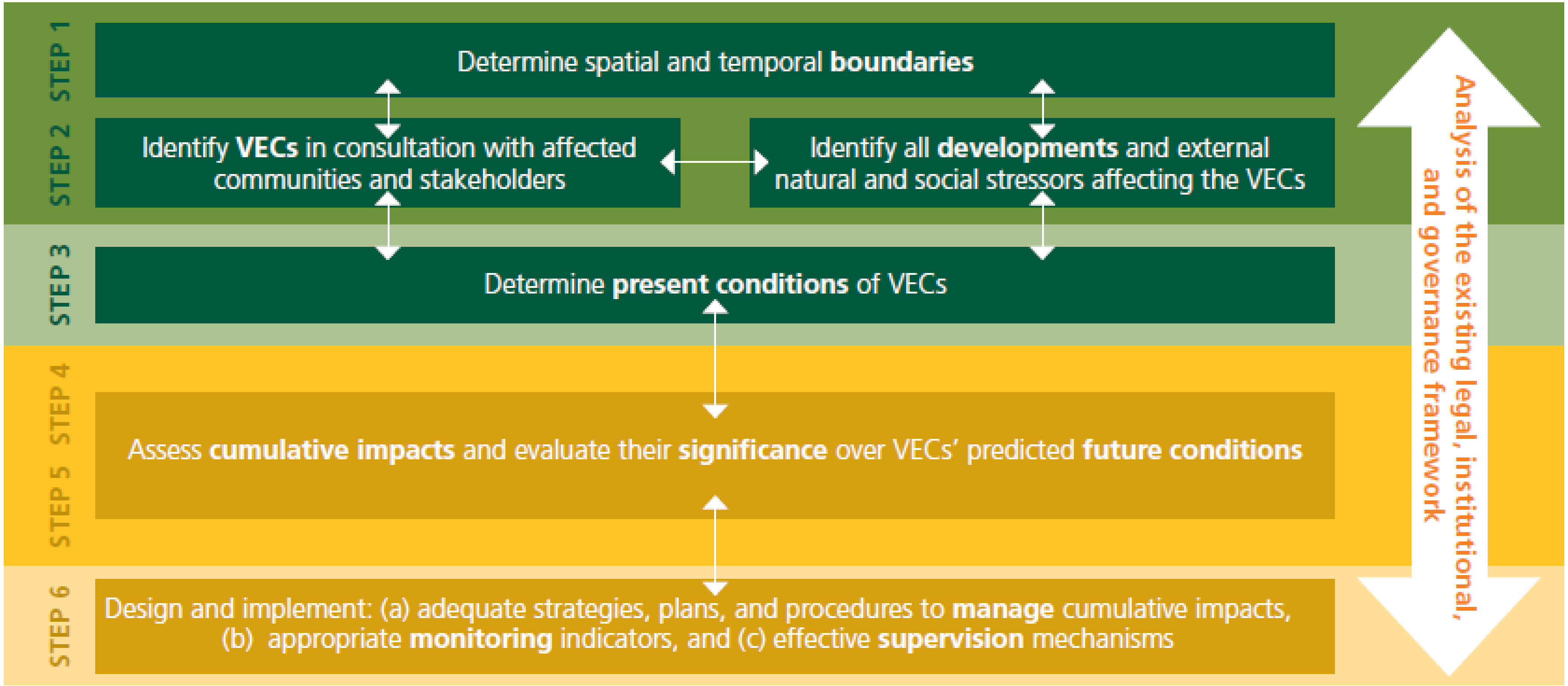
CIA



A CIA focuses on **VECs**, assessing how the VECs will be impacted under scenarios of current, planned, and future projects and stressors. A CIA assesses selected VECs in an expanded spatial and temporal boundary.

Source: World Bank/IFC, 2013

World Bank/IFC 6-Step CIA Process



VECs

- Environmental and social components considered as important by the scientific community and/or concerns of affected communities. Examples:
  - Physical features, habitats, wildlife populations (e.g., biodiversity, water supply)
  - Ecosystem services (e.g., protection from natural hazards, provision of food)
  - Natural processes (e.g., water and nutrient cycles, microclimate)
  - Social conditions (e.g., community health, economic conditions)
  - Cultural heritage or cultural resources aspects (e.g., archaeological, historic, traditional sites)





Step 1: Preliminary VECs Identified for the UAHEP CIA

Preliminary VECs:

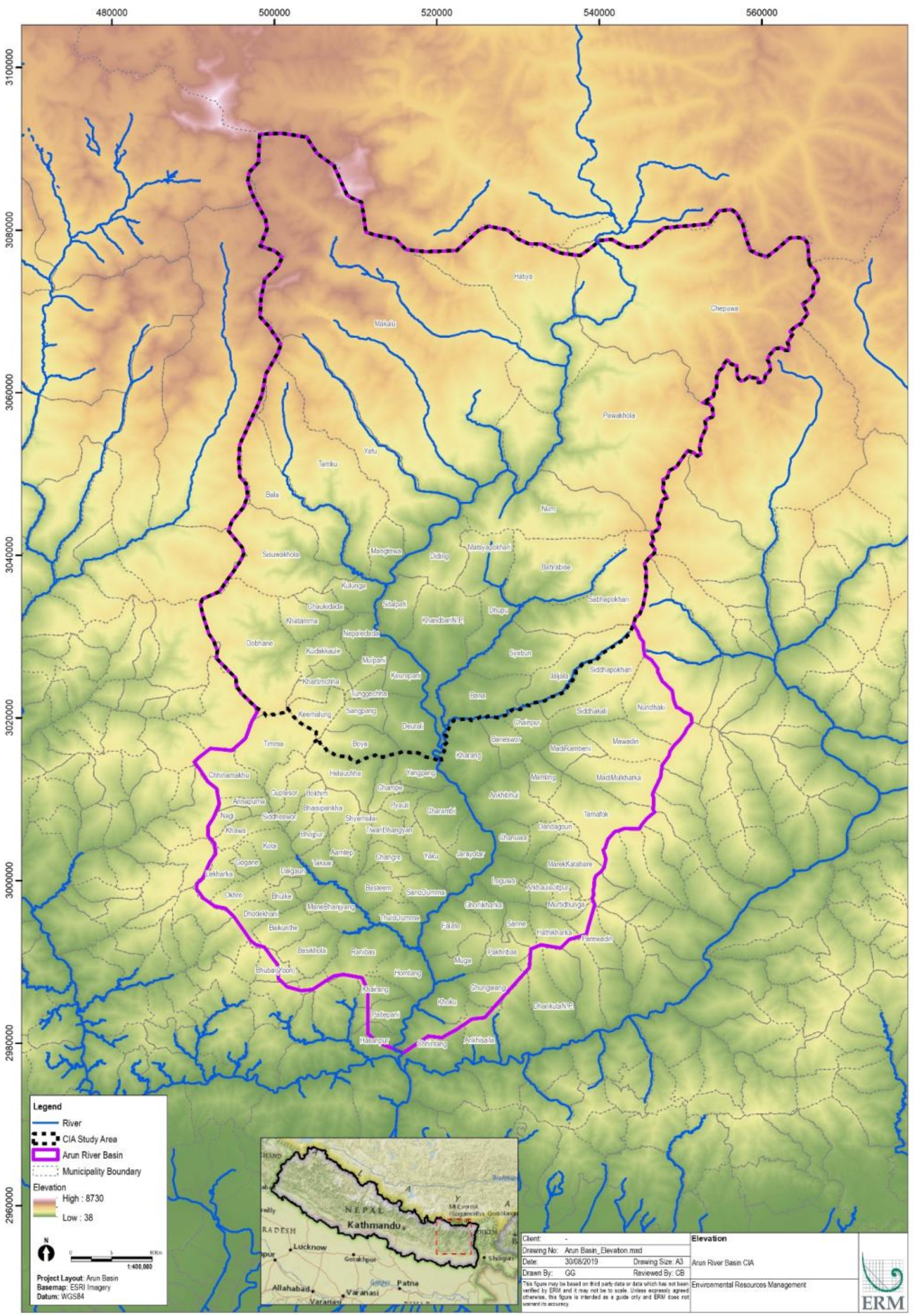
1. Water resources, especially changes in the flow regime;
2. Fish and aquatic habitat, especially the common snow trout, which is the most abund migratory fish found in the Upper Arun River;
3. Forest loss and fragmentation, including effects on birds and wildlife species;
4. Livelihoods – impacts on traditional and river dependent livelihoods;
5. Social Cohesion - changes in traditional lifestyles, use of natural resources, ecosyste services, cultural practices, differential effects on women; and
6. Makalu Barun National Park (MBNP – effects on MBNP core and buffer areas.

Step 1: Spatial Boundary

UAHEP CIA Study Area

Objective: Establish a spatial boundary that encompasses the geographic extent of impacts (from other past, present, and predictable future developments) that influence VEC conditions throughout the time period during which UAHEP impacts will occur

The spatial boundary for this CIA encompasses the Arun River Basin from the Nepal/Tibet border to the confluence of the Arun River and Sabha Khola. The CIA study area is situated in Sankhuwasabha District.



Step 1: UAHEP CIA Temporal Boundary

Objective: Establish a temporal boundary that considers past, existing and reasonably foreseeable future activities/projects

Temporal Boundary for the UAHEP CIA

- The temporal boundary for the CIA analysis is typically related to the life expectancy of the identified project, in this case UAHEP. For other projects, we typically include those which will reasonably happen within the next 10-15 years

Step 2: Identify Projects and Stressors in the UAHEP CIA Study Area

Objectives:

- Identify other past, existing, or planned projects within the boundaries
- Identify presence of natural influences / stressors

Questions to answer:

- Are there any other existing or planned activities affecting the same VEC?
- Are there any natural forces / phenomena affecting the same VECs?

Rules of Thumb:

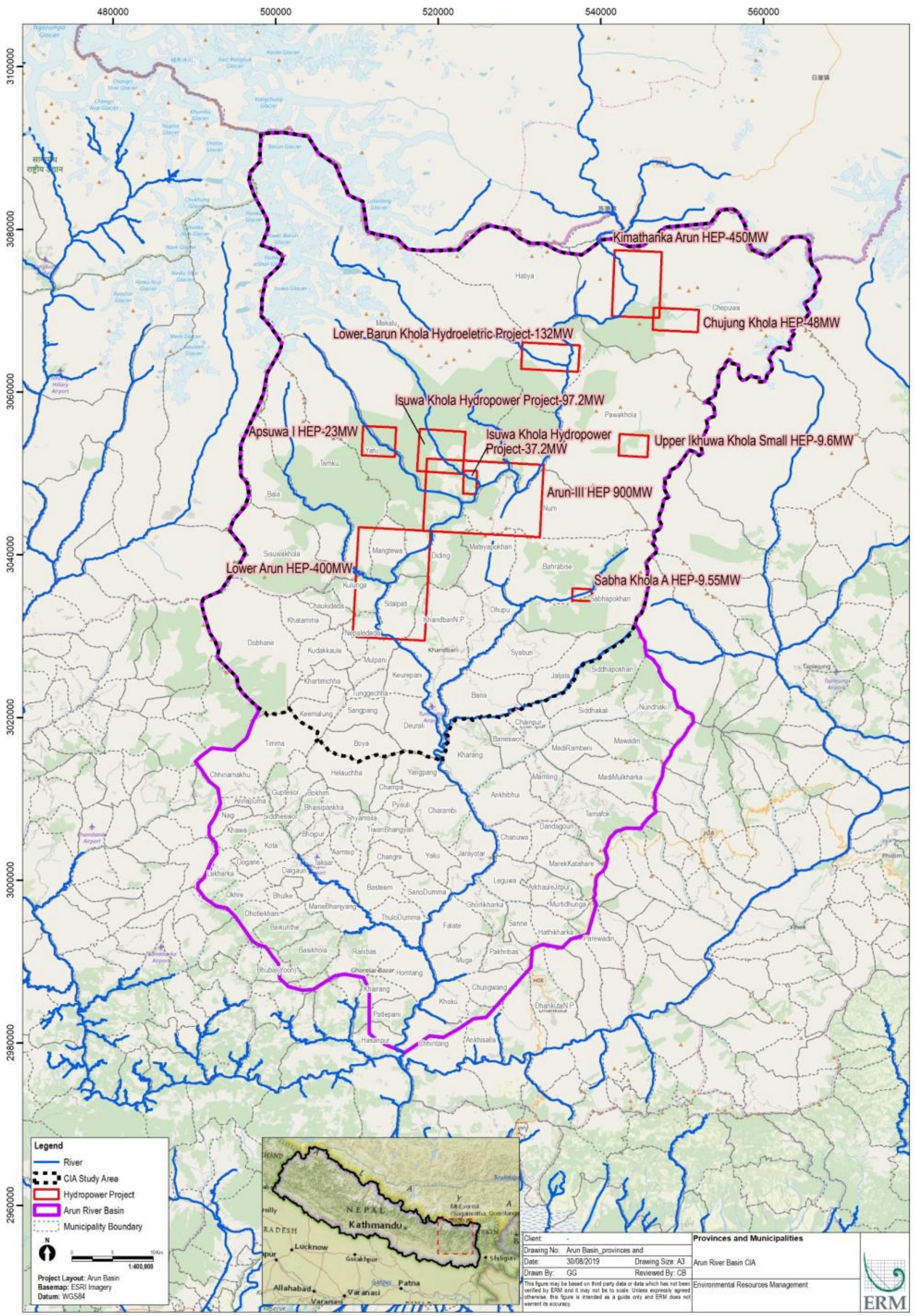
- Based on existing information and available sources
- Classify projects by common characteristics
- Obtain, to the extent possible, enough information to be able to estimate their impacts on VECs
- Consider the certainty (or uncertainty) of future or planned activities

Step 2: Identify HEPs in the CIA Study Area

Project	License Status	Capacity (MW)	River	Municipality/District	Promoter
Apsuwa I	Survey - Issued	23	Apsuwa	Makalu,Yafu (Sankhuwasabha)	Ram Janaki Hydropower Pvt. Ltd
Arun III	Generation - Issued	900	Arun	Diding,Num,Makalu,Matsya, Pokhari,Mangtewa,Pathibhara (Sankhuwasabha)	Satluj Jal Vidyut Nigam Limited
Chujung Khola	Survey - Issued	48	Chujung Khola	Chepuwa (Sankhuwasabha)	Sangrila Urja Pvt. Ltd
Ikhuwa Khola	Survey - Issued	30	Ikhuwa	Makalu	Upper Arun Hydro Electric Limited
Isuwa Khola	Survey – Issued	97.2	Isuwa Khola	Makalu (Sankhuwasabha)	KBNR Isuwa Power Ltd.; Dolakha Nirman Company Pvt. Ltd.
Kimathanka Arun	Survey – Issued	450	Arun	Keemathnka,Chepuwa (Sankhuwasabha)	Vidhyut Utpadan Company Limited
Lower Arun	N/A	400	Arun	Bhot Khola Rural Municipality, Sankhuwasabha	
Lower Barun Khola	Generation – Applied	132	Barun Khola	Bhot Khola Rural Municipality, Sankhuwasabha	Ampik Energy Pvt Ltd
Lower Isuwa Khola	Survey – Issued	37.7	Isuwa Khola	Makalu (Sankhuwasabha)	Isuwa Energy Pvt. Ltd
Sabha Khola A	Survey – Issued	9.55	Sabha Khola	Sabha Pokhari (Sankhuwasabha)	Sankhuwasabha Power Development Pvt.Ltd
Upper Arun	Survey – Applied	1,040*	Arun	Pathibhara,Pawakhola (Sankhuwasabha)	Upper Arun Hydro Electric Limited
Upper Ikhuwa Khola Small	Survey - Issued	9.6	Ikhuwa Khola	Pawakhola (Sankhuwasabha)	Khadga Bdr Karkee
Total		3,147.05			

Step 2: HEPs in the UAHEP CIA Study Area

Objective:
Identify other past, existing, or planned projects within the boundaries



Step 2: Stressors in the UAHEP CIA Study Area

Stressors: sources or conditions that could affect or cause physical, biological, or social stress on VECs

Potential stressors include:

- Climate change
- Natural disasters
- Deforestation
- Landslides

Step 3: Establish VEC Baseline

- Objectives:
  - Define existing condition of the selected VECs
  - Understand its potential reaction to stress - resilience / recovery time
  - Assess trends

- Questions to answer:
  - What is the existing condition of the selected VECs?
  - What are the indicators used to asses such condition?
  - What additional data is needed?
  - Who may already have this information?

Step 3: Establish VEC Baseline

- VEC Indicators:
  - To define appropriate indicators, one needs to understand the VEC's condition (is the VEC condition stable, deteriorating, improving?)
  - Indicators help assess VEC *threshold* – state beyond which the VEC condition is unstainable, unviable
  - Examples :
    - Total land cover for habitat fragmentation
    - Macroinvertebrate population for aquatic habitat conditions
    - Total number of incidents for community health

- Rules of Thumb:
  - Defining indicators, trends and thresholds can be data intensive – but many sources available (e.g., EISA, universities, research institutes, government agencies, historical societies, NGO, individuals)
  - Refer to existing regulations (e.g. water quality/ air quality)

Step 3: Establish VEC Baseline

VEC	Baseline Condition & Key Components	Key Indicators	Key Sources of Information
Water resources, especially changes in the flow regime			
Fish and aquatic habitat			
Forest loss and fragmentation, including effects on birds and wildlife species			
Livelihoods – impacts on traditional and river dependent livelihoods			
Social Cohesion - changes in traditional lifestyles, use of natural resources, ecosystem services, cultural practices, differential effects on women			
Makalu Barun National Park (MBNP – effects on MBNP core and buffer areas.)			

Steps 4, 5, 6 – Assessing Cumulative Impacts & Mitigation Measures

VEC	Key Stressors	Key Impacts	Suggested Mitigation Measures
Water resources, especially changes in the flow regime			
Fish and aquatic habitat			
Forest loss and fragmentation, including effects on birds and wildlife species			
Livelihoods – impacts on traditional and river dependent livelihoods			
Social Cohesion - changes in traditional lifestyles, use of natural resources, ecosystem services, cultural practices, differential effects on women			
Makalu Barun National Park (MBNP – effects on MBNP core and buffer areas.)			

Closing Note

Thank you

The business of sustainability

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ANNEX C NEPAL ADMINISTRATIVE AND LEGAL FRAMEWORK

Constitution
Constitution of Nepal, 2015
Plans
National Water Plan, 2005
Brief Guideline for Preparation of Water Use Master Plan, 2017
Strategies
Agriculture Development Strategy 2015–2035
Forest Sector Strategy 2016–2025
National Energy Crisis Reduction and Electricity Development Decade, 2015
National Energy Strategy of Nepal, 2013
National Water Resources Strategy, 2002
Rural water supply and Sanitation National Strategy, 2004
Policies
Climate change Policy 2019
Draft Water Resources Policy, 2019
Forest Policy,2000
Hydropower Development Policy (HDP), 1992 and Hydropower Development Policy, 2001
Irrigation Policy, 2013
Land Acquisition, Resettlement and Rehabilitation Policy, 2015
Land Use Policy, 2015
National Agriculture Policy, 2004
Public-Private Partnership Policy, 2015
Water-induced Disaster Management Policy, 2015
Acts
Aquatic Protection Act, 1960
Civil Code, 2017
Consumer Protection Act, 1999
Criminal Code, 2017
Development Board Act, 2706
Disaster Risk Reduction and Management Act, 2017
Draft Irrigation Act, 2015
Draft Water Supply and Sanitation Act, 2018
Electricity Act, 1992
Environment Protection Act, 2019
Essential Commodity Protection Act, 1955
Forest Act, 1993 and Forest Act, 2019
Guthi Corporation Act, 1976
Industrial Enterprises Act, 1992
Inter-governmental Fiscal Management Act, 2017

Land Acquisition Act, 1977
Lands Act, 1964
Land Use Act, 2019
Local Government Operation Act, 2017
Natural Resources and Fiscal Commission, 2017
Nepal Electricity Authority Act, 1984
Nepal Electricity Regulatory Commission Act, 2017
Public Private Partnership (PPP) and Investment Act, 2019
Water Resources Act, 1992 and Draft Water Resources Act, 2019
Water Supply Management Board Act, 2006
Provincial Acts
Irrigation Act, 2018 (P-1)
Rules
Drinking Water Rules, 1998
Electricity Rules, 1993
Environment Protection Rules, 2020
Forest Rules, 2020
Irrigation Rule, 2000
Rafting Rule, 2006
Water Resources Rule, 1993
Guidelines/Directives/Manuals/ Working Procedures
Directives for Use of Forest for National Prioritized Projects, 2017
Guidelines to Provide Land for Construction of Infrastructure Projects in Conservation Areas 2024
Directives on Licensing of Hydropower Projects, 2016
Drinking Water Service Operation Directive, 2012
EIA/IEE Working Procedure for Hydropower and Transmission Lines, 2016
Hydropower Environmental Impact Assessment (EIA) Manual, 2018
Gender Equality and Social Inclusion Mainstreaming Guideline for Irrigation and Water Induced Disaster Prevention Sectors, 2014, Ministry of Irrigation
Guidelines for Study for Hydropower Projects, 2003
Land Ceiling Exemption Order, 2017
Local Energy Development Directive, 2017
National Drinking Water Quality Standard, 2005
National EIA Guideline, 1993

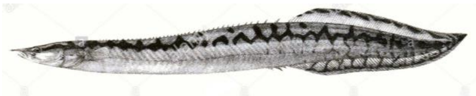
ANNEX D FISH SPECIES POTENTIALLY PRESENT IN THE ARUN BASIN

Fish Species Potentially Present in the Arun River Basin

S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
1		*Amblyceps mangois*	Torrent catfish/ Baljung, Bokshi macho	LC	Endemic, R	125mm	Mid distance	No known commercial importance
2		*Anguilla bengalensis*	Longfin freshwater eel, Indian Mottled Eel/ Raj Bam, Rem	NT		2,000mm / 6kg	Long distance	Commercial fisheries; Likely for aquaculture; gamefish; TP, PR
3		*Barbus Chilinoides = Naziritor chelynoides*	Dark mahseer	VU		600 – 700mm	Long distance	valuable
4		*Barilius barila*	Barna Baril / Faketa Chahale	LC		100mm	Resident	Used as bait
5		*Barilius barna*	Barna Barile/ Pati Pattaure, Titerkane, Faketa	LC	C	150mm	Resident	Minor commercial importance to fisheries
6		*Barilius bendelisis*	Hamilton's Barila/ Chiple Faketa, Gurdere	LC	C	227mm	Resident	Commercial importance to fisheries
7		*Barilius shacra*	Chacra Baril/ Fakete	LC	Uncommon CL	130mm	-	No known commercial importance

S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
8		*Barilius vagra*	Vagra Baril/ Lam faketa	LC	Uncommon	156mm	Resident	No known commercial importance
9		*Balitora brucei*		NT	Unknown	Small < 100mm	Resident	No known commercial importance
10		*Botia Geto= Botia dayi Hora=Botia dario*	Bengal loach Necktie Loach, Striped Stone Loach/ Bothn	LC	CL, PR	150mm		Commercial: aquarium species
11		*Botia almorhae= B. lohachata= B. grandis= B. rostrata*	Yoyo-Loach, Tiger Loach/ Baghi, Getu	NE	Uncommon, CL Slow warter	154mm	Resident	Commercial: aquarium species
12		*Channa gachua*	Dwarf snakehead	LC		small		No known commercial importance. Aquarium fish
13		*Clupisoma garua*	Garua Bachcha, Guarchcha/ Jalkapoor, Baikha	LC	Uncommon	609mm / 3kg	Long distance	Commercial: fisheries; gamefish
14		*Clupisoma montana*	Kocha Garua/ Jalkapoor	LC	Uncommon	290mm	-	No known commercial importance
15		*Crossocheilus latius latius*	Gangetic Laita, Stone Roller/ Lohari, Mate Buduna	DD	C	150mm	Resident	No known commercial importance

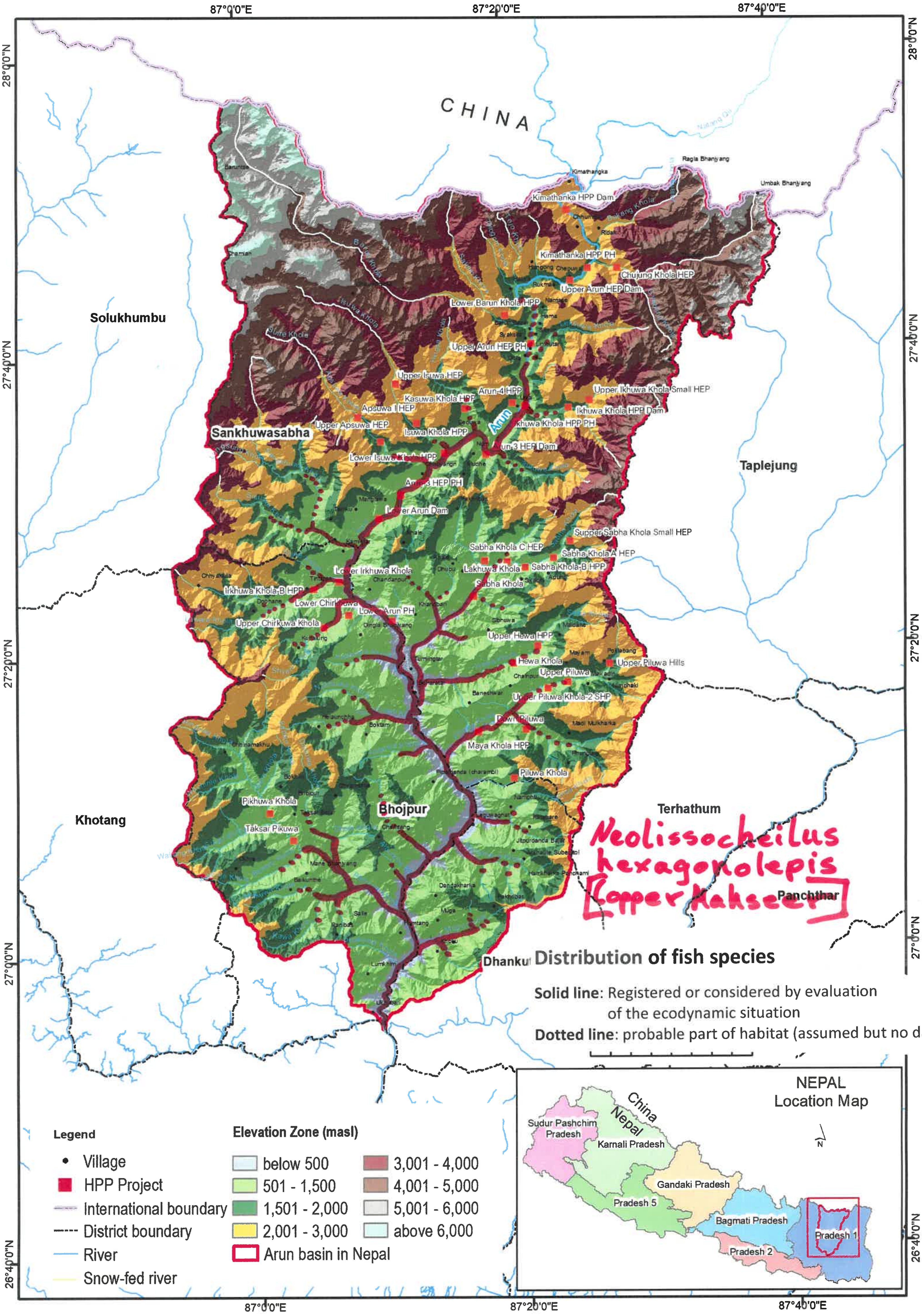
S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
16		Glyptosternum blythii =*Exostoma blythii* = *Myersglanis blythii*	Dwarf Catfish, Tilchabre	DD	unknown	70-80 mm	short distance	No known commercial importance
17		*Euchiloglanis hodgarti=* Parachiloglanis hodgarti	Catfish	LC	unknown			No known commercial importance
18		*Garra annandalei*	Buduna, stone sucker,	LC	Uncommon	150mm	Resident	No known commercial importance
19		*Garra gotyla gotyla*	Stone Sucker/ Nakato	LC	C	145mm	Resident	Minor commercial fishery importance
20		*Garra rupecula = Garra rupicola*	Buduna	NT	Unknown	small	resident	low
21		*Glyptothorax cavia*	Vedro	LC	CL	175mm	resident	Minor commercial fishery importance
22		*Glyptothorax indicus*	Catfish Capre	LC	Fast flowing rivers	120mm		No known commercial importance
23		*Glyptothorax pectinopterus*	Capre	LC	Uncommon	180mm	Resident	No known commercial importance
24		*Glyptothorax telchitta*	Telcapre	LC	Common	152mm	Resident	Minor commercial fishery importance

S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
25		*Glyptothorax trilineatus*	Telcapre	LC	common		resident	No information
26		*Hetropneustes fossilis*						
27		*Labeo angra*	Thilke	LC		220mm		Subsistence fisheries
28		*Labeo dero (Sinilabeo dero)*	Kalebans, River Rohu/ Gurdi, Bashari	LC	C	750mm	Mid distance	Commercial fisheries; usually used as bait
29		*Mastacembelus armatus*	Chuche Bam	LC			resident	-
30		*Neolissochilus hexagonolepis*	Katli/ Katle	NT	GF, TP	1,200mm / 11 kg	Mid distance	Fisheries: Commercial Aquaculture: Commercial Gamefish: Yes
31		*Noemacheilus bevani*	Gadela				Resident	
32		*Noemacheilus botia = Acanthocobitis botia*	Loach	LC	Common Hilly clearwater rivers	small		Medicine aquarium
33		*Pseudecheneis crassicauda*	Kabre	DD	CL, PR	140mm		No known commercial importance

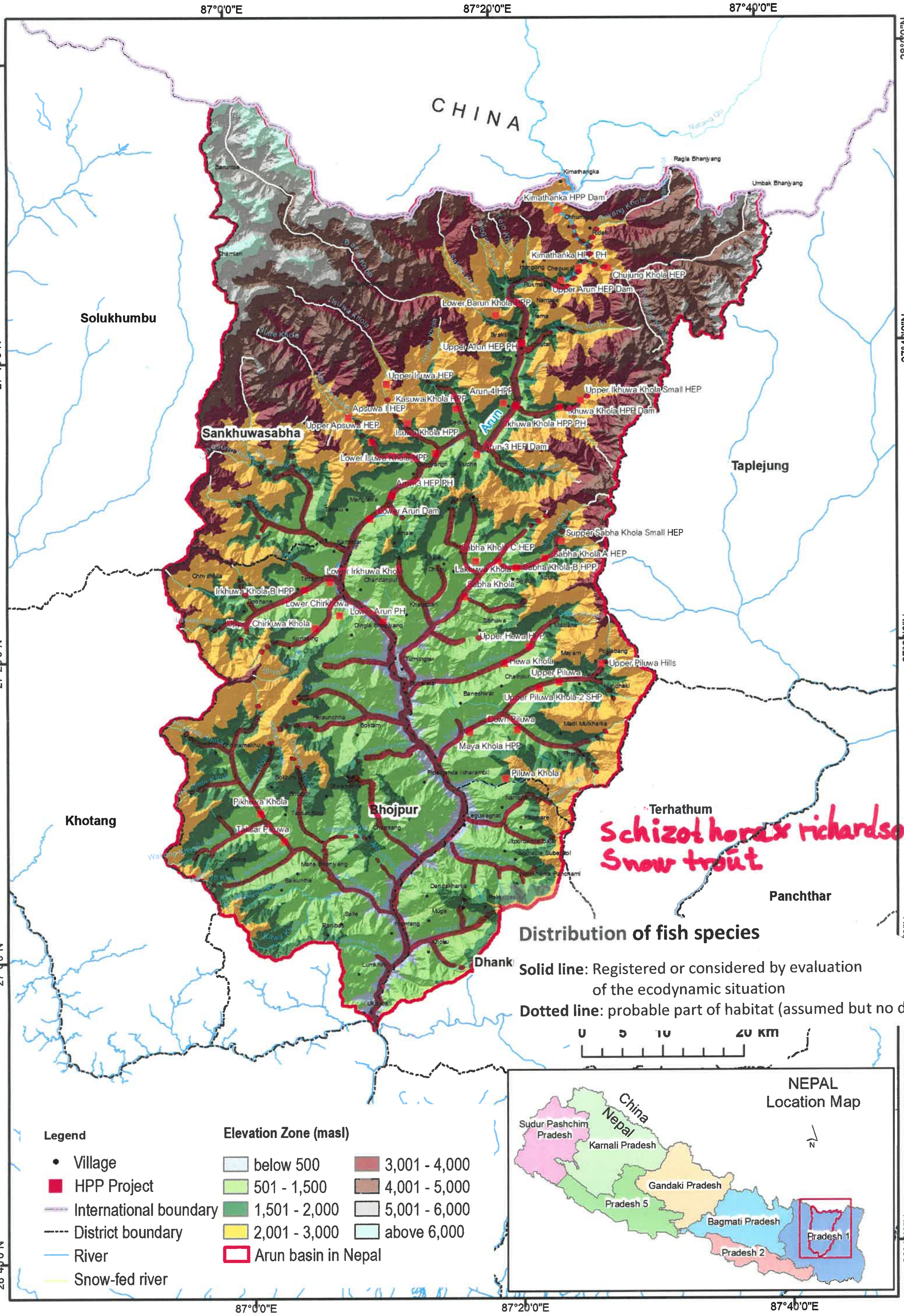
S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
34		*Pseudecheneis sulcatus*	Sulcatus / Kabre	LC	CL, PR	200mm	Resident	No known commercial importance
35		*Psilorhynchus pseudecheneis*	Stone carp, Tite machha	LC	Endemic, CL, PR	200mm		No known commercial importance
36		*Puntius sarana*	Oliv barbe	LC		300 mm	resident	Not known
37		*Schistura multifaciata = Nemacheilus rupicola*		LC		100 mm	resident	No interest
38		*Schistura rupecula*	Stone loach Bhotee Gadelo	LC	CL, PR	85mm		No known commercial importance
39		*Schistura savona*		LC		small	Resident	No known commercial importance
40		*Schizothoraichthys progastus*	Pointednosed Snowtrout/ Chuche Asla	LC	C	500mm	Mid distance	Commercial: fisheries; gamefish
41		*Schizothorax plagiostomus*	Golden Snowtrout, Spotted	NE	Declining	600mm / 2kg	Mid distance	Commercial: fisheries

S/N	Image	Scientific Name	English Name/ Local Name	IUCN Red-List Status	Status in Nepal	Max. Length / Weight	Migratory behaviour	Value to local communities
42		*Schizothorax richardsonii*	Bluntnosed Snowtrout/ Buche Asla, Budhe Asla	VU	Declining	600mm / 2kg	Resident	Commercial: fisheries; gamefish
43		*Tor putitora*	Putitor Mahseer/ Pahale Sahar Golden Mahseer, Mansar, Ratar	EN	GF, PR, TP	1,800mm / 48kg	Long distance	Commercial fisheries; aquaculture; gamefish; aquariums
44		*Tor tor*	Tor Mahseer/ Falame Sahar	DD	GF, PR, TP	2,000mm / 9 kg	Long Distance	Commercial fisheries; aquaculture; gamefish

ANNEX E ESTIMATED DISTRIBUTION RANGE OF SELECT FISH SPECIES IN THE ARUN BASIN



87°0'0"E
87°20'0"E
87°40'0"E
28°0'0"N
27°40'0"N
27°20'0"N
27°0'0"N
26°40'0"N
CHINA
Solukhumbu
Sankhuwasabha
Taplejung
Khotang
Terhathum
Panchthar
Dhankuta
Bhojpur
Arun
Kimathanka HPP Dam
Kimathanka HPP PH
Chujung Khola HEP
Upper Arun HEP Dam
Lower Barun Khola HPP
Upper Arun HEP PH
Upper Isuwa HEP
Arun-4 HPP
Upper Ikhuwa Khola Small HEP
Kasuwa Khola HPP
Apsuwa I HEP
Ikhuwa Khola HPP Dam
Upper Apsuwa HEP
Isuwa Khola HPP
Ikhuwa Khola HPP PH
Lower Isuwa Khola HPP
Arun-3 HEP PH
Lower Arun Dam
Supper Sabha Khola Small HEP
Sabha Khola C HEP
Sabha Khola A HEP
Lakhuwa Khola
Sabha Khola-B HPP
Lower Irkhuwa Khola
Irkhuwa Khola-B HPP
Sabha Khola
Lower Chirkuwa
Lower Arun PH
Upper Chirkuwa Khola
Upper Hewa HPP
Hewa Khola
Upper Piluwa Hills
Upper Piluwa
Upper Piluwa Khola-2 SHP
Lower Piluwa
Maya Khola HPP
Piluwa Khola
Pikhuwa Khola
Taksar Pikuwa
Ragla Bhanjyang
Umbak Bhanjyang
Kimathangka
Neolissocheilus hexagonolepis [Copper Mahseer]
Distribution of fish species
Solid line: Registered or considered by evaluation of the ecodynamic situation
Dotted line: probable part of habitat (assumed but no data)
NEPAL
Location Map
China
Nepal
Sudur Pashchim Pradesh
Karnali Pradesh
Gandaki Pradesh
Pradesh 5
Bagmati Pradesh
Pradesh 2
Pradesh 1
Legend
Village
HPP Project
International boundary
District boundary
River
Snow-fed river
Elevation Zone (masl)
below 500
501 - 1,500
1,501 - 2,000
2,001 - 3,000
3,001 - 4,000
4,001 - 5,000
5,001 - 6,000
above 6,000
Arun basin in Nepal



Distribution of fish species

Solid line: Registered or considered by evaluation of the ecodynamic situation

Dotted line: probable part of habitat (assumed but no data)