

# **ANNEX 10**

## **STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)**

---



---

<b>Annex 10</b>	<b>Strategic Environmental Assessment (SEA)</b> .....	<b>10-1</b>
10.1	Legal and Institutional Framework for SEA .....	10-1
10.1.1	Legal Framework on Environmental and Social Considerations .....	10-1
10.1.2	Legal Framework on SEA .....	10-4
10.1.3	Institutional Framework for SEA.....	10-5
10.2	Policy of SEA .....	10-7
10.2.1	Analysis of Power Development Scenarios .....	10-7
10.2.2	Analysis of Optimum Scenario .....	10-9
10.2.3	Good Practices from Priority Projects .....	10-9
10.3	Environmental and Social Challenges with Existing Projects.....	10-10
10.4	Scoping.....	10-11
10.4.1	Hydropower Plant .....	10-11
10.4.2	Renewable.....	10-12
10.4.3	Others .....	10-13
10.5	Evaluation of Development Scenarios .....	10-15
10.5.1	Protected Areas .....	10-15
10.5.2	Chure Conservation Area.....	10-19
10.5.3	Key Biodiversity Area .....	10-23
10.5.4	Forest.....	10-27
10.5.5	Livelihood/ Cropland.....	10-31
10.5.6	Resettlement.....	10-35
10.5.7	Climate Change.....	10-37
10.5.8	Summary - Evaluation of Development Scenarios.....	10-38
10.6	Evaluation of Optimum Scenario .....	10-40
10.6.1	Impact Assessment .....	10-40
10.6.2	Impact Assessment by Sub-basin .....	10-40
10.7	Stakeholder Consultations.....	10-63
10.7.1	1st Stakeholder Consultation .....	10-63
10.7.2	2nd Stakeholder Consultation .....	10-65
10.8	Examination of Mitigation Measures and Monitoring.....	10-68
10.9	Good Practices Learnt from Priority Projects.....	10-71

---



## ANNEX 10 STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

This project falls under the sectors/characteristics that are likely to have an impact on the general public, or areas that are likely to be impacted, as listed in the “Guidelines for Environmental and Social Considerations” (published in April 2010). However, in consideration of the sector, project content, and area characteristics, it is judged that the undesirable impact on the environment is not significant, and therefore the project is classified under Category B. The concept of SEA (Strategic Environmental Assessment) will be introduced in this IPSPD (Integrated Power System Development Plan).

### 10.1 LEGAL AND INSTITUTIONAL FRAMEWORK FOR SEA

#### 10.1.1 Legal Framework on Environmental and Social Considerations

##### (1) Environmental Legislation

The main environmental laws and regulations in Nepal are EPA (Environmental Protection Act) 2019 and EPR (Environmental Protection Rules) 2020, which are the revised versions of the EPA and EPR established in 1997. Local legislation on environmental and social considerations is given in the table below.

**Table 10.1-1 Local Legislation on Environmental and Social Considerations**

No.	Domestic legislation, policies and guidelines	Year established	Outline
<b>General</b>			
1	Constitution of Nepal (2072/2015)	2015	Outlines the legal rights and principles in Nepal.
<b>Environmental</b>			
1	National Environmental Policy (2076/2019)	2019	Stipulates a strategy, action plans and institutional framework etc. in the environmental field.
2	EPA (2076/2019)	2019	Requires the conservation of the environment and measures to prevent pollution.
3	EPR (2077/2020)	2020	Defines the EIA (Environmental Impact Assessment) procedures, requirements and regulations.
4	EIA Guidelines (2052/1993)	1993	Joint guidelines established with the IUCN (International Union for Conservation of Nature) that gives further details on EIA procedures, such as community participation.
5	Forest Law (2076/2019) and Regulations (2079/2022)	2019/ 2022	Defines the regulations concerning deforestation due to development (protection of important tree species, reforestation, etc.)
6	National Parks and Wildlife Conservation Act (2029/1973)	1973	Stipulates principles and rules for national parks in Nepal.
7	National Biodiversity Strategy and Action Plan (2014-2020)	2014	Describes a short-term and long-term plan for biodiversity conservation.
8	National Climate Change Policy (2076/2019)	2019	Describes a promotion of climate change mitigation and adaptation measures as well as a transition to low carbon society etc.
<b>Social</b>			
1	Land Acquisition Law (2034/1977)	1977	Defines the regulations on land acquisition and rights in Nepal.
2	Law concerning the expropriation of real estate (2013/1956)	2013	Defines the procedures and compensation for expropriation of property for public purposes.
3	Land use Policy of Nepal, (2072/2015)	2015	Stipulates land management based on a land use plan to achieve efficient and sustainable land management.

Source: JICA Study Team

In addition, Nepali government signed upon environment-related international conventions etc. as shown in table below.

**Table 10.1-2 International Agreements and Declarations concerning Environmental Issues signed by Nepal Government (examples)**

No.	Items
1	Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar), 1987
2	Convention on International Trade in Endangered Species of Wild Fauna and Flora, 1975
3	Vienna convention for the protection of the ozone layer, 1994
4	Montreal Protocol on substances that deplete the ozone layer, 1987
5	Basel convention on the control of trans-boundary movements of hazardous wastes and their disposal, 1996
6	Convention on biological diversity, 1993
7	United Nations framework convention on climate change, 1992
8	Kyoto Protocol to the United Nations Frame-work Convention on Climate Change, 1997/16/10/2005
9	Stockholm Convention on Persistent Organic pollutants, 2001
10	Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade, 1998
11	Indigenous and Tribal Peoples Convention, 1989 (No. 169)

Source: Prepared by JICA Study Team

## (2) EIA System of Nepal

Under the EPA 2019 and EPR 2020, projects are classified into one of the following categories depending on the size and type of project, and the type of environmental assessment required depends on this classification: (a) Projects that require EIA, (b) Projects that require IEE (Initial Environmental Examination), (c) Projects that require BES (Brief Environmental Study).

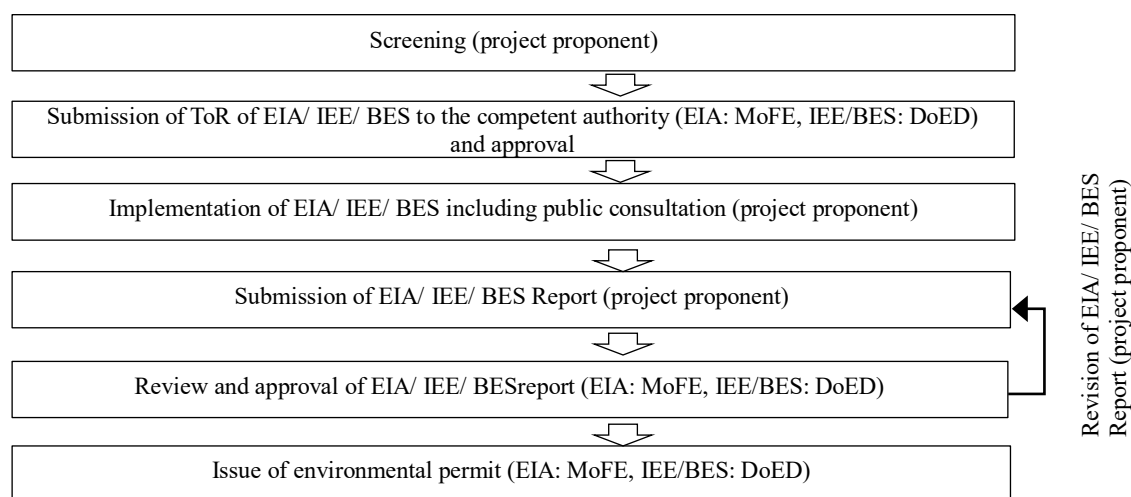
**Table 10.1-3 Categorization Criteria**

Category	Power generation plants	Transmission line	Distribution line	Others
Projects which require EIA	Hydropower projects with more than 10 MW	N/A	N/A	Projects which require an area of more than 5ha
Projects which require IEE	Hydropower projects with less than 10 MW	Transmission line with more than 132kV or transmission line which passes through protected areas etc.	N/A	Projects which require an area of 1- 5ha
Project which require BES	N/A	Transmission line with 66-132kV which passes through forest area	N/A	-

Notes: EIA, IEE and BES are not required for distribution line projects.

Source: JICA Study Team based on EPR

The EIA/ IEE/ BES approval process is given in the figure below.



Source: JICA Study Team

**Figure 10.1-1 Approval Process of EIA/ IEE/ BES**

### (3) Environmental Standards in Nepal

The National Ambient Air Quality Standard 2012 and National Noise Standard 2012 of Nepal have set compliance standards as given in the tables below. Water quality standards for drinking water and wastewater have also been established.

**Table 10.1-4 Air Quality Standards in Nepal**

Parameter	Unit	Period	Limit
TSP	µg/m <sup>3</sup>	24 hours	230
PM <sub>10</sub>	µg/m <sup>3</sup>	24 hours	120
PM <sub>2.5</sub>	µg/m <sup>3</sup>	24 hours	40
SO <sub>2</sub>	µg/m <sup>3</sup>	1 year	50
		24 hours	70
NO <sub>2</sub>	µg/m <sup>3</sup>	1 year	40
		24 hours	80
CO	µg/m <sup>3</sup>	8 hours	10000
Lead	µg/m <sup>3</sup>	1 year	0.5
Benzene	µg/m <sup>3</sup>	1 year	5
Ozone	µg/m <sup>3</sup>	8 hours	157

Source: National Ambient Air Quality Standard 2012; Section 62, Number 19, Nepal Gazette, Part 5, 2069/04/29, Notice 2

**Table 10.1-5 Air Emission Standards (Diesel Generators) in Nepal**

Capacity	Unit	CO	HC	NO <sub>x</sub>	PM
Less than 8 kW	g/kWh	8	1.3	9.2	1
More than 8 kW, Less than 19 kW	g/kWh	6.6	1.3	9.2	0.85
More than 19 kW, Less than 37 kW	g/kWh	6.5	1.3	9.2	0.85
More than 37 kW, Less than 75 kW	g/kWh	6.5	1.3	9.2	0.85
More than 75 kW, Less than 130 kW	g/kWh	5	1.3	9.2	0.7
More than 130 kW	g/kWh	5	1.3	9.2	0.54

Source: National Air Emission Standards; Section 62, Number 30, Nepal Gazette, Part 5, 2069/07/13, Notice 2

**Table 10.1-6 Air Emission Standards (Industrial Boilers) in Nepal**

Steam generation boiler	Unit	PM
Less than 2,000 kg/h	mg/Nm <sup>3</sup>	1,200
More than 2,000 kg/h, Less than 10,000 kg/h	mg/Nm <sup>3</sup>	800
More than 10,000 kg/h, Less than 15,000 kg/h	mg/Nm <sup>3</sup>	600
More than 15,000 kg/h	mg/Nm <sup>3</sup>	150

Source: National Air Emission Standards; Section 62, Number 30, Nepal Gazette, Part 5, 2069/07/13, Notice 2

**Table 10.1-7 Noise Standards in Nepal**

Areas	Time	
	Daytime (dB(A))	Nighttime (dB(A))
Industrial areas	75	70
Commercial areas	65	55
Residential areas (rural)	45	40
Residential areas (urban)	55	50
Mixed residential areas	63	55
Protected areas	50	40

Source: National Noise Standard 2012; Section 62, Number 30, Nepal Gazette Part 5, 2069/7/13

### 10.1.2 Legal Framework on SEA

The above-mentioned EAP 2019 and EPR 2020 stipulate the procedure of SEA (Strategic Environmental Assessment); however, since this procedure was recently introduced, no previous cases were confirmed in Nepal. The discussions with the implementing agency, MoEWRI, were held regarding the process to be applied to this master plan, and as a result, it was confirmed that this master plan would be an internal document approved by MoEWRI and would not require the SEA procedures in EPA 2019 and EPR 2020<sup>1</sup>.

<sup>1</sup> As observed in the Pokhara City Wastewater Management Master Plan (developed after the EPR 2020) where the SEA procedures stipulated in EPR 2020 were not automatically applied, each ministry and agency in charge flexibly judges its applicability, according to the actual situation. Note that this SEA is positioned as part of this master plan, and a separate SEA report will not be prepared.

**Table 10.1-8 Laws/Regulations related to SEA in Nepal**

Local laws/ Regulations	Contents
EPA 2019	<p>9. Strategic environmental assessment</p> <p>(1) Prior to the implementation of such policy, program or project as may be specified by the Government of Nepal by a notification in the Nepal Gazette, the strategic environmental assessment shall be carried out in relation to such a policy, program or project.</p> <p>(2) Other provisions relating to strategic environmental assessment shall be as prescribed.</p>
EPR 2020	<p>10. Strategic environmental Assessment</p> <p>(1) The relevant ministry of Nepal government for the purpose of section 9 subsection 1 of the regulation will prepare a list of policy, program and project that requires strategic environment assessment and submit it to the cabinet.</p> <p>(2) According to rule (1), before submitting the list of policy, program and project to the cabinet, the relevant ministry must take consent from National Planning Commission</p> <p>(3) Upon receiving the list of policy, program and project that requires strategic environmental assessment, the cabinet can approve the request submitted.</p> <p>(4) The relevant ministry that is related to strategic environmental assessment will determine the geographical coverage of the strategic environmental assessment and submit a report of geographical coverage by the policy, program or project for approval at the ministry itself.</p> <p>(5) According to the report submitted as per rule (4), the ministry after receiving the report can approve it within 30 days from the date of submission at ministry for approval.</p> <p>(6) Once the ministry approves the report as per rule (5), along with the approval letter and geographical report, it must be further submitted to a cabinet meeting for the approval of geographical coverage.</p> <p>(7) Once the geographical coverage area is approved as per rule (6), the relevant ministry will prepare a strategic environmental assessment report, and once the report is prepared, it must be open to public opinion and feedback by publishing a written notice in national daily newspaper. The report must be uploaded in the relevant ministry website which can be downloaded for the public opinion and comments.</p> <p>(8) Once the notice is published in national daily newspaper as per rule (7), any individual or organization that has comment or feedback on the report must submit it within the stipulated deadline in the notice to the relevant ministry.</p> <p>(9) After incorporating the feedback received as per rule (8), the report must be presented again at the relevant ministry for the approval</p> <p>(10) The report received as per rule (9), if found appropriate and satisfactory, the ministry must provide its consent to the report within 30 days of the submission of the report.</p> <p>(11) With the consent of relevant ministry as per rule (10), the final report must be submitted to the cabinet for approval.</p> <p>(12) The cabinet can approve the report received as per rule (11).</p> <p>(13) Strategic environmental assessment will follow the principles as mentioned in Annex 15 of this regulation (Note: Annex 15 describes Format/ Principles of strategic environmental assessment.)</p>

Source: JICA Study Team

### 10.1.3 Institutional Framework for SEA

#### (1) MoFE (Ministry of Forests and Environment)

MoFE is an agency which is in charge of environmental sector in Nepal. This agency is responsible for EIA, and it sets environmental standards of air, noise and water quality etc. The review and approval of IEE/BES in some specific sectors are delegated to the Ministry in charge of each sector. As for power sector, DoED (Department of Electricity Department) reviews and approves IEE/BES.

#### (2) MoEWRI (Ministry of Energy, Water Resources and Irrigation)

MoEWRI is in charge of policy making, regulations, planning in power sector, including

transmission and distribution lines. NEA and DoED have been established under MoEWRI. MoEWRI has Water, Meteorology and Environmental Division, which reviews and approves IEE with collaboration with DoED. In the Division one joint secretary and two experts have been assigned.

**(3) DoED (Department of Electricity Development)**

DoED is responsible for regulations of power sector in Nepal under MoEWRI. Delegated by MoFE, DoED reviews and approves IEE/BES. DoED has Environmental Division, which has 6 members (including one senior divisional engineer.)

**(4) NEA (Nepal Electric Authority)**

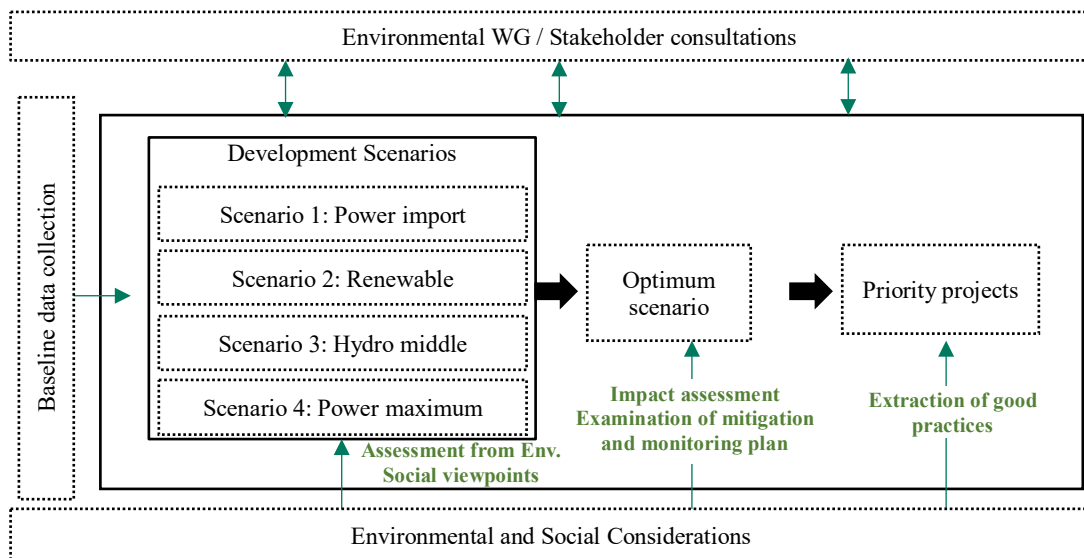
NEA was established in 1985 as an agency to do overall management of power sector. NEA has nine directorates; the ESSD (Environmental and Social Study Department) under Engineering Services Directorates is responsible for environmental and social considerations. The ESSD is composed of Environmental Study Division (15 staff members) and Environmental Monitoring Division (2 staff members). In the ESSD, there are environmental experts, flora and fauna experts and social experts, and the department is responsible for conducting EIA, implementing environmental management plans, and monitoring. Although this department is not specialized in land acquisition or resettlement action plans, a social expert from ESSD is assigned in every project.

## 10.2 POLICY OF SEA

This project is classified as Category B under JICA Guidelines for Environmental and Social Considerations (April 2010). In this master plan, the concept of SEA was applied, with the consideration of the points below.

- ❖ To minimize negative impacts and maximize positive impacts; to manage and monitor the residual impacts. In the study, especially cumulative impacts along river basins of hydropower development projects will be taken into careful consideration. The results will be incorporated into the master plan.
- ❖ To conduct meaningful consultation at the earlier stage of the study in order to ensure transparency and accountability of the master plan.
- ❖ In Nepal since SEA has not been fully conducted before, the concepts and approach of SEA will be closely discussed with the implantation agency which should be mainly in charge of environmental and social considerations in Nepal, so that environmental and social considerations are appropriately implemented from the master plan preparation stage to the monitoring stage.

The workflow of SEA is shown in figure below. During the scoping and draft master plan preparation stages of the SEA, environmental working groups (WGs) and stakeholder consultations were held, and the opinions of stakeholders were reflected in the results of the SEA.



Source: JICA Study Team

**Figure 10.2-1 Draft Workflow of SEA**

### 10.2.1 Analysis of Power Development Scenarios

In this study, multiple power development scenarios were examined based on 3E (Energy security, Economy, Environment) as part of the integrated power development plan up to 2040.

The Department of Electricity Development (DoED) of MoEWRI has centralized jurisdiction over the investigation, construction and operation of power generation and transmission projects exceeding 1 MW in Nepal, and the progress of each project is categorized as follows.

**Table 10.2-1 Category of DoED Project List**

	Category	Overview
a	Power Plants	Projects under operation
b	Construction License/ Application for Construction License	Projects with construction license granted or projects which are applying for construction license.
c	Survey License/ Application for Survey License	Projects with survey license (investigation of power generation and transmission is possible) granted or projects which are applying for survey license
d	Government of Nepal (GoN) Reserved Projects	GoN reserved projects for investigation and construction
e	Other Projects	Projects of “Forwarded to Local Government”/“Selected for Competitive Bidding”

Note: Hydropower plant projects registered in the list of DoED project list are in total 829 locations (43,887MW), including existing power plants. (as of May 2021)

Source: JICA Study Team

Considering the DoED project list above, the following four scenarios are currently being considered. Based on the power source composition for each of these scenarios, environmental and social impacts will be evaluated, in consideration of the characteristics of each power source. Although “e) Other Projects” are not included in the scope of the power development plan, these were considered for a reference purpose from the perspective of SEA, which aims to broadly evaluate environmental and social impact of Nepal's potential hydropower projects.

- (1) Power Import:  
scenario in which hydroelectric power plants already under construction are developed, but new hydropower development is limited (only hydropower sites corresponding to a and b in Table 10.2-1 are developed). The shortage of power demand in the dry season will be covered by importing power.
- (2) Renewable:  
scenario for maximum utilization of renewable energy (development of only hydropower sites corresponding to a and b in Table 10.2-1). Since there is a shortage of power demand in the dry season, it will be supplemented by power imports and solar power generation.
- (3) Hydro Middle:  
scenario for hydropower development already under construction and hydropower development at the Survey License stage (only hydropower sites corresponding to a, b and c in Table 10.2-1 are developed). A shortage of power demand is not expected.
- (4) Hydro Maximum:  
scenario in which all hydropower developments listed in the DoED project list are implemented. A shortage of power demand is not expected.

In addition, the institutional issues that would be necessary to realize development scenarios are sorted out, and recommendations on the institutional aspects that need to be considered are formulated. In particular, consideration will be given to developing a mechanism to manage cumulative impacts for each basin.

**Table 10.2-2 Overview of Development Scenarios**

No.	Development Scenario	Power Source Composition as of 2040									
		ROR	PROR	STO	Diesel/Oil	Solar	Wind	Biomass	Renewable	Import	Total
1	Power Import	6,635	4,515	982	53	751	6	15	2,901	4,300	20,158
		33	23	5	-	4	-	-	14	21	100
2	Renewable	6,635	4,515	982	53	751	6	15	8,542	4,100	25,599
		26	18	4	-	3	-	-	33	16	100
3	Hydro Middle	12,193	10,738	5,390	53	751	6	15	2,901	0	32,048
		38	34	17	-	2	-	-	9	0	100
4	Hydro Maximum	14,869	12,831	12,370	53	841	6	15	2,901	0	43,887
		34	29	28	-	2	-	-	7	0	100

Note: ROR; Run of River, PROR; Peaking Run of River, STO: Storage

Upper; generation capacity (MW), lower; percentage of total power generation capacity (%) ("-" : lower than 1%)

Source: JICA Study Team

### 10.2.2 Analysis of Optimum Scenario

The selected optimal scenario was analyzed from environmental and social perspectives. Since it was expected that the conditions would differ for each river system, especially in hydropower development, the environmental and social issues that should be considered for each river system were analyzed; and mitigation measures and monitoring methods were examined.

### 10.2.3 Good Practices from Priority Projects

In this master plan, hydropower priority projects were selected from the hydropower projects listed in the optimal scenario to accelerate future hydropower development. Although the evaluation of each site should be carried out in each F/S and EIA, good practices that can be used as reference for future hydropower development in Nepal were extracted.

### 10.3 ENVIRONMENTAL AND SOCIAL CHALLENGES WITH EXISTING PROJECTS

Regarding the hydropower generation projects that have already been planned and operated, environmental and social issues were examined for each river system. In particular, some projects that involve large-scale, involuntary resettlement of residents have already generated conflicts with residents, so it is necessary to pay attention to environmental and social considerations.

**Table 10.3-1 Examples of Environmental and Social Challenges with Existing Projects**

No.	Project name	Outline	Environmental and social challenges
1	Mugu Karnali storage hydropower project	<ul style="list-style-type: none"> <li>• Development Stage: Survey license</li> <li>• Type: STO</li> <li>• Capacity: 1,902 MW</li> <li>• River System: Karnali</li> </ul>	<ul style="list-style-type: none"> <li>• The construction of the largest reservoir-type hydropower plant in Nepal is expected to affect ecosystems such as fish and downstream.</li> <li>• Cumulative impacts should be considered as multiple projects are planned for the Karnali river system.</li> </ul>
2	Tanahu hydropower project	<ul style="list-style-type: none"> <li>• Development Stage: Construction licence</li> <li>• Type: STO</li> <li>• Capacity: 140 MW</li> <li>• River System: Trishuli</li> </ul>	<ul style="list-style-type: none"> <li>• 758 affected households and 86 involuntary resettled households are expected.</li> <li>• Affected households include indigenous people (<i>Janajati</i>), and consideration based on the prepared Indigenous People's Plan is required.</li> <li>• Complaints have been made from affected people regarding resettlement and compensation. (*1)</li> </ul>
3	Budhi Gandaki storage hydropower project	<ul style="list-style-type: none"> <li>• Development Stage: GoN</li> <li>• Type: STO</li> <li>• Capacity: 1,200 MW</li> <li>• River System: Budhi Gandaki</li> </ul>	<ul style="list-style-type: none"> <li>• 8,000 households (approximately 50,000 people) are expected to be affected. (*2)</li> </ul>
4	Sun Koshi 2 hydropower project	<ul style="list-style-type: none"> <li>• Development Stage: GoN</li> <li>• Type: STO</li> <li>• Capacity: 1,116 MW</li> <li>• River System: Sun Koshi</li> </ul>	<ul style="list-style-type: none"> <li>• Loss of vegetation and ecosystems is expected, and an IUCN extinct tree species (<i>Acacia catechu</i>) has been confirmed. There are also concerns about the deterioration of water quality during operation. (*3)</li> </ul>
5	Sun Koshi 3 hydropower project	<ul style="list-style-type: none"> <li>• Development Stage : GoN</li> <li>• Type: STO</li> <li>• Capacity: 536 MW</li> <li>• River System: Sun Koshi</li> </ul>	
6	Dudhkoshi storage hydropower project	<ul style="list-style-type: none"> <li>• Development Stage : GoN</li> <li>• Type: STO</li> <li>• Capacity: 536 MW</li> <li>• River System: Sun Koshi</li> </ul>	<ul style="list-style-type: none"> <li>• 1,150 households (of which 988 are partially affected) are expected to be affected. (*4)</li> </ul>
7	Sapta Kosi high dam multipurpose project	<ul style="list-style-type: none"> <li>• Development Stage : GoN</li> <li>• Type: STO</li> <li>• Capacity: 3,300 MW</li> <li>• River System : Sun Koshi</li> </ul>	<ul style="list-style-type: none"> <li>• Involuntary resettlement of 75,000 people is expected, and there are protest movements from residents. (*5)</li> </ul>

Note: ROR: Run of River, PROR: Peaking Run of River, STO: Storage

(\*1) <https://cemsoj.wordpress.com/human-rights-advocacy/tanahu-hydropower-project/>

(\*2) <https://www.thethirdpole.net/en/livelihoods/budhi-gandaki-nepals-mega-dam-remains-a-mirage/>

(\*3) <https://www.adb.org/sites/default/files/linked-documents/47036-001-nep-earfab.pdf>

(\*4) <https://thehimalayantimes.com/nepal/dudhkoshi-storage-hydroelectric-project-to-affect-1150-households>

(\*5) <https://ejatlas.org/conflict/sapta-kosi-high-dam-multipurpose-project-nepal#>  
<https://www.thethirdpole.net/en/energy/protests-scupper-india-nepal-dam/>

Source: JICA Study Team

## 10.4 SCOPING

The outline of the baseline information for each power source assumed in the development scenarios and the points to be noted in terms of environmental and social aspects in SEA are summarized below.

### 10.4.1 Hydropower Plant

Hydropower is the main power source in Nepal, accounting for more than 90% of the power generation capacity. Looking at new hydropower development sites on the DoED project list, three major rivers, the Karnali River, the Gandaki River and the Koshi River, account for 96% of the total, and each river system has the following characteristics.

- ❖ **Karnali River:**  
Survey licenses are generally granted, but relatively few hydropower development projects have progressed to the construction stage.
- ❖ **Gandaki River:**  
Construction license and survey license have been granted. Since many existing power plants are located near demand areas, the development has been progressing.
- ❖ **Koshi River:**  
Construction license and survey license have been granted. Compared to the above written two rivers, it has a wider catchment area and tends to have a higher output. Most of the development sites at the river system near Kathmandu is under the construction stage where construction license has been granted.

Looking at the breakdown of the DoED project list, among the new hydropower development plans (725 sites), 71% (512 sites), 18% (130 sites) and 11% (83 sites) of hydropower projects are respectively “less than 30MW”, “30MW to less than 100MW”, and “more than 100MW”. Hydropower sites of 30 MW or more have been mostly identified throughout Nepal, and development rights have been granted; hence, how to realize the development of these sites is one of the challenges.

Apart from hydropower projects described in the DoED project list, there are the Sapta Koshi multi-purpose dam project (3,000 MW) downstream of the Koshi main river, which is expected to be developed through bilateral cooperation with India, and the Pancheshwar multi-purpose dam project that flows along the border with India (6,780 MW including reverse regulating pond).

The following points need to be paid attention to in SEA. (1) The situation of the development plan is different for each river system, and (2) The evaluation should consider that environmental and social impacts are different depending on the power generation method (ROR: Run of River, PROR: Peaking Run of River, STO: Storage).

- ❖ **Physical environment/Natural environment**
  - Impacts on downstream discharge (E-flow) are expected due to the construction of reservoirs and regulating reservoirs.
  - Impediments to the migration of aquatic organisms by dams and impacts on river ecosystems due to changes in flow rate are expected. A particular attention to cumulative impacts is necessary in river systems where hydropower development is concentrated.
  - ROR hydropower development projects are not expected to change flow rate or have

significant impacts on ecosystems.

❖ Social environment

- For hydropower development, large-scale involuntary resettlement and land acquisition are expected if there are houses within the planned reservoir or regulating pond. If fisheries are being carried out downstream of power generation facilities, attention should be paid to the impact on fisheries due to changes in flow rate, water quality, etc.
- Large-scale involuntary resettlement and land acquisition are not expected for ROR type hydropower development projects.

**Table 10.4-1 Items to be taken into Considerations for Hydroelectric Power Generation in SEA**

No.	Items to be taken into considerations for SEA	Hydropower		
		ROR	PROR	STO
1	E flow	B	A	A
2	Air pollution	B	B	B
3	Water pollution	B	B	B
4	Waste	B	B	B
5	Protected areas	C	C	C
6	Ecosystem	B	A	A
7	Land acquisition/ Involuntary resettlement	B	A	A
8	Indigenous peoples	C	C	C
9	Natural hazards (landslide, flood etc.)	C	C	C
10	Climate change	C	C	C

Note: A (Significant impact anticipated), B (Moderate impact anticipated), C (Impact can vary depending on site locations), D (no or negligible impact)

ROR: Run of River, PROR: Peaking Run of River, STO: Storage

Source: JICA Study Team

### 10.4.2 Renewable

Hydropower is the main power source in Nepal, but each scenario of this master plan considers the installation of renewable energy toward 2040. In this SEA, solar power generation was examined in consideration of the following points, since solar power generation is more likely to be introduced among renewable energies.

- SEA will pay attention to land acquisition and accompanying resettlement for evaluation, especially for large-scale solar power generation.
- Since Nepal is mountainous in the north-central part of the country, large-scale development is difficult in steep mountainous areas. From the viewpoint of securing suitable land, it is assumed that solar power will be introduced in the southern part of the country, mainly in the Terai Plain. On the other hand, since the Terai Plain is an agricultural area, it is necessary to pay attention to the impact on livelihoods.

**Table 10.4-2 Items to be Taken into Considerations for Renewable Energy (Solar) in SEA**

No.	Items to be taken into considerations for SEA	Renewable energy (Solar)
1	E flow	D
2	Air pollution	B
3	Water pollution	B
4	Waste	B
5	Protected areas	C
6	Ecosystem	B
7	Land acquisition/ Involuntary resettlement	A
8	Indigenous peoples	C
9	Natural hazards (landslide, flood etc.)	C
10	Climate change	C

Note: A (Significant impact anticipated), B (Moderate impact anticipated), C (Impact can vary depending on site locations), D (no or negligible impact)  
Source: JICA Study Team

### 10.4.3 Others

SEA considers the following as environmental and social impacts common to all power sources.

#### ❖ Transmission lines

- In Nepal, RoW (Right of Way) is established under overhead transmission lines<sup>2</sup>. Construction of structures within the RoW is not permitted, so in the case there are residential structures within the RoW of the transmission line, they will be subject to relocation. In addition, land acquisition is required for the tower section. Also, when there is farmland under the transmission line when it is constructed, the farmland will be temporarily unusable, so the attention must be paid to the impact on livelihoods.

#### ❖ Protected areas/ Ecosystems

- Nepal designated 12 National Parks, 1 Wildlife Reserve and 1 Hunting, 6 Conservation Areas, and 13 Buffer Zones as Protected Area under the National Parks and Wildlife Conservation Act. Any development in these areas must be approved by the authorities prior to development. Acts of damming or altering the flow of rivers are prohibited, and in hydropower development, restrictions on maintenance flow, etc. are required.
- 31 KBAs (Key Biodiversity Areas) have been identified throughout Nepal.
- SEA examines information on Protected Areas and important habitats to avoid significant impacts.

#### ❖ Indigenous Peoples

- Under the National Foundation for the Development of Indigenous Nationalities Act, 59 ethnic groups are defined as indigenous peoples (*Janajati* in the local language), distributed throughout the country.
- Consideration should be given to making plans that adequately reflect the opinions of stakeholders, as there are cases of opposition from local residents in existing reservoir-type

<sup>2</sup> The RoW is defined according to the voltage: 46 m for 400 kV transmission lines (23m from the center line to both ends), 30m for 220 kV transmission lines (15m from the center line to both ends), and 18 m for 132 kV and 66 kV transmission lines (9m from the center line to both ends).

hydropower development projects.

- In particular, Nepal ratified the ILO (International Labor Organization) Convention on Indigenous and Tribal Peoples in Independent Countries (No. 169) in 2007, and indigenous peoples will be taken into consideration in the master planning process.

Based on the above, the main objectives and judgment criteria of SEA in this master plan are shown in the table below.

**Table 10.4-3 SEA Objectives and Decision-making Criteria**

	Items	Objectives of SEA	Decision-making criteria of SEA
1	E flow	<ul style="list-style-type: none"> <li>• Avoidance/mitigation of impacts to E flow</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan avoid the impact on E flow?</li> </ul>
2	Air pollution	<ul style="list-style-type: none"> <li>• Reduction of air pollution power sector</li> <li>• Proper management of air pollutants</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan contribute to the reduction of air pollutants from power sector?</li> <li>• Does the master plan encourage the establishment of air pollutant monitoring?</li> </ul>
3	Water pollution	<ul style="list-style-type: none"> <li>• Reduction of water contaminants in power sector</li> <li>• Proper management of water contaminants</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan contribute to the reduction of water contaminants from power sector?</li> <li>• Does the master plan encourage the establishment of water contaminants monitoring?</li> </ul>
4	Waste	<ul style="list-style-type: none"> <li>• Proper management of waste (including hazardous waste)</li> </ul>	<ul style="list-style-type: none"> <li>• Is there a potential for significant environmental and social impacts from waste generated?</li> </ul>
5	Protected areas	<ul style="list-style-type: none"> <li>• Avoidance of impacts on protected areas in power sector</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan avoid projects within protected areas?</li> </ul>
6	Ecosystem	<ul style="list-style-type: none"> <li>• Avoidance/mitigation of impacts to critical habitat</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan encourage the development of a system to avoid and manage impacts to critical habitat?</li> </ul>
7	Land acquisition/ Involuntary resettlement	<ul style="list-style-type: none"> <li>• Avoidance or minimization of land acquisition and involuntary resettlement</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan take land constraints into account?</li> </ul>
8	Indigenous peoples	<ul style="list-style-type: none"> <li>• Avoidance/mitigation of impacts to cultures of indigenous peoples</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan include opinions from indigenous peoples?</li> </ul>
9	Natural disaster (landslide, flood etc.)	<ul style="list-style-type: none"> <li>• Response to natural hazards such as landslide, etc.</li> </ul>	<ul style="list-style-type: none"> <li>• Does the master plan address the risk of natural disasters?</li> </ul>
10	Climate change	<ul style="list-style-type: none"> <li>• Reduction of CO<sub>2</sub> emission in power sector</li> <li>• Response to disasters in light of the impacts of climate change</li> </ul>	<ul style="list-style-type: none"> <li>• Do the study results of scenarios (including power mix) contribute to the reduction of CO<sub>2</sub> emissions?</li> <li>• Does the master plan address the increased risk of disasters due to climate change?</li> </ul>

Source: JICA Study Team

## 10.5 EVALUATION OF DEVELOPMENT SCENARIOS

The comparative analysis of four development scenarios examined under this master plan ((i) Power import, (ii) Renewable, (iii) Hydro middle, (iv) Hydro maximum) was conducted from environmental and social viewpoints as below. In assessing the development scenarios, based on the project list provided by DoED, data on the development areas assumed in each scenario was overlaid with data on each environmental and social component (protected areas, conservation areas, ecosystems, forests, livelihoods/farmland, residential areas), and only the overlapping areas were calculated to conduct a comparative assessment of the scenarios<sup>3</sup>.

### 10.5.1 Protected Areas

Nepal has 12 National Parks, 1 Wildlife Reserve and 1 Hunting, 6 Conservation Areas, and 13 Buffer Zones as Protected Area under the National Parks and Wildlife Conservation Act.

It was found out that there are hydropower projects planned within protected areas; the protected area overlapped with hydropower projects is described as below:

- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts on protected areas would be more significant compared with other scenarios; especially, more impacts will be predicted along Koshi river.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts on protected areas would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts on protected areas would be less significant compared with other scenarios.

**Table 10.5-1 Protected Areas overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	103 km <sup>2</sup>	1,050 km <sup>2</sup>	1,076 km <sup>2</sup>	95 km <sup>2</sup>	2,324 km <sup>2</sup>
2	Renewable	103 km <sup>2</sup>	1,050 km <sup>2</sup>	1,076 km <sup>2</sup>	95 km <sup>2</sup>	2,324 km <sup>2</sup>
3	Hydro middle	269 km <sup>2</sup>	1,221 km <sup>2</sup>	1,446 km <sup>2</sup>	108 km <sup>2</sup>	3,044 km <sup>2</sup>
4	Hydro maximum	559 km <sup>2</sup>	1,501 km <sup>2</sup>	2,551 km <sup>2</sup>	841 km <sup>2</sup>	5,452 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team

<sup>3</sup> The development scenarios examined were based on data provided by DoED. Since the project boundary is shown in a rectangular frame, the area can be larger than the actual impact area; however, the four scenarios were analyzed under the same conditions, and the analysis results of the scenarios themselves are not affected.

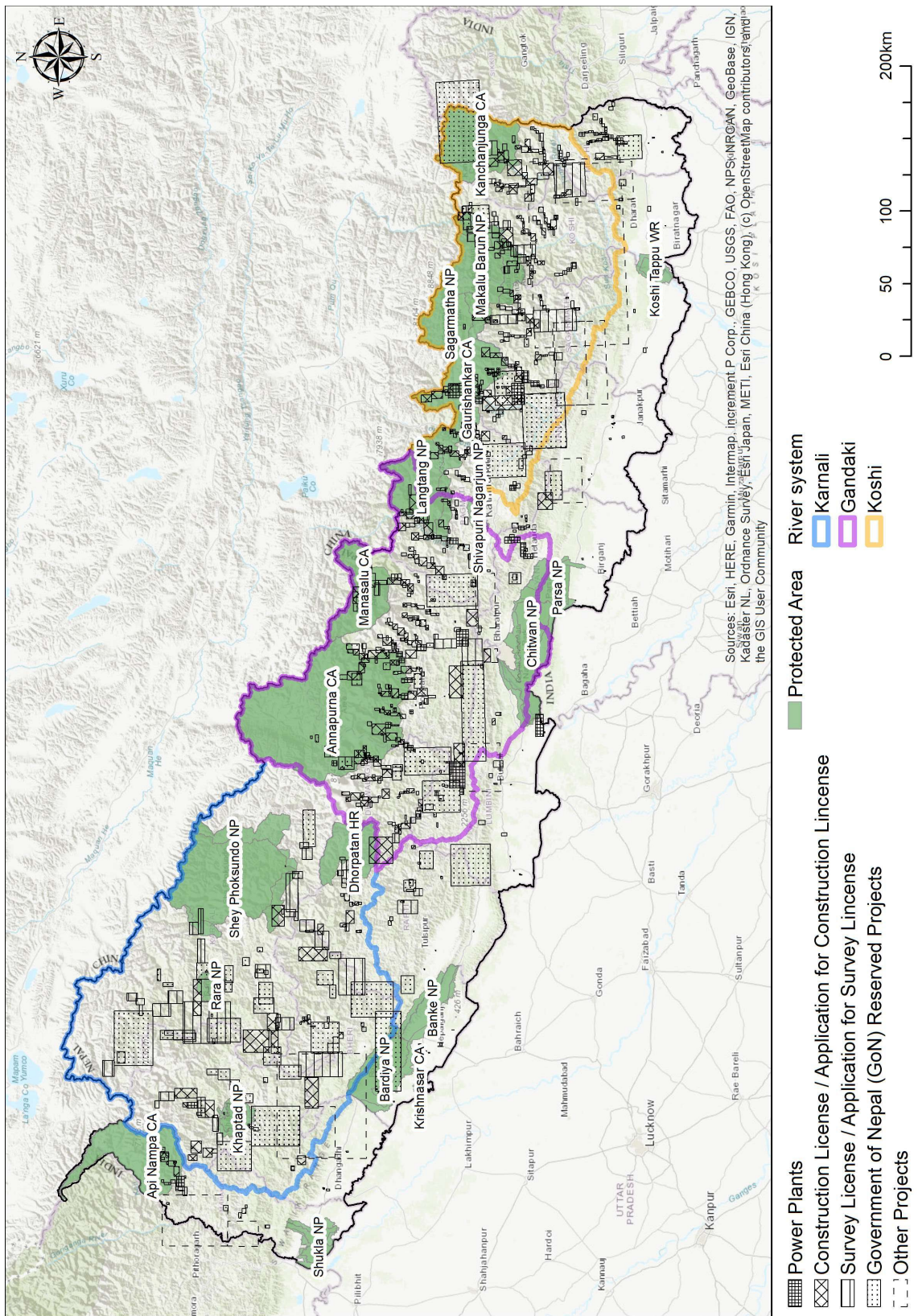
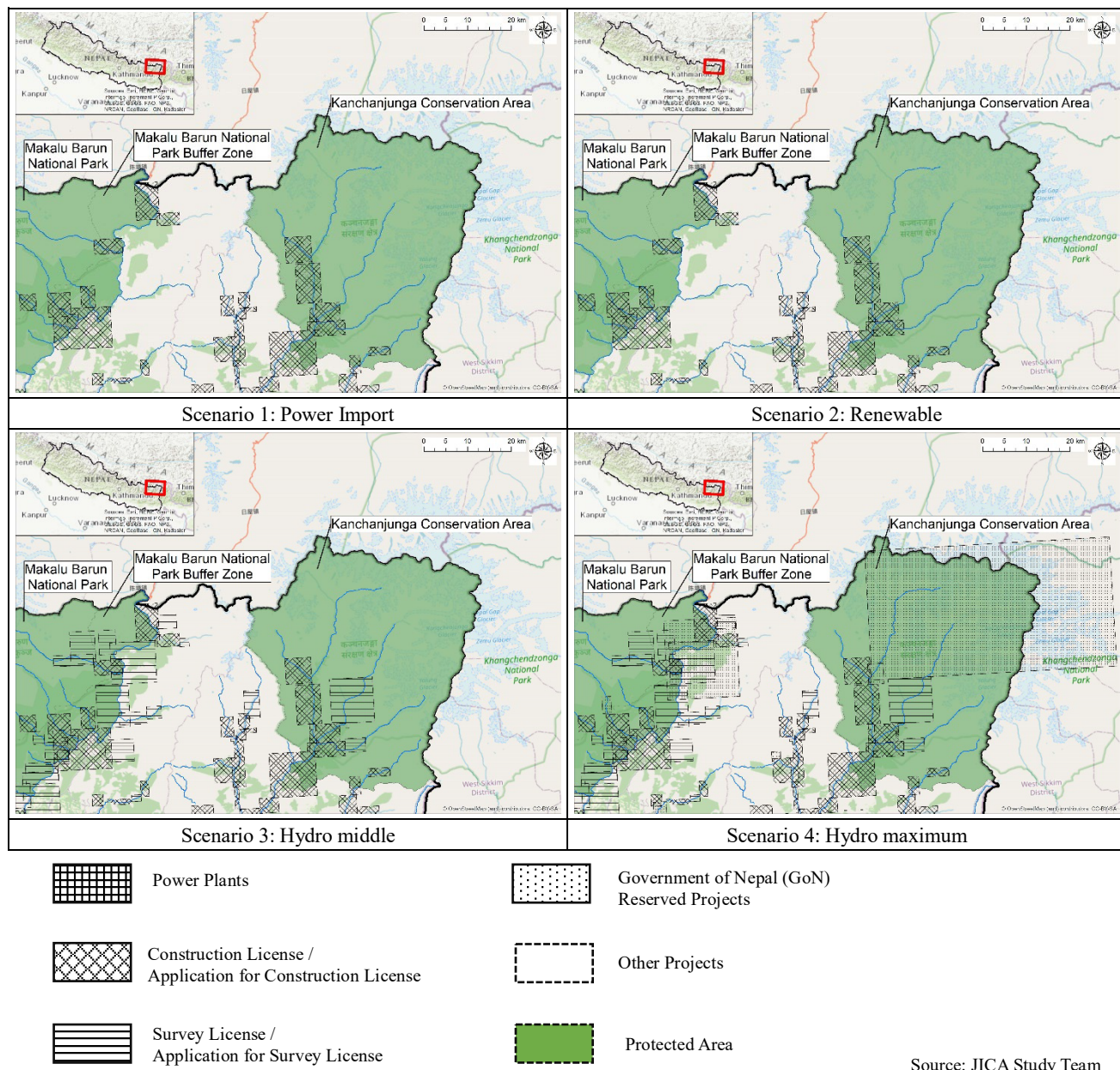


Figure 10.5-1 Protected Areas Overlapped with Hydropower Development Scenarios (Nationwide)



**Figure 10.5-2 Protected Areas Overlapped with Hydropower Development Scenarios (Koshi River)**  
(1)

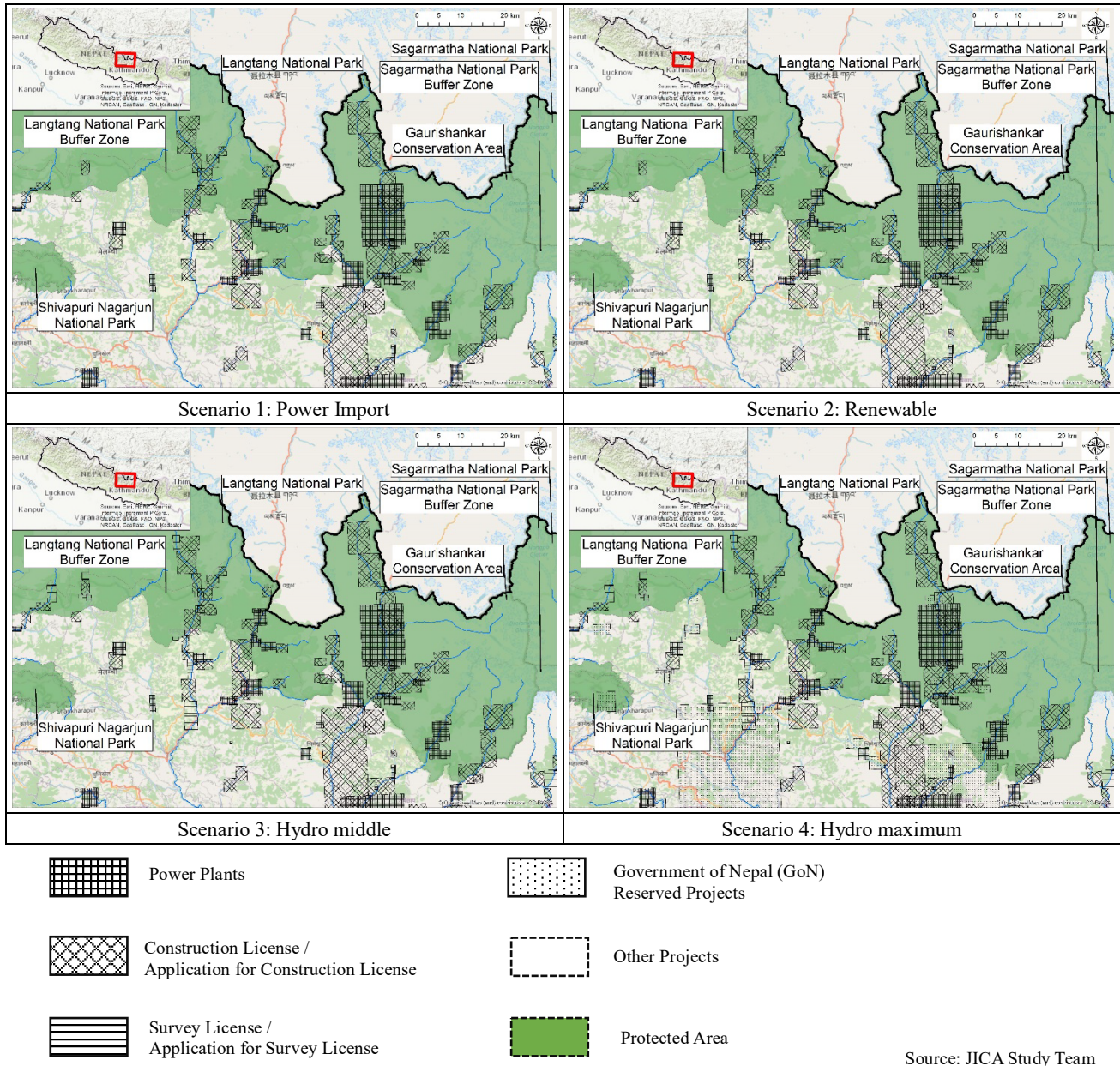


Figure 10.5-3 Protected Areas Overlapped with Hydropower Development Scenarios (Koshi River)  
(2)

## 10.5.2 Chure Conservation Area

Chure Conservation Area is one of the main watersheds for the conservation of surface and underground water for the plain area and low land in Nepal. This region is considered to be highly valuable for its biodiversity, wildlife and their habitats and for maintaining connectivity between different protected areas in Nepal.

It was found out that there are hydropower projects planned within Chure Conservation Area; the Chure Conservation Area overlapped with hydropower projects is described as below:

- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts on Chure Conservation Area would be more significant compared with other scenarios; especially, more impacts will be predicted along Koshi river.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts on Chure Conservation Area would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts on Chure Conservation Area would be less significant compared with other scenarios.

**Table 10.5-2 Chure Conservation Area overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	34 km <sup>2</sup>	33 km <sup>2</sup>	13 km <sup>2</sup>	111 km <sup>2</sup>	191 km <sup>2</sup>
2	Renewable	34 km <sup>2</sup>	33 km <sup>2</sup>	13 km <sup>2</sup>	111 km <sup>2</sup>	191 km <sup>2</sup>
3	Hydro middle	94 km <sup>2</sup>	40 km <sup>2</sup>	15 km <sup>2</sup>	150 km <sup>2</sup>	299 km <sup>2</sup>
4	Hydro maximum	1,652 km <sup>2</sup>	321 km <sup>2</sup>	1,601 km <sup>2</sup>	2,078 km <sup>2</sup>	5,652 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team

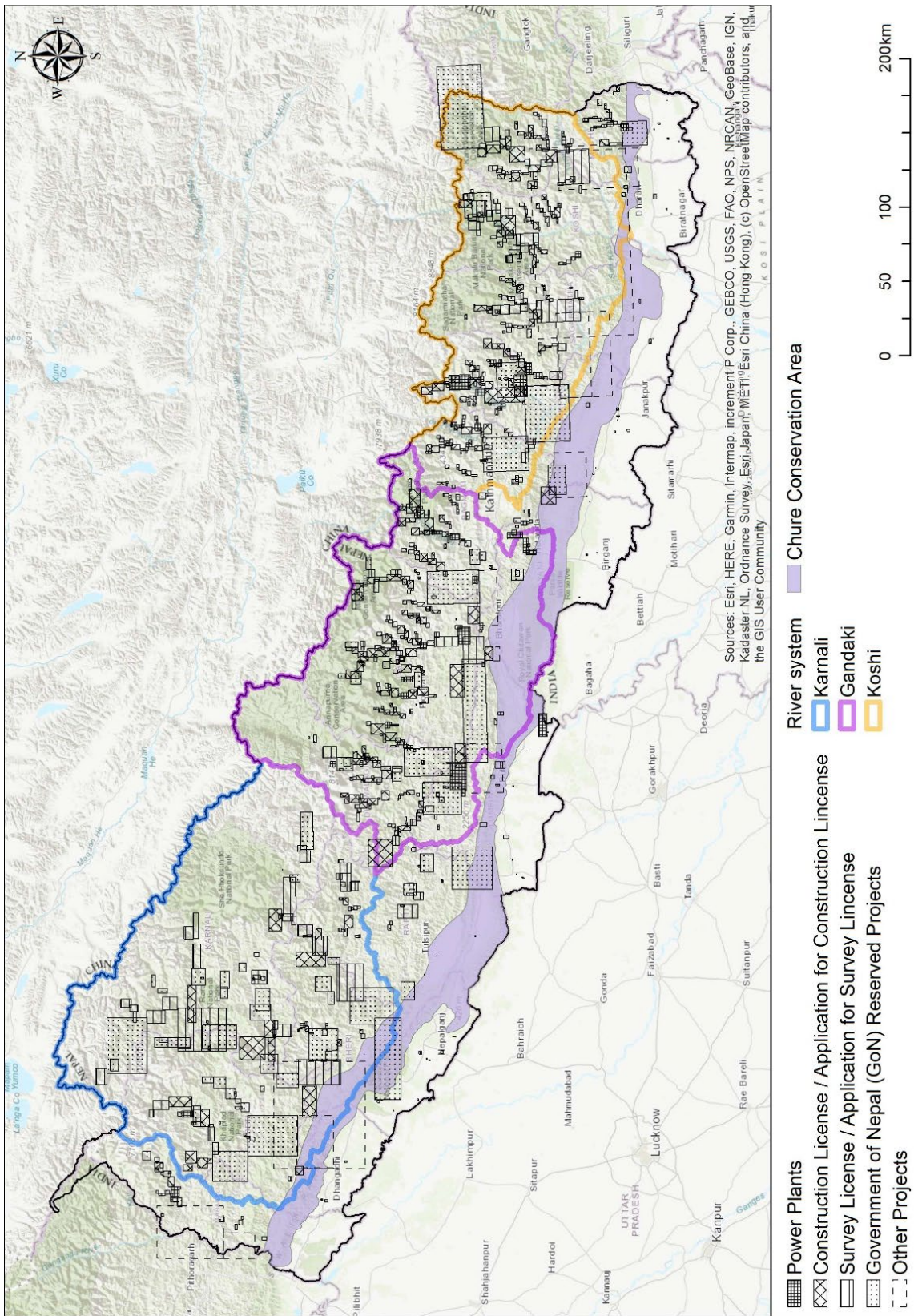
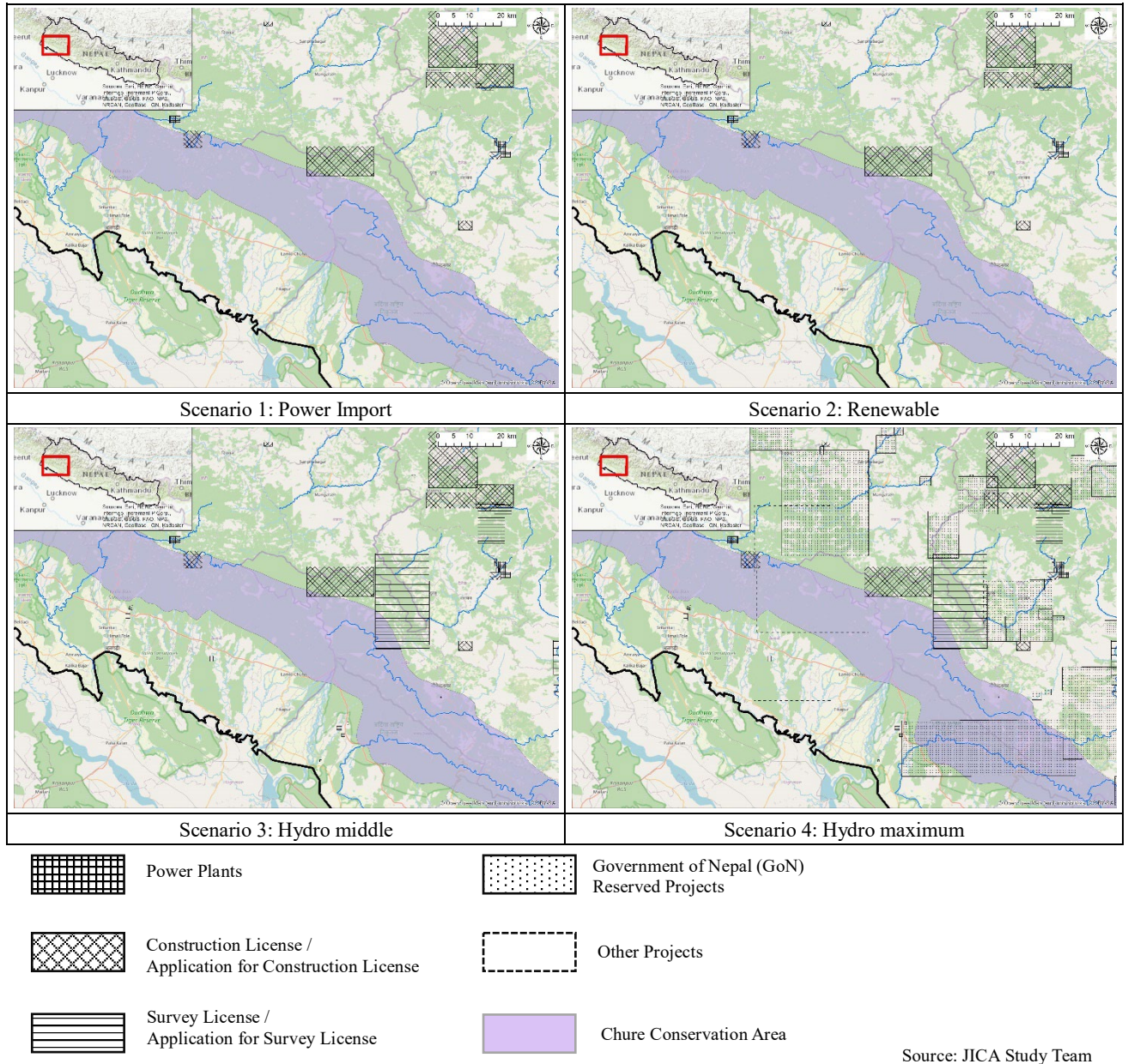
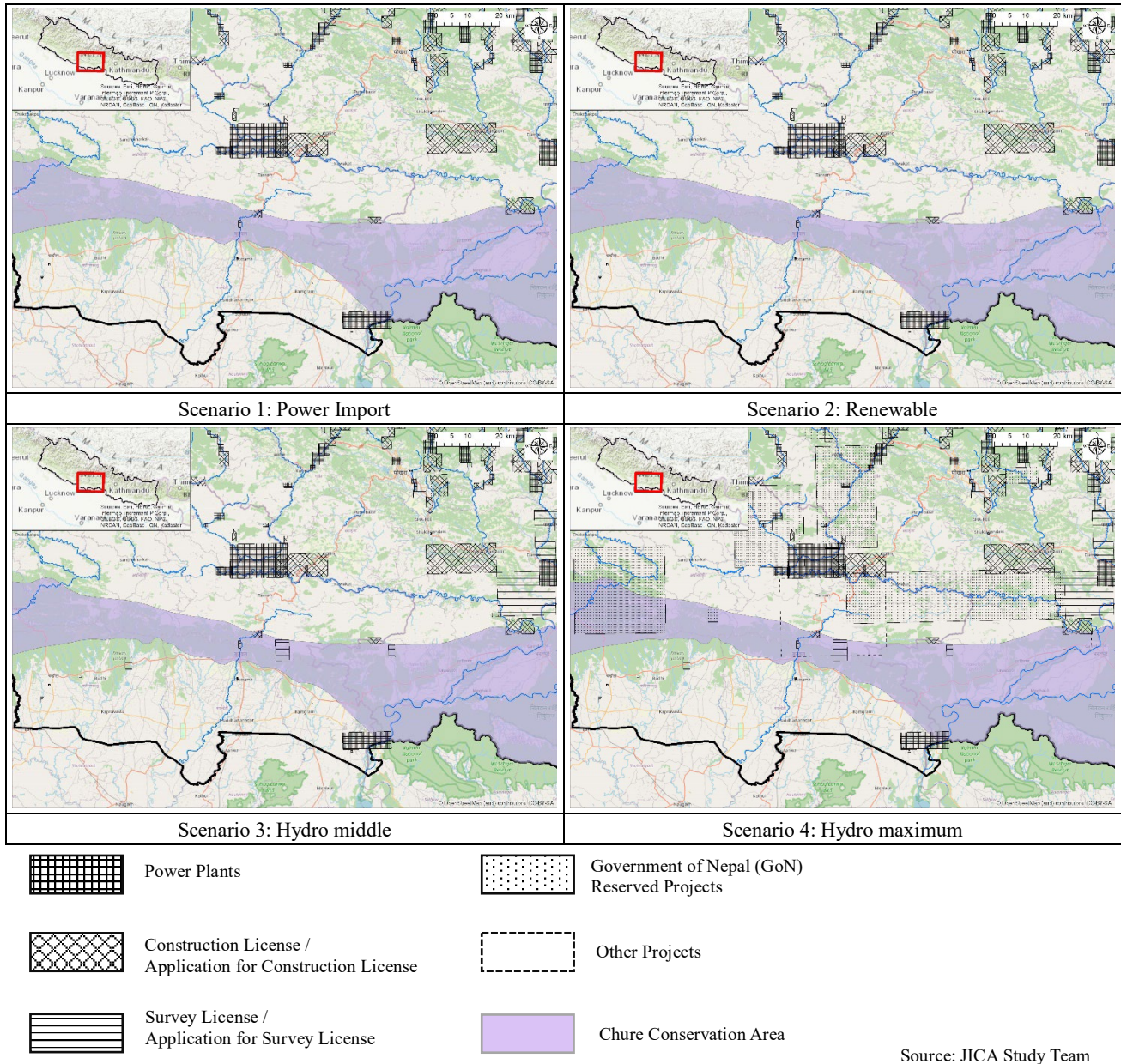


Figure 10.5-4 Chure Conservation Area with Hydropower Development Scenario (Hydro Maximum Scenario) (Nationwide)



**Figure 10.5-5 Chure Conservation Area Overlapped with Hydropower Development Scenarios (Karnali River)**



**Figure 10.5-6** Chure Conservation Area Overlapped with Hydropower Development Scenarios (Gandaki River and other rivers)

### 10.5.3 Key Biodiversity Area

In Nepal there are thirty-one (31) KBAs, which contribute significantly to the global persistence of biodiversity and represent important sites for biodiversity conservation in terrestrial, freshwater and marine ecosystems.

It was found out that there are hydropower projects planned within KBAs; the overlapped with hydropower projects is described as below:

- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts on KBAs would be more significant compared with other scenarios; especially, more impacts will be predicted along Koshi river.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts on KBAs would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts on KBAs would be less significant compared with other scenarios.

**Table 10.5-3 KBAs overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	102 km <sup>2</sup>	1,077 km <sup>2</sup>	784 km <sup>2</sup>	6 km <sup>2</sup>	1,969 km <sup>2</sup>
2	Renewable	102 km <sup>2</sup>	1,077 km <sup>2</sup>	784 km <sup>2</sup>	6 km <sup>2</sup>	1,969 km <sup>2</sup>
3	Hydro middle	288 km <sup>2</sup>	1,250 km <sup>2</sup>	1,394 km <sup>2</sup>	10 km <sup>2</sup>	2,942 km <sup>2</sup>
4	Hydro maximum	611 km <sup>2</sup>	1,560 km <sup>2</sup>	3,234 km <sup>2</sup>	703 km <sup>2</sup>	6,108 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team

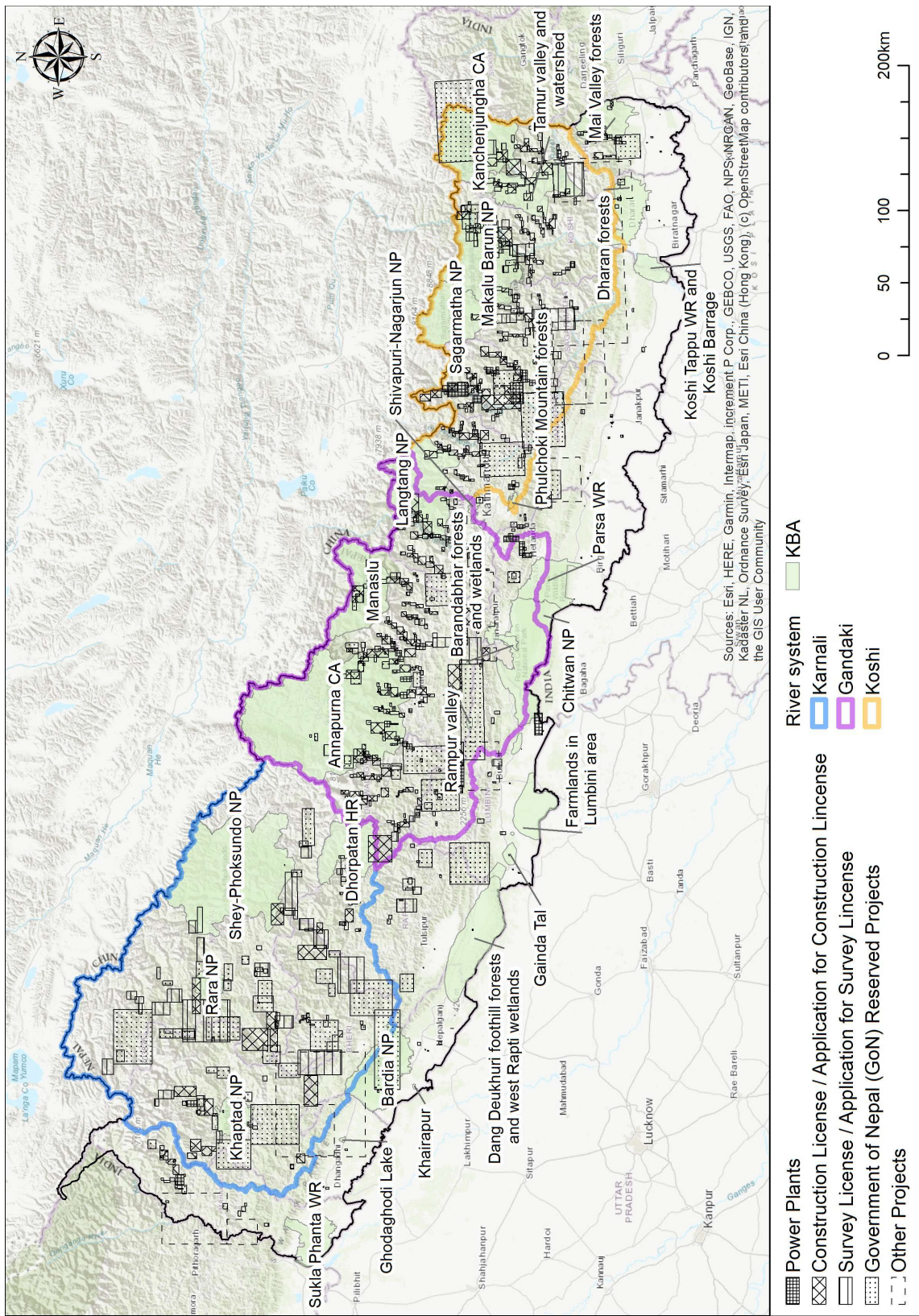
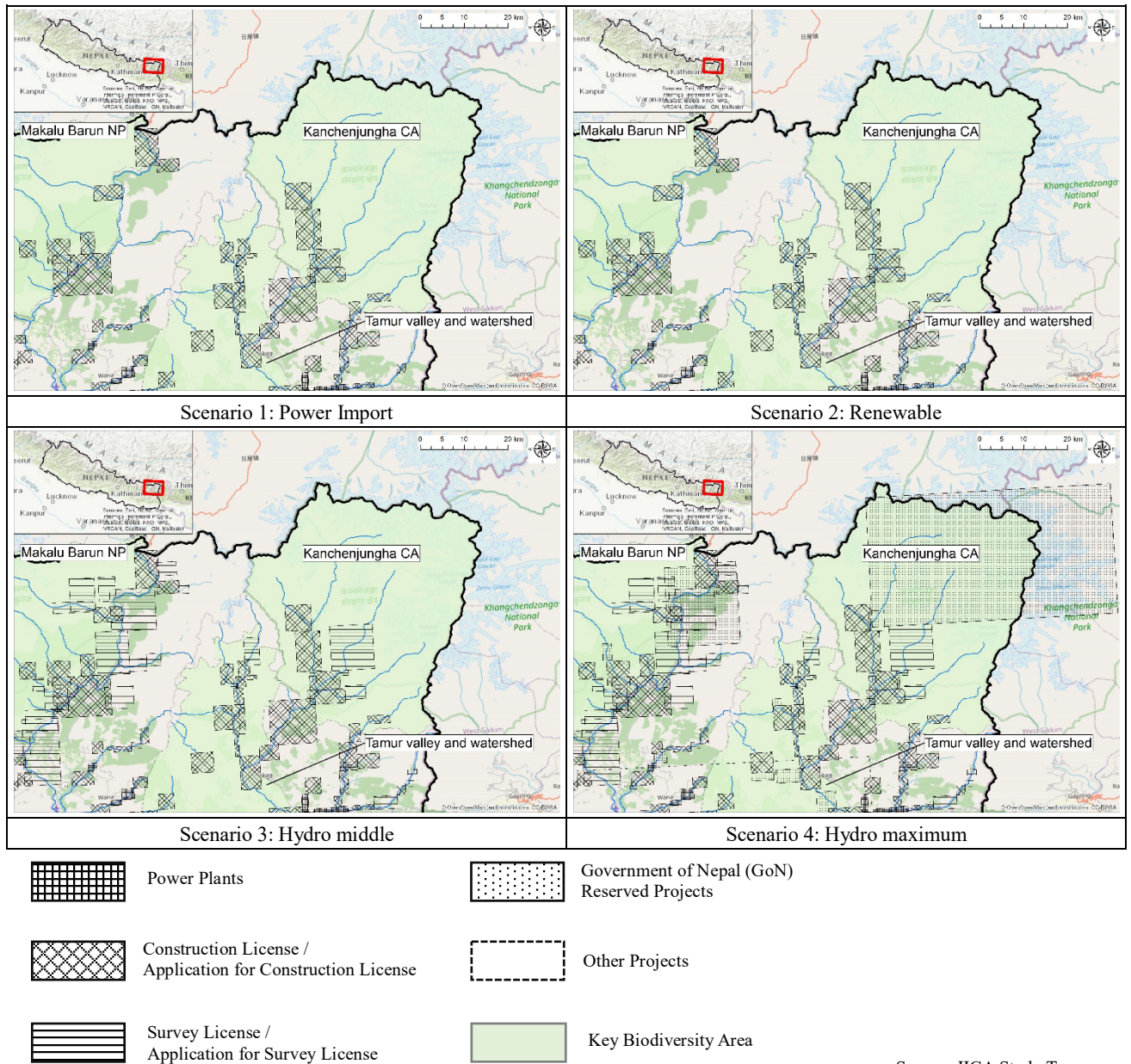
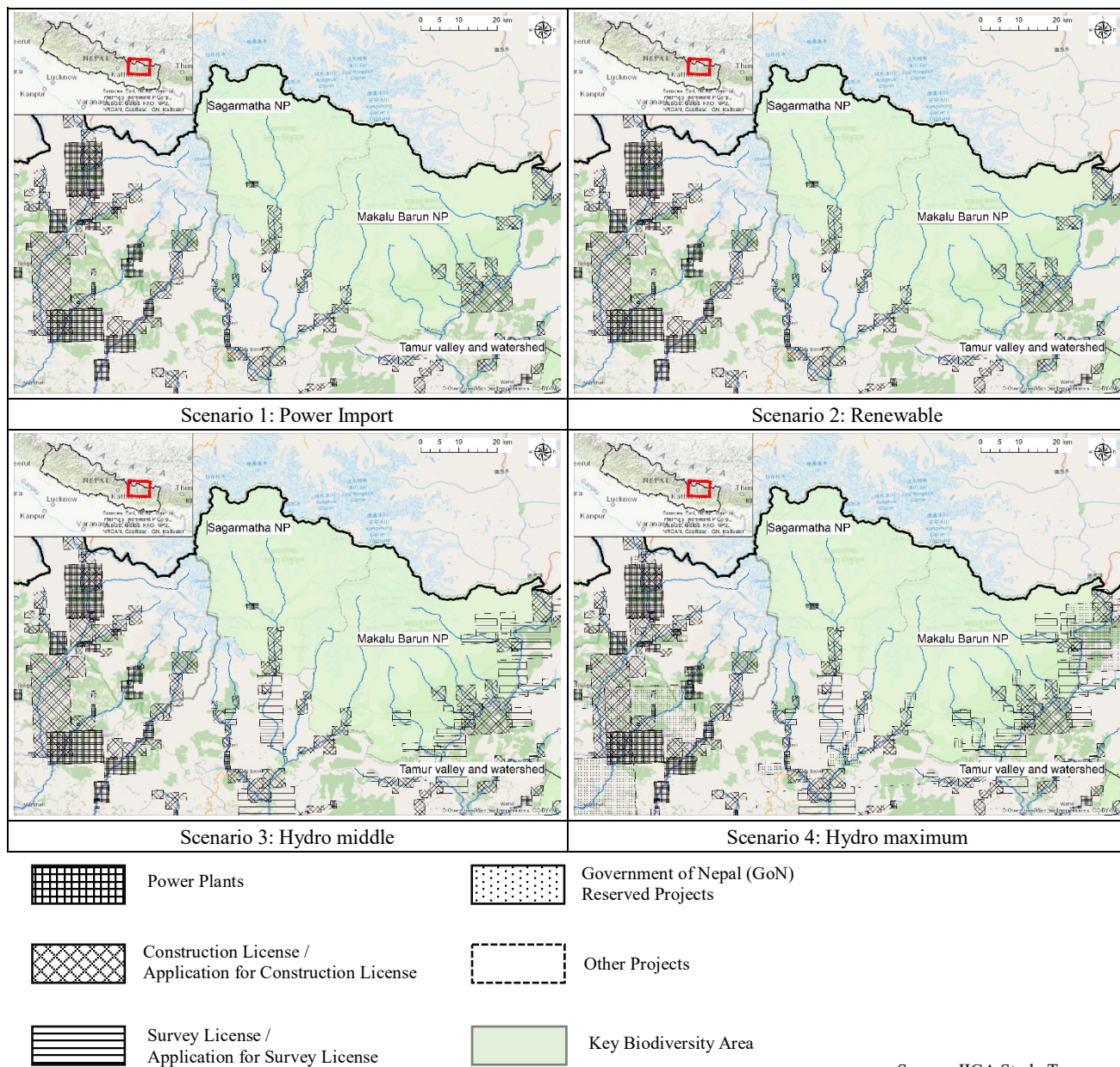


Figure 10.5-7 KBAs with Hydropower Development Scenario (Hydro Maximum Scenario) (Nationwide)



**Figure 10.5-8 KBAs Overlapped with Hydropower Development Scenarios (Koshi River) (1)**



**Figure 10.5-9 KBAs Overlapped with Hydropower Development Scenarios (Koshi river) (2)**

### 10.5.4 Forest

In Nepal approximately 40 % of the land is covered by forest. The forest is considered as important areas from biodiversity viewpoints; in addition, it serves as a source of revenue through timber exports, for example, in forest of Trai region, as well as the utilization of non-timber forest products.

It was found out that there are hydropower projects planned within forest; the overlapped with hydropower projects is described as below:

- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts on forest would be more significant compared with other scenarios.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts on forest would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts on forest would be less significant compared with other scenarios.

**Table 10.5-4 Forest overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	825 km <sup>2</sup>	1,892 km <sup>2</sup>	1,954 km <sup>2</sup>	194 km <sup>2</sup>	4,865 km <sup>2</sup>
2	Renewable	825 km <sup>2</sup>	1,892 km <sup>2</sup>	1,954 km <sup>2</sup>	194 km <sup>2</sup>	4,865 km <sup>2</sup>
3	Hydro middle	2,298 km <sup>2</sup>	2,278 km <sup>2</sup>	2,920 km <sup>2</sup>	339 km <sup>2</sup>	7,835 km <sup>2</sup>
4	Hydro maximum	5,387 km <sup>2</sup>	6,620 km <sup>2</sup>	9,305 km <sup>2</sup>	3,093 km <sup>2</sup>	24,405 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team

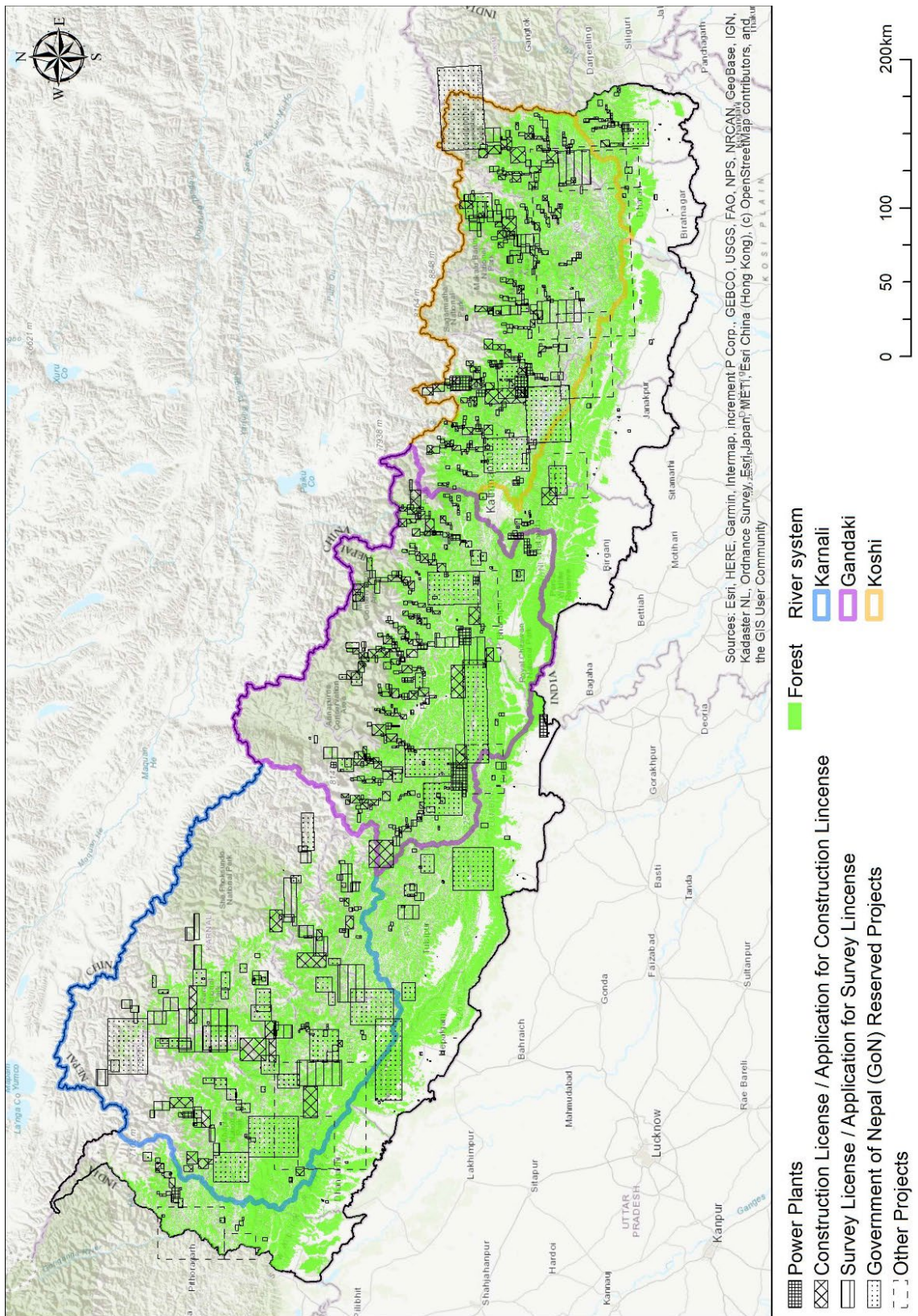


Figure 10.5-10 Forest with Hydropower Development Scenario (Hydro Maximum Scenario) (Nationwide)

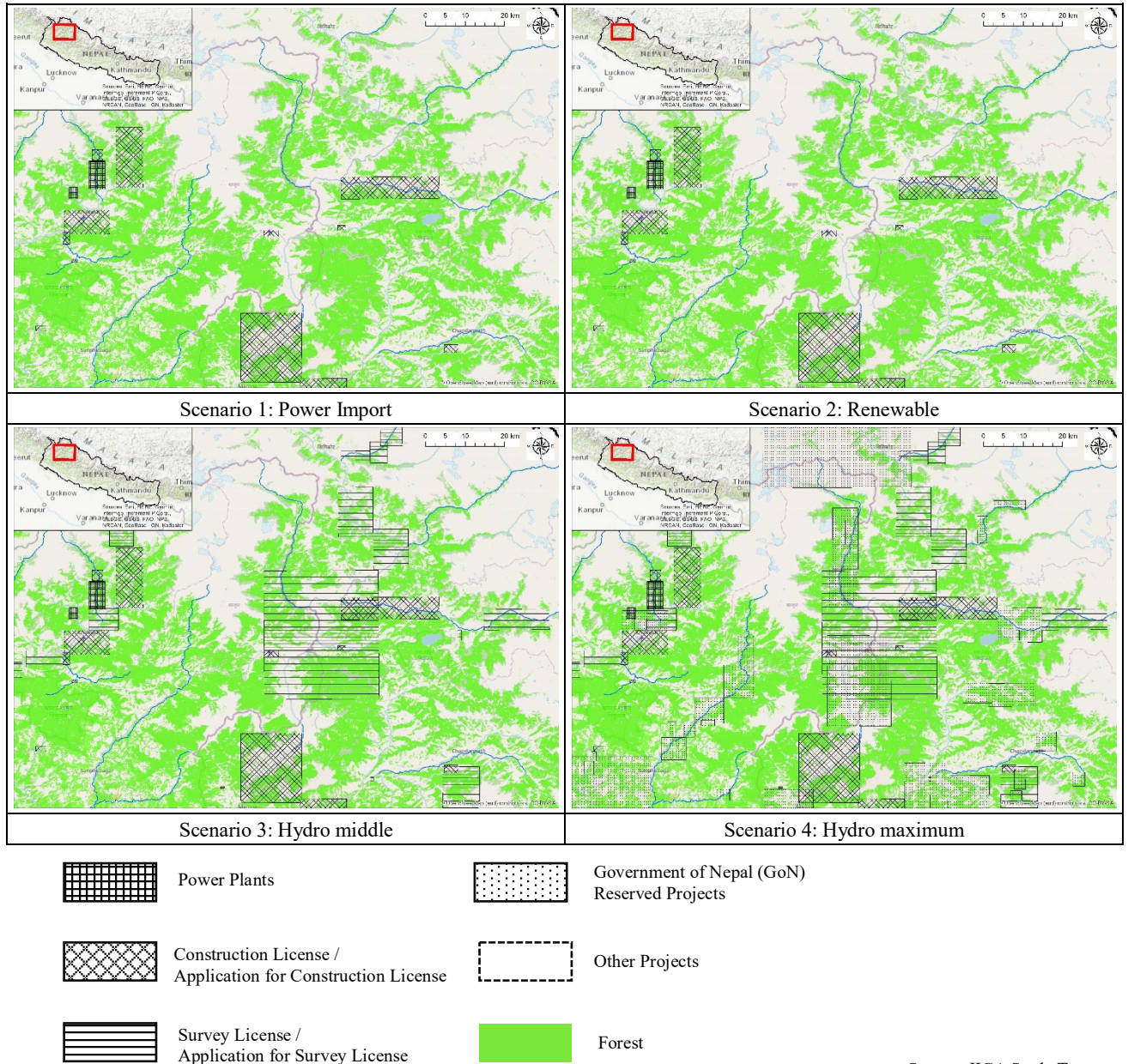


Figure 10.5-11 Forest Overlapped with Hydropower Development Scenarios (Karnali River) (1)

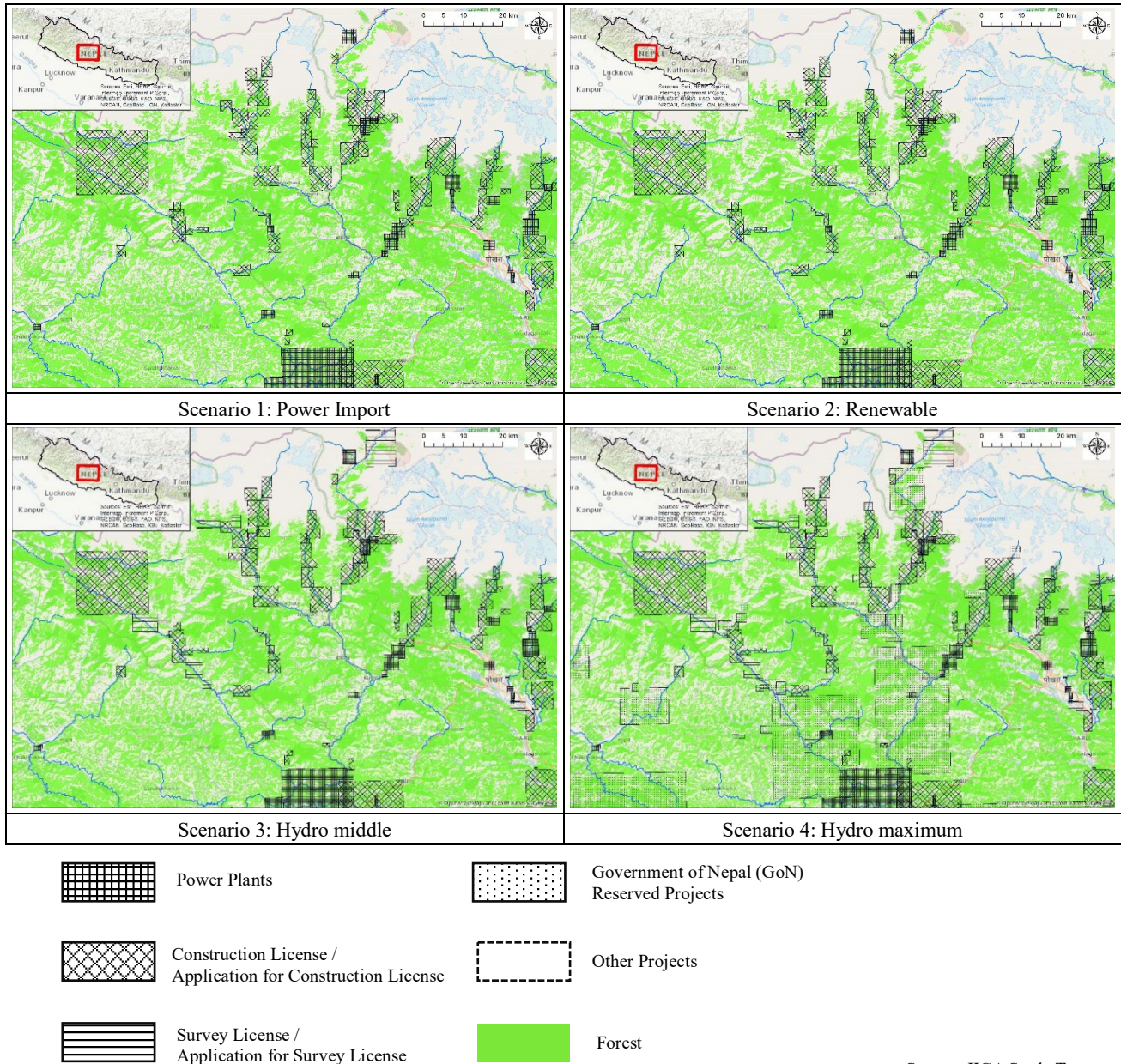


Figure 10.5-12 Forest Overlapped with Hydropower Development Scenarios (Gandaki river) (2)

### 10.5.5 Livelihood/ Cropland

The agriculture and forestry sector remains the main industry in Nepal. Most of agricultural lands lies in southern part of Nepal, Terai region. The main agricultural products are rice, maize, wheat, potatoes and sugarcanes etc.

It was found out that there are hydropower projects planned within cropland; the overlapped with hydropower projects is described as below:

- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts on cropland would be more significant compared with other scenarios.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts on cropland would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts on cropland would be less significant compared with other scenarios.

**Table 10.5-5 Cropland overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	517 km <sup>2</sup>	750 km <sup>2</sup>	583 km <sup>2</sup>	108 km <sup>2</sup>	1,958 km <sup>2</sup>
2	Renewable	517 km <sup>2</sup>	750 km <sup>2</sup>	583 km <sup>2</sup>	108 km <sup>2</sup>	1,958 km <sup>2</sup>
3	Hydro middle	887 km <sup>2</sup>	1,517 km <sup>2</sup>	1,158 km <sup>2</sup>	183 km <sup>2</sup>	3,745 km <sup>2</sup>
4	Hydro maximum	3,560 km <sup>2</sup>	2,127 km <sup>2</sup>	4,932 km <sup>2</sup>	1,080 km <sup>2</sup>	11,700 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team

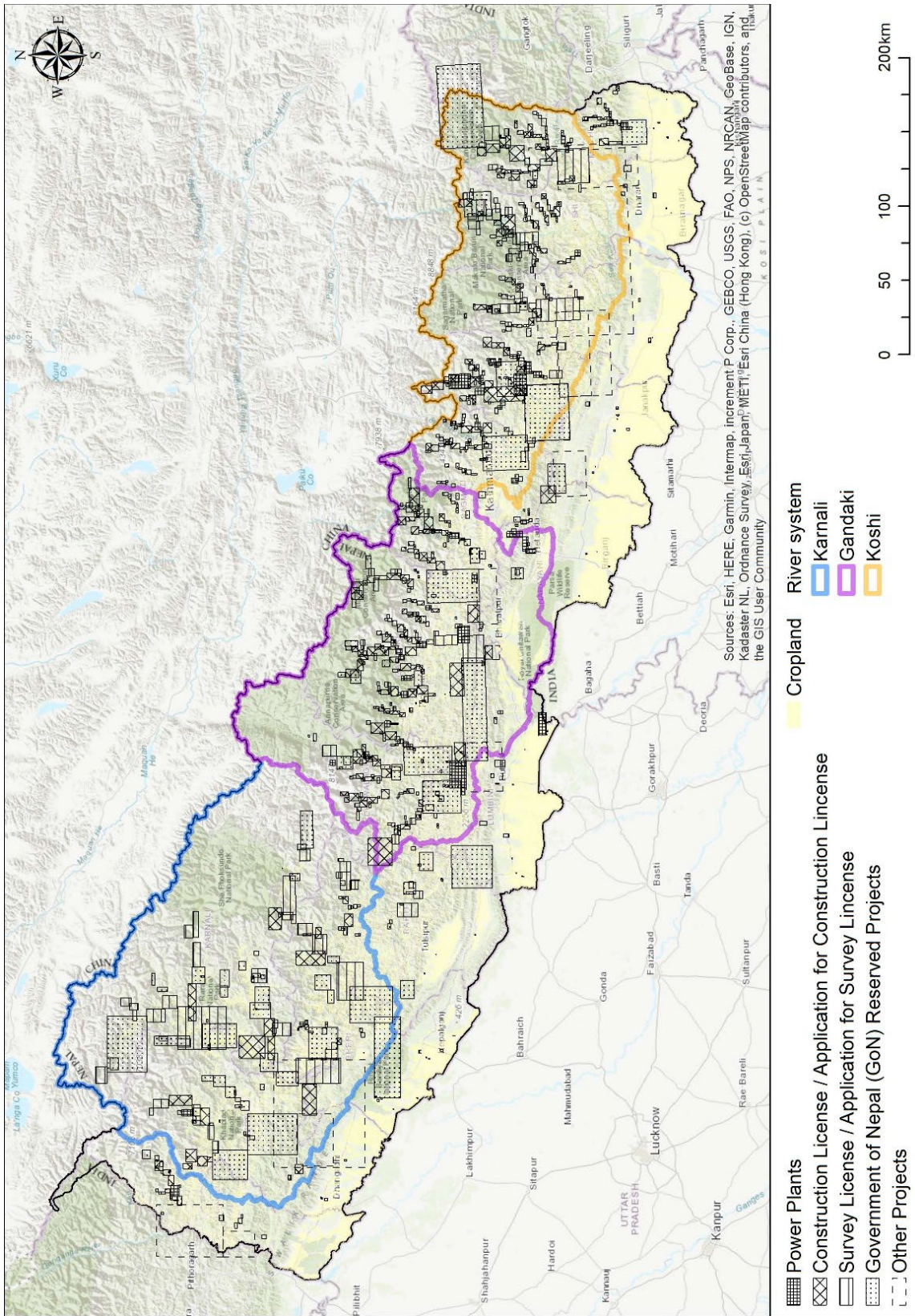


Figure 10.5-13 Cropland with Hydropower Development Scenario (Hydro Maximum Scenario) (Nationwide)



**Figure 10.5-14 Cropland Overlapped with Hydropower Development Scenarios (Karnali River) (1)**

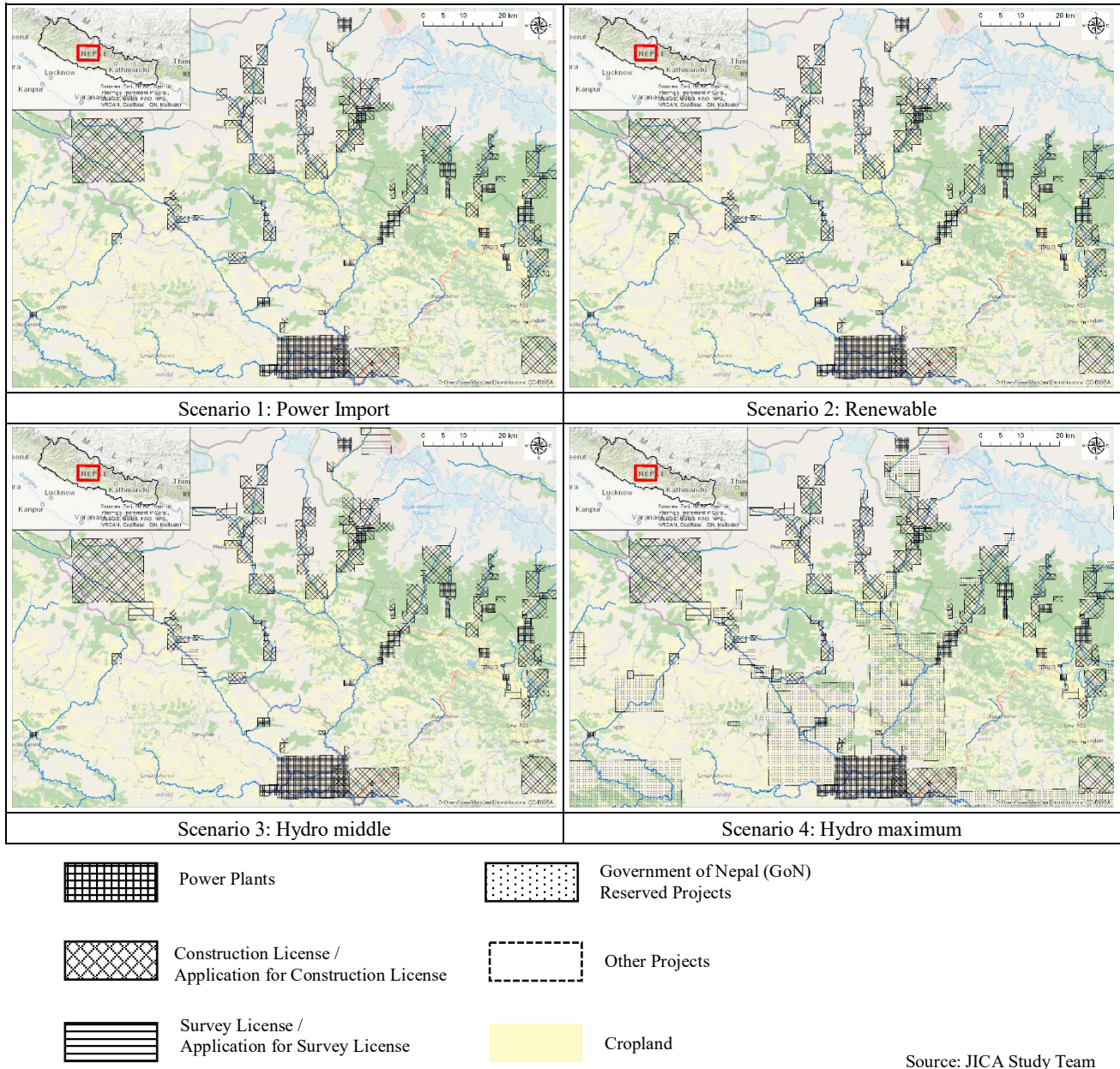


Figure 10.5-15 Cropland Overlapped with Hydropower Development Scenarios (Gandaki River) (2)

### 10.5.6 Resettlement

The total population in Nepal is 26,494,504. From the viewpoints of population size, Kathmandu, Pokhara and Patan are the major cities in Nepal. The population growth rate in Nepal from 2001 to 2011 was 1.35 % per year. While population decline was seen on the north-eastern side of Nepal, population growth was observed in some cities such as Kathmandu. In consideration of population growth, impact by resettlement due to hydropower development needs to be considered.

It was found out that there are hydropower projects planned within build-up areas; the overlapped with hydropower projects is described as below:

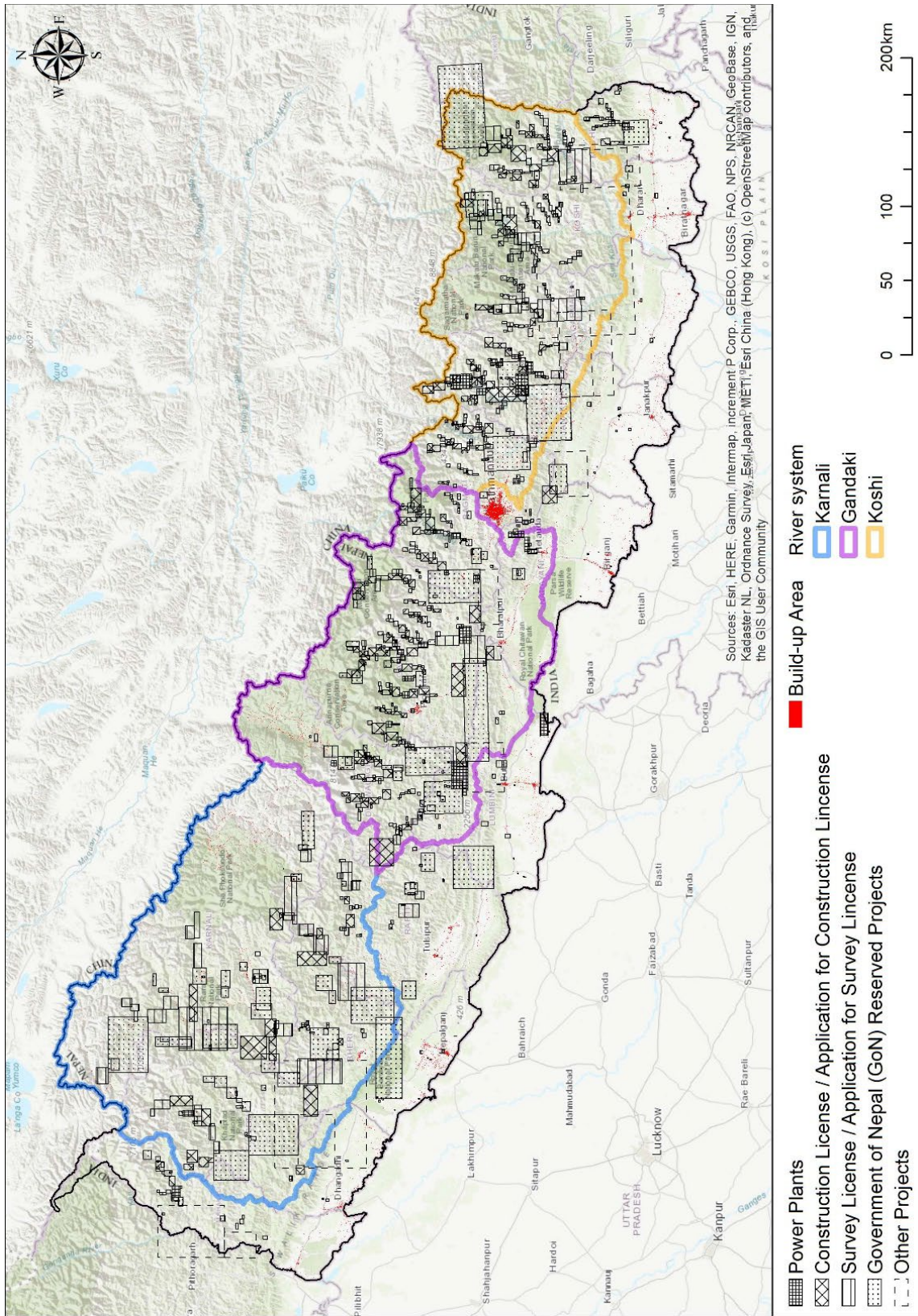
- When “Hydropower maximum scenario” is selected, it is anticipated that the impacts by resettlement would be more significant compared with other scenarios.
- When “Hydropower middle scenario” is selected, it is anticipated that the impacts by resettlement would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that impacts by resettlement would be less significant compared with other scenarios.

**Table 10.5-6 Build-up Areas overlapped with Hydropower Development Areas by Each River Basin**

	Scenario	Karnali river	Gandaki river	Koshi river	Other rivers	Total in Nepal
1	Power import	3 km <sup>2</sup>	13 km <sup>2</sup>	7 km <sup>2</sup>	1 km <sup>2</sup>	24 km <sup>2</sup>
2	Renewable	3 km <sup>2</sup>	13 km <sup>2</sup>	7 km <sup>2</sup>	1 km <sup>2</sup>	24 km <sup>2</sup>
3	Hydro middle	20 km <sup>2</sup>	17 km <sup>2</sup>	10 km <sup>2</sup>	3 km <sup>2</sup>	50 km <sup>2</sup>
4	Hydro maximum	38 km <sup>2</sup>	31 km <sup>2</sup>	59 km <sup>2</sup>	8 km <sup>2</sup>	136 km <sup>2</sup>

Note: “Other rivers” includes the river basins except Karnali, Gandaki and Koshi rivers.

Source: JICA Study Team



Source: JICA Study Team

Figure 10.5-16 Build-up Areas with Hydropower Development Scenario (Hydro Maximum Scenario) (Nationwide)

### 10.5.7 Climate Change

The annual CO<sub>2</sub> emissions (kton) and emissions rate (g-CO<sub>2</sub>/kWh) are shown in Figure 10.5-1 and reductions of CO<sub>2</sub> emission by power export to neighbouring countries (kton) are shown in Figure 10.5-2<sup>4</sup>.

The key findings of the analysis regarding CO<sub>2</sub> emission and rates are described as below:

- As power generation is mainly composed of hydropower and renewable energy in Nepal, CO<sub>2</sub> emissions are still lower than in other countries even in 2022. CO<sub>2</sub> emissions rate will be gradual declines as the introduction of hydropower increases in all Scenarios.
- In “Power Import” and “Renewable” scenarios, CO<sub>2</sub> emissions are anticipated to increase, as hydropower development decreases and electricity imports increase. However, it should be noted that emissions are low compared to neighbouring country, India<sup>5</sup>, even in “Power Import” and “Renewable” scenarios.
- In “Hydro Middle” and “Hydro Maximum”, CO<sub>2</sub> emissions will remain at extremely low levels.

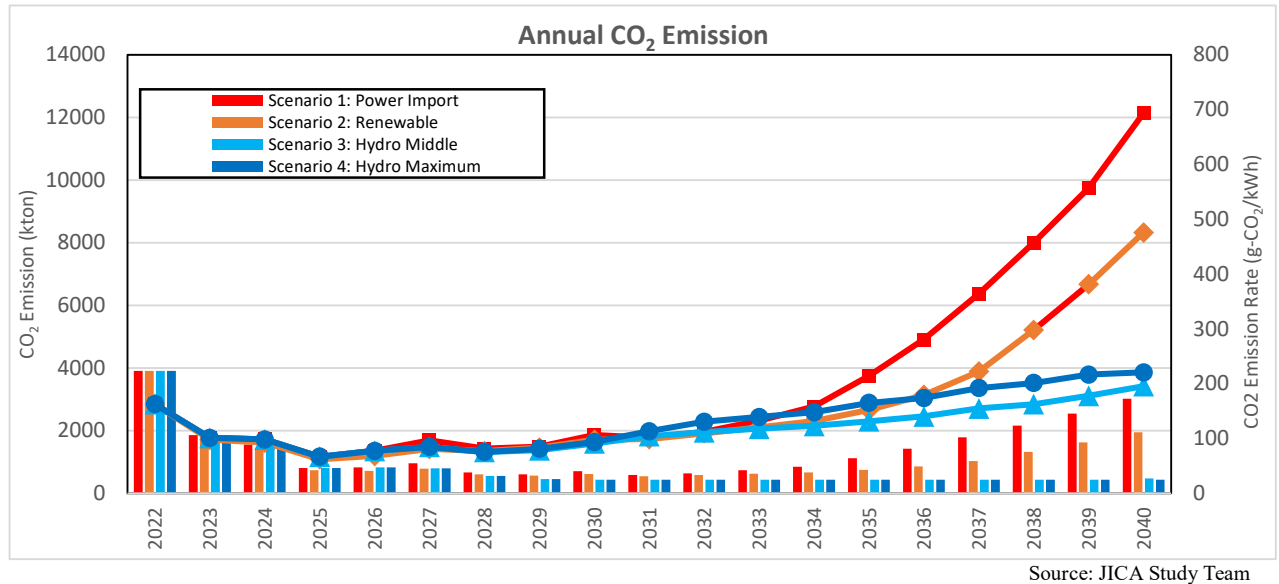


Figure 10.5-1 Comparison of CO<sub>2</sub> Emissions and Rate

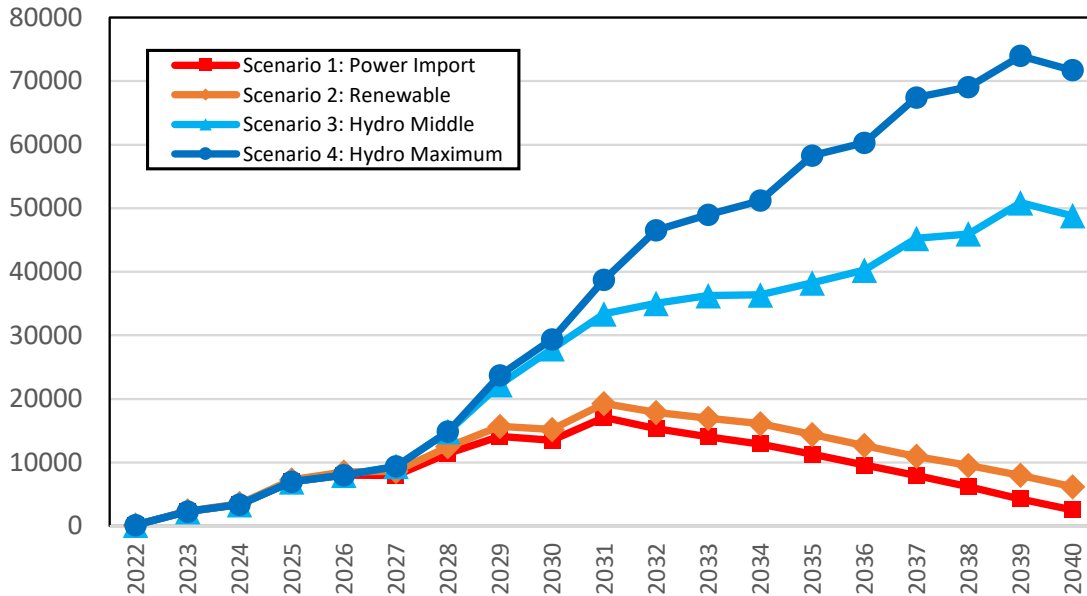
The key findings of the analysis regarding CO<sub>2</sub> reduction are described as below:

- In “Hydro Middle” and “Hydro Maximum”, larger reduction of CO<sub>2</sub> emissions by electricity exports is anticipated after 2027 than in “Power Import” and “Renewable” scenarios, because hydropower development is accelerated. Exporting hydropower-generated electricity contributes a lot to reduction of CO<sub>2</sub> emission in India and Bangladesh which mainly rely on thermal power in power supply.
- At present, incentives from these CO<sub>2</sub> reductions have not been institutionalised. However,

<sup>4</sup> The calculation was done as follows:  
(Emission factor for each power source in the IPCC's Technology-specific Cost and Performance Parameters (Lifecycle emission value in "Table A.III.2 | Emissions of selected electricity supply technologies (gCO<sub>2</sub>eq / kWh)") x (Planned power generation by each power source) / (Total planned power generation)

<sup>5</sup> 820 g-CO<sub>2</sub>/kWh

if a carbon tax or other incentive system is developed in the future, benefits such as carbon credits may be available in addition to the power purchase which contribute to the increase of income for Nepal. In case of the carbon tax with 30 USD/ton, the CO<sub>2</sub> reduction in “Hydro Maximum Scenario” in 2040 is calculated to be 70,531 kton equivalent to 2,115.9 MUSD in price<sup>6</sup>.



Source: JICA Study Team

Figure 10.5-2 Comparison of CO<sub>2</sub> Reduction by Power Export

### 10.5.8 Summary - Evaluation of Development Scenarios

The summary of the comparative analysis results of four development scenarios from environmental and social viewpoints (Protected areas, Chure conservation area, KBAs, Forest, Climate change, Cropland, Resettlement) is described as below.

- When “Hydropower maximum scenario” is selected, more environmental and social impacts would be anticipated compared with other scenarios; this scenario would have less impact on climate change.
- When “Hydropower middle scenario” is selected, it is anticipated that environmental and social impacts would be less significant compared with “Hydro maximum scenario”, while more impacts compared with “Power import” and “Renewable scenario”.
- When “Power import” or “Renewable scenario” is selected, it is anticipated that environmental and social impacts would be less significant compared with other scenarios; these scenarios would have more impact on climate change.

<sup>6</sup> When power export from Nepal increases, India's CO<sub>2</sub> emissions, which mainly rely on thermal power, will be reduced. The amount of CO<sub>2</sub> reduction calculated based on the amount of power export in 2040 assumed in the Hydro Maximum scenario was multiplied by the assumed unit price of a carbon tax.

**Table 10.5-7 Summary – Comparison Analysis of Development Scenarios**

	Items	Power import	Renewable	Hydro middle	Hydro maximum
1	Protected areas	C	C	B	A
2	Chure conservation				
3	area				
4	KBAs				
5	Forest				
6	Cropland				
7	Resettlement	A	B	C	C

Note: A (More environmental and social impact is anticipated),  
B (Moderate environmental and social impact is anticipated),  
C (Less environmental and social impact is anticipated)

Source: JICA Study Team

It should be noted that optimum scenario will be selected based on the aspects of “3E (Energy Security, Economy and Environment) + Policy (consistency with Policy)”. The summary of evaluation each Scenario in accordance with 3E + Policy are described as follows:

- **Scenario 1: Power import**  
It is assumed to be a feasible scenario with low capital investment and environmental impact. However, it has low energy self-sufficiency in 2040, supply risks of power import interruptions and cost escalation risks such as fuel inflation. It is also difficult to achieve the goals set out in the policy of power sector.
- **Scenario 2: Renewable**  
Similarly to Scenario 1, the capital investment cost and environmental impact is relatively lower and the import dependency is also low due to the generation of renewable energy. On the other hand, it is necessary to include the regulation capacity from neighboring countries against the intermittency of VRE (Variable Renewable Energy) mainly derived from solar in order to secure the grid stability.
- **Scenario 3: Hydro middle**  
It requires power imports only during February, but it is possible to supply power to domestic demand and neighboring countries even in drought years. Although the capital investment required is high, it is assumed to be feasible in case of power trade promoted. Since the environmental impact is relatively significant, mitigation measures would be essential.
- **Scenario 4: Hydro maximum**  
It can secure to supply power to meet domestic demand and neighboring countries even in the drought year. Compared to Scenario 3, the capital investment and environmental impact would also be very high, and feasibility needs to be fully considered.

Based on the results of the comparative analysis of development scenarios based on the evaluation of “3E (Energy Security, Economy and Environment) + Policy (consistency with Policy)”, “Scenario 3: Hydro middle” was selected as the base case for Optimum Scenario.

## 10.6 EVALUATION OF OPTIMUM SCENARIO

### 10.6.1 Impact Assessment

The optimal scenario selected in this master plan was evaluated from an environmental and social perspective. In this section, the evaluation was carried out for each of the following river systems and rivers; the points to be considered in terms of environmental and social considerations from the viewpoints of protected areas, ecosystems, cultural heritage, etc. were analyzed<sup>7</sup>.

**Table 10.6-1 List of River Basin for Evaluation of Optimum Scenario for Environmental and Social Considerations**

No.	River basins	Sub-basin
1	Karnali	Karnali, Seti West
2	Bheri	Bheri, Sano Bheri
3	Kaligandaki	Kali Gandaki, Badigad
4	Trishuli	Trishuli, Seti, Marsyangdi, Budhi Gandaki
5	Sun Koshi	Sun Koshi, Bhote Koshi, Dudh Koshi, Likhu, Tama Koshi/Khimiti
6	Arun	Arun
7	Tamor	Tamor
8	Others	Babai, Rapti, Bagmati

### 10.6.2 Impact Assessment by Sub-basin

#### (1) Karnali

##### 1) Karnali river

The hydropower projects planned along the Karnali river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-1.

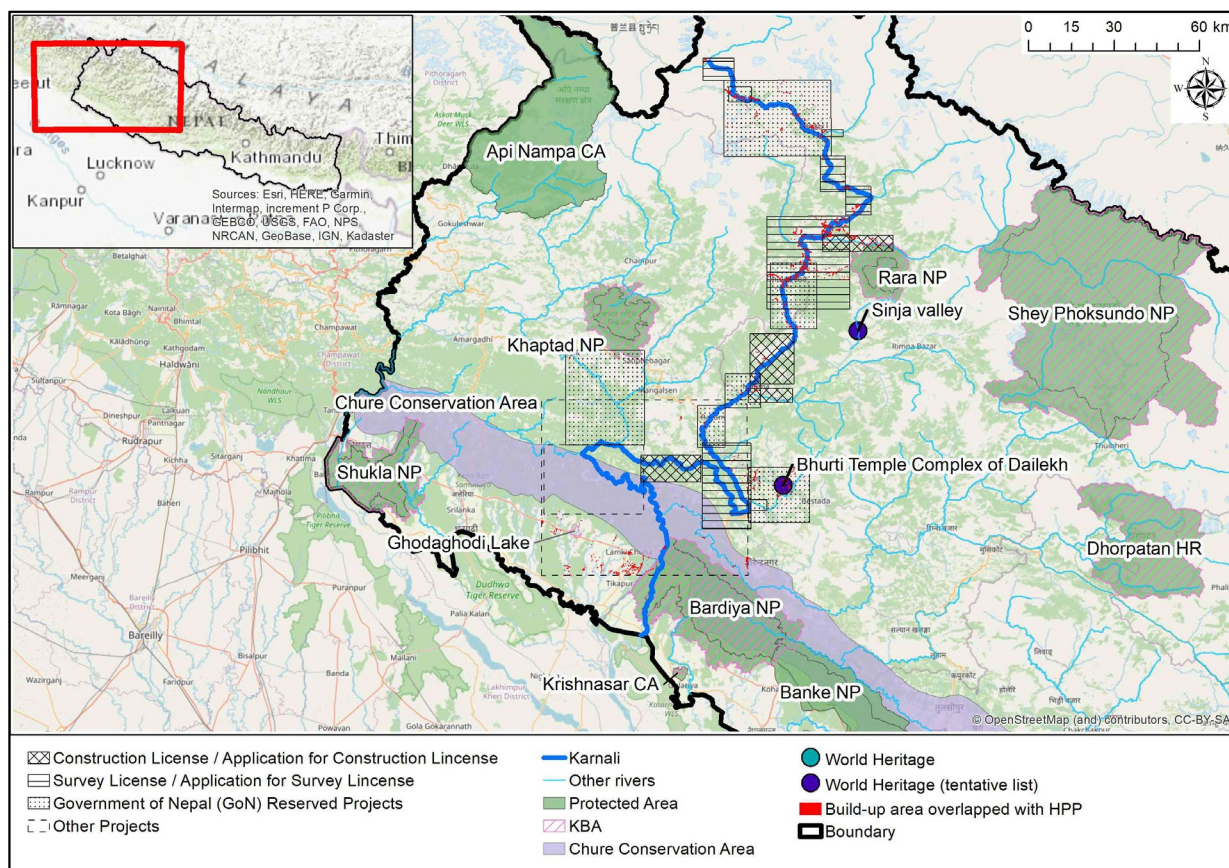
Hydropower projects are already planned for most of the Karnali river; hence, the cumulative impacts are expected to be significant. Bardiya National Park (KBA/IBA (Important Bird and Biodiversity Areas)) is located within the proposed hydropower project area.

The national park (area: 968 km<sup>2</sup>) is located in the Terai plains. It was established for the purpose of conserving ecosystems, and rare species listed on the IUCN Red List (birds: 2 CR, 2 EN, 7 VU, 11 NT, mammals: 5 EN, 7 VU, reptiles: 1 CR, 3 EN, 2 VU) have been confirmed (Table 10.6-2).

Of these species, the attention should be paid to the impacts on the South Asian River Dolphin<sup>8</sup> due to changes in water volume and habitat fragmentation caused by the construction of dams and weirs. In addition, if large-scale deforestation is carried out due to the hydropower project, there is concern about the impact on these terrestrial ecosystems due to the loss of habitat.

<sup>7</sup> The hydroelectric power plan used in this section was based on the site boundaries provided by DoED, and the planning area may be larger than the actual area, subject to the maturity of the plan. Therefore, it is recommended that more detailed investigations be carried out for each project at the F/S stage.

<sup>8</sup> South Asian River Dolphin is found in freshwater in Nepal, India and Bangladesh. (Source: IUCN Red List <https://www.iucnredlist.org/species/41756/50383346>)



Source: JICA Study Team

**Figure 10.6-1** Hydropower Projects along the Karnali River and Items of Environmental and Social Considerations

**Table 10.6-2** Rare Species Confirmed in Bardiya National Park, which was the basis for the selection of KBA

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Gyps bengalensis</i>	White-rumped Vulture	CR
2	<i>Gyps tenuirostris</i>	Slender-billed Vulture	CR
3	<i>Houbaropsis bengalensis</i>	Bengal Florican	EN
4	<i>Syphéotides indicus</i>	Lesser Florican	EN
5	<i>Aquila clanga</i>	Greater Spotted Eagle	VU
6	<i>Clanga hastata</i>	Indian Spotted Eagle	VU
7	<i>Francolinus gularis</i>	Swamp Francolin	VU
8	<i>Grus antigone</i>	Sarus Crane	VU
9	<i>Haliaeetus leucoryphus</i>	Pallas's Fish-eagle	VU
10	<i>Leptoptilos javanicus</i>	Lesser Adjutant	VU
11	<i>Mycteria leucocephala</i>	Painted Stork	VU
12	<i>Anhinga melanogaster</i>	Oriental Darter	NT
13	<i>Aythya nyroca</i>	Ferruginous Duck	NT
14	<i>Buceros bicornis</i>	Great Hornbill	NT
15	<i>Ephippiorhynchus asiaticus</i>	Black-necked Stork	NT
16	<i>Graminicola bengalensis</i>	Rufous-rumped Grassbird	NT
17	<i>Haliaeetus albicilla</i>	White-tailed Sea-eagle	NT
18	<i>Ichthyophaga humilis</i>	Lesser Fish-eagle	NT
19	<i>Ichthyophaga ichthyaetus</i>	Grey-headed Fish-eagle	NT
20	<i>Mycteria leucocephala</i>	Painted Stork	NT
21	<i>Sarcogyps calvus</i>	Red-headed Vulture	NT

	Scientific name	Common name	Category under IUCN red list
22	<i>Sterna acuticauda</i>	Black-bellied Tern	NT
Mammals			
1	<i>Caprolagus hispidus</i>	Hispid Hare	EN
2	<i>Elephas maximus</i>	Asian Elephant	EN
3	<i>Panthera tigris</i>	Tiger	EN
4	<i>Platanista gangetica</i>	South Asian River Dolphin	EN
5	<i>Rhinoceros unicornis</i>	Indian Rhinoceros	EN
6	<i>Cuon alpinus</i>	Dhole	VU
7	<i>Lutra lutra</i>	Eurasian Otter	VU
8	<i>Lutrogale perspicillata</i>	Smooth-coated Otter	VU
9	<i>Melursus ursinus</i>	Sloth Bear	VU
10	<i>Prionailurus viverrinus</i>	Fishing Cat	VU
11	<i>Rucervus duvaucelii</i>	Barasingha	VU
12	<i>Tetracerus quadricornis</i>	Four-horned Antelope	VU
Reptiles			
1	<i>Batagur kachuga</i>	Red-crowned Roofed Turtle	CR
2	<i>Batagur dhongoka</i>	Three-striped Roofed Turtle	EN
3	<i>Gavialis gangeticus</i>	Gharial	EN
4	<i>Indotestudo elongata</i>	Yellow-headed Tortoise	EN
5	<i>Crocodylus palustris</i>	Mugger	VU
6	<i>Melanochelys tricarinata</i>	Three-keeled Land Tortoise	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14324>)

Of the 230 species of freshwater fish known to exist in Nepal (16 of which are endemic), two species have been found in the Karnali River, but these are not migratory.

**Table 10.6-3 Endemic Species Confirmed in the Karnali River**

	Scientific name	Category under IUCN red list
1	<i>P. serratula</i>	LC
2	<i>Balitora eddsi</i>	DD

Source: JICA Study Team

## 2) Seti West river

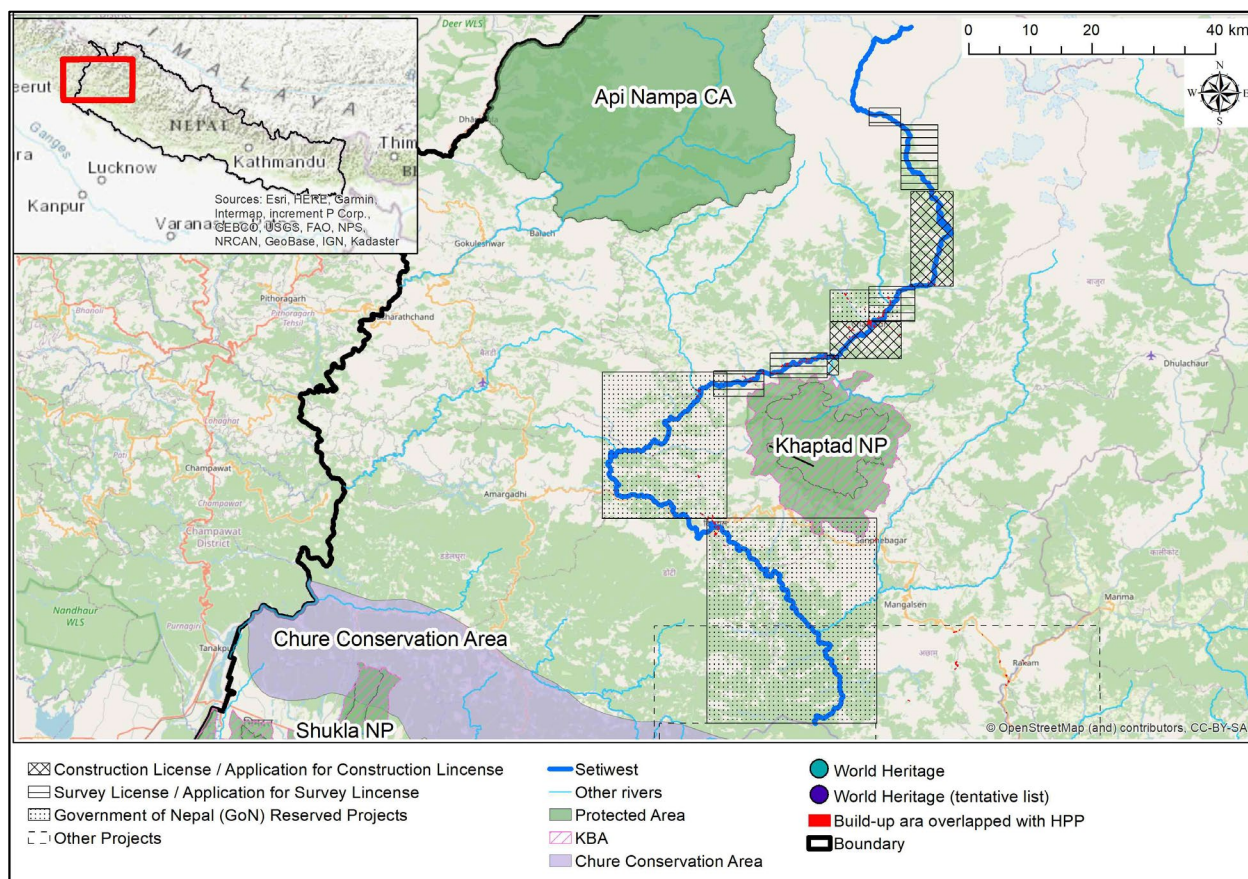
The hydropower projects planned along the Seti West river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-2.

Hydropower projects are already planned for a large part of the Seti West river; hence, cumulative impacts are likely to be significant. Khaptad National Park (KBA/IBA) is located within the proposed hydropower project area.

Khaptad National Park (area: 225 km<sup>2</sup>) is located in the Terai plains. It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (birds: 1 CR, 1 VU, 4 NT) have been confirmed (Table 10.6-4).

Khaptad National Park is home to the Khaptad Baba Ashram, where the saint Khaptad Baba (known as *Swami Sachchidananda*) is meditated and worshipped. Temples, stone statues, etc. remain, making it a spiritually and culturally important site.

Seven species of migratory fish have been identified along the Seti river. Species that migrate long distances in particular may be seriously affected by the hydropower projects due to the disruption of their migration, so the attention should be paid to this.



Source: JICA Study Team

**Figure 10.6-2 Hydropower Projects along the Seti West River and Items of Environmental and Social Considerations**

**Table 10.6-4 Rare Species Confirmed in Bardiya National Park, which was the basis for the selection of KBA**

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Gyps bengalensis</i>	White-rumped Vulture	CR
2	<i>Saxicola insignis</i>	White-throated Bushchat	VU
3	<i>Aegypius monachus</i>	Cinereous Vulture	NT
4	<i>Phylloscopus tyleri</i>	Tytlers Leaf-warbler	NT
5	<i>Sarcogyps calvus</i>	Red-headed Vulture	NT
6	<i>Tragopan satyra</i>	Satyr Tragopan	NT

Source: Prepared by JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14332>)

**Table 10.6-5 Migratory Fish Confirmed in the West Seti River**

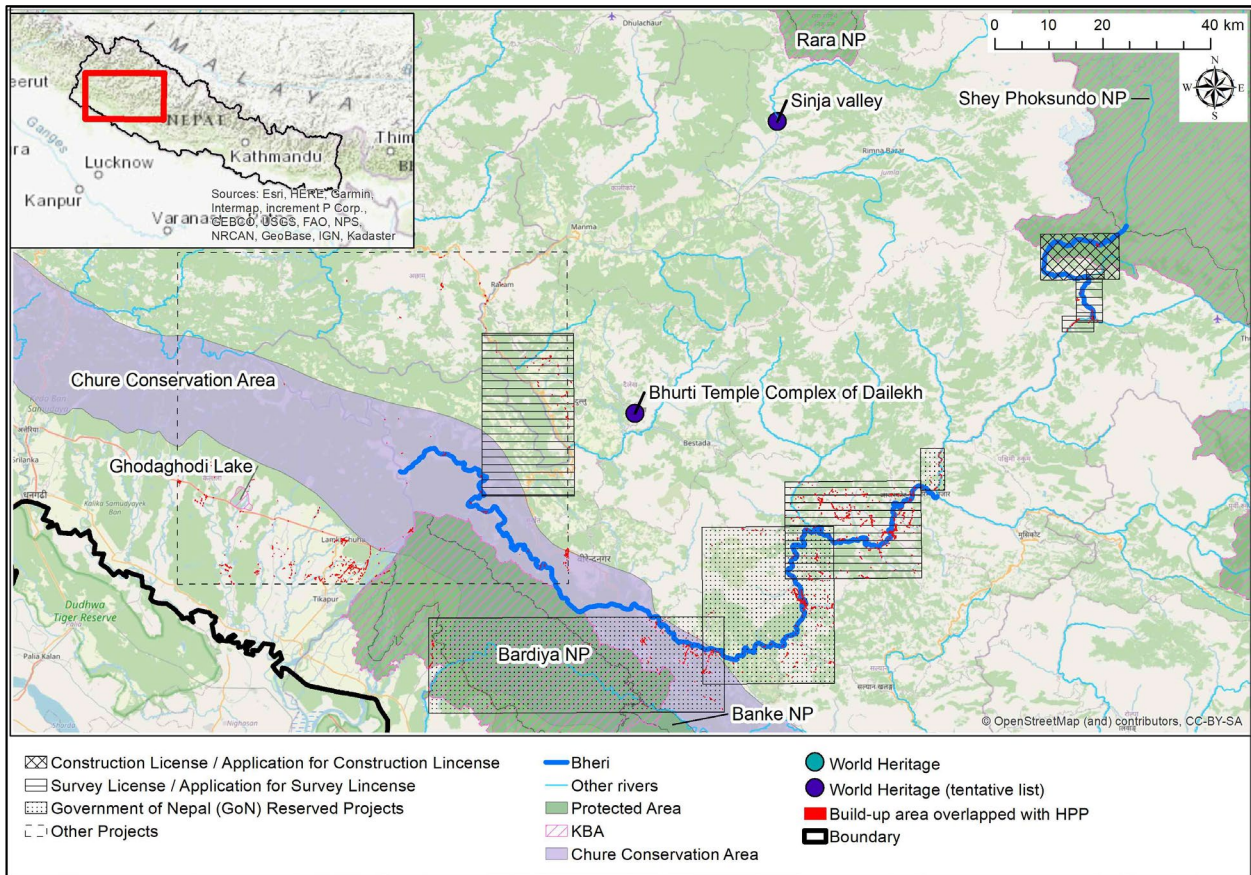
	Scientific name	Common name	Short/ Long distance	Category under IUCN red list
1	<i>Schizothorax plagiostomus</i>	Snow trout	Short distance	VU
2	<i>Schizothoracichthys progastus</i>	Dinnawah snowtrout	Short distance	LC
3	<i>Neolissochilus hexagonolepis</i>	Katli	Short distance	NT
4	<i>Labeo pangusia</i>	Pangusia labeo	Short distance	NT
5	<i>Tor putitora</i>	-	Long distance	EN
6	<i>Ompok bimaculatus</i>	Butter catfish	Long distance	NT
7	<i>Anguilla bengalensis</i>	Indian mottled eel	Long distance	NT

Source: Prepared by JICA Study Team based on Seti West Hydropower Project record

## (2) Bheri

### 1) Bheri river

The hydropower projects along the Bheri River and its environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-3.



Source: JICA Study Team

**Figure 10.6-3 Hydropower Projects along the Bheri River and Items of Environmental and Social Considerations**

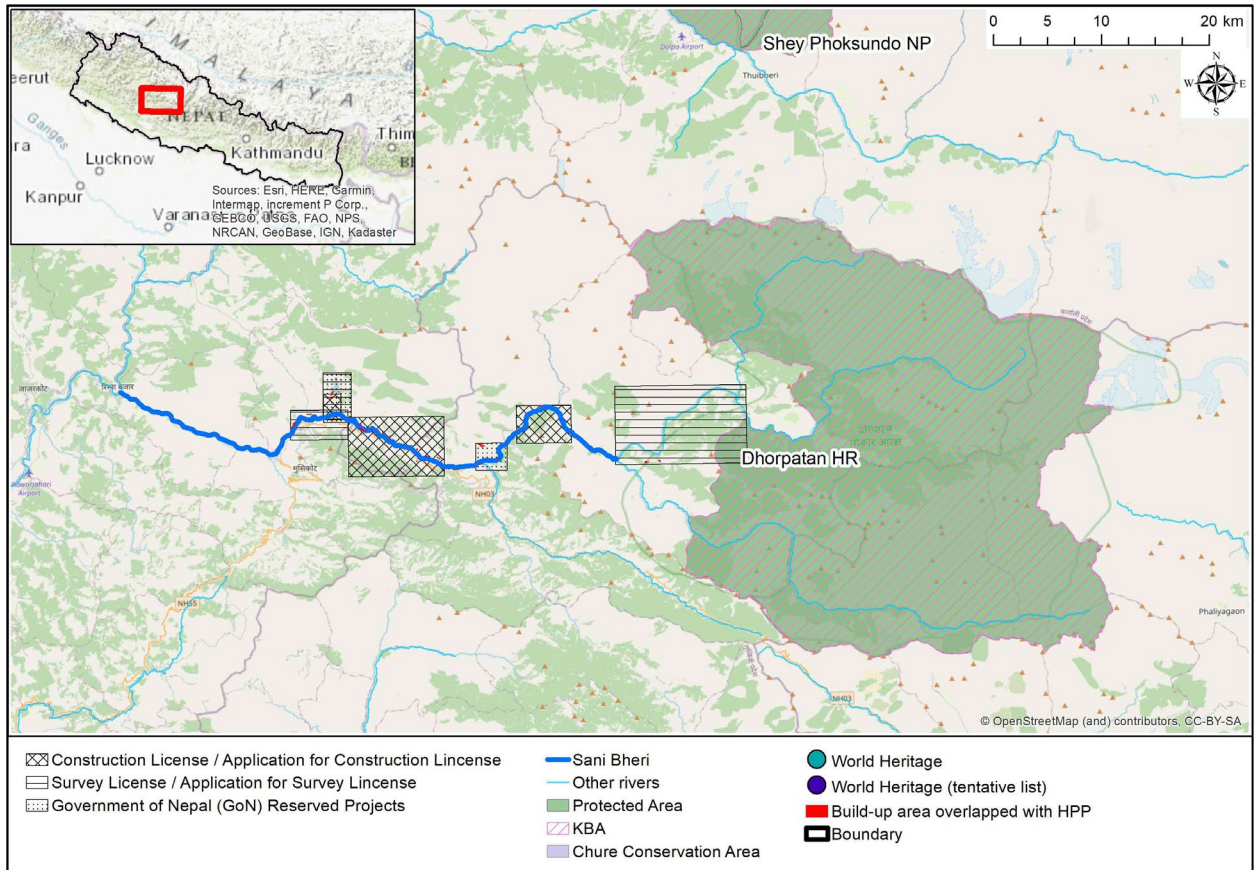
Bardiya National Park (KBA/IBA) is located within the hydropower project areas. The national park is located in the Terai plains (area: 968 km<sup>2</sup>). It was established for the purpose of preserving ecosystems, and rare species on the IUCN Red List (birds: 2 CR, 2 EN, 7 VU, 11 NT; mammals: 5 EN, 7 VU; reptiles: 1 CR, 3 EN, 2 VU) have been confirmed (Table 10.6-2).

Of these species, the attention should be paid to the impact of changes in water volume and habitat fragmentation due to the construction of dams and weirs on the South Asian River Dolphin<sup>9</sup>. In addition, if large-scale deforestation is carried out due to the hydroelectric power project, there is concern about the impact of habitat loss on these terrestrial ecosystems.

<sup>9</sup> South Asian River Dolphin is found in freshwater in Nepal, India and Bangladesh. (Source: IUCN Red List <https://www.iucnredlist.org/species/41756/50383346>)

## 2) Sani Bheri river

The hydropower projects along the Sani Bheri river and its environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-4.



Source: JICA Study Team

**Figure 10.6-4** Hydropower Projects along the Sani Bheri River and Items of Environmental and Social Considerations

The Dhorpatan Hunting Reserve (KBA/IBA), stipulated in the National Parks and Wildlife Conservation Act, may be located in part of the hydropower project areas.

**Table 10.6-6** Rare Species Confirmed in Dhorpatan Hunting Reserve, which was the basis for the selection of KBA

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Catreus wallichii</i>	Cheer Pheasant	VU
2	<i>Circus macrourus</i>	Pallid Harrier	NT
3	<i>Tragopan satyra</i>	Satyr Tragopan	NT

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14328>)

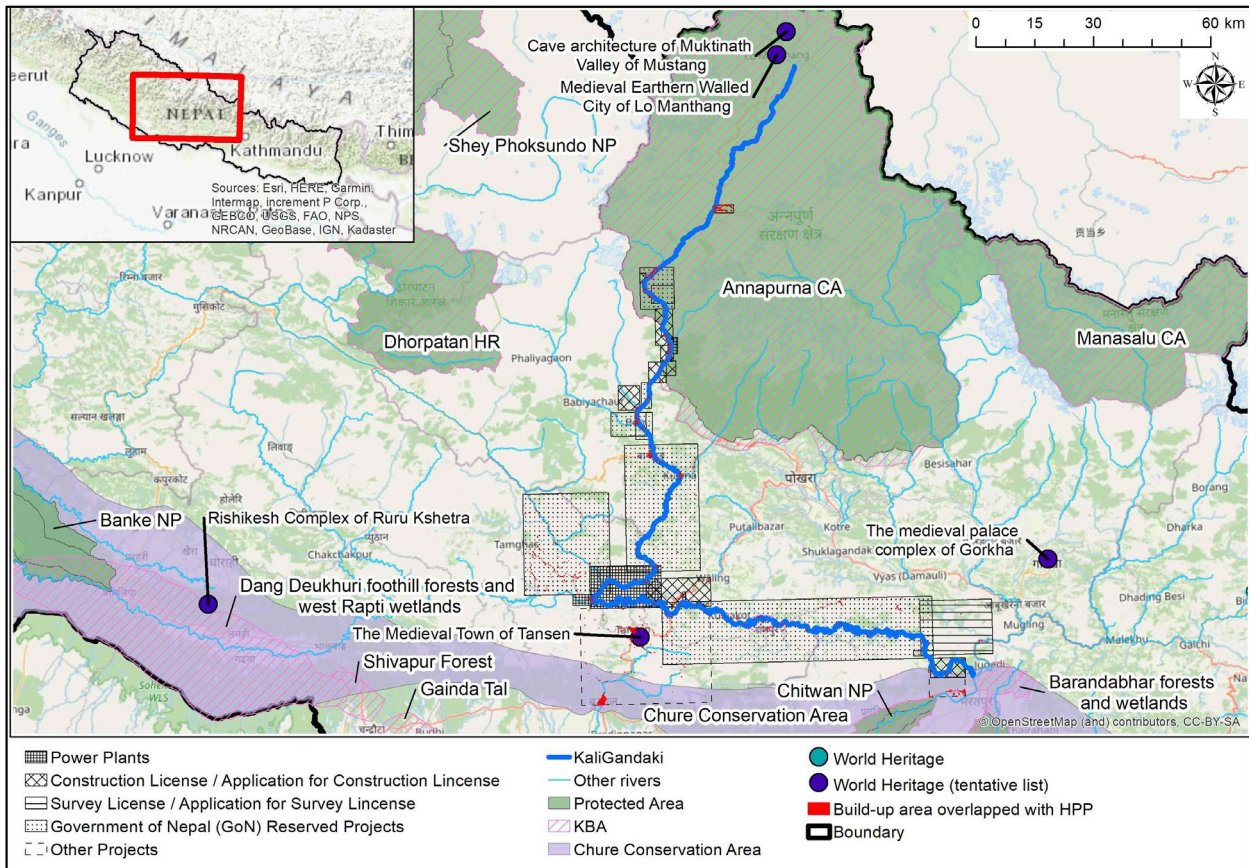
The Dhorpatan Hunting Reserve (KBA/IBA) is the only hunting reserve in Nepal (area 1,325 km<sup>2</sup>) and is an area where hunting is permitted for the purpose of wildlife management. In addition to hunting, local residents are permitted to use the area for timber, firewood, fodder, and pasture. It is a habitat for Blue sheep (a mammal of the *Bovidae* family of the *Artiodactyla*

order), and rare bird species on the IUCN Red List (one VU species, two NT species) have been confirmed (Table 10.6-6).

### (3) Kali Gandaki

#### 1) Kali Gandaki river

The hydropower projects planned along the Kali Gandaki river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-5.



Source: JICA Study Team

**Figure 10.6-5 Hydropower Projects along the Kali Gandaki River and Items of Environmental and Social Considerations**

Hydropower projects are already planned for a large part of the Kali Gandaki River; hence, the cumulative impacts are likely to be significant. In addition, the Annapurna Conservation Area (KBA/IBA) stipulated in the National Parks and Wildlife Conservation Act is located within the hydropower project areas.

The national park is the largest national park in Nepal (area: 7,629 km<sup>2</sup>). It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (amphibians: 1 VU species, birds: 2 CR species, 6 VU species, 6 NT species, mammals: 2 EN species, 6 VU species) have been confirmed (Table 10.6-7).

Medieval Town of Tansen, which is on the tentative list of UNESCO World Heritage candidates, may be located within the hydropower project area. This site contains cultural

heritage such as buildings and temples of the Newari people, and was submitted to UNESCO as a candidate for World Heritage in 2008.

**Table 10.6-7 Rare Species Confirmed in Annapurna Conservation Area, which was the basis for the selection of KBA**

	Scientific name	Common name	Category under IUCN red list
	Reptiles		
1	<i>Nanorana rostandi</i>	Dubois' paa frog	VU
	Birds		
1	<i>Gyps bengalensis</i>	White-rumped Vulture	CR
2	<i>Gyps tenuirostris</i>	Slender-billed Vulture	CR
3	<i>Aquila heliaca</i>	Eastern Imperial Eagle	VU
4	<i>Catreus wallichi</i>	Cheer Pheasant	VU
5	<i>Falco naumanni</i>	Lesser Kestrel	VU
6	<i>Gallinago nemoricola</i>	Wood Snipe	VU
7	<i>Clanga clanga</i>	Greater Spotted Eagle	VU
8	<i>Haliaeetus leucoryphus</i>	Pallas's Fish-eagle	VU
9	<i>Aegypius monachus</i>	Cinereous Vulture	NT
10	<i>Aythya nyroca</i>	Ferruginous Duck	NT
11	<i>Circus macrourus</i>	Pallid Harrier	NT
12	<i>Indicator xanthonotus</i>	Yellow-rumped Honeyguide	NT
13	<i>Sarcogyps calvus</i>	Red-headed Vulture	NT
14	<i>Tragopan satyra</i>	Satyr Tragopan	NT
	Mammals		
1	<i>Ailurus fulgens</i>	Red Panda	EN
2	<i>Panthera uncia</i>	Snow Leopard	EN
3	<i>Capricornis sumatraensis</i>	Serow	VU
4	<i>Macaca assamensis</i>	Assam Macaque	VU
5	<i>Melursus ursinus</i>	Sloth Bear	VU
6	<i>Neofelis nebulosa</i>	Clouded Leopard	VU
7	<i>Ovis ammon</i>	Argali	VU
8	<i>Ursus thibetanus</i>	Himalayan Black Bear	VU

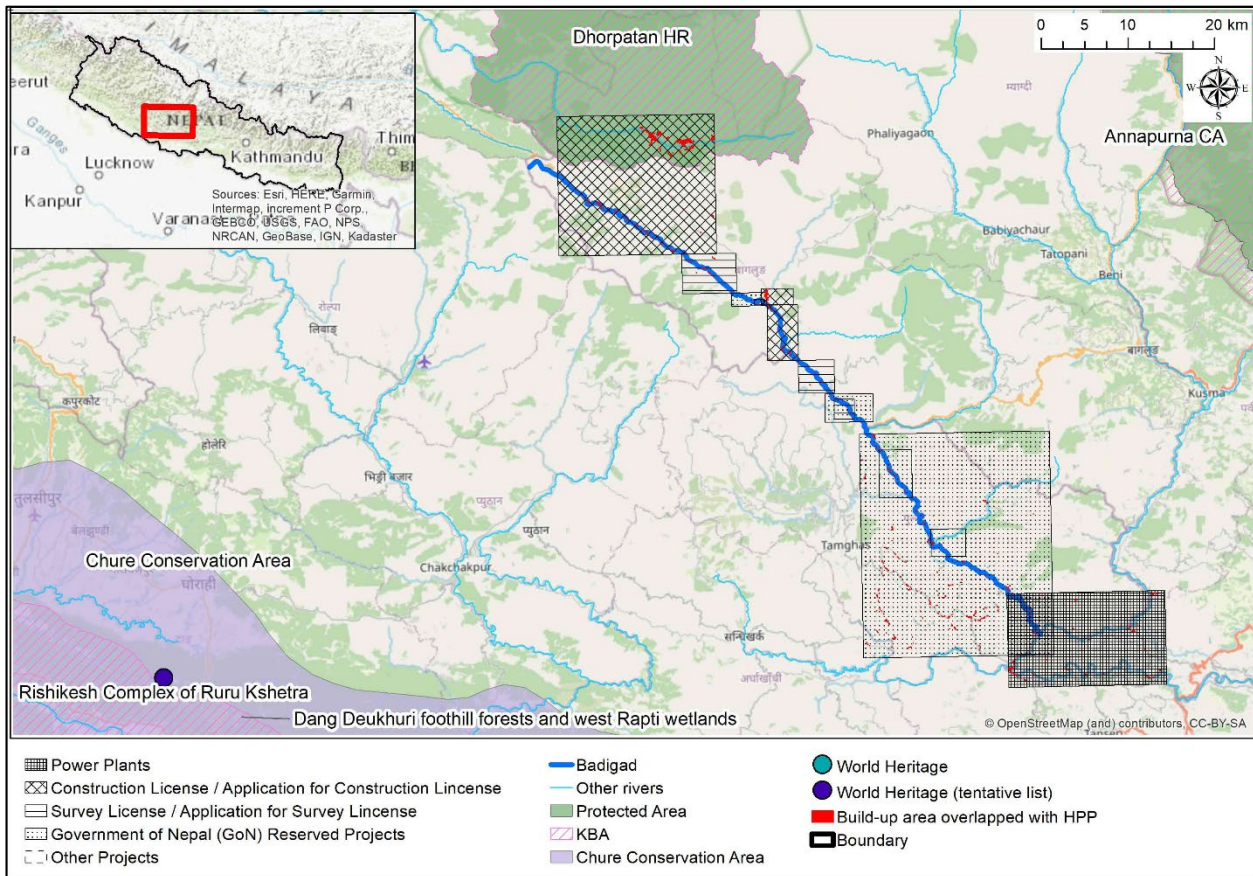
Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14322>)

## 2) Badigad river

The hydropower projects planned along the Badigad river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-6.

The Dhorpatan Hunting Reserve (KBA/IBA), stipulated in the National Parks and Wildlife Conservation Act, may be located in part of the hydropower project areas.

The Dhorpatan Hunting Reserve (KBA/IBA) is the only hunting reserve in Nepal (area 1,325 km<sup>2</sup>) and is an area where hunting is permitted for the purpose of wildlife management. In addition to hunting, local residents are permitted to use the area for timber, firewood, fodder, and pasture. It is a habitat for Blue sheep (a mammal of the Bovidae family of the Artiodactyla order), and rare bird species on the IUCN Red List (one VU species, two NT species) have been confirmed (Table 10.6-6).



Source: JICA Study Team

**Figure 10.6-6 Hydropower Projects along the Badigad River and Items of Environmental and Social Considerations**

#### (4) Trishuli

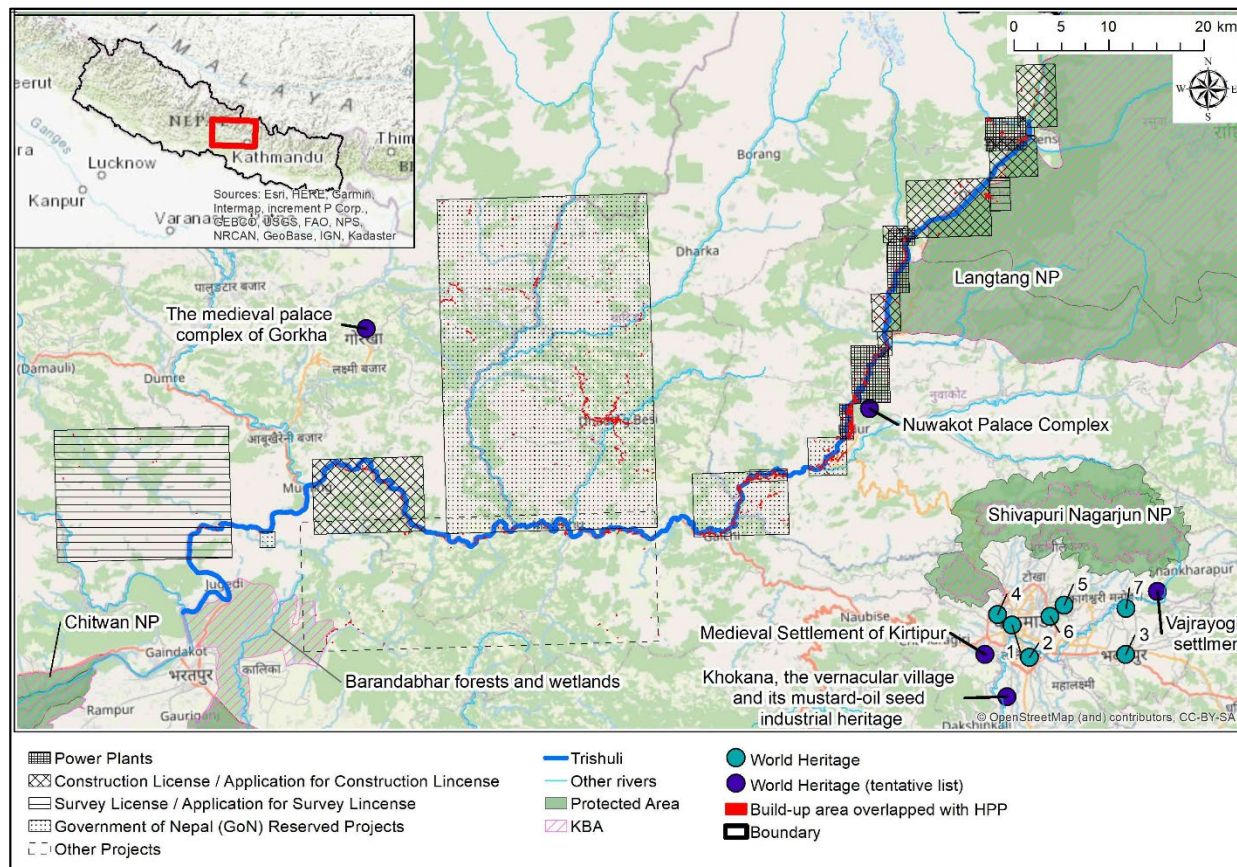
##### 1) Trishuli river

The hydropower projects planned along the Trishuli river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-6.

Hydropower projects are already planned for a large part of the Trishuli River, and the cumulative impacts are likely to be significant. In addition, Langtang National Park (KBA/IBA), as stipulated by the National Parks and Wildlife Conservation Act, is located within the hydropower project areas.

The national park is located about 40 km north of the capital Kathmandu (area: 1,710 km<sup>2</sup>). It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (4 VU bird species, 6 NT species, 1 EN mammal species, 3 VU mammal species) have been confirmed (Table 10.6-8).

The Nuwakot Palace Complex, which is on the tentative list of UNESCO World Heritage candidates, may be located near the proposed hydroelectric project site. This site contains cultural heritage such as temples built during the Malla period, and was submitted to UNESCO as a candidate for World Heritage in 2008.



Source: JICA Study Team

**Figure 10.6-7** Hydropower Projects along the Trishuli River and Items of Environmental and Social Considerations

**Table 10.6-8** Rare Species Confirmed in Langtang National Park, which was the basis for the selection of KBA

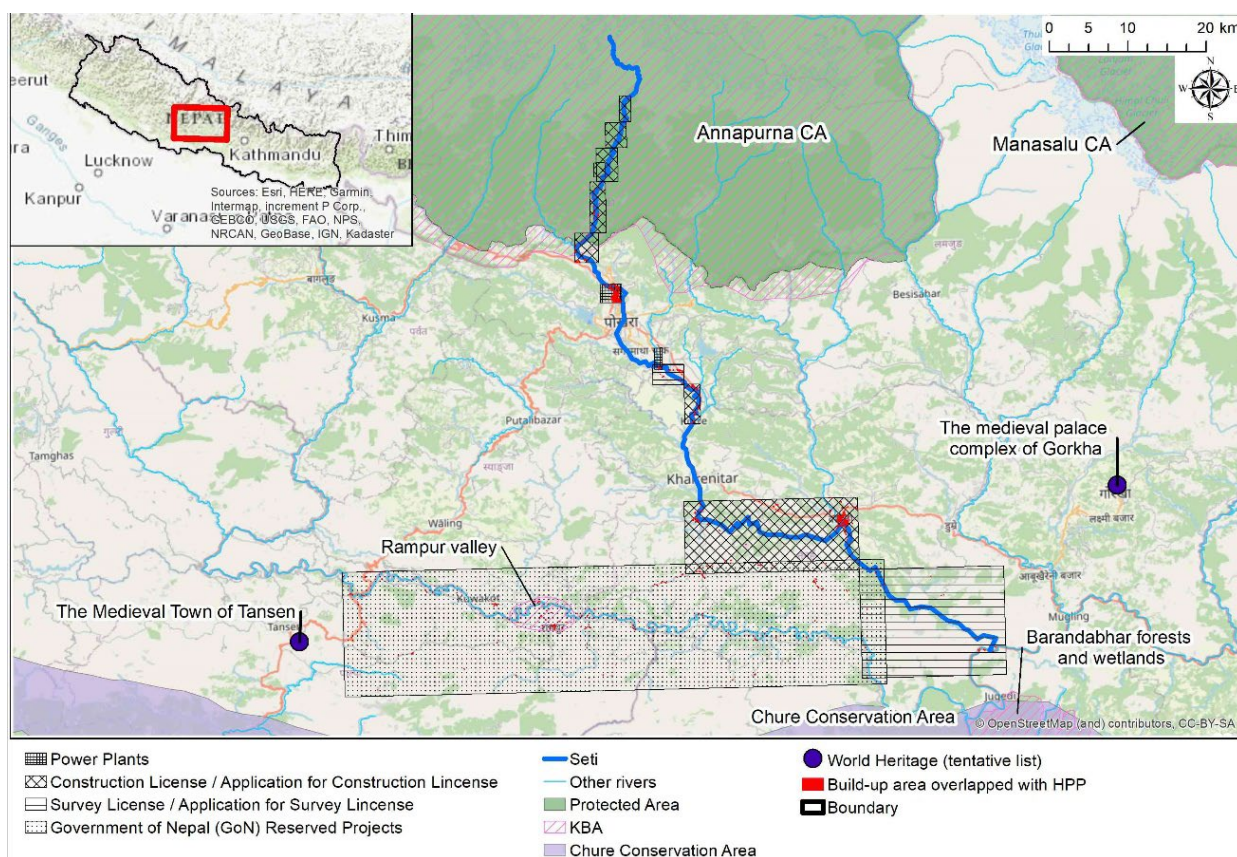
	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Aquila clanga</i>	Greater Spotted Eagle	VU
2	<i>Aquila heliaca</i>	Eastern Imperial Eagle	VU
3	<i>Gallinago nemoricola</i>	Wood Snipe	VU
4	<i>Saxicola insignis</i>	White-throated Bushchat	VU
5	<i>Aegypius monachus</i>	Cinereous Vulture	NT
6	<i>Circus macrourus</i>	Pallid Harrier	NT
7	<i>Emberiza aureola</i>	Yellow-breasted Bunting	NT
8	<i>Indicator xanthonotus</i>	Yellow-rumped Honeyguide	NT
9	<i>Sarcogyps calvus</i>	Red-headed Vulture	NT
10	<i>Tragopan satyra</i>	Satyr Tragopan	NT
	Mamals		
1	<i>Ailurus fulgens</i>	Red Panda	EN
2	<i>Macaca assamensis</i>	Assam Macaque	VU
3	<i>Neofelis nebulosa</i>	Clouded Leopard	VU
4	<i>Ursus thibetanus</i>	Himalayan Black Bear	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14334>)

## 2) Seti river

The hydropower projects planned along the Seti river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are

shown in Figure 10.6-8.



Source: JICA Study Team

**Figure 10.6-8 Hydropower Projects along the Seti River and Items of Environmental and Social Considerations**

Hydropower projects are already planned for a large part of the Seti River; hence, cumulative impacts are likely to be significant.

The Annapurna Conservation Area (KBA/IBA) stipulated in the National Parks and Wildlife Conservation Act lies within the proposed hydropower project area. The conservation area is the largest national park in Nepal (area: 7,629 km<sup>2</sup>). It was established for the purpose of conserving ecosystems, etc., and contains rare species listed in the IUCN Red List (amphibians: 1 VU species, birds: 2 CR species, 6 VU species, 6 NT species, mammals: 2 EN species, 6 VU species) (Table 10.6-7).

The Rampur valley (KBA/IBA) lies within the proposed hydropower project area. The area is 2,787 km<sup>2</sup>, and contains rare species listed in the IUCN Red List (birds: 2 CR species, 1 VU species) (Table 10.6-9).

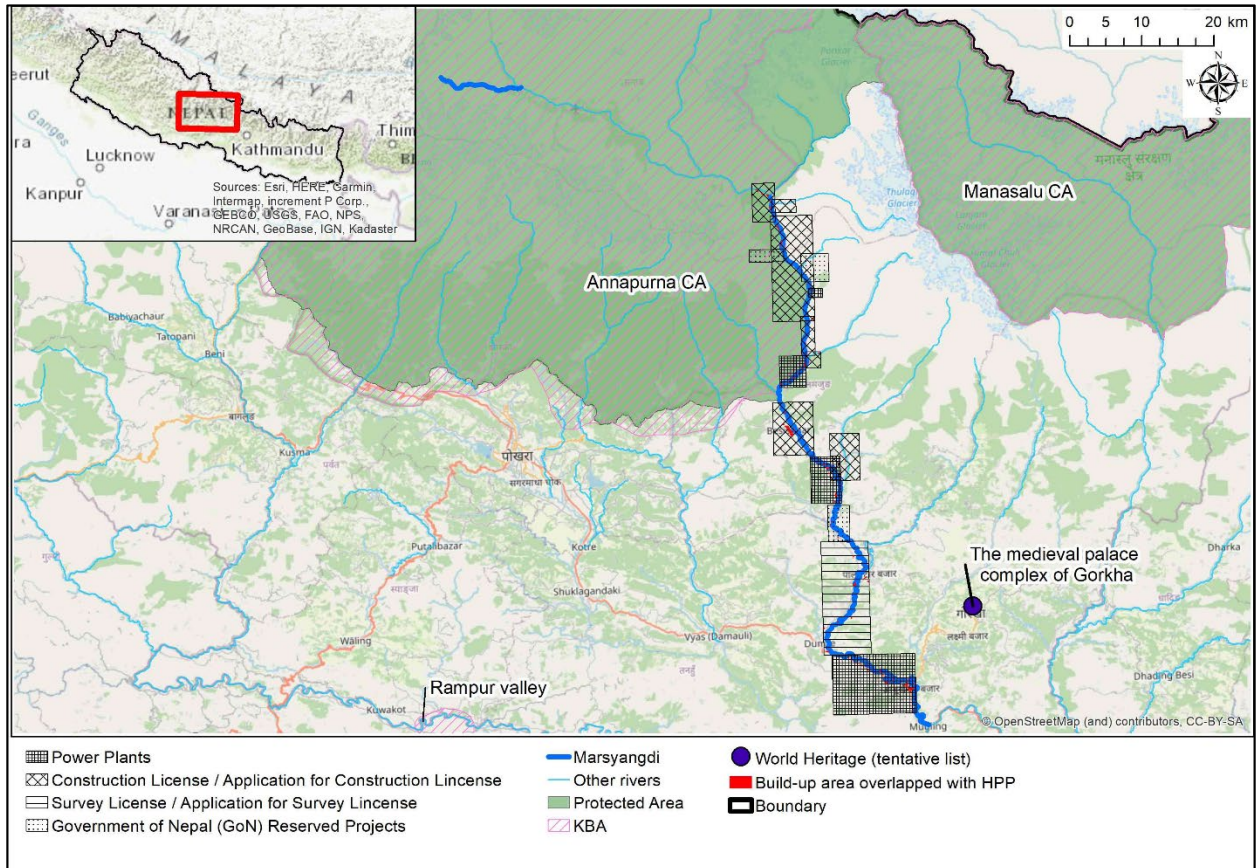
**Table 10.6-9 Rare Species Confirmed in Rampur Valley, which was the basis for the selection of KBA**

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Gyps bengalensis</i>	White-rumped Vulture	CR
2	<i>Gyps tenuirostris</i>	Slender-billed Vulture	CR
3	<i>Sarcogyps calvus</i>	Red-headed Vulture	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/18503>)

### 3) Marsyangdi river

The hydropower projects planned along the Marsyangdi river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-9.



Source: JICA Study Team

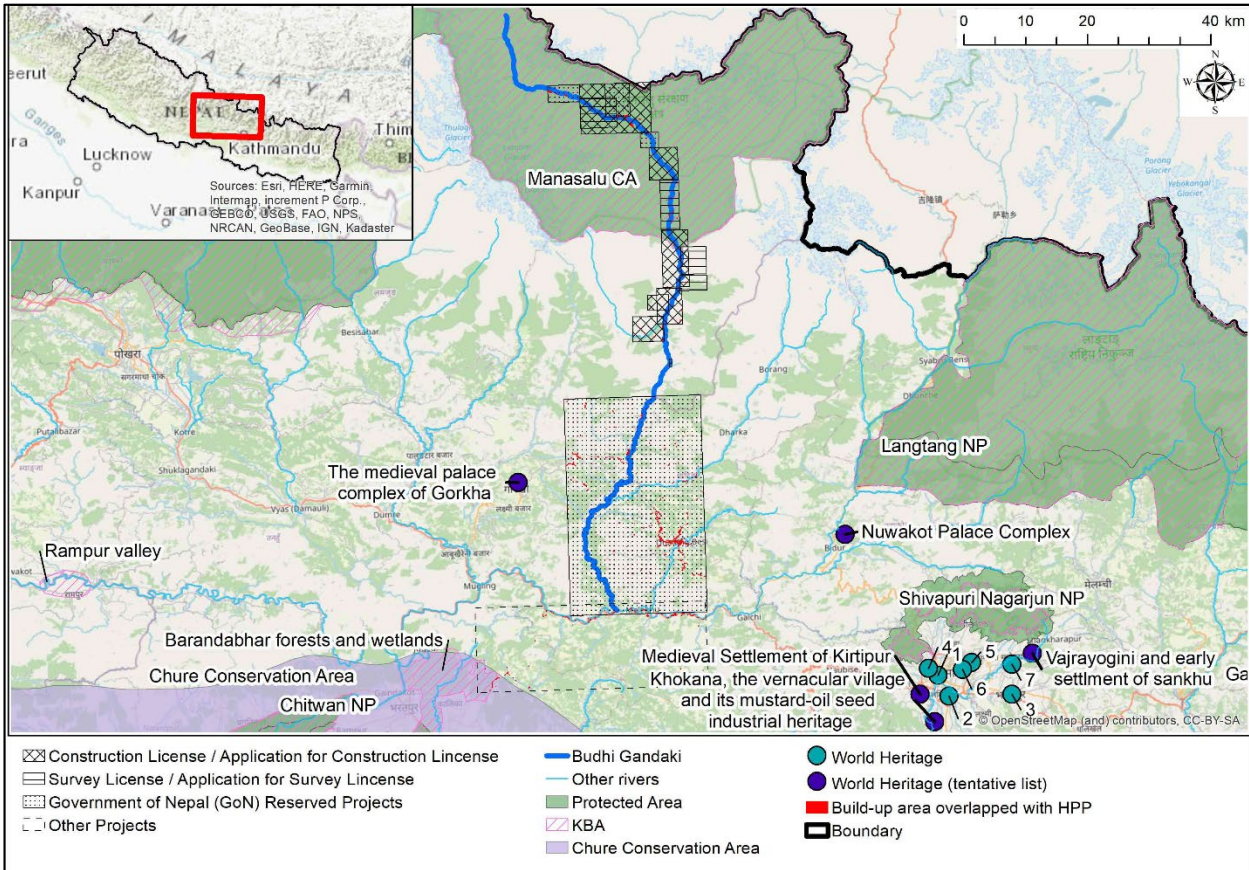
**Figure 10.6-9 Hydropower Projects along the Marsyangdi River and Items of Environmental and Social Considerations**

Hydropower projects are already planned for a large part of the Marsyangdi River; hence, the cumulative impacts are expected to be significant. In addition, the Annapurna Conservation Area (KBA/IBA) stipulated in the National Parks and Wildlife Conservation Act is located within the hydropower project areas.

The conservation area is Nepal's largest national park (area: 7,629 km<sup>2</sup>). It was established with the aim of conserving ecosystems, and rare species on the IUCN Red List (amphibians: 1 VU species, birds: 2 CR species, 6 VU species, 6 NT species, mammals: 2 EN species, 6 VU species) have been confirmed (Table 10.6-7).

### 4) Budhi Gandaki river

The hydropower projects planned along the Budhi Gandaki river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-10.



Source: JICA Study Team

**Figure 10.6-10 Hydropower Projects along the Budhi Gandaki River and Items of Environmental and Social Considerations**

Hydropower projects are already planned for a large part of the Budhi Gandaki River; hence, the cumulative impacts are expected to be significant. In addition, the Manasalu Conservation Area, stipulated in the Law on the Conservation of National Parks and Wildlife, is located within the area of the hydropower project areas.

The conservation area covers an area of 1,663 km<sup>2</sup>, and has been identified as home to 33 mammal species, 110 bird species, and 3 reptile species. Trekking is popular in the area, and natural resources such as firewood and medicinal herbs are also utilized by the surrounding communities. There are also cultural heritage sites such as Buddhist temples, so the caution is required.

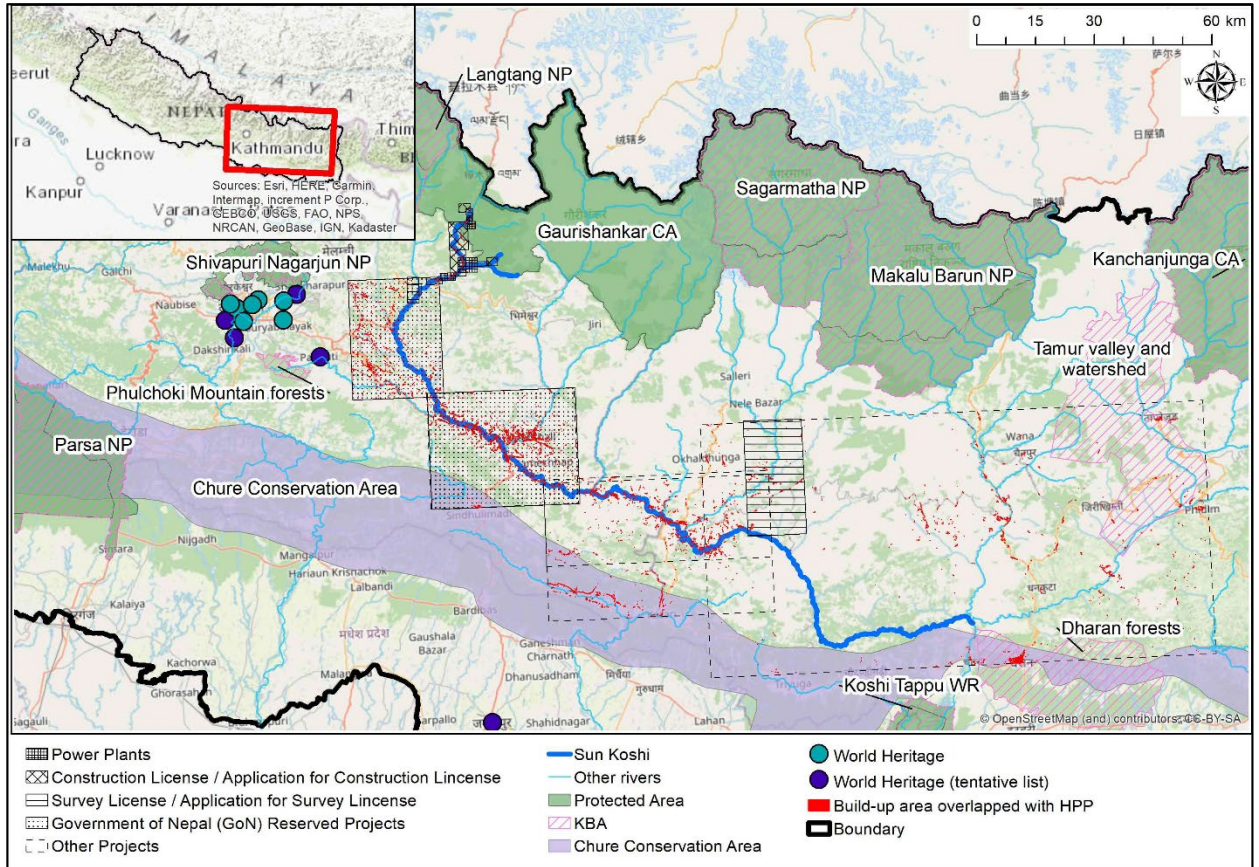
## (5) Sun Koshi

### 1) Sun Koshi river

The hydropower projects planned along the Sun Koshi river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-11.

Hydropower projects are already planned for a large part of the Sun Koshi River; hence, the cumulative impacts are expected to be significant. In addition, the Gaurisankar Conservation Area, stipulated in the National Parks and Wildlife Conservation Act, is located within the proposed hydroelectric project area.

The conservation area covers an area of 2,179 km<sup>2</sup> and is managed by the Nepalese NGO National Trust for Nature Conservation. It serves as an ecological corridor connecting Sagarmatha National Park and Langtang National Park, and is home to 77 mammal species, 16 fish species, and 235 bird species. In addition, the area is famous for glacial lakes, and attention should be paid to the possibility of GLOF (Glacial Lake Outburst Floods).



Source: JICA Study Team

**Figure 10.6-11 Hydropower Projects along the Sun Koshi River and Items of Environmental and Social Considerations**

## 2) Bote Koshi river

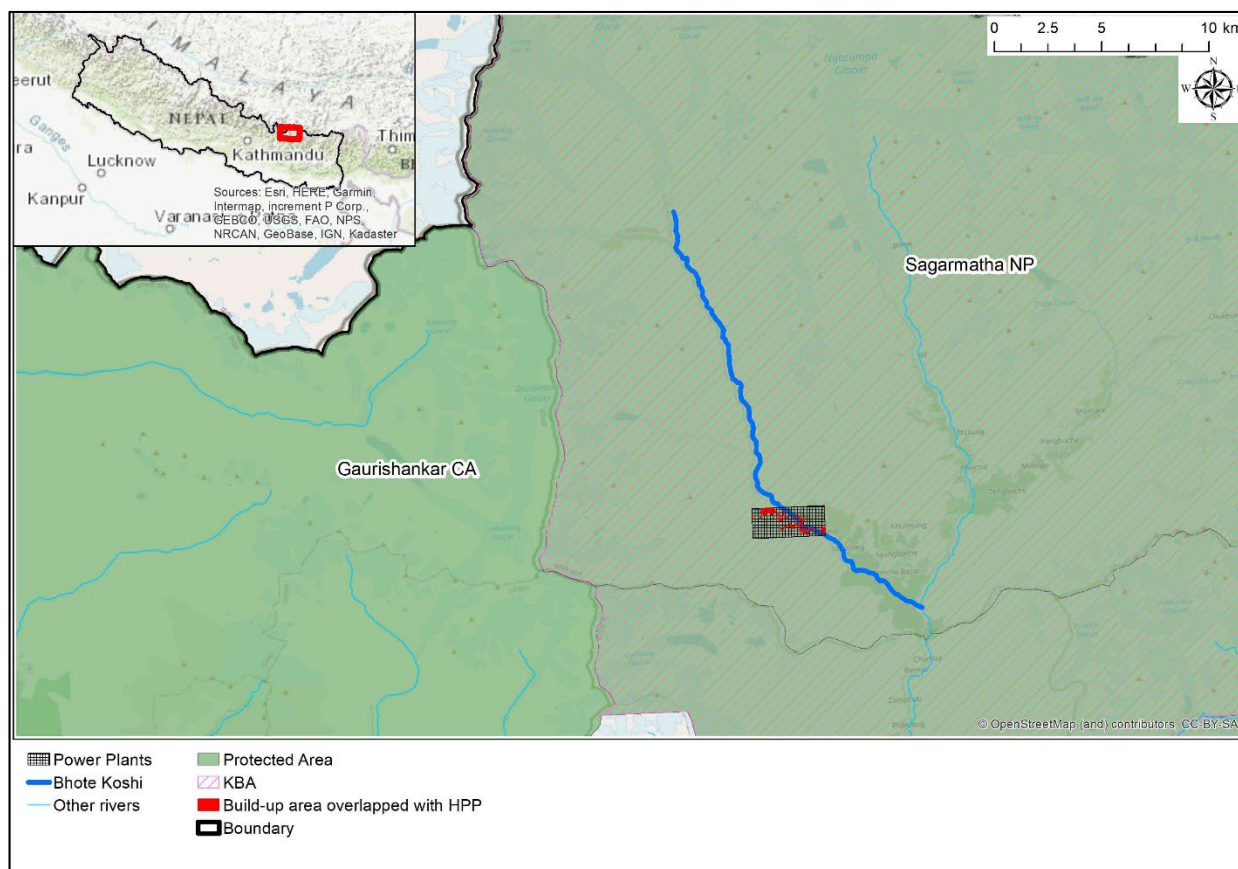
The hydropower projects planned along the Bote Koshi river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-12.

The Bote Koshi River flows through Sagarmatha National Park (National Park/KBA/IBA) which is regulated by the National Parks and Wildlife Conservation Act, and there is one project in operation.

The national park (area: 1,148 km<sup>2</sup>) is also designated as a UNESCO World Heritage Site<sup>10</sup>. It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (2 VU bird species, 3 NT mammal species, 1 EN mammal species, 3 VU mammal species) have been confirmed (Table 10.6-10). While trekking is an important source of income for the

<sup>10</sup> It was registered in 1979 as a natural heritage site that meets the 10 criteria of the UNESCO World Heritage Site inscription criteria, which states "(vii) to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance."

ethnic minority (Sherpa), there are concerns about the impact on the environment due to the increase in tourists.



Source: JICA Study Team

**Figure 10.6-12** Hydropower Projects along the Bote Koshi River and Items of Environmental and Social Considerations

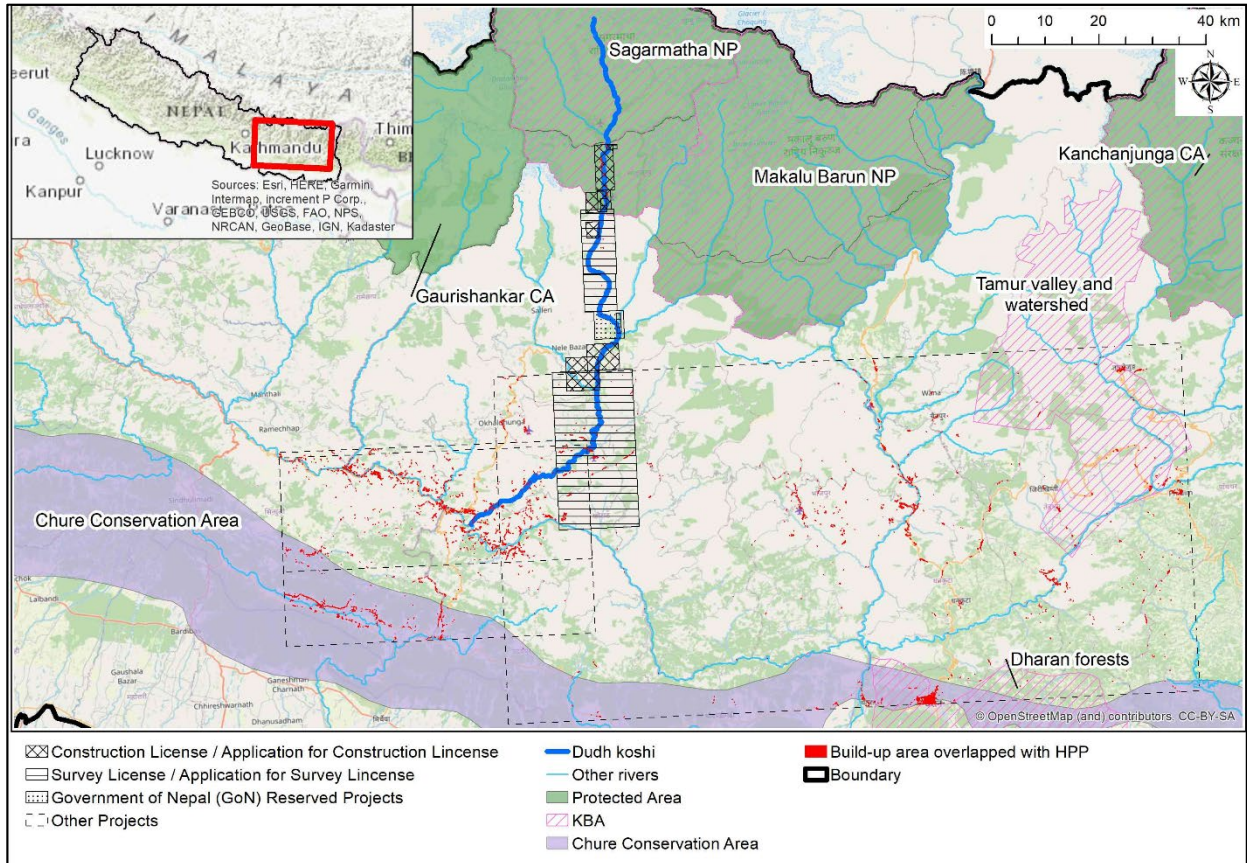
**Table 10.6-10** Rare Species Confirmed in Sagarmatha National Park, which was the basis for the selection of KBA

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Aquila heliaca</i>	Eastern Imperial Eagle	VU
2	<i>Gallinago nemoricola</i>	Wood Snipe	VU
3	<i>Aegypius monachus</i>	Cinereous Vulture	NT
4	<i>Aythya nyroca</i>	Ferruginous Duck	NT
5	<i>Tragopan satyra</i>	Satyr Tragopan	NT
	Mammals		
1	<i>Ailurus fulgens</i>	Red Panda	EN
2	<i>Capricornis sumatraensis</i>	Serow	VU
3	<i>Hemitragus jemlahicus</i>	Himalayan Tahr	VU
4	<i>Ursus thibetanus</i>	Himalayan Black Bear	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14342>)

### 3) Dudh Koshi river

The hydropower projects planned along the Dudh Koshi river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-13.



Source: JICA Study Team

**Figure 10.6-13 Hydropower Projects along the Dudh Koshi River and Items of Environmental and Social Considerations**

Hydropower projects are already planned for a large part of the Dudh Koshi River; hence, the cumulative impacts are expected to be significant. In addition, Sagarmatha National Park (KBA/IBA) is located within the hydropower project areas, as stipulated by the National Parks and Wildlife Conservation Act.

The national park (area: 1,148 km<sup>2</sup>) is also designated as a UNESCO World Heritage Site<sup>11</sup>. It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (2 VU bird species, 3 NT mammal species, 1 EN mammal species, 3 VU mammal species) have been confirmed (Table 10.6 10). While trekking is an important source of income for the ethnic minority (Sherpa), there are concerns about the impact on the environment due to an increase in tourists

#### 4) Likhu river

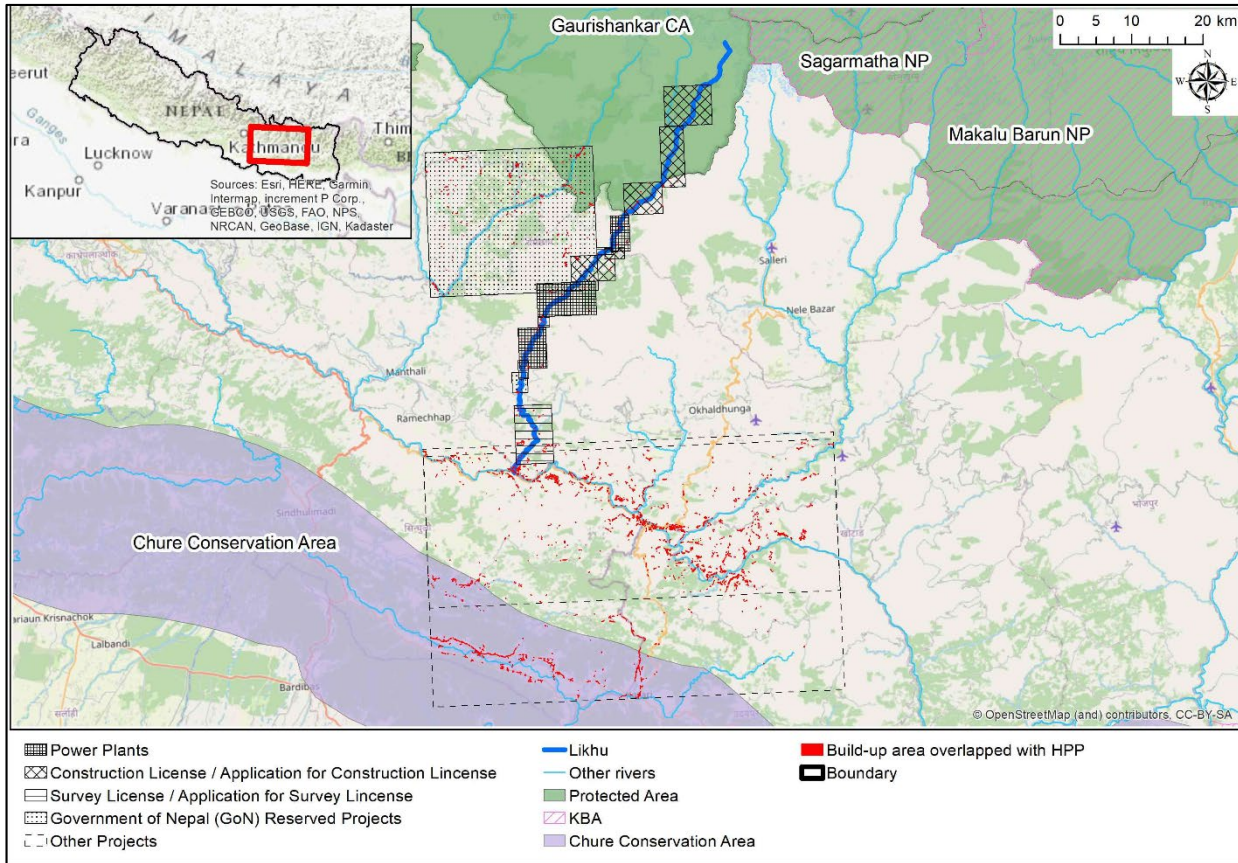
The hydropower projects planned along the Likhu river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-14.

Hydropower projects are already planned for a large part of the Likhu River; hence, the cumulative impacts are likely to be significant. In addition, the Gaurisankar Conservation Area, stipulated in the National Parks and Wildlife Conservation Act, is located within the

<sup>11</sup> It was registered in 1979 as a natural heritage site that meets the 10 criteria of the UNESCO World Heritage Site inscription criteria, which states "(vii) to contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance."

hydropower project areas.

The conservation area covers an area of 2,179 km<sup>2</sup> and is managed by the Nepalese NGO National Trust for Nature Conservation. It serves as an ecological corridor connecting Sagarmatha National Park and Langtang National Park, and is home to 77 mammal species, 16 fish species, and 235 bird species. The area is also famous for its glacial lakes, and attention is required from the perspective of GLOF.



Source: JICA Study Team

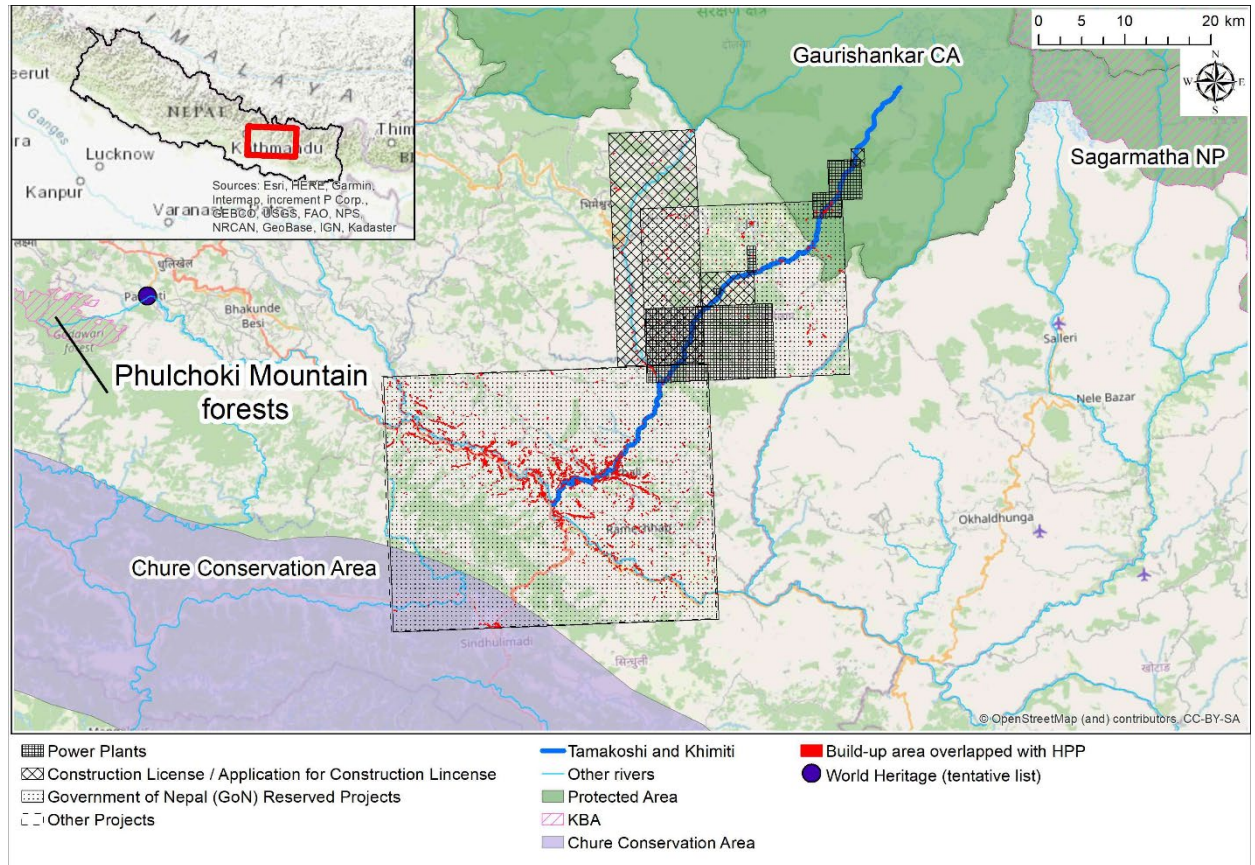
**Figure 10.6-14** *Hydropower Projects along the Likhu River and Items of Environmental and Social Considerations*

### 5) Tamakoshi / Khimiti river

The hydropower projects planned along the Tamakoshi / Khimiti river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-15.

Hydropower projects are already planned for most of the Tamakoshi/Khimiti River; hence, the cumulative impacts are likely to be significant. In addition, the Gaurisankar Conservation Area, stipulated in the National Parks and Wildlife Conservation Act, is located within the hydropower project areas.

The conservation area covers an area of 2,179 km<sup>2</sup> and is managed by the Nepalese NGO National Trust for Nature Conservation. It serves as an ecological corridor connecting Sagarmatha National Park and Langtang National Park, and 77 species of mammals, 16 species of fish, and 235 species of birds have been identified. The area is also famous for glacial lakes, and attention is required from the perspective of GLOF.



Source: JICA Study Team

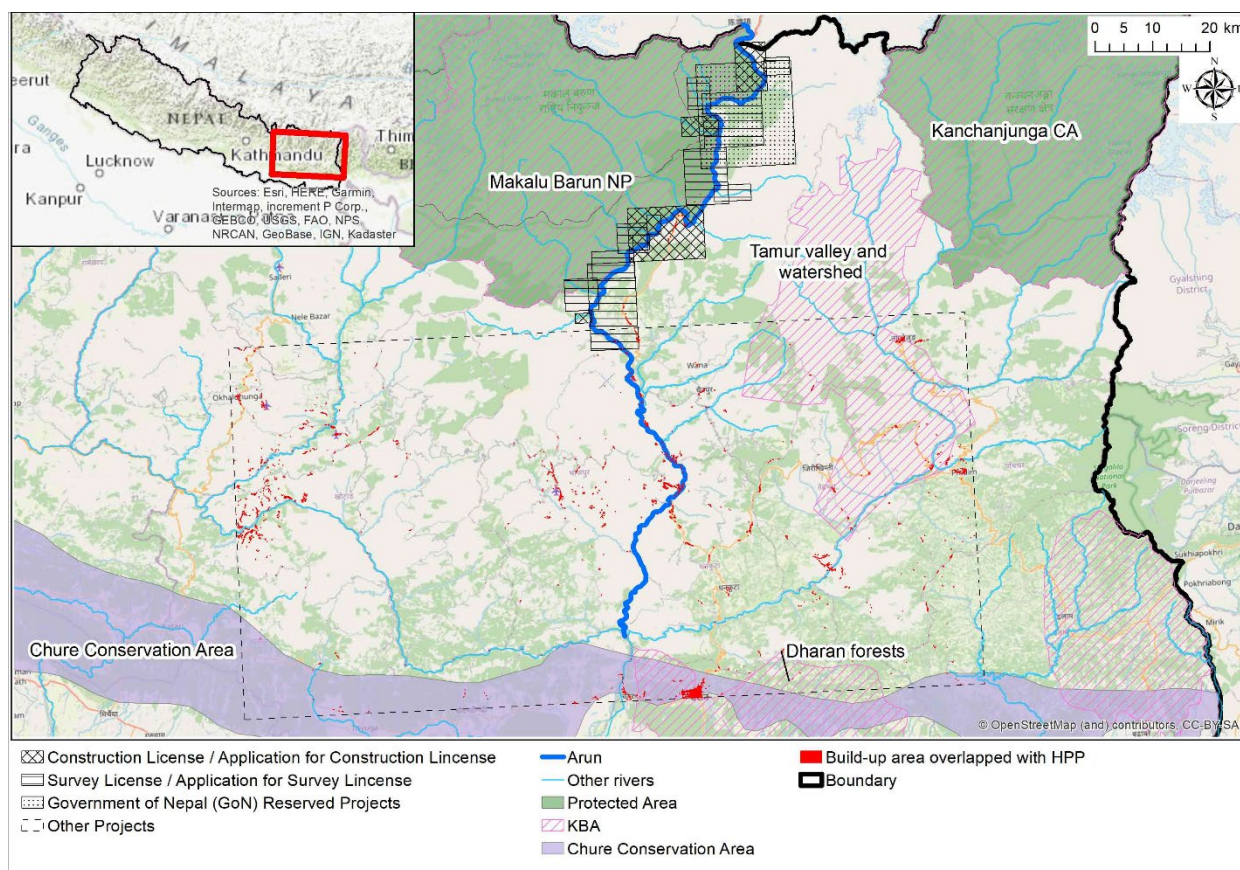
**Figure 10.6-15 Hydropower Projects along the Tamakoshi / Khimiti River and Items of Environmental and Social Considerations**

## (6) Arun river basin

The hydropower projects planned along the Arun river basin and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-16.

In the Arun River system, hydropower development is planned intensively in the upper reaches; hence, the cumulative impacts are expected to be significant. In addition, Makalu Barun National Park (KBA/IBA), which is stipulated in the National Parks and Wildlife Conservation Act, is located within the hydropower project areas.

Makalu Barun National Park (area: 1,510 km<sup>2</sup>) is adjacent to the west of Sagarmatha National Park. It was established with the aim of conserving ecosystems, etc., and rare species on the IUCN Red List (2 VU bird species, 3 NT mammal species, 2 EN mammal species, 3 VU mammal species) have been confirmed (Table 10.6-11). In addition, since it was designated a national park, a community-based conservation approach has been adopted, and ecotourism and other activities have been utilized as a means of livelihood for residents.



Source: JICA Study Team

**Figure 10.6-16** Hydropower Projects along the Arun River Basin and Items of Environmental and Social Considerations

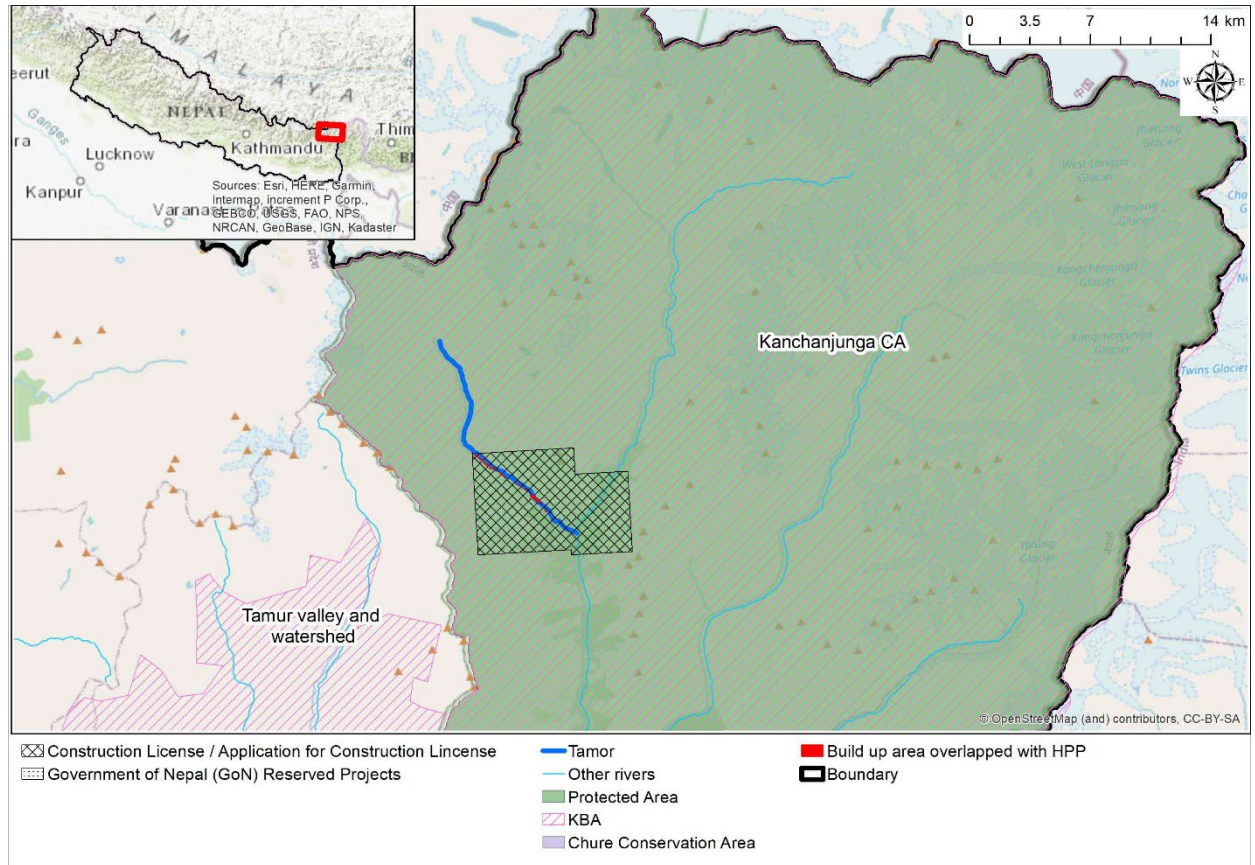
**Table 10.6-11** Rare Species Confirmed in Makalu Barun National Park, which was the basis for the selection of KBA

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Aquila heliaca</i>	Eastern Imperial Eagle	VU
2	<i>Gallinago nemoricola</i>	Wood Snipe	VU
3	<i>Indicator xanthonotus</i>	Yellow-rumped Honeyguide	NT
4	<i>Spelaornis caudatus</i>	Rufous-throated Wren-babbler	NT
5	<i>Tragopan satyra</i>	Satyr Tragopan	NT
	Mammals		
1	<i>Ailurus fulgens</i>	Red Panda	EN
2	<i>Panthera uncia</i>	Snow Leopard	EN
3	<i>Hemitragus jemlahicus</i>	Himalayan Tahr	VU
4	<i>Neofelis nebulosa</i>	Clouded Leopard	VU
5	<i>Ursus thibetanus</i>	Himalayan Black Bear	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14338>)

## (7) Tamor

The hydropower projects planned along the Tamor river basin and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-17.



Source: JICA Study Team

**Figure 10.6-17 Hydropower Projects along the Tumor River Basin and Items of Environmental and Social Considerations**

In the Tumor river basin, the Kanchanjunga Conservation Area, as defined by the National Parks and Wildlife Conservation Act, is located within the hydropower project areas.

The conservation area covers an area of 2,035 km<sup>2</sup>. It borders the Qomolangma National Nature Preserve in Tibet, China to the north and the Khangchendzonga National Park in India to the east, and is an area rich in biodiversity. It is also inhabited by indigenous peoples.

## (8) Others

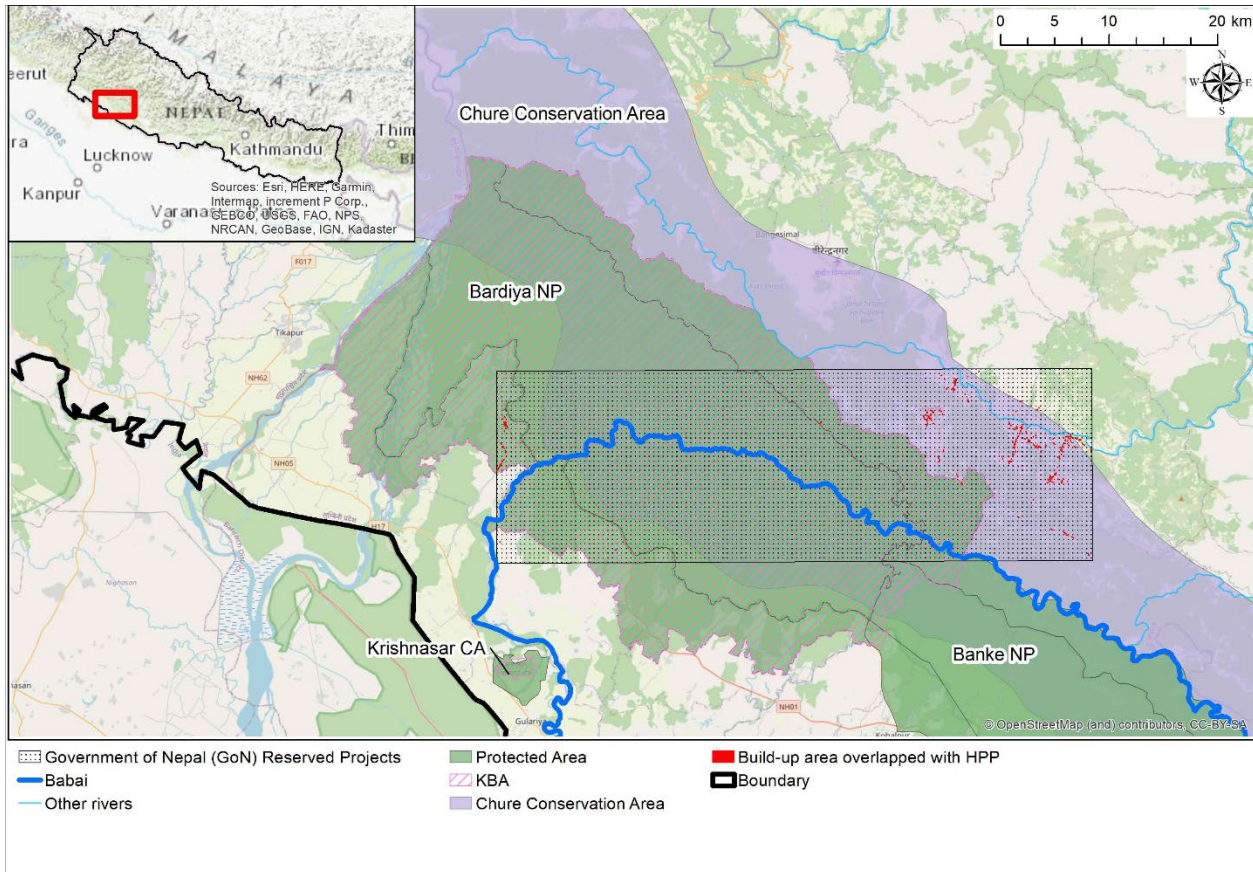
### 1) Badai river

The hydropower projects planned along the Badai river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-18.

Along the Badai River, Bardiya National Park (KBA/IBA), stipulated by the National Parks and Wildlife Conservation Act, is located within the hydropower project areas.

This national park (area: 968 km<sup>2</sup>) is located in the Terai plains. It was established for the purpose of conserving ecosystems, and rare species on the IUCN Red List (birds: 2 CR, 2 EN, 7 VU, 11 NT; mammals: 5 EN, 7 VU; reptiles: 1 CR, 3 EN, 2 VU) have been confirmed (Table 10.6-2).

Of these species, the attention should be paid to the impact of changes in water volume and habitat fragmentation due to the construction of dams and weirs on the South Asian River Dolphin<sup>12</sup>. In addition, if large-scale deforestation is carried out due to the hydroelectric power project, there is concern about the impact of habitat loss on these terrestrial ecosystems.



Source: JICA Study Team

**Figure 10.6-18 Hydropower Projects along the Babai River and Items of Environmental and Social Considerations**

## 2) Rapti river

The hydropower projects planned along the Rapti river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-19.

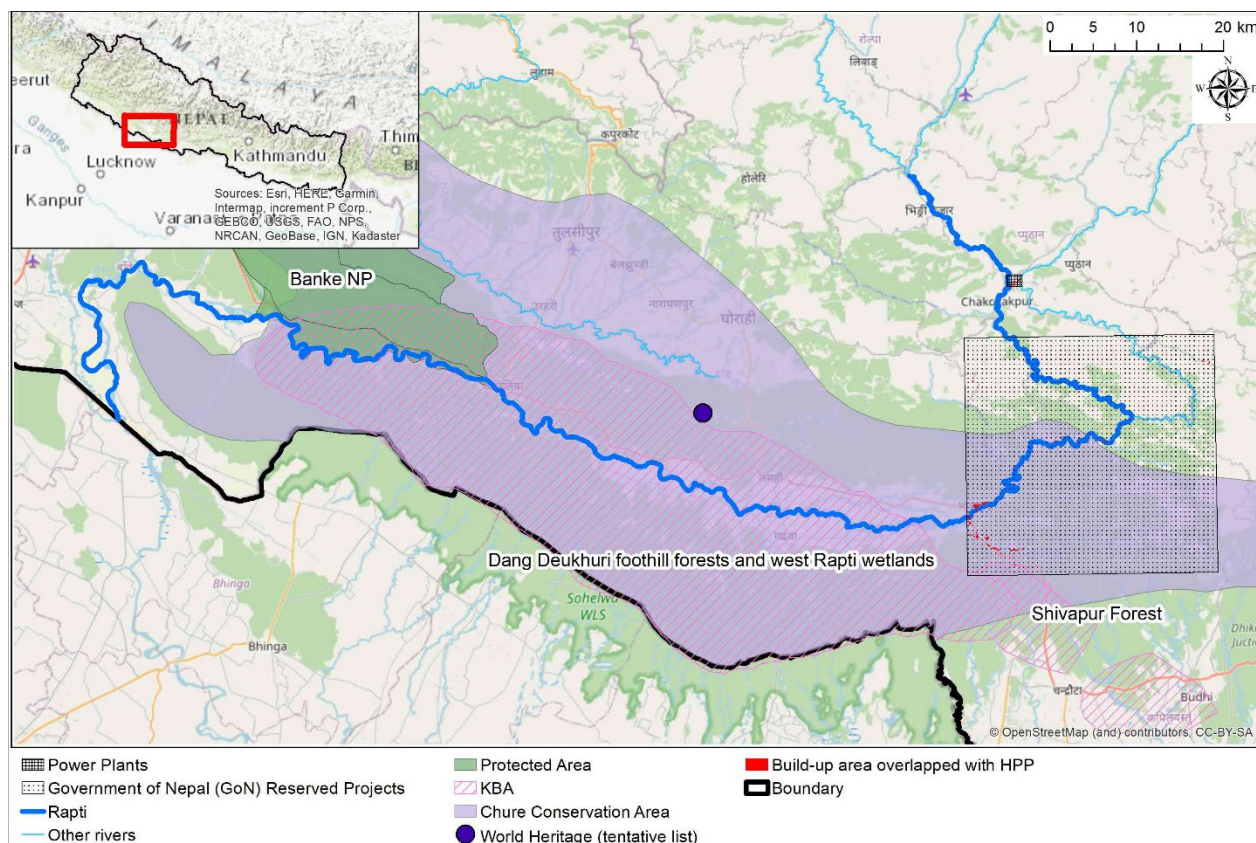
Along the Rapti River, two KBAs (Shivapur Forests and Dang Deukhuri foothill forests/west Rapti wetlands) may be located in the hydropower project areas.

Shivapur forests has an area of 8,757 km<sup>2</sup>. It was established for the purpose of ecosystem conservation, and has rare species on the IUCN Red List (1 EN and 1 VU reptile species) (Table 10.6 12).

Dang Deukhuri foothill forests/West Rapti wetlands has an area of 166,153 km<sup>2</sup>. It was established for the purpose of ecosystem conservation, and has rare species on the IUCN Red

<sup>12</sup> South Asian River Dolphin is found in freshwater in Nepal, India and Bangladesh. (Source: IUCN Red List <https://www.iucnredlist.org/species/41756/50383346>)

List (2 CR, 1 VU, 2 NT birds, 1 EN and 1 VU mammal species) (Table 10.6-13).



Source: JICA Study Team

**Figure 10.6-19 Hydropower Projects along the Rapti River and Items of Environmental and Social Considerations**

**Table 10.6-12 Rare Species Confirmed in Shivapur Forests, which was the basis for the selection of KBA**

	Scientific name	Common name	Category under IUCN red list
	Reptiles		
1	<i>Indotestudo elongata</i>	Yellow-headed Tortoise	EN
2	<i>Melanochelys tricarinata</i>	Three-keeled Land Tortoise	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/27317>)

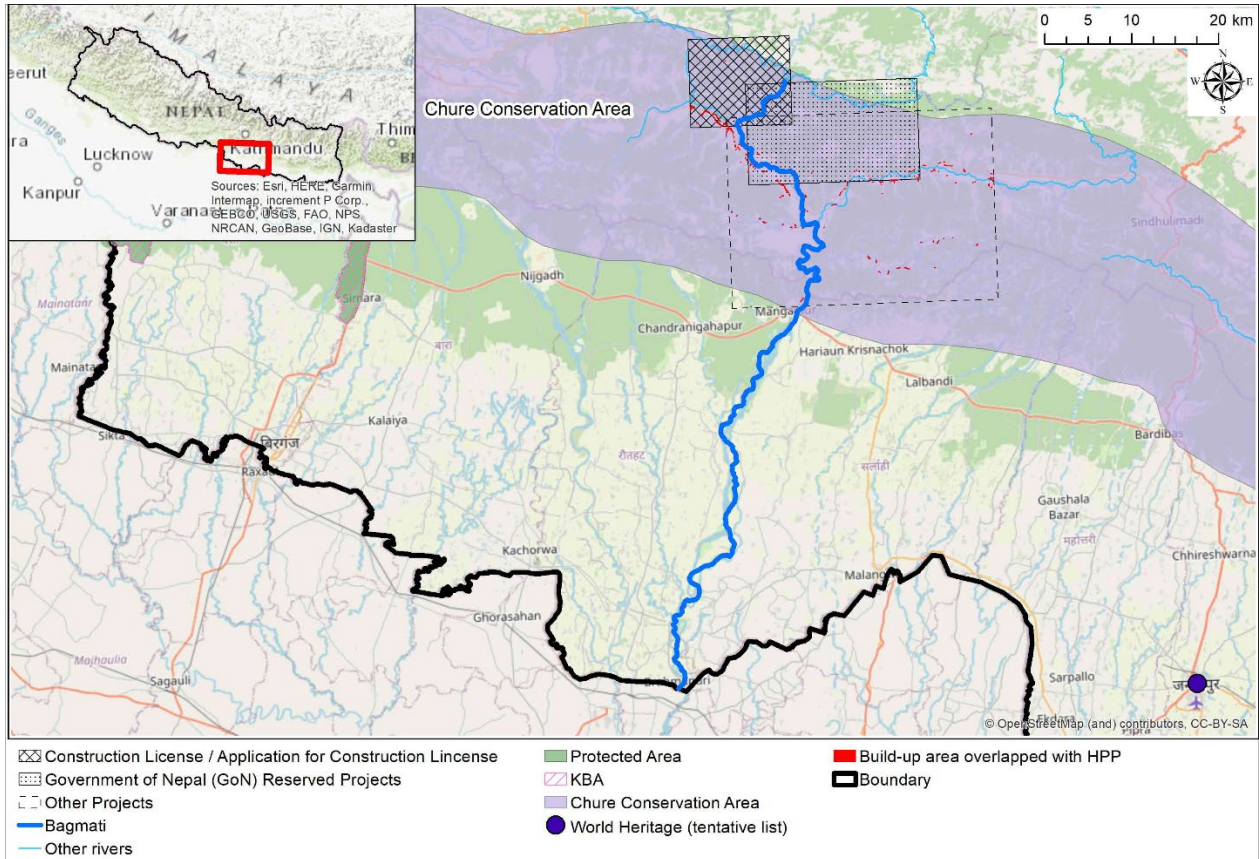
**Table 10.6-13 Rare Species Confirmed in Dang Deukhuri foothill forests/west Rapti wetlands, which was the basis for the selection of KBA**

	Scientific name	Common name	Category under IUCN red list
	Birds		
1	<i>Gyps bengalensis</i>	White-rumped Vulture	CR
2	<i>Gyps tenuirostris</i>	Slender-billed Vulture	CR
3	<i>Leptoptilos javanicus</i>	Lesser Adjutant	VU
4	<i>Sarcogyps calvus</i>	Red-headed Vulture	NT
5	<i>Aegypius monachus</i>	Cinereous Vulture	NT
	Mammals		
1	<i>Panthera tigris</i>	Tiger	EN
2	<i>Lutrogale perspicillata</i>	Smooth-coated Otter	VU

Source: JICA Study Team based on KBA website (<https://www.keybiodiversityareas.org/site/factsheet/14326>)

### 3) Bagmati river

The hydropower projects planned along the Bagmati river and their environmental and social consideration components (protected areas, world heritage sites, residential areas, etc.) are shown in Figure 10.6-20.



Source: JICA Study Team

**Figure 10.6-20 Hydropower Projects along the Bagmati River and Items of Environmental and Social Considerations**

In the hydropower project areas along the Bagmati River, with the exception of the Chure Conservation Area, no national parks or KBAs as stipulated in the National Parks and Wildlife Conservation Act have been identified, nor have any UNESCO World Heritage sites (including those on the tentative list).

## 10.7 STAKEHOLDER CONSULTATIONS

In order to conduct meaningful consultations with stakeholders at an early stage and to ensure transparency and accountability of the master plan, stakeholder consultations and consultations with the Environmental Working Group, etc. were conducted. The outline of the consultations with stakeholders regarding this master plan is shown in the table below.

**Table 10.7-1 Stakeholder Consultations Conducted for the Master Plan Development**

Item	Date	Participants	Main discussion points
Stakeholder consultation	May 31, 2023	50 participants (MoEWRI, DoED, NEA, WECS, USAID, IFC, ICIMOD (International Centre for Integrated Mountain Development), NEFIN (Nepal Federation of Indigenous Nationalities), Nepal Association of Impact Assessment etc.)	<ul style="list-style-type: none"> <li>• Project outline</li> <li>• SEA approach/methodologies</li> <li>• Concerns/ requests for power sector development</li> </ul>
	August 2024 (planned)	-	<ul style="list-style-type: none"> <li>• Mitigation measures, monitoring plan etc.</li> </ul>
Environmental WG	June 21, 2022	38 participants (MOEWRI, DoED, NEA)	<ul style="list-style-type: none"> <li>• WG kick-off meeting</li> </ul>
	February 7, 2023	3 participants (MOEWRI, NEA)	<ul style="list-style-type: none"> <li>• SEA approach/methodologies</li> </ul>
	May 26, 2023	4 participants (MOEWRI, DoED, NEA)	<ul style="list-style-type: none"> <li>• Development scenario for SEA</li> </ul>
	December 21, 2023	4 participants (MOEWRI, DoED, NEA)	<ul style="list-style-type: none"> <li>• Optimum scenario for SEA</li> </ul>

Source: JICA Study Team

### 10.7.1 1st Stakeholder Consultation

The 1<sup>st</sup> stakeholder consultation was held on May 31, 2023. The main discussion points are described as below.

**Table 10.7-2 Outline of 1<sup>st</sup> Stakeholder Consultation**

Item	Contents
Date	14:00 -18:00 on May 31, 2023
Venue	Skyhall / Hotel Himalaya
Participants	50 participants (MoEWRI, DoED, NEA, WECS, USAID, IFC, ICIMOD, NEFIN, Nepal Association of Impact Assessment etc.)
Agenda	<ul style="list-style-type: none"> <li>• Outline and progress of IPSDP</li> <li>• SEA approach, scoping, evaluation of development scenery</li> <li>• Questions and answers/ Group discussion</li> </ul>

Source: JICA Study Team

The main opinions and questions raised at the 1<sup>st</sup> stakeholder consultation are shown in the table below.

**Table 10.7-3 Main Opinions and Questions/Answers during 1<sup>st</sup> Stakeholder Consultation**

No.	Opinion/Question	Answers from MoEWRI/ JICA Study Team
1	Hydropower development is anticipated to have environmental and social impacts on ecosystems, livelihoods, indigenous peoples, etc., and these aspects need to be properly assessed in the SEA.	The impacts of hydropower development will be analyzed at a high level in the SEA to ensure that future development is appropriately managed. The SEA will assess development scenarios and optimal scenario from an environmental and social perspective and incorporate these into the planning.
2	Cumulative impacts are an important factor. Climate change and transboundary issues also need to be taken into account.	Cumulative impacts are important, and cumulative impacts on each water system will be taken into account in the SEA. CO <sub>2</sub> reduction and transboundary issues will also be considered in the SEA.
3	The introduction of renewable energy sources such as solar power generation may lead to changes in land use, so it is necessary to properly evaluate the impact on agricultural land, etc. Another concern is the impact of power transmission lines.	The SEA will take into account changes in land use and impacts on livelihoods due to large-scale mega solar projects. Land acquisition within the ROW of transmission lines will also be considered in the SEA.

Source: JICA Study Team

In the group discussion held at the 1<sup>st</sup> stakeholder consultation, participants were divided into groups to exchange opinions and discuss concerns regarding hydropower development, renewable energy, power transmission lines, etc. The main opinions and questions and answers are shown in the table below.

**Table 10.7-4 Results of Group Discussion at the 1<sup>st</sup> Stakeholder Consultation**

No.	Item	Challenges/ Concerns Raised during Group Discussion
1	Hydropower development	<ul style="list-style-type: none"> <li>· It is desirable to consider the following environmental and social impacts of hydropower development under SEA. <ul style="list-style-type: none"> <li>- Impacts on E flow and river flow</li> <li>- Forests and vegetation</li> <li>- Climate change and GLOF</li> <li>- Resettlement</li> <li>- Impacts on downstream areas, such as livelihoods</li> <li>- Indigenous peoples, use of rivers, religious and cultural values</li> <li>- Transboundary issues</li> <li>- Cumulative impacts</li> </ul> </li> <li>· It is recommended to consider the possibility of developing green hydrogen using hydropower.</li> <li>· It is suggested to consider topographical conditions such as high-altitude mountainous areas, densely populated mid-altitude hilly areas, and low-altitude plains when considering the impacts of development. In particular, many hydropower development projects are planned in high-altitude mountainous areas, where the local residents are generally ethnic minorities and their livelihoods are vulnerable, so it is necessary to consider correcting disparities.</li> </ul>
2	Renewable energy	<ul style="list-style-type: none"> <li>· It is advisable to consider the environmental and social impacts of renewable energy development, including: <ul style="list-style-type: none"> <li>- Changes in land use, loss of livelihoods</li> <li>- Landscape</li> <li>- Waste management, such as disposal of batteries</li> </ul> </li> </ul>
3	Transmission lines	<ul style="list-style-type: none"> <li>· It is advisable to consider the environmental and social impacts of power transmission line projects, including:</li> </ul>

No.	Item	Challenges/ Concerns Raised during Group Discussion
		<ul style="list-style-type: none"> <li>- Flora and fauna, deforestation, habitat fragmentation</li> <li>- Land acquisition, loss of livelihoods</li> <li>- Landscape</li> </ul>
4	Others	<ul style="list-style-type: none"> <li>· It is recommended that the SEA also considers the following:                             <ul style="list-style-type: none"> <li>- Establishment of policies for environmental protection</li> <li>- Appropriate planning for strengthening resilience to climate change</li> <li>- Securing an appropriate budget for compensation</li> <li>- Raising residents' awareness of environmental conservation</li> </ul> </li> </ul>

Source: JICA Study Team



Opening remarks by MoEWRI

Group discussion

Participants

Source: JICA Study Team

**Figure 10.7-1 1<sup>st</sup> Stakeholder Consultation**

### 10.7.2 2nd Stakeholder Consultation

The 2<sup>nd</sup> stakeholder consultation was held on August 6, 2024. The main discussion points are described as below.

**Table 10.7-5 Outline of 2<sup>nd</sup> Stakeholder Consultation**

Item	Contents
Date	14:00 -18:00 on August 6, 2024
Venue	Skyhall / Hotel Himalaya
Participants	33 participants (MoEWRI, DoED, NEA, MoFE, WECS, IPPN, IFC, Nepal Association of Impact Assessment, Eco Network Global, Nepal Environment Society, Nepal Network for Social Development, Economic and Environmental Dialogue etc.)
Agenda	<ul style="list-style-type: none"> <li>• Overview of IPSDP</li> <li>• Evaluation of development scenarios and optimal scenarios in SEA, results of mitigation measures, recommendations, etc.</li> <li>• Q&amp;A, discussion</li> </ul>

Source: JICA Study Team

The main opinions and questions raised at the 2<sup>nd</sup> stakeholder consultation are shown in the table below.

**Table 10.7-6 Main Opinions and Questions/Answers during 2<sup>nd</sup> Stakeholder Consultation**

No.	Opinion/Question	Answers from MoEWRI/ JICA Study Team
1	In addition to hydropower development projects, the impacts of transmission line projects are also important; and it is recommended to describe them separately as necessary. For example, it should be noted that land acquisition and resettlement are often issues within the RoW of transmission lines rather than hydropower projects itself.	The impacts of transmission lines will be analyzed and described separately as appropriate.
2	Since there are also study results available from WECS, USAID, etc., it is desirable to fully utilize them. In the WECS water resources master plan, a strategic environmental and social assessment was carried out.	The SEA was conducted while exchanging information with relevant environmental and social consultants such as WECS's water resources master plan. It is understood that there are no major discrepancies in the criteria used.
3	It is recommended to describe issues expected at the implementation stage of each project in the recommendations section.	The IPSDP's recommendations will be reviewed and updated as appropriate.
4	Nepal also has issues with systems and regulations related to environmental and social considerations. For example, it is important to create a mechanism for developers along the same watershed to cooperate and collaborate from the perspective of watershed management.	The IPSDP's recommendations will be reviewed and updated as appropriate.
5	In Nepal, not only national parks but also different categories of protected areas are stipulated by the law, such as conservation areas; and it is desirable to reflect these differences.	The Nepal's National Parks and Wildlife Conservation Act (2029 (1973)) has been confirmed in this study, and the JICA Study Team is aware of the differences in each category. However, this SEA was a high-level analysis using GIS data for the purpose of comparative evaluation of each scenario, and detailed impact assessment of each project was not conducted. Therefore, it is expected that the impact assessment on protected areas will be conducted taking into account the differences in categories in the environmental impact assessment of each project.

Source: JICA Study Team



Source: JICA Study Team

**Figure 10.7-2 2<sup>nd</sup> Stakeholder Consultation**

## 10.8 EXAMINATION OF MITIGATION MEASURES AND MONITORING

From the F/S (Feasibility Study) stage onwards, environmental and social considerations are expected to be carried out in accordance with local laws and regulations such as EPA 2019 and EPR 2020, taking into account the natural and social conditions of each individual project. It is advisable to conduct EIA and IEE according to the sector and scale requirements, while referring to the JICA Environmental and Social Guidelines and the World Bank Safeguard Policy, and to avoid the environmental and social impacts of the project as much as possible in line with the mitigation hierarchy, and to consider measures to minimize, reduce and mitigate those that cannot be avoided. In the process, it is important to provide opportunities for stakeholders such as the central government, provincial governments and affected people to express their opinions and to hold meaningful consultations. In addition, appropriate monitoring should be carried out. If any concerns are identified during monitoring, corrective measures should be taken. The main points to keep in mind are as follows:

### 1) **Basin-wide cumulative impact assessment / Cooperation and collaboration between project developers**

In Nepal, the progress of development plans varies from river basin to river basin and cumulative impacts can be significant in some river basins due to multiple hydropower projects; therefore, it is necessary to evaluate the cumulative impacts for each river basin and consider appropriate mitigation measures from the perspective of river basin management. In particular, in river basins where development plans would be concentrated, such as the Gandaki River basin (where many existing power plants are located near demand areas and development is progressing), it is recommended to carry out development that takes cumulative impacts into account at an early stage. In addition, it is recommended that Nepal strategically consider free-flowing rivers in order to avoid significant cumulative impacts on each river system and to conserve the flow rate and continuity of the river basins.

Environmental management is also sometimes not properly implemented from the perspective of watershed management in Nepal; and there are cases that environmental measures (such as the installation of fish passages to allow migratory fish to move around) are not carried out effectively in multiple hydropower projects located along the same river basin. It is recommended that cooperation and collaboration among project developers along the basin, including private hydropower developers, be promoted in order to properly conduct river basin management.

### 2) **E flow**

Hydropower projects may affect environmental flow (E flow), including minimum water flow, and may cause changes in the flow rate of the entire river and downstream areas, as well as habitat fragmentation. If adverse effects are anticipated by hydropower development, it is advisable to refer to guidelines such as "IFC Good practice handbook - Environmental flows for hydropower projects (2018)" and to develop and implement an E flow management plan based on evaluation of E flows.

### 3) **Protected areas**

When developing a project within a protected area (national park, wildlife sanctuary, hunting reserve, conservation area, buffer zone) defined in the local country's National Parks and Wildlife Conservation Act (2029/1973), permission from the authorities must be obtained prior to development. Damming or modifying the flow of rivers is prohibited, and restrictions such as maintenance flow are required for hydropower development. In addition, when

implementing within a Ramsar site based on an international treaty, the project must be carried out in accordance with the management plan of each Ramsar site. It is advisable to plan and implement the project in accordance with the mitigation hierarchy.

#### **4) Ecosystem / Forest**

Water intake, storage, and discharge associated with hydroelectric power generation projects may change river flow rates and water levels, potentially affecting ecosystems such as aquatic organisms and waterfowl. There is also a concern that the construction of dams and intake weirs could cut off river channels and impede the upstream migration of migratory fish. When such impacts are anticipated, it is necessary to evaluate the impact on E flow and aquatic ecosystems and reflect them in environmental management plans and monitoring plans.

In addition, deforestation due to hydroelectric development is expected to have permanent or temporary effects on flora and fauna. In particular, when a project is planned within a KBA or critical habitat is identified, the consideration should be given to minimizing the impact in the layout of the project plan, including access roads and other ancillary facilities. In addition, when local residents rely on forest use for timber and NTFPs (Non-timber Forest Products) as a source of income and adverse effects from the project are expected, it is recommended that livelihood restoration plans be formulated and implemented based on discussions with affected people.

#### **5) Appropriate compensation for land acquisition, involuntary resettlement, and loss of livelihood, distribution of benefits, etc.**

One of the challenges facing hydropower development in Nepal is compensation for projects involving resettlement and land acquisition, which has led to criticism from NGOs and complaints from residents. It is desirable to formulate and implement a resettlement action plan that includes payment of compensation at replacement cost. In particular, when large-scale resettlement is required for reservoir-type hydroelectric power plants or power transmission lines, it is important to secure sufficient budgets and implementation systems.

In addition to physical resettlement, if economic resettlement such as loss of livelihood occurs, it is recommended that livelihood restoration plans be formulated and implemented in accordance with procedures stipulated in local national laws (Land Acquisition Act (2034/1977), Real Estate Expropriation Act (2013/1956)), and with reference to good practices of hydropower projects in Nepal undertaken by the World Bank and other international donors.

Looking at the country as a whole, the benefits of power development are concentrated in the urban areas of Kathmandu and Pokhara, while the areas directly affected by the development are those surrounding the site. It is desirable to consider correcting these disparities in benefits.

#### **6) Indigenous Peoples**

The National Foundation for Development of Indigenous Nationalities Act defines 59 ethnic groups as indigenous peoples, and they are widely distributed in the mountainous areas where hydroelectric power projects are planned. In addition, Nepal has ratified the ILO Convention on Indigenous and Tribal Peoples in Independent Countries (No. 169). If adverse effects on indigenous peoples are anticipated, it is recommended that meaningful consultations be held with indigenous peoples affected by the projects from an early planning stage and that their consent be obtained based on the principle of FPIC (Free, Prior and Informed Consent). In addition, if indigenous peoples are included among the affected peoples, it is advisable to formulate an IPP (Indigenous Peoples Plan) and implement measures accordingly.

## **7) Natural hazards**

Natural disasters in Nepal include landslides caused by heavy rains during the monsoon season. In addition, projects may suffer significant physical damage due to GLOFs. When selecting project sites, it is advisable to avoid areas with high disaster risks such as landslides and GLOFs, and to develop emergency response plans in the event of a disasters etc.

## **8) Climate change**

Nepal has formulated policies such as the National Climate Change Policy (2076/2019), and hydropower is considered to be a desirable form of power generation in terms of greenhouse gas emissions. However, as mentioned above, it is recommended to evaluate physical risks associated with climate change in relation to the risks of GLOFs, etc., and to consider alternatives and incorporate them into the design.

## 10.9 GOOD PRACTICES LEARNT FROM PRIORITY PROJECTS

In this master plan, after consultation with relevant organizations, priority hydropower projects were identified from hydropower projects listed in the optimal scenario. Among them, projects that are already underway in Nepal and are planned to be financed by donors were reviewed, and good practices were extracted. It is recommended that environmental and social considerations be appropriately implemented in accordance with local laws and good practices in the planning and implementation of future hydropower projects.

**Table 10.9-1 Example of Good Practices from Priority projects**

No.	Item	Contents
1	Project name	<ul style="list-style-type: none"> <li>Upper Arun hydropower project</li> </ul>
2	Salient features	<ul style="list-style-type: none"> <li>Power generation type: Reservoir type</li> <li>Rated output: 1,061 MW</li> <li>Annual power generation: 4,478 GW</li> <li>Water system: Arun River basin/ Koshi River system</li> <li>Dam height: 100m</li> <li>Reservoir area: 0.201 km<sup>2</sup></li> <li>Others: Environmental and social documents were prepared based on the World Bank's Safeguard Policy (Environmental and Social Standards; ESS).</li> </ul>
3	Anticipated impacts on environmental aspects	<ul style="list-style-type: none"> <li>Critical habitat: critical habitats of rare species, including four mammal species, may be affected.</li> <li>Protected area: The proposed project site is adjacent to a protected area and is located within the buffer zone of some of the project's facilities.</li> </ul>
	Good practices	<ul style="list-style-type: none"> <li><b>Critical habitat assessment and biodiversity management plan formulation:</b> An impact assessment on rare mammal species was conducted, and it was found that species that meet the conditions for a critical habitat<sup>13</sup> would be affected. As a result, a biodiversity management plan was formulated based on the principle of no net loss, including offsets for the same species.</li> <li><b>Alternative analysis:</b> Infrastructure construction was avoided within the core area of the protected area adjacent to the project site; and alternatives were considered from an early stage in the planning process in an effort to minimize the negative impact on the protected area.</li> </ul>
4	Anticipated impacts on social aspects	<ul style="list-style-type: none"> <li>Physical and economic resettlement: 335 households (1,723 people) will be affected by land acquisition (of which 22 households (109 people) will be physically resettled).</li> <li>Approximately 99% of the affected people are indigenous people.</li> </ul>
	Good practices	<ul style="list-style-type: none"> <li><b>Compensation at full replacement cost and securing an appropriate budget:</b> Compensation was paid on top of the amount required by the local country's laws and regulations, and a monitoring budget was also secured as planned.</li> <li><b>Consent based on FPIC principles:</b> Consultations were held with indigenous peoples and an indigenous peoples plan was developed. A tri-party agreement was then signed between representatives of the affected indigenous peoples, the local government, and the project proponent.</li> </ul>

Source: JICA Study Team

<sup>13</sup> The World Bank ESS (Environmental and Social Standards) defines critical habitats as follows:

- Habitat of significant importance to Critically Endangered or Endangered species, as listed in the IUCN Red List of threatened species or equivalent national approaches
- Habitat of significant importance to endemic or restricted-range species
- Habitat supporting globally or nationally significant concentrations of migratory or congregatory species
- Highly threatened or unique ecosystems
- Ecological functions or characteristics that are needed to maintain the viability of the biodiversity values described above in (a) to (d).

# **ANNEX 11**

## **ECONOMIC AND FINANCIAL ANALYSIS**



---

<b>Annex 11</b>	<b>Economic and Financial Analysis .....</b>	<b>11-1</b>
11.1	Purpose and Structure of this Chapter .....	11-1
11.1.1	Purpose of Economic and Financial Analysis .....	11-1
11.1.2	Structure of this Chapter .....	11-1
11.2	Basic Information and Preparation for Analysis .....	11-3
11.2.1	Basic Data on Nepal's Economy and Public Finance .....	11-3
11.2.2	Basic Funding Flows and Assumptions .....	11-4
11.2.3	Calculation of Various Expenses and Income, etc. ....	11-7
11.3	Economic Analysis .....	11-11
11.3.1	Objectives, Methods and Evaluation Indicators of Economic Analysis .....	11-11
11.3.2	Results of Economic Analysis .....	11-12
11.4	Financial Analysis .....	11-14
11.4.1	Analysis of Financing for Investment .....	11-14
11.4.2	Analysis of Domestic Electricity Tariffs .....	11-20
11.4.3	The Summary of Financial Analysis .....	11-22
11.5	Analysis of Impact on Nepal Macroeconomy .....	11-24
11.5.1	Objectives, Methods and Prerequisites for Nepal's Macroeconomic Impact Analysis .....	11-24
11.5.2	Analysis of the Impact on External Debt .....	11-24
11.5.3	Analysis of the Impact on Foreign Exchange Reserves .....	11-25
11.5.4	Analysis of the Impact of Electricity Exports on the Trade Balance .....	11-27
11.5.5	Analysis of the Impact of Electricity Exports on GDP .....	11-28
11.5.6	Analysis of Job Creation Effects .....	11-28
11.6	Conclusion of Economic and Financial Analysis .....	11-31

---



## ANNEX 11 ECONOMIC AND FINANCIAL ANALYSIS

### 11.1 PURPOSE AND STRUCTURE OF THIS CHAPTER

#### 11.1.1 Purpose of Economic and Financial Analysis

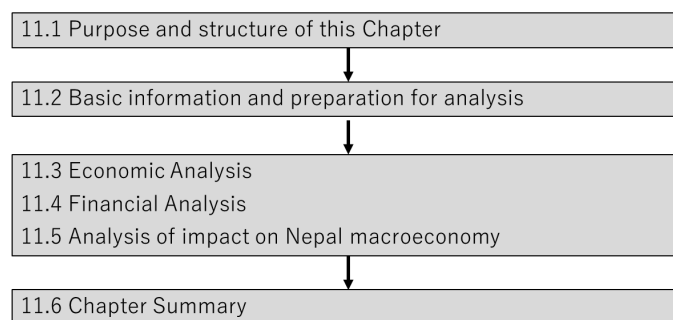
Conventional economic and financial analyses in the power sector use the IRR (Internal Rate of Return) as an indicator to evaluate the adequacy of projects and to evaluate LRMC (Long-Run Marginal Cost), which is commonly used to examine the electricity price level. IRR is calculated only with cash flow information generated from projects and is used as an index to measure the profitability of the project. LRMC refers to the additional cost (marginal cost) required to produce one unit of goods, which is also calculated from the amount of expenditure. In the case of power generation projects, the cost of generating electricity required to produce one additional unit of electricity is determined, and this is used as the basis for examining the electricity price level. In the study of economic and financial analyses in conventional development plans, the emphasis has been on how future electricity prices can fluctuate, referring to LRMC.

However, since the IRR and LRMC are calculated only on the basis of future expenditures and do not consider the income and expenditure and financial status of the implementing entity of the plan, the financial situation and the impact on the fiscal and macroeconomic effects of the target country are not taken into account in the analysis. Since these items are considered to be important points in the analysis of this master plan, how to incorporate them into the analysis matters.

Significant investment is required to implement IPSDP (Integrated Power System Development Plan). Therefore, in the financial analysis, we firstly prepare a cash flow table for the IPSDP period with the government-related organization that promotes the IPSDP as the implementing entity to be analyzed, and analyze the procurement of funds necessary for investment. Subsequently, the level of electricity charges, which has often been examined using the LRMC, will be examined using the financial statements of the implementing entity. In addition, given the amount of funds required for investment and the expected increase in exports, the implementation of the IPSDP is expected to have a significant impact on the macroeconomy of Nepal. Therefore, we will also try to analyze the impact on the macroeconomy based on the results of the financial analysis. Since a cost-benefit analysis using IRR can be applied to this project as an index to measure the economic benefits of the IPSDP, it is adopted in the economic analysis section of this chapter.

#### 11.1.2 Structure of this Chapter

The structure of this chapter is shown in the following figure.



Source: JICA Study Team

**Figure 11.1-1 Structure of this chapter**

First of all, basic information related to the subsequent analysis is organized. This information includes the compilation of basic data on Nepal's economy and finances, the establishment of basic financial flows and assumptions, and the estimation of the amount of various expenses.

In order to verify whether the implementation of the IPSDP will bring economic benefits to Nepal, the EIRR (Economic Internal Rate of Return) is calculated in 11.4, the analysis is carried out using the financial statements of the IPSDP implementing entity. Finally, macroeconomics and the impact of the financing required for investment on Nepal's finances (external debt and foreign exchange reserves) is analyzed, as well as the impact of electricity exports expected to increase by IPSDP (the trade balance and GDP (Gross Domestic Product) growth). In addition, the new job creation effects that the implementation of IPSDP can create is analyzed.

## 11.2 BASIC INFORMATION AND PREPARATION FOR ANALYSIS

### 11.2.1 Basic Data on Nepal's Economy and Public Finance

We will summarize the basic data on Nepal's economy and finance as a basis for analyses.

Nepal's economy over the past decade has generally shown positive growth. The average real GDP growth rate for the 10 years from 2012 to 2021 was 4.5%<sup>1</sup>. In 2020, the real GDP growth rate fell to minus 2.4% due to the impact of the global pandemic, but recovered to 4.2% in 2022. Agriculture accounted for 25.8% of GDP by industry, followed by wholesale trade at 15.7%, real estate at 9.4%, and education at 8.0%. There has been no significant change in the ratio of GDP by industry over the past 10 years. For an overview of Nepal's economy, Chapter 1 (1.1.2 and 1.1.3) also provides more detailed information. Focusing on the power sector, electricity sales are estimated to account for about 1.4% of GDP<sup>2</sup>. In relation to the IPSDP, it is important to increase the contribution of the power sector to the Nepal economy (contribution to Nepal GDP) by increasing electricity exports, based on the Nepal government's policy of making the power sector a growth industry.

Looking at trade, Nepal's main export items are clothing and agricultural products, and high-priced items such as industrial products and medical equipment are the main import items. As for the trade balance, the trade deficit continues. As for the import and export of electricity, as of 2020/2021, the export value was 316 million rupees (about 370 million yen) and the import value was 21,821 million rupees (about 25,530.57 million yen), and the power sector is also in a trade deficit<sup>3</sup>. As with the real GDP growth rate mentioned above, another important point to check is how the implementation of the IPSDP may affect the improvement of the trade balance of Nepal as a whole.

The following table summarizes the main data on the macroeconomy of Nepal.

**Table 11.2-1 Key Figures for Macroeconomy in Nepal<sup>4</sup>**

Sections	Number Value	
	2020/2021	2021/2022
Real GDP	31.1 billion dollars (approx. 4.66 trillion yen)	33 billion dollars (approx. 4.95 trillion yen)
Real GDP Growth Rate	4.2%	5.6%
balance of trade	▲1.355 trillion rupees (▲1.585 trillion yen)	▲1.661 trillion rupees (▲1.943 trillion yen)
Amount of electricity exports* <sup>1</sup>	316 million rupees (approx. 369 million yen)	3.884 billion rupees (approx. 45.44 billion yen)
Amount of electricity imports* <sup>2</sup>	21.821 billion rupees (approx. 25.531 billion yen)	15.466 billion rupees (approx. 180.95 billion yen)
Unemployment rate* <sup>3</sup>	13.12%	10.9%

\*<sup>1</sup> Revenue from NEA's international sales

\*<sup>2</sup> NEA's Electricity Purchase Costs from India

\*<sup>3</sup> Share of total working population (total working population is approximately 8.9 million (2022/2023))

Source: Nepal Economy 2024 (Embassy of Japan in Nepal), Current Macroeconomic and Financial Situation (Nepal Rastra Bank), World Development Indicators (World Bank)

<sup>1</sup> For real GDP growth figures, see IMF "World Economic Outlook Databases (April 2024)"

<sup>2</sup> According to the NEA's financial statements, the amount of domestic electricity sales was 70,543 million rupees (about 82.53 billion, 5.31 million yen), electricity export value of 316 million rupees (about 369.72 million yen). This was taken into account by adding the 2020/2021 GDP of 3.69 billion dollars.

<sup>3</sup> Figures for imports and exports of electricity are based on NEA's financial statements (2020/2021)

<sup>4</sup> When converting Nepalese rupees to dollars, the conversion rate was 1 rupee = 0.0075 dollars. The same applies below.

Next, the main data on the finances of the Nepalese government are summarized in the following table.

**Table 11.2-2 Data on the finances of the Government of Nepal**

item	numeric value	remarks
Government Budget	1.632 trillion rupees (1.909 trillion yen)	2022/2023
Budget Revenue Breakdown	Tax and non-tax income (69.1%) Domestic borrowings (14.3%) Loans from foreign countries (13.5%) Grant Aid from Foreign Countries (3.1%)	2022/2023
External debt as a percentage of GDP	21.7%	2022/2023
Percentage of budget allocation to MoEWRI	2.8% of budget appropriations	2021/2022
Foreign exchange reserves	11.74 billion dollars (approx. 1.76 trillion yen)	2022/2023

Source: Nepal Economy 2024 (Embassy of Nepal), Current Macroeconomic and Financial Situation (Nepal Rastra Bank), and World Development Indicators (World Bank)

Nepal's external debt risk at present is considered to be low<sup>5</sup>. In addition, the amount of foreign exchange reserves is equivalent to 10 months' worth of imports<sup>6</sup>, which implies that foreign currency reserves are not considered to be insufficient according to the criteria in Section 11.4.

## 11.2.2 Basic Funding Flows and Assumptions

In this section, we will summarize the basic financial flows in Nepal's power sector, which are the prerequisites for conducting economic and financial analysis.

### (1) Sector-Related Organizations

The government organizations involved in hydropower generation in Nepal can be roughly organized as shown in Figure 11.2-1.

40% of the grid-connected power plants (based on 2023 output) are owned and operated by NEA (Nepal Electric Authority) or a subsidiary of NEA. In terms of installed capacity, NEA owns 1,135.1 MW of hydroelectric power plants, 53.4 MW of diesel power plants, and 25 MW of solar power. Most of the hydroelectric power generation development by IPP (Independent Power Producer)s is small and medium-sized projects with a capacity of 30 MW or less, but as of 2023, IPPs have an installed capacity of 1,544. It reached 5 MW. As of June 2024, the separation of transmission and distribution (unbundling) is being discussed in connection with the revision of the Electricity Law, but the government is expected to take the lead in developing the power sector in Nepal, especially large-scale projects that require a lot of funding<sup>8</sup>. In this sense, the current structure and financial flows are expected to continue for the time being.

The NEA seeks funding for the development of power sources, mainly from revenues from the sale of electricity and the export of electricity. However, its income and equity (capital and retained earnings) are not enough to finance development, so it borrows. The lenders are the Ministry of Finance of the Government of Nepal or a private financial institution, and the borrowings from the Government of Nepal include the subleasing of funds loaned to the Government of Nepal by

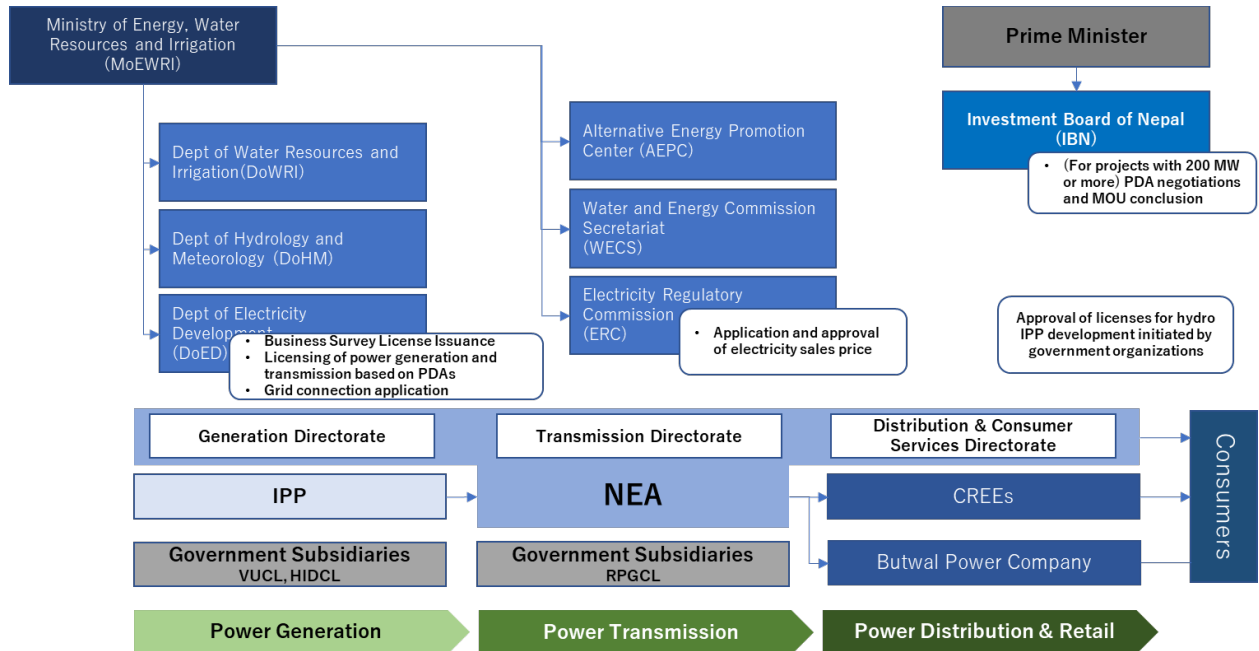
<sup>5</sup> According to the World Bank Group and IMF Joint World Bank IMF Debt Sustainability analysis (2022).

<sup>6</sup> According to Nepal Rastra Bank "Current Macroeconomic and Financial Situation (2022/23)".

<sup>7</sup> Relevant information on the revision of the Electricity Act is provided in Chapters 2 and 14 of this report.

<sup>8</sup> With regard to the discussion of unbundling of the NEA, VUCL has already been established in the power generation sector and RPGCL in the transmission sector as a receptacle after unbundling. However, it has not yet been decided how it will be integrated with these organizations.

donors. Investment targets basically include power generation facilities, transmission and distribution facilities, and substations. The main expenditures include the maintenance and management of the facility, the purchase of electricity from domestic IPPs, and the import of electricity from India. A part of NEA's business profit is expected to be dividends to shareholders, but at the time of the survey, NEA did not pay dividends and reinvested profits<sup>9</sup> for the purpose of investment.



Source: JICA Study Team

**Figure 11.2-1 Organizations Related to the Power Sector in Nepal**

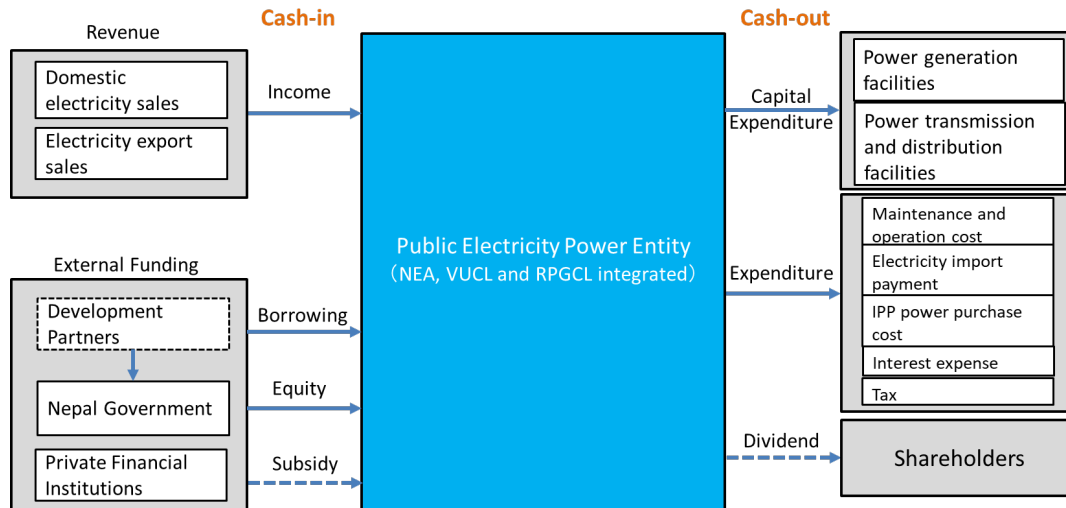
In addition to the NEA, VUCL (Vidhyut Utpadan Co., Ltd.) is responsible for the development of hydroelectric power sources. RPGCL (Ratriya Prasaran Grid Co. Ltd.) is responsible for the development of transmission. However, since it is not clear which institution will be responsible for the development of which power source in the future, the implementing entity that integrates NEA, VUCL, and RPGCL will be set as the target of the analysis.

**(2) Development status of government entities**

The financial flow of public electric power company assumed in financial analysis is the following flow chart.

Figure 11.2-2 summarizes the financial flow diagram focusing on the major business entities in Nepal's power sector, NEA, VUCL, and RPGCL.

<sup>9</sup> This statement is based on interviews with NEA executives and a review of NEA's financial statements.



Source: JICA Study Team

**Figure 11.2-2 Basic Funding Flows in Nepal's Electricity Sector**

Supplementary explanations regarding the main items shown in the above figure are as follows.

- "Income" refers to cash-in from the proceeds of domestic electricity sales and electricity exports. Currently, in Nepal, the NEA is centrally responsible for the sale of electricity. Based on this, it is assumed that public electric power companies will continue to be centrally responsible for the sale of electricity in the future.
- With regard to "Borrowing", as will be described later, capital investment is required for the implementation of the IPSDP. When the public power utility cannot cover the capital investment fund with its cash reserves, it will need to borrow from the Nepalese government or private financial institutions.
- With regard to "Equity", it is expected that shareholders will increase their capital in order to cover the expenditures necessary for capital investment. This analysis is based on the premise that the necessary funds will be procured through borrowings or capital increases by shareholders (the ratio is borrowing: capital increase = 7:3, which is commonly used in project finance in Nepal), from the perspective of implementing the IPSDP in a sound financial position by the electric power sector.
- "Capital Expenditure" refers to expenditure for capital investment (power generation facilities, transmission and distribution facilities) required for the implementation of the IPSDP. As in the case of borrowing, the funds for capital investment will be allocated to shareholders (currently assumed to be the Nepalese government).
- "Expenditure" are costs for items that are mainly recorded as expenses for accounting purposes, assuming operation and maintenance expenses, payments for electricity imports, costs for purchasing electricity from IPPs, interest expenses on borrowings, and tax.
- "Subsidy" and "Dividend" are not directly taken into account in financial analysis but can be assumed as financial flows. Subsidies are the same as investment in that the government provides funds to public power companies without the premise of repayment, but the government of Nepal gains the status of a shareholder of a public power company by providing funds through equity investment. With regard to dividends, NEA is currently reinvesting the profits earned without paying dividends, and since the investment funds for the IPSDP are large, the financial analysis follows the method of reinvesting the funds without paying dividends.

The above is the premise of the financial flow of the financial analysis, and in this section, we will also summarize the current funding sources of NEA, VUCL, and RPGCL, which make up the public electric power entity (Chapter 2 also summarizes the capital structure). As mentioned above, NEA is reinvesting its profits, while VUCL and RPGCL are investing by raising funds by equity because they do not have income from the sale of electricity. In the financial analysis, it is assumed that the investment comes from the Nepal government, but VUCL currently gains investment from some non-government agencies. In addition, although the two institutions do not borrow at this time, it was stated in the interview with VUCL that there is a possibility of borrowing in the future. Therefore, in the financial analysis, the premise of financing by borrowing is also placed as described above.

**Table 11.2-3 The source of finance (NEA, VUCL and RPGCL)**

Procurement Agencies	Procurement Methods	Main Suppliers
NEA <sup>10</sup>	Borrowing	Donor Agencies Government of Nepal
	Equity investment	Government of Nepal
VUCL <sup>11</sup>	Borrowing	NA
	Equity investment <sup>12</sup>	Ministry of Energy, Water Resources and Irrigation (MoEWRI) (20%), General Public (17%), NEA (10%), Employees' Provident Fund (10%), Nepal Doorsanchar Company Limited (10%), Residents of the project area (10%), Ministry of Finance (5%), Department of Justice (5%), Citizen Investment Trust (5%), etc.
RPGCL	Borrowing	NA
	Equity investment <sup>13</sup>	MoEWRI (46.01%), Ministry of Finance (21.03%), etc.

Source: JICA Study Team based on the annual reports of each institution

### 11.2.3 Calculation of Various Expenses and Income, etc.

The following table shows the results of calculations for various types of capital investment and income, which are the basic inputs for conducting various analyses. In the following, the estimation method for each item is shown. The numbers set are based on the optimal scenario in Chapter 7.

#### (1) Amount of capital investment

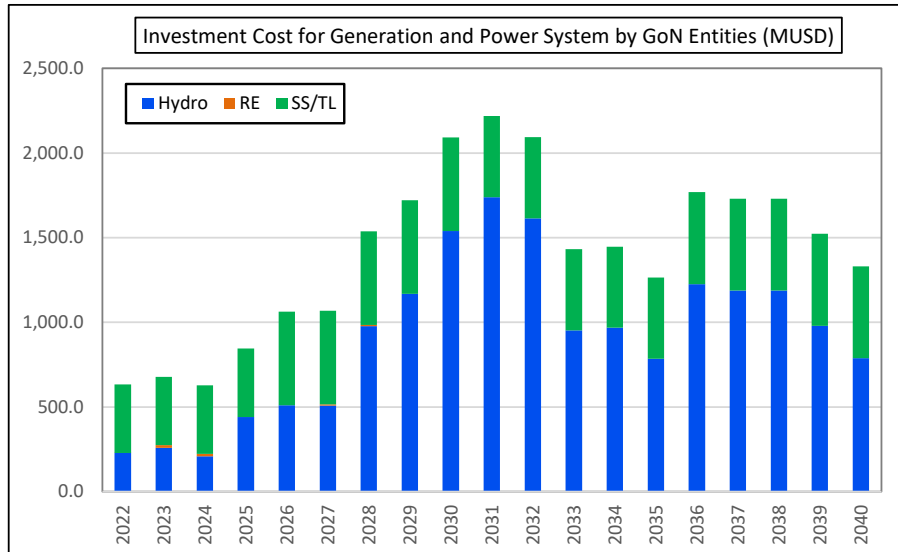
Capital investment costs are set in accordance with Chapter 7 and Chapter 9. The following figure shows the annual change in capital investment over the 19-year period covered by the simulation. The total amount of renewal investments during the period covered is 26,804 million dollars, with a maximum of 2,218 million dollars (2031) and an average of 1,411 million dollars.

<sup>10</sup> The NEA did not provide a detailed breakdown of borrowers and investors in its report.

<sup>11</sup> The most recent available report is as of 2021.

<sup>12</sup> Investment ratio in parentheses

<sup>13</sup> ditto

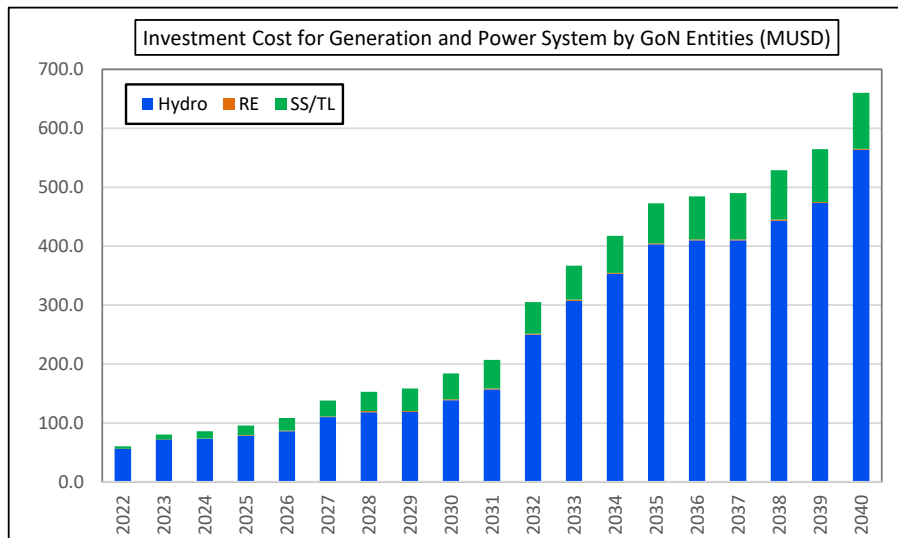


Source: JICA Study Team

**Figure 11.2-3 Changes in capital expenditure over time**

**(2) Operation and maintenance costs**

Operation and maintenance costs were calculated based on past results and maintenance costs per kilowatt of new power plants under the assumption of 54 dollars/kW per year for hydropower and 14.4 dollars/kW for solar power. The total operation and maintenance costs during the period covered are expected to be 5,563 million dollars, with a maximum of 660.1 million dollars (2040) and an average of 293 million dollars.



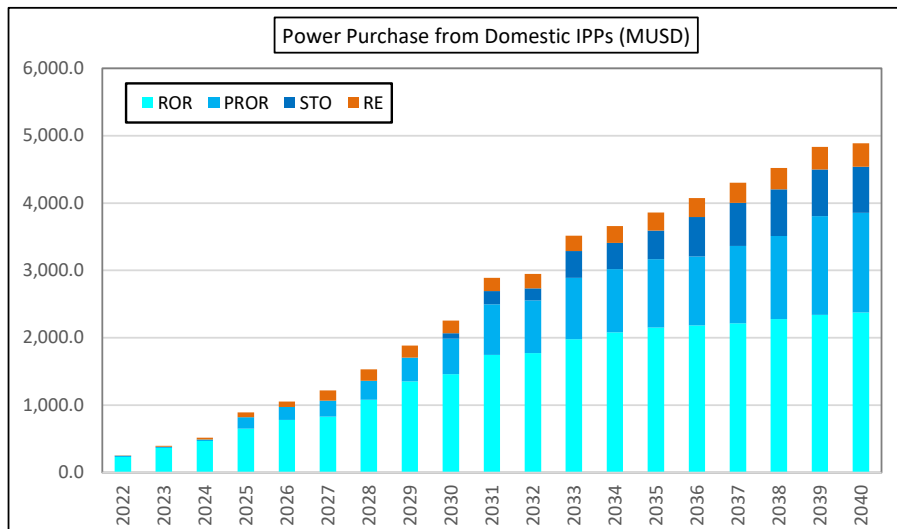
Source: JICA Study Team

**Figure 11.2-4 Changes in maintenance and management costs over time**

**(3) Cost of purchasing electricity from IPP**

The cost of purchasing electricity from IPPs was determined by multiplying the existing power generation facilities operated by IPPs in Nepal and the amount of electricity to be developed by IPPs in the future, as shown in Chapter 7, by the unit price set for each power supply configuration. Although it is assumed that the unit price of electricity purchased will fluctuate in the future, since

the purpose of this simulation is to evaluate the degree of impact of IPSPD, it is assumed that the unit price of electricity purchased will remain constant over the period covered by the simulation. The unit price per power supply configuration is 0.050 dollars/kWh for ROR, 0.060 dollars/kWh for PROR, 0.080 dollars/kWh for STO, and 0.060 dollars/kWh for solar. The total cost of purchasing electricity from IPPs during the period covered is 49,496 million, with a maximum of 4,890 million dollars (2040). In addition, the change over time in the cost of purchasing electricity from IPP is shown in the following figure.

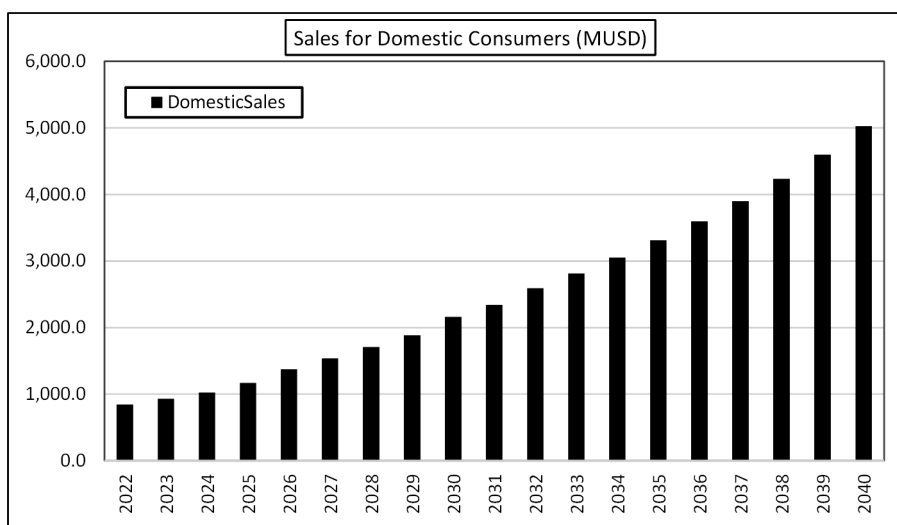


Source: JICA Study Team

Figure 11.2-5 Purchase of electricity for each power supply configuration cost

**(4) Domestic electricity sales**

Domestic electricity sales are set based on Chapter 7. Since fluctuations in future demand and policies are expected, the unit price of electricity sold is set within the range of the unit price used in the sensitivity analysis described later. The total domestic electricity sales during the period covered by the target period were 48,096 million dollars, with a maximum of 5,027 million dollars (2040).

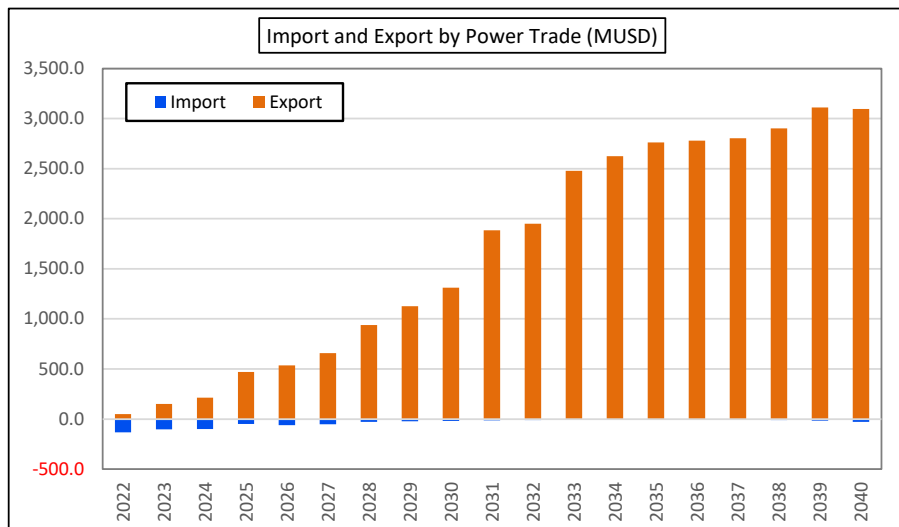


Source: JICA Study Team

Figure 11.2-6 Changes in domestic electricity sales over time

**(5) Cost of power interchange**

Electricity export sales are set based on the import and export plan for power interchange to neighboring countries. Although the unit price of electricity sold for export is expected to fluctuate in the future, the purpose of this simulations to evaluate the degree of impact of the IPSDP. As of 2024, most of Nepal's electricity exports are carried out through IEX (Indian Energy Exchange Limited), so this price will be used as a reference for the electricity sales price of electricity exports. Here, the unit price of electricity for the 2023 IEX was kept constant at 0.070 dollars/kWh. In addition, financial analysis includes sensitivity analysis of the selling price of electricity exports to analyze the financial impact on the public electricity power company when the price fluctuates. The total cost of importing electricity during the period covered will be 650 million dollars. On the other hand, the total export sales are 31,852 million dollars, with a maximum of 3,097 million dollars (2040).



Source: JICA Study Team

**Figure 11.2-7 Changes in electricity export sales over time**

## 11.3 ECONOMIC ANALYSIS

### 11.3.1 Objectives, Methods and Evaluation Indicators of Economic Analysis

The economic analysis will determine whether the implementation of the IPSDP will bring economic benefits to the Nepalese economy. As a method, we will use the cost-benefit analysis method, which is widely used in this type of analysis. The EIRR is used as an analytical indicator<sup>14</sup>. This is an indicator of the extent of the impact of the IPSDP on the national economy.

As a specific method of economic analysis, the annual cash flow is calculated for the difference between the case where the plan is implemented (hereinafter referred to as the "with case") and when it is not implemented (hereinafter referred to as the "without case"). The discount rate is determined with which the present value of the net benefit obtained by subtracting the cash flow related to the cost from the cash flow related to the benefit is zero.

If the calculated EIRR exceeds the "hurdle rate", we judge that the IPSDP will have a positive impact (i.e., the IPSDP investment is justified). In this analysis, the hurdle rate is set at 9%. This is the rate commonly used by ADB (Asian Development Bank) for evaluation using the EIRR, which is also used by ADB in power projects in Nepal and will be used in this analysis<sup>15</sup>.

The items of costs and benefits subject to this economic analysis and the calculation method are shown below.

#### (1) Cost

The cost consists of capital investment costs and maintenance and management costs. The cash flow figures for each year are given in Table 11.3-1 and are higher than those given in Section 11.2.3 because they include development by private IPPs. Economic analysis takes into account all relevant costs and benefits occurring within a country.

##### 1) Capital Expenditure Cost

This is the amount of capital investment required by the implementation of the with case, which is the cost of the construction of the power plant, power transmission and distribution network (However, in accordance with the general method for calculating the EIRR, the standard conversion factor is considered for capital investment that is expected to be procured in Nepal<sup>16</sup>. Conversion factor for this analysis is 0.93, according to the number used by ADB). In addition, if depreciation has not been completed in the last year of the analysis period and there is the residual value, it will be considered as a benefit (negative cost). This suggests that the facility will be used beyond the analysis period and economic benefits will be generated.

##### 2) Operation and Maintenance Cost

It includes labor costs and repair costs necessary for the maintenance and management of equipment.

---

<sup>14</sup> The economic internal rate of return is often denoted as EIRR. The study later identified the Equity IRR. In order to avoid confusion between the two companies, the former is "Economic IRR", the latter "EIRR".

<sup>15</sup> This hurdle rate is used in an ADB-supported power project in Nepal. For instance "Electric Grid Modernization Project (PPR NEP 54107)" In the economic analysis of 9% The discount rate is used. (<https://www.adb.org/sites/default/files/linked-documents/54107-001-ea.pdf>)

<sup>16</sup> This is a coefficient for correcting the price of domestically procured goods from the international level of prices by assuming that they are distorted from the international level by tariffs, subsidies, etc., and correcting the distortion and converting it to the international level price.

## **(2) Benefit**

The benefits consist of reducing electricity imports, electricity exports, and greenhouse gas reductions.

### **1) Reduction of Electricity Import**

Compared to the without case, the with case reduces the dependence on imports of electricity and can be expected to reduce the cost of imports. This import reduction will be evaluated at 0.070 US dollars /kWh, which is set with reference to the 2023 IEX electricity unit price, and the amount of the benefit of reducing electricity imports will be calculated.

### **2) Electricity Export**

Compared to the without case, it is assumed that the with case will promote the export of electricity to neighboring countries. The amount of the increase in electricity exports is evaluated at 0.070 US dollars/kWh, which is the same as the benefit of reducing electricity imports, and the amount of the benefit from electricity exports is calculated.

### **3) Reduction of Greenhouse Gas Emissions**

In the with case, the development of hydropower-derived electricity can be expected to reduce greenhouse gas emissions in neighboring countries that import electricity from Nepal. This effect is measured by using a carbon price of 40 US dollars /tCO<sub>2</sub>eq (estimated as a carbon price in developing countries that declare net zero) estimated by the IEA.

## **11.3.2 Results of Economic Analysis**

As a result of the economic analysis, the calculated EIRR was 10.1%, which exceeded the hurdle rate. The cash flows of costs and benefits used in calculating the EIRR are shown in Table 11.3-1.

As mentioned above, the calculated EIRR exceeds the hurdle rate, and in that sense, the implementation of the IPSDP can be justified from an economic point of view. If we look at the cash flow table in detail, we can see that there is a volume zone of capital expenditure in the middle of the analysis period (around 2030). While the costs will outweigh the benefits until 2032, the benefits will not exceed the costs until 2033 or later.

In addition, although the end year of this economic analysis is 2040, the benefits of investing in IPSDP are expected to continue after 2040. This is reflected in the fact that there is about 50 billion dollars of residual value left on capital expenditures as of 2040, and it is expected that benefits will be expected after 2040, using the equipment invested by 2040. In other words, the benefits of IPSDP can be enjoyed over a long period of time, looking ahead to 2040.

**Table 11.3-1 Cash Flows of Costs and Benefits and Calculated EIRR**

Unit: Millions of dollars

Year	Economic Cost				Economic Benefit				Net Benefit
	Capital Expenditure Cost	Operation and Maintenance Cost	Residual Value	Total Cost	Reduction of Electricity	Electricity Export	Reduction of Greenhouse Gas Emissions	Total Benefit	
2022	1,925	0	0	1,925	0	0	0	0	-1,925
2023	2,427	59	0	2,486	58	213	100	371	-2,114
2024	2,519	98	0	2,618	157	299	140	596	-2,022
2025	2,728	217	0	2,945	373	657	308	1,338	-1,608
2026	3,260	270	0	3,530	559	750	352	1,661	-1,869
2027	4,767	367	0	5,133	740	923	433	2,096	-3,037
2028	5,433	410	0	5,843	940	1,315	616	2,871	-2,972
2029	7,042	525	0	7,567	1,130	1,576	738	3,444	-4,123
2030	6,488	673	0	7,160	1,407	1,838	861	4,106	-3,055
2031	6,563	861	0	7,424	1,599	2,640	1,237	5,476	-1,948
2032	5,708	980	0	6,689	1,850	2,730	1,279	5,860	-829
2033	5,180	1,202	0	6,382	2,084	3,468	1,625	7,178	795
2034	3,957	1,292	0	5,249	2,326	3,676	1,722	7,724	2,475
2035	3,866	1,402	0	5,268	2,584	3,866	1,812	8,261	2,993
2036	4,062	1,484	0	5,546	2,869	3,892	1,824	8,584	3,038
2037	3,582	1,537	0	5,118	3,165	3,926	1,840	8,931	3,812
2038	3,181	1,626	0	4,807	3,494	4,062	1,904	9,460	4,653
2039	2,473	1,731	0	4,204	3,847	4,354	2,040	10,242	6,038
2040	1,582	1,831	-51,112	-47,699	4,260	4,336	2,032	10,628	58,326

EIRR 10.1%

Source: JICA Study Team

## 11.4 FINANCIAL ANALYSIS

In this section, as described in Section 11.1.1, we conduct a financial analysis focusing on fund raising, electricity tariffs and export prices setting to examine the financial feasibility of IPSDP.

Regarding the former, it is assumed that the implementation of IPSDP will lead to new capital investment as described in Section 11.2.3. If the public electric power company itself does not have enough investment funds for the capital investment, it will need to borrow funds or accept investment from outside, which will increase the public utility's debt burden, especially in the case of borrowing. In addition, accepting loans or investment from the government will have an impact on the government's finances. . For this reason, it is useful to examine the amount of necessary fund raising and cash flow over the analysis period (2022 to 2040). Based on this analysis, Section 11.5 considers the impact on the finances of the Nepalese government.

Regarding the latter, electricity tariff setting, the setting of electricity tariffs is directly linked to the burden on the people, and if it is high, it puts pressure on the people's lives, while if it is low, the power utility's income will decrease and its financial situation will worsen. Consideration of appropriate electricity tariff levels in mid- to long-term power development is an important evaluation indicator for the plan and is worthy of consideration in the financial analysis of public power subsidiaries. In addition, as the revenue from electricity export has a significant impact on the financial status of the public electric power company, the prices of electricity export is also a target of analysis

Here, we prepare cash flow statements for the public electric power company during the IPSDP analysis period and analyze cash flows based on fundraising for capital investment and electricity tariff settings. First, we analyze cash flows if the current basic conditions of the power sector are followed, and capture the cash situation of public power utilities over the analysis period. Next, we conduct a sensitivity analysis using the cash position and borrowing interest rates of public power utilities as variables, and sensitivity analysis of electricity export prices and consider the setting of electricity tariffs and the electricity export prices, from the perspective of cash flows.

### 11.4.1 Analysis of Financing for Investment

#### (1) Purpose of the analysis

Since the implementation of the IPSDP is expected to lead to new capital investment, and the amount of funds required for capital investment is large. It is useful to examine how the necessary funds can be procured over the course of the year. Therefore, the financial analysis begins with the preparation of a future cash flow of the public electric power company for financing for capital investment and analyzes them.

#### (2) Assumption about funding

The premise for analysis is as follows.

- First of all, income obtained from business activities, which is the amount after repayment of interest and borrowings is a source of investment in the followings years. This is based on the premise that NEA is currently reinvesting the profits earned.
- If the funds are insufficient for the amount required for investment, the funds required for investment will be covered by borrowing and shareholder contributions. The ratio of borrowings to shareholder contributions is 7:3.

### **(3) Financial statement items required for the preparation of the cash flow**

The cash flow is prepared by the indirect method based on the balance sheet and income statement. The following is a list of items in the balance sheet and income statement of the public electric power company that have been calculated with following assumptions.

#### **[Balance Sheet Items]**

##### **1) Asset**

###### **① New Facilities for IPSDP**

They are facilities with new investments for the implementation of the IPSDP, and the amount of expenditure on capital expenditure for each year is depreciated on a straight-line method of 30 years.

###### **② Facilities at the end of 2021**

Revenue has been generated since 2022, the first year of the IPSDP, which also comes from the use of equipment invested before 2021. Therefore, the facilities of NEA, VUCL and RPGCL at the end of 2021 are taken into account on the balance sheet<sup>17</sup>, which is depreciated (straight-line method) in the analysis period.

###### **③ Assets at the end of 2021**

Balance of assets at the end of 2021 other than capital expenditures will be taken into account, and balances on the balance sheet will be matched. With the exception of investments in subsidiaries and affiliates, the majority of the funds are liquid assets and loans, which are expected to be converted into cash during the analysis period.

##### **2) Liabilities**

###### **① New Borrowing for IPSDP**

As per the financing assumptions, the public power company uses borrowing for capital investments. Here, the calculation is based on the borrowing rate currently used by NEA at 5%. The repayment period shall be 30 years (of which the deferral period is 10 years<sup>18</sup>).

###### **② Borrowing at the end of 2021**

As liabilities, the balance of borrowings at the end of 2021 is considered. Suppose that this will be repaid over a period of 20 years.

##### **3) Equity**

Other than equity investment and retained earnings by IPSDP, equity at the end of 2021 will also be taken into account.

#### **[Profit and Loss Statement Items]**

The revenue and expense items used are domestic electricity sales (0.070 dollars/kWh), electricity

<sup>17</sup> It is set up simply for the purpose of preparing the financial statements of a hypothetical public electric power company for this financial analysis, and does not prepare strict consolidated financial statements.

<sup>18</sup> Referring to the repayment period of yen loans, we heard that the average period of time close to the same assumption was used for ADB.

export sales (0.070 dollars/kWh), operation and maintenance costs, payments for electricity imports (0.070 dollars/kWh), and electricity purchase costs from IPPs (ROR: 0.050 dollars/kWh, PROR: 0.060 dollars/kWh, STO: 0.080 dollars/kWh, and solar: 0.060 dollars/kWh), as described in Section 11.2.3. Domestic electricity tariff levels are calculated based on the cash position and borrowing interest rates in Section 11.4.2, but as mentioned above, a benchmark of 0.070 dollars/kWh is used to create the cash flow statement. A corporate tax rate of 20% is applied.

In addition, inflation of 3% per annum will be taken into account in the financial analysis of new capital investments, domestic electricity sales, electricity export sales, operation and maintenance costs, payments for electricity imports, and payment for IPP<sup>19</sup>. Additionally, Balance sheets and income statements are posted as references.

#### **(4) Results of the analysis on financing**

As can be seen from the cash flow statement, until around 2034, it will be necessary to cover the funds necessary for capital investment through borrowings and shareholder contributions in addition to the funds held on hand from business activities. On the other hand, from 2035 onwards, capital investment will be possible without raising funds from outside the public power utility. Table 11.4-1 is the amount of funds held on hand (the amount that public power utilities can invest on their own) and the amount of funds required for capital investment. In the figure, the difference between the orange line graph (amount of funds needed for capital investment) and the blue line graph (amount that public electric power utilities can invest on their own) is the amount that must be raised through borrowing and shareholder investment, and the graph shows the need for borrowing and shareholder investment until around 2034.

Looking at the average rate of ROE (Return On Equity) and ROA (Return on Asset) over the analysis period of public electric power entity, ROE is about 10% and ROA is about 5%. This is close to the profit margin calculated with reference to the most recent NEA financial statements (9% for ROE and 4% for ROA)<sup>20</sup>. Also from the viewpoint of profit margin, the model calculated here is used as a benchmark model.

---

<sup>19</sup> Apply the same inflation rate as the IRR calculation for individual projects in Chapter 12.

<sup>20</sup> This is the profit margin calculated by the JICA study team based on the items in the balance sheet and income statement described in the assumptions from the NEA's financial statements. We also received feedback from NEA and donors that it is appropriate to set ROE of 10% and ROA of 5% as the basis for profit margins.

**Table 11.4-1 Cash Flow Statement**

(million dollars)	(Year)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
<b>Cash flows from operating activities</b>																				
Profit before income tax		165	238	266	391	449	566	770	769	760	942	1,087	1,392	1,753	2,037	2,078	2,191	2,492	2,966	3,450
Depreciation		144	169	193	228	273	319	390	472	577	692	804	881	962	1,033	1,138	1,243	1,351	1,449	1,536
Loan interest		87	102	113	132	156	178	220	265	328	396	448	454	452	444	436	426	414	400	382
Income tax paid		-33	-48	-53	-78	-90	-113	-154	-154	-152	-188	-217	-278	-351	-407	-416	-438	-498	-593	-690
Loan interest paid		-68	-65	-61	-58	-55	-51	-48	-44	-41	-38	-35	-34	-33	-33	-35	-38	-43	-50	-61
<b>Total</b>		294	397	457	615	734	898	1,179	1,308	1,472	1,805	2,088	2,415	2,783	3,074	3,202	3,384	3,716	4,171	4,616
<b>Cash flows from investing activities</b>																				
Payment for new facilities for IPSPD		-690	-765	-721	-1,044	-1,339	-1,386	-2,127	-2,476	-3,136	-3,461	-3,356	-2,312	-2,408	-2,146	-3,140	-3,159	-3,254	-2,921	-2,601
<b>Total</b>		-690	-765	-721	-1,044	-1,339	-1,386	-2,127	-2,476	-3,136	-3,461	-3,356	-2,312	-2,408	-2,146	-3,140	-3,159	-3,254	-2,921	-2,601
<b>Cash flows from financing activities</b>																				
New borrowings for IPSPD		372	377	275	458	554	504	908	956	1,328	1,440	1,134	218	69	0	0	0	0	0	0
Repayment of borrowings for IPSPD		0	0	0	0	0	0	0	0	0	0	-19	-37	-51	-74	-102	-127	-172	-220	-287
Repayment of borrowings residual at 2021		-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68	-68
Equity by shareholders		159	162	118	196	238	216	389	410	569	617	486	93	30	0	0	0	0	0	0
<b>Total</b>		463	471	324	586	724	652	1,229	1,297	1,828	1,989	1,533	206	-21	-142	-170	-195	-241	-288	-355
<b>Net increase in cash</b>																				
<b>Total</b>		68	103	60	158	119	165	280	129	164	333	264	309	354	786	-108	30	222	961	1,661
<b>Cash at end of year by IPSPD</b>																				
<b>Total</b>		68	171	231	389	508	672	952	1,082	1,246	1,579	1,843	2,152	2,506	3,292	3,183	3,214	3,436	4,397	6,058

Source: JICA Study Team

Table 11.4-2 Balance Sheet

(million dollars)	(Year)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
	Cash by IPSPD	68	171	231	389	508	672	952	1,082	1,246	1,579	1,843	2,152	2,506	3,292	3,183	3,214	3,436	4,397	6,058
	New facilities for IPSPD	667	1,383	2,032	2,968	4,155	5,343	7,201	9,325	12,005	14,895	17,568	19,119	20,687	21,920	24,043	26,080	28,103	29,696	30,882
<b>Asset</b>	Facilities at the end of 2021	2,175	2,054	1,933	1,812	1,691	1,571	1,450	1,329	1,208	1,087	967	846	725	604	483	362	242	121	0
	Assets at the end of 2021	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583	583
	<b>Total Asset</b>	<b>3,492</b>	<b>4,191</b>	<b>4,779</b>	<b>5,752</b>	<b>6,937</b>	<b>8,168</b>	<b>10,186</b>	<b>12,319</b>	<b>15,042</b>	<b>18,143</b>	<b>20,960</b>	<b>22,699</b>	<b>24,500</b>	<b>26,399</b>	<b>28,293</b>	<b>30,239</b>	<b>32,363</b>	<b>34,797</b>	<b>37,523</b>
	New borrowing for IPSPD	372	749	1,024	1,482	2,037	2,541	3,449	4,405	5,732	7,172	8,287	8,468	8,486	8,412	8,310	8,183	8,010	7,790	7,503
	Borrowing at the end of 2021	1,296	1,228	1,160	1,092	1,023	955	887	819	751	682	614	546	478	409	341	273	205	136	68
<b>Liabilities</b>	Interest payable	19	56	107	181	283	410	583	803	1,090	1,448	1,862	2,282	2,701	3,113	3,514	3,903	4,274	4,623	4,944
	<b>Total Liabilities</b>	<b>1,687</b>	<b>2,033</b>	<b>2,291</b>	<b>2,755</b>	<b>3,343</b>	<b>3,906</b>	<b>4,918</b>	<b>6,026</b>	<b>7,572</b>	<b>9,303</b>	<b>10,763</b>	<b>11,296</b>	<b>11,664</b>	<b>11,933</b>	<b>12,165</b>	<b>12,358</b>	<b>12,489</b>	<b>12,550</b>	<b>12,516</b>
	Share capital	1,583	1,745	1,862	2,059	2,296	2,513	2,902	3,311	3,880	4,497	4,983	5,077	5,106	5,106	5,106	5,106	5,106	5,106	5,106
<b>Equity</b>	Retained earnings	222	413	625	938	1,297	1,750	2,366	2,981	3,590	4,344	5,213	6,327	7,729	9,359	11,022	12,775	14,768	17,141	19,901
	<b>Total Equity</b>	<b>1,805</b>	<b>2,157</b>	<b>2,488</b>	<b>2,997</b>	<b>3,594</b>	<b>4,262</b>	<b>5,268</b>	<b>6,292</b>	<b>7,470</b>	<b>8,841</b>	<b>10,197</b>	<b>11,404</b>	<b>12,836</b>	<b>14,466</b>	<b>16,128</b>	<b>17,881</b>	<b>19,874</b>	<b>22,247</b>	<b>25,007</b>

Source: JICA Study Team

**Table 11.4-3 Profit and Loss Statement**

(million dollars)	(Year)	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Revenue	Domestic Electricity Sales	843	959	1,084	1,277	1,545	1,783	2,040	2,319	2,738	3,058	3,485	3,892	4,353	4,862	5,439	6,075	6,797	7,596	8,558
	Electricity Export	70	220	317	718	845	1,070	1,570	1,938	2,328	3,445	3,669	4,801	5,241	5,678	5,887	6,116	6,519	7,197	7,382
	<b>Total Revenue</b>	<b>913</b>	<b>1,178</b>	<b>1,401</b>	<b>1,995</b>	<b>2,389</b>	<b>2,853</b>	<b>3,610</b>	<b>4,258</b>	<b>5,066</b>	<b>6,503</b>	<b>7,154</b>	<b>8,693</b>	<b>9,594</b>	<b>10,540</b>	<b>11,326</b>	<b>12,191</b>	<b>13,316</b>	<b>14,794</b>	<b>15,940</b>
Cost	Operation and maintenance cost	61	83	90	103	119	156	176	186	221	255	392	486	569	662	695	720	798	875	1,057
	Depreciation	144	169	193	228	273	319	390	472	577	692	804	881	962	1,033	1,138	1,243	1,351	1,449	1,536
	Payment for electricity import	186	150	147	75	97	82	49	36	35	35	23	22	0	0	0	11	23	36	68
	Payment for IPP	271	436	593	1,066	1,294	1,553	2,004	2,529	3,145	4,193	4,401	5,479	5,859	6,362	6,979	7,601	8,237	9,068	9,447
	Loan interest	87	102	113	132	156	178	220	265	328	396	448	454	452	444	436	426	414	400	382
	<b>Total Cost</b>	<b>748</b>	<b>940</b>	<b>1,136</b>	<b>1,604</b>	<b>1,940</b>	<b>2,288</b>	<b>2,839</b>	<b>3,489</b>	<b>4,306</b>	<b>5,561</b>	<b>6,067</b>	<b>7,301</b>	<b>7,841</b>	<b>8,502</b>	<b>9,248</b>	<b>10,000</b>	<b>10,824</b>	<b>11,828</b>	<b>12,490</b>
Profit	Profit before income tax	165	238	266	391	449	566	770	769	760	942	1,087	1,392	1,753	2,037	2,078	2,191	2,492	2,966	3,450
	Income Tax	33	48	53	78	90	113	154	154	152	188	217	278	351	407	416	438	498	593	690
	<b>Net Profit</b>	<b>132</b>	<b>191</b>	<b>213</b>	<b>313</b>	<b>359</b>	<b>452</b>	<b>616</b>	<b>615</b>	<b>608</b>	<b>754</b>	<b>870</b>	<b>1,113</b>	<b>1,403</b>	<b>1,630</b>	<b>1,662</b>	<b>1,753</b>	<b>1,994</b>	<b>2,373</b>	<b>2,760</b>

Source: JICA Study Team

## 11.4.2 Analysis of Domestic Electricity Tariffs

### (1) Purpose of the analysis

In this section, we calculate the level of electricity tariffs for domestic consumers based on the cash position of public electric power company, and consider the level of electricity tariffs taking into account fundraising.

### (2) Cases of the cash position to be analyzed

We will move domestic electricity prices and consider the electricity price levels in the following two cases. Case 1 is a case where cash is shorted, making it difficult to operate a sound business from a financial perspective. Case 2 can be regarded as a case where there is a margin of income in running a business. It is assumed that the electricity tariff will be applied consistently throughout the analysis period.

- Case 1: Domestic electricity tariff levels that will result in a negative cash balance of public power utilities from 2023<sup>21</sup> onwards. This is the level of electricity prices when cash shortages occur even if the funds necessary for investment are procured through borrowing and investment.
- Case 2: The level of domestic electricity prices at which the funds retained by business activities during the analysis period exceed the funds required for investment. In this case, all of the funds required for capital investment can be covered by the income from the business.

In addition to setting up Case 1 and Case 2, we will also conduct a sensitivity analysis based on borrowing rates. The setting width of the variable is 5.0% to 10.0%<sup>22</sup>.

### (3) The level of electricity tariffs according to each case

Based on the above case settings, the level of domestic electricity charges was calculated to be 0.055 dollars/kWh (Case 1) and 0.130 dollars/kWh (Case 2). If the domestic electricity price level calculated in Case 1 and Case 2 is taken as the threshold, the level of domestic electricity prices can be set between \$0.055 and \$0.130 per kWh, although it is considered only from the cash position. The profit margins of Case 1 and Case 2 are ROE of 3.0% (Case 1) and ROE of 18.0% (Case 2), respectively.

**Table 11.4-4 The level of electricity tariffs**

Electricity Tariffs and Profit Level		Interest Rate (%)	
		5.0%	10.0%
Case	Case 1	0.054 dollars/kWh (ROE:3.0% ROA:1.0%)	0.058 dollars/kWh (ROE:2.0% ROA:0.0%)
	Benchmark Case <sup>23</sup>	0.070 dollars/kWh (ROE:10.0% ROA:5.0%)	0.070 dollars/kWh (ROE:8.0% ROA:4.0%)
	Case 2	0.130 dollars/kWh (ROE:18.0% ROA:15.0%)	0.132 dollars/kWh (ROE:18.0% ROA:15.0%)

Source: JICA Study Team

<sup>21</sup> For the convenience of calculation, the amount of investment by the electric power business entity in 2022 is based on the estimated business income from the actual value in 2021, and does not fluctuate according to the electricity rates based on this analysis.

<sup>22</sup> The interest rate of 10% is the interest rate that will be applied when assuming borrowing from a commercial bank in Nepal, and the interest rate for borrowing from a commercial bank is also set at 10% when calculating the IRR of individual projects in Chapter 12. The analysis here assumes that the interest rate of government loans will rise to the same level as that of loans from commercial banks.

<sup>23</sup> In the cash flow analysis in the previous section, an interest rate of 5.0% is used as the benchmark case.

**(4) Sensitivity analysis of electricity export sales prices**

In addition to examining domestic electricity rates, we will also examine the selling price of electricity exports. In Nepal's power sector, the proportion of sales from electricity exports is expected to fluctuate between 37% and 55% after 2027 as power source development progresses. As described previously, the selling price for electricity exports is determined not only by the Nepalese side but also by the demand of neighboring countries such as India and Bangladesh, so the selling price is set at 0.070 dollars/kWh based on IEX's track record. However, since this price setting is expected to have a significant impact on the business operations of the power sector, we will consider the impact on the profit margins and financial status of public power utilities if this price were to fall.

The analysis uses 0.030 dollars/kWh, 0.040 dollars/kWh, 0.050 dollars/kWh, and 0.060 dollars/kWh to set prices that have fallen from 0.070 dollars/kWh. The smallest price of 0.030 dollars/kWh was set based on the 2020 IEX annual average trading fee of 0.031 dollars/kWh, assuming that the selling price of electricity exports falls to this level. Note that conditions other than the selling price of electricity exports are the same as those used in the benchmark case. The results calculated using the above variable settings are shown in the table below.

**Table 11.4-5 Result of sensitivity analysis of electricity export sales prices**

Result of Analysis		Electricity Export Sales Prices (dollars/kWh)				
		0.030 dollars/kWh	0.040 dollars/kWh	0.050 dollars/kWh	0.060 dollars/kWh	0.070 dollars/kWh
Profit Level	ROE	-39.0%	-4.0%	4.0%	7.0%	10.0%
	ROA	-3.0%	0.0%	2.0%	4.0%	5.0%
Financial Status	Cash Short	No	No	No	No	No
	Insolvency	<u>Yes</u>	No	No	No	No

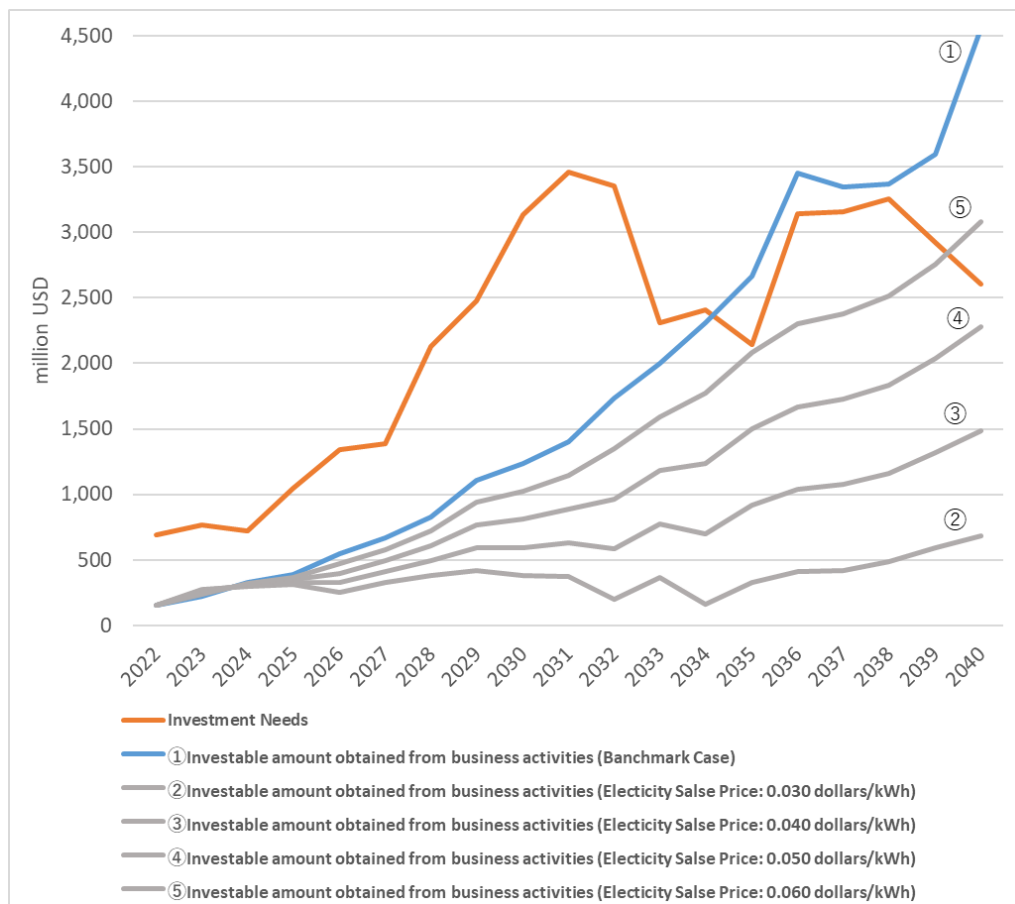
Source: JICA Study Team

From the results of this calculation, even if the selling price of electricity exports falls to 0.030 dollars/kWh, there will be not cash shortfall, but the deficit will accumulate, resulting in a negative net asset and insolvency. Since the public power utility will have a significant cash shortfall, it will need to raise more external funds (borrowings and shareholder contributions) than in the benchmark case for capital investment, and the Nepalese government's capital contributions will also increase, which could ultimately lead to the public power utility going bankrupt due to insolvency (profit margins: ROE -39.0% and ROA -3.0%). To secure a profit margin similar to the baseline (ROE 10.0%) and to utilize a significant amount of the public power utility's own funds for capital investment, it will be necessary to set domestic electricity tariffs at the level of 0.101 dollars/kWh, which would increase the burden on the public.

In this case, it may be necessary to consider measures such as suspending unprofitable businesses through a thorough review of current businesses, improving project profitability by reviewing costs for new businesses, and increasing the added value of electricity sales. However, there are limits to reviewing business profitability, and in reality, if the selling price of electricity exports falls to a level where ROE and ROA become negative (below 0.050 dollars/kWh), it is expected that a review of the development plan itself will be necessary.

### 11.4.3 The Summary of Financial Analysis

Based on the above analysis, from the perspective of cash position alone, there is room to lower the electricity tariff to around 0.055 dollars/kWh. However, in this case, the need for external fundraising will increase, raising the uncertainty of procurement, and potentially increasing the government's financial burden. On the other hand, if all capital investment funds are to be covered by the revenues of public electric power utilities, electricity tariffs would have to be raised by around double the current level, which would increase the burden on citizens. If IPSPD is implemented based on the current electricity tariff level of 0.070 dollars/kWh, capital investment can be promoted using the revenues of the public electric power company in combination with borrowing and investment, and an increase in the burden on citizens due to a significant increase in electricity tariffs can be avoided.



Source: JICA Study Team

**Figure 11.4-1 Relationship between available investment amount from cash on hand and capital investment amount**

The results of the study on the selling price of electricity exports suggest that if the situation in potential export destinations, India and Bangladesh, changes significantly in the future and the selling price for electricity exports falls to 0.030 dollars/kWh, public power utilities may become insolvent. Even in the case of other selling prices, the dependency on external funds such as borrowing and shareholder contributions increases compared to the benchmark case, increasing the uncertainty of fund raising possibilities.

One possible way to make up for the loss of revenue from electricity exports would be to raise domestic electricity tariffs, but this would increase the burden on the public. Therefore, if the

selling price of electricity exports falls, it may become necessary to reconsider the plans envisaged in the IPSDP by taking measures such as discontinuing unprofitable projects through careful review of the projects, improving the profitability of projects by reviewing the costs of new projects, and increasing the added value of electricity sales. However, there are limits to how much a business profitability can be reviewed, and in reality, if the selling price of electricity exports falls to a level where ROE and ROA become negative (below 0.050 dollars/kWh), it is expected that a review of the development plan itself will be necessary.

Considering the current electricity situation in neighboring countries, it is thought that the electricity export selling price set at 0.070 dollars/kWh will not deviate significantly, but a medium to long term plan such as IPSDP will need to be updated periodically to reflect the surrounding environment of the electricity sector. The figure below shows the relationship between the amount of investment available in the funds reserved by the public electricity power company and the amount of capital investment required to implement the IPSDP for each electricity selling price.

## 11.5 ANALYSIS OF IMPACT ON NEPAL MACROECONOMY

### 11.5.1 Objectives, Methods and Prerequisites for Nepal's Macroeconomic Impact Analysis

In the previous section, we conducted a financial analysis focusing on public electric power companies. This section examines the macroeconomic impact of IPSDP on Nepal. Specifically, the impact on external debt, foreign exchange reserves, the impact of electricity exports on the trade balance, the impact of electricity exports on the GDP, and the impact on employment.

Figures used in this analysis are the same as the previous paragraph (domestic electricity sales charges : 0.070 dollars/kWh, borrowing rate : 5.0%). However, since the growth rate of GDP below is assumed to be real GDP, the inflation rate of 3% is not considered.

#### (1) Assumptions for the analysis of GDP

The baseline GDP is set as follows.

- GDP for each year is firstly calculated at 8% per annum (the reason for setting the growth rate is below), and then adding the income from electricity export sales on top is.
- The growth rate is referred to that of Chapter 5, with the growth rate of Middle case, industrial (10.14%), Commercial (7.71%) and others (7.12%).
- Revenue from electricity export sales for each year of financial analysis is added to the GDP set in this way to form the baseline GDP<sup>24</sup>. Electricity exports are expected to be accelerated by the implementation of the IPSDP and are assumed to be generated exogenously by the implementation of the IPSDP.

### 11.5.2 Analysis of the Impact on External Debt

#### (1) Objectives, methods and prerequisites for the analysis of the impact on external debt

##### 1) Baseline external debt

Looking at Nepal's external debt over the past 10 years, it has hovered around 20% of GDP, so the baseline external debt is assumed to be 20% of GDP set in this analysis (of which 3.0%<sup>25</sup> is assumed to be originally allocated to the electricity budget and is excluded to avoid duplication with the borrowing of external debt due to the implementation of the IPSDP).

##### 2) External debt by IPSDP

If the public electric power company receives a loan and shareholder contribution, it is assumed that it will be funded from the government budget of Nepal. When the debt is injected from the government budget, the following two cases are assumed to be used in the analysis of external debt. In both cases, the balance of external debt is calculated taking into account the repayment period of 30 years (10 years is a grace period).

- Case 1: The government budget to be input refers to the current budget structure of the Nepal government and consists of "tax and non-tax revenues: external debt: domestic

<sup>24</sup> Electricity export revenues for each year are the same as electricity export revenues used in financial analysis.

<sup>25</sup> As described in Chapter 2, since 2.8% of Nepal's budget is allocated to the MoEWRI, which has jurisdiction over the electricity sector, it is assumed that 3% of the external debt will also be allocated to the electricity budget.

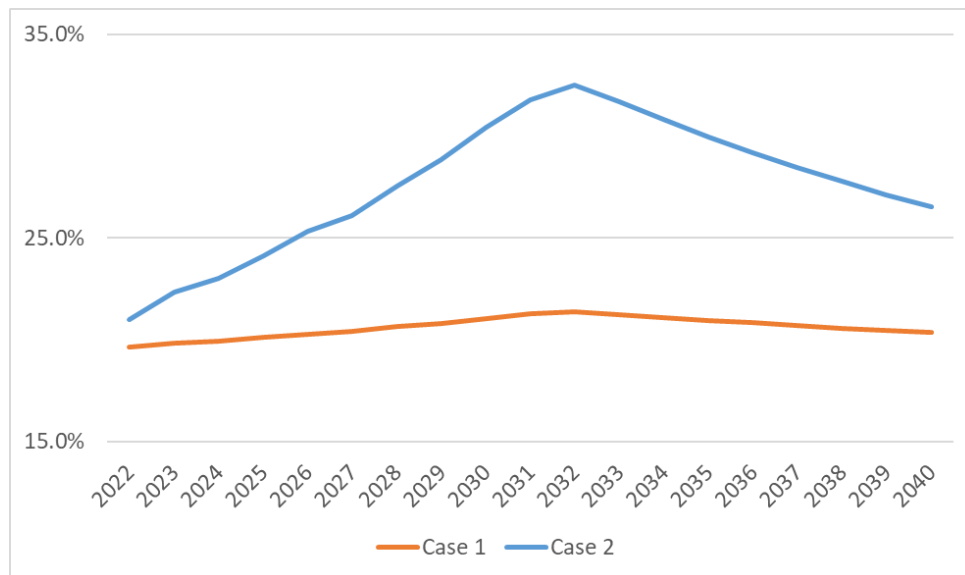
borrowings = 70 : 15 : 15". This means 15% of the loans and shareholder contributions will come from external debt.

- Case 2: A case in which all of the government budget is financed by external debt. In this case, 100% of the loans and shareholder contributions are derived from external debt.

The external debt under the IPSDP is added to the baseline external debt in 1) above, resulting in the balance of external debt for each year.

## (2) Results of the Impact Analysis on External Debt

External debt per GDP ratio is Figure 11.5-1. In both cases, the external debt will be increased around 2031-2032, when the demand for funds by the public electric power company is high. The ratio will increase up to 21.4% (Case 1), up to 32.5% (Case 2), respectively. For reference, even among developing countries in Asia with higher income levels than Nepal, such as Viet Nam (36.1%), Philippines (28.7%), Thailand (38.4%), the ratio is about 30% to 40%. Since the other factors are fixed and external debt that takes into account only the financing of electricity development, it is not possible to make a general comparison, but it is not an exceptionally high figure compared to the external debt of these countries.



Source: JICA Study Team

**Figure 11.5-1 External Debt as a Percentage of GDP**

### 11.5.3 Analysis of the Impact on Foreign Exchange Reserves

#### (1) Objectives, methods and prerequisites for the analysis of the impact on foreign exchange reserves

Foreign exchange reserves serve as reserve assets in the event that it becomes difficult to repay external debts or settle import payments. Therefore, in analyzing foreign exchange reserves, the ratio of foreign exchange reserves to external debt is calculated<sup>26</sup>. At the same time, in order to see how much room there is to pay for imports, we also estimate how many months of foreign

<sup>26</sup> However, bearing in mind that India is the main market for electricity exports, and that future electricity exports are expected to be denominated in India rupees, in such cases they differ from borrowed currencies (yen, dollars, etc.), and that while foreign exchange reserves are generally used as an indicator of safety in relation to short-term external debt, the external debt assumed in this analysis has a long repayment period, The ratio is only a guideline.

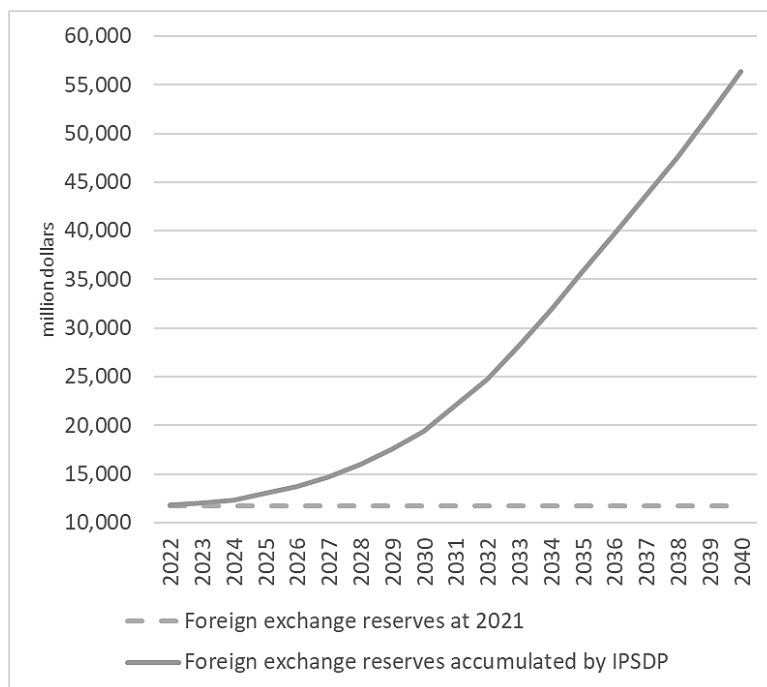
exchange reserves are equivalent to the value of imports.

In analyzing the impact on foreign exchange reserves, the following assumptions are made:

- 1) Foreign exchange reserves are formed by adding imports from electricity export sales from the IPSDP each year to the 2021 foreign exchange reserve of 11.7 billion dollars.
- 2) The value of imports for each year refers to the average ratio of imports to GDP over the past five years, which is 35% of the baseline GDP.

**(2) Results of the Analysis on Foreign Exchange Reserves**

Calculated according to the assumptions, the foreign exchange reserves, which take into account the income from electricity export sales by the IPSDP, accumulate as shown in the graph below.



Source: JICA Study Team

**Figure 11.5-2 Changes in Foreign Exchange Reserves**

Although the level of 1.0 is sometimes used as a measure of foreign exchange reserves for short-term external debt balance, the current<sup>27</sup> analysis assumes that the external debt to be procured to be used in the power sector is a concessional fund with a long repayment period. If it is more than 1.0 times, it is considered to have exceeds this level. From the calculation results, even when the ratio was minimal, it was 1.44 times (Case 1 of the analysis of external debt) or 1.01 times (case 2 of the analysis of external debt), so it exceeded 1.0 in both cases.

As for the value of imports, it was estimated that foreign exchange reserves worth at least 10 months of imports would be secured over the analysis period. The three-month level<sup>28</sup> is sometimes used as a measure of foreign exchange reserves relative to the value of imports, but the results of this analysis show that the level of foreign exchange reserves equivalent to one year of imports is secured, so the level of this guideline is exceeded.

<sup>27</sup> Nomura Asset Management's "Economic Words for Investment" Vol.2 Foreign Exchange Reserves

<sup>28</sup> ditto

### 11.5.4 Analysis of the Impact of Electricity Exports on the Trade Balance

#### (1) Objectives, methods and prerequisites for the analysis of the impact of electricity exports on the trade balance

Nepal has a trade deficit. The implementation of the IPSDP is expected to improve the trade deficit by promoting electricity exports to neighboring countries. Therefore, we will analyze the expected benefits from electricity exports from the implementation of the IPSDP from the perspective of improving the trade deficit.

The assumptions used in the analysis are as follows.

##### 1) GDP

The GDP estimated in this section is calculated by subtracting the following revenues from electricity export sales from the baseline GDP.

##### 2) Baseline trade deficit

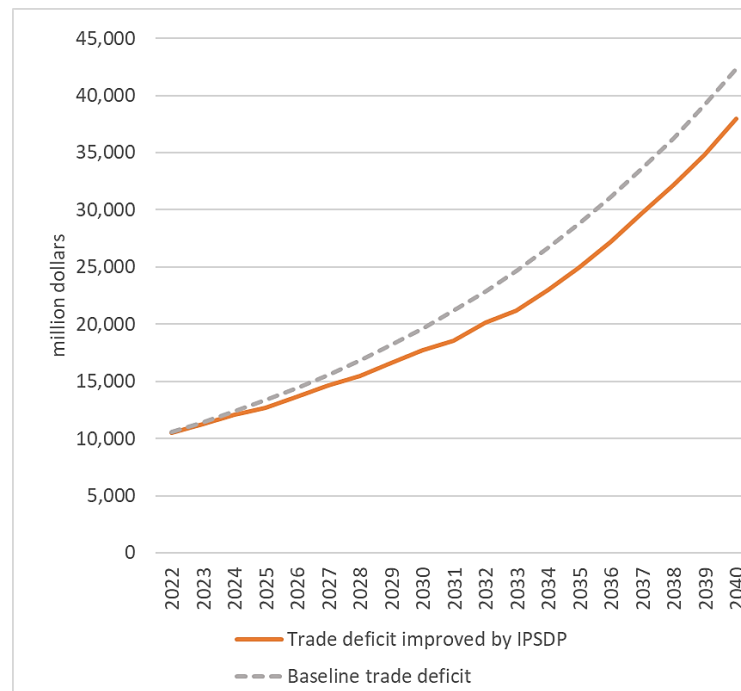
Over the past 10 years, the trade deficit has averaged 32% of GDP. Therefore, the amount of the baseline trade deficit will be 32% of GDP for each year, and this trade deficit will be improved by electricity exports.

##### 3) Income from electricity export sales

Electricity export sales used in financial analysis are used.

#### (2) Results of Analysis of the Impact of Electricity Exports on the Trade Balance

baseline trade deficit, electricity exports were estimated to improve the trade deficit by up to 14%.



Source: JICA Study Team

**Figure 11.5-3 Reduction of trade deficit**

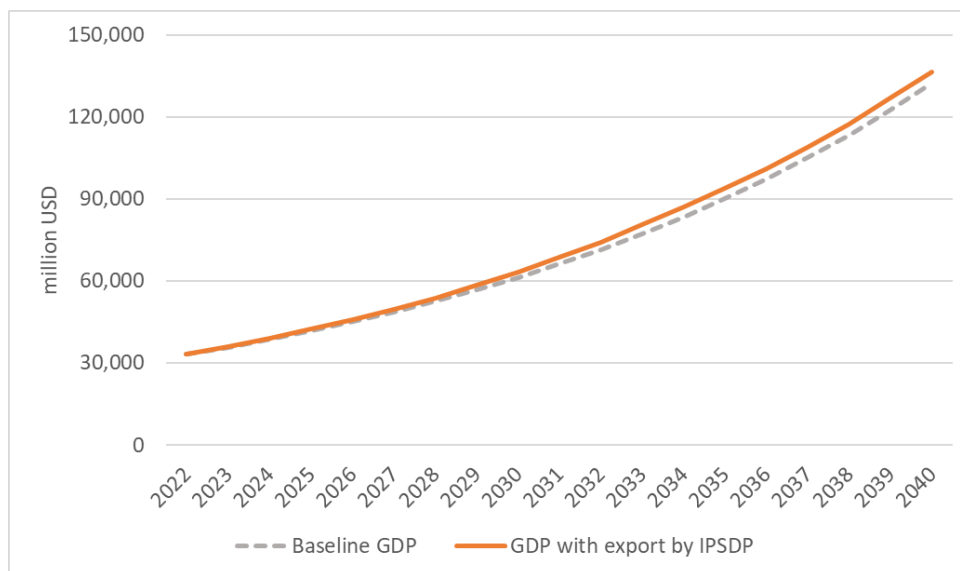
### 11.5.5 Analysis of the Impact of Electricity Exports on GDP

**(1) Object, methods and prerequisites for the analysis of the impact of electricity exports on GDP**

In order to analyze the expected benefits from electricity exports from the implementation of the IPSDP from the perspective of GDP, we estimate the extent to which GDP will be boosted by revenues from electricity export sales. The GDP and electricity export revenues used in the analysis are those used in the previous analysis. At the same time, the contribution of electricity exports to GDP is also estimated.

**(2) Results of Analysis of the Impact of Electricity Exports on GDP**

The GDP, which takes into account revenues from electricity export sales, changes as shown in the graph below. It was estimated that the amount of income from electricity export sales would increase year by year, and that the maximum GDP would be increased by about 5% compared to the absence of IPSDP exports. Compared to the previous fiscal year, the GDP growth rate is about 8%.



Source: JICA Study Team

*Figure 11.5-4 Trends in GDP taking into account income from electricity export sales*

### 11.5.6 Analysis of Job Creation Effects

**(1) Objectives, methods and prerequisites for the analysis of the effect of job creation**

The implementation of the IPSDP is expected to create jobs associated with the construction of power generation facilities. In this analysis, we analyze the benefits of the development of integrated power systems from the perspective of job creation. MoEWRI's Energy Development Roadmap and Action Plan estimates the number of people employed to build a 1,000 MW hydropower plant as follows:

**Table 11.5-1 MoEWRI Estimation of the number of personnel required to build a 1,000 MW hydroelectric power plant**

Occupation of personnel	Number of people
Manager	50-60
Engineer	500-600
Workplace leadership personnel, such as directors and foremen	1,500-2,000
Skilled workers with a variety of skills and abilities	5,000-6,000
General Workers	20,000-25,000
sum	27,050-33,600

Source: JICA Study Team with reference to the Energy Development Roadmap and Action Plan (MoEWRI)

In analyzing the effects of the IPSDP on job creation, we will try to estimate the number of personnel required to construct a 1,000 MW hydroelectric power plant, using the capital investment costs and installed capacity estimated by the JICA study team. Since detailed analysis of each occupation is not the purpose of macroeconomic analysis, the average labor cost is used to estimate the number of people equivalent to the total number of people estimated by MoEWRI.

The following figures are used for estimation.

**Table 11.5-2 Figures used to estimate employment**

item	numeric value
Installed Capacity	Of the increase in installed capacity from 2026 to 2040 in the optimal scenario described in Chapter 7, 26,876 MW related to hydropower generation will be used.
Amount of capital investment	Of the cumulative investment in the optimal scenario described in Chapter 7, 47,262.4 million dollars will be used for hydropower generated from 2026 to 2040.
Ratio of labor costs to capital investment	As for available data, the Ministry of Health, Labour and Welfare of Japan has set the labor cost rate for the construction of hydroelectric power generation facilities at 19%. In addition, when ADB conducted an economic analysis of the Tanahu development in Nepal, the ratio of labor costs to construction costs was 42 percent. Therefore, in this analysis, it is assumed that labor costs account for 20%-40% of capital investment.
Labor cost	According to the 2018 census conducted by the Nepali government, the annual salary per employee in the electricity, gas and heat supply industry was Rs 770,000. In addition, according to the salary index of the Central Bank of Nepal, the salary level of workers in the industrial sector has increased by 1.43 times from 2018/2019 to 2022/23. Based on the above, the annual labor cost per employee is 8,258 dollars/year, which is converted at 1 rupee = 0.0075 dollars.

Source: JICA Study Team

Using the above figures, the number of employees per year was first calculated from the amount of capital investment and labor costs, and then the number of employees for the construction of a hydroelectric power plant of 1,000 MW was calculated from the calculated number of people and the installed capacity.

[Calculation formula used for estimation]

$$\textcircled{1} \frac{\text{Labor costs in capital expenditure (per year)}}{\text{Labor cost per capita (per year)}} = \text{Number of employees (per employee)}$$

$$\textcircled{2} \frac{\text{Number of employees (per year)}}{\text{Increase in installed capacity (MW) (per year)}} = \text{Number of employees (per 1,000 MW)}$$

## (2) Results of Analysis of Job Creation Effects

The following table compares the number of employees employed per 1,000 MW estimated by the JICA study team with the estimates of MoEWRI<sup>29</sup>.

**Table 11.5-3 Comparison of the estimates of MoEWRI with that of the JICA Study Team**

	Estimation of MoEWRI	Estimates by JICA Study Team	Assumptions about the JICA Study Team's estimates
lower limit	27,050 people/1,000MW	42,765 people/1,000MW	Assuming that labor costs account for 20% of capital investment expenses
upper limit	33,600 people/1,000MW	85,530people/1,000MW	Assuming that labor costs account for 40% of capital investment expenses

Source: JICA Study Team

Since the estimates differ depending on how labor and labor costs are taken, the estimates of the JICA study team are higher than the estimates of MoEWRI, but in all estimates, the effect of job creation per 1,000 MW of hydroelectric power plants is expected to be tens of thousands of workers.

Using the figures for the labor force and unemployment rate in Table 11.2-1, the number of unemployed people in 2022/2023 is estimated to be about 980,000. If about 27,000 workers are employed per 1,000 MW hydropower plant, as in the lower end of MoEWRI's estimate, this will have the effect of reducing the number of unemployed people by about 3%, and if about 85,000 workers are employed per 1,000 MW hydropower plant, which is the upper end of the study team's estimate, this will have the effect of reducing the number of unemployed people by about 9%.

<sup>29</sup> MoEWRI's estimates were included in "Energy Development Road Map".

## 11.6 CONCLUSION OF ECONOMIC AND FINANCIAL ANALYSIS

In light of the objectives set forth at the beginning of this chapter, the results of analyses and studies conducted and the suggestions obtained are summarized below.

- In the economic analysis, it was confirmed that the EIRR exceeds the social discount rate (hurdle rate). In this sense, investments under the IPSDP are justified.
- In the financial analysis, with regard to the benchmark case, it was confirmed that in the first half of the analysis period, it was likely that it would be difficult to secure the necessary funds for IPSDP investment without the use of borrowings and shareholder contributions, but in the second half of the analysis period, it was confirmed that the funds held on hand by business activities may exceed the funds required for investment.
- From 2022 to 2032, an increase in the government's external debt is inevitable as it will cover the funds needed for investment, but it is expected that it will not put extreme pressure on public finances.
- In terms of foreign exchange reserves, trade balance, GDP and job creation, the IPSDP is expected to have a positive impact on macroeconomic indicators. IPSDP can benefit Nepal in terms of economic growth and international trade.

Thus, in the analysis conducted in this chapter, positive results were obtained. However, the above analysis is one of the results of the analysis based on many assumptions, and the results are not guaranteed. In this sense, it is important to appropriately monitor the implementation status of the IPSDP, review assumptions and figures as necessary.



# **ANNEX 12**

## **CONSIDERATION OF THE FINANCING ASPECTS OF IPSDP**

---



---

<b>Annex 12</b>	<b>Consideration of the Financing Aspects of IPSDP .....</b>	<b>12-1</b>
12.1	Objective and Structure.....	12-1
12.2	Current Status of Power Project Financing in Nepal .....	12-3
12.2.1	Demand Side Information: Funding of Major Business Entities .....	12-3
12.2.2	Supply-side Information: Suppliers of Business Capital.....	12-5
12.2.3	Situation of Project Finance in Nepal.....	12-7
12.2.4	Laws and Regulations related to Power Development .....	12-8
12.3	Basic Consideration on Financing Method of IPSDP .....	12-10
12.3.1	Overall IPSDP Investment Plan, Capital Needs and Business Financing Options.....	12-10
12.3.2	Considerations regarding Financing for Power Generation Projects.....	12-11
12.3.3	Considerations regarding Financing for Power Transmission and Distribution Businesses .....	12-13
12.3.4	Basic considerations for realizing IPSDP financing.....	12-14
12.4	Analysis of the Effectiveness of Concessional Funding .....	12-19
12.4.1	Selection of Target Projects .....	12-19
12.4.2	Consideration of Analytical Methods and Indicators .....	12-23
12.4.3	Analysis of the Effectiveness of the Lower Seti Concessional Fund Application.....	12-25
12.4.4	Analysis of the Effectiveness of Sunkoshi 3 Concessional Funding.....	12-29
12.4.5	Analysis of the effectiveness of Phukot Karnali Concessional Funding .....	12-35
12.4.6	Implications from the Analysis .....	12-39
12.5	Funding Plan for IPSDP Implementation.....	12-40
12.5.1	Methodology .....	12-40
12.5.2	Analysis .....	12-43

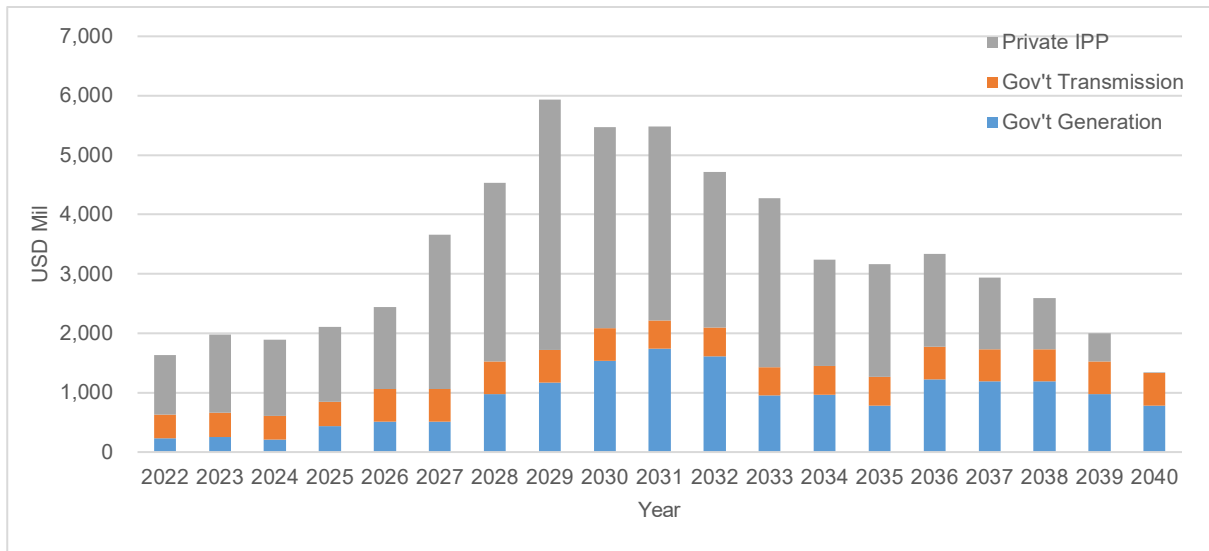
---



## ANNEX 12 CONSIDERATION OF THE FINANCING ASPECTS OF IPSDP

### 12.1 OBJECTIVE AND STRUCTURE

This chapter examines how to finance the individual projects included in the IPSDP and makes recommendations for its realization. A large amount of funds needs to be raised to realize the IPSDP. The calculations made in Chapter 11 "Economic and Financial Analysis" and elsewhere highlighted <sup>1</sup>that huge investment would be required for the hydro power generation project<sup>2</sup>.



Note: The classification of government (estimated)/private (estimated) was made by the JICA study team after confirming the proponents of each target project. Projects that were clearly being promoted by the GoN were classified as "Investment by the GoN (estimated)," while other projects were classified as "Investment by the private sector (estimated)." PPPs were classified as the latter.

Source: JICA Study Team

**Figure 12.1-1 Investment Plans and Capital Demand in IPSDP**

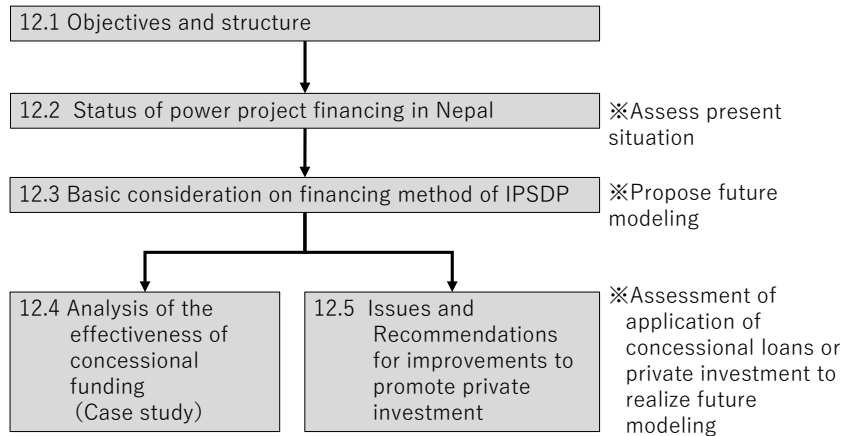
It was confirmed that the GoN can afford to cover the costs from a fiscal perspective. However, the methodologies of fundraising remain to be assessed by GoN. As for the private sector investment, how to attract such a large amount of capital remains a critical issue.

Regarding the use of private funds, it is impossible to cover the capital demand with the financial capabilities of domestic business companies and financial institutions alone, and in that sense, foreign investment and financing is essential. For hydroelectric power generation projects, which require large investment amounts, it is common to solicit investment and financing not only from general investors but also from international development financial institutions to execute project, as seen in examples from other Asian countries. In an environment where there is a clear demand for renewable energy sourced electricity in India and Bangladesh, it is expected that investment and finance sourced from these countries could accelerate power development and realize electricity exports. This chapter will assess options based on these understanding.

The structure of this chapter is as shown in the following figure.

<sup>1</sup> This amount is for the initial investment (CAPEX) only and does not include costs for operation, maintenance or renewal (OPEX).

<sup>2</sup> Details regarding the process, method, conditions, etc. for creating the table will be described later.



Source: JICA Study Team

**Figure 12.1-2 Structure of Chapter 12**

Section 12.2, the study elaborates collected information for this survey with respect to the hydropower project financing in Nepal. Specifically, we summarize information on the demand side (funding of major project operators) and the supply side (suppliers of project funds), and then review an actual situation of project financing. In addition, the study touched on relevant laws and regulations.

Next, Section 12.3 focuses on IPSDP and summarizes the basic concepts and options for project financing, separately for power generation and transmission, while considering the scale of various projects and the economics of investment projects outlined in the plan because of the study of the "ideal state. In response to this, as a study on effective use of funds to realize the plan, Section 12.4 analyzes the effectiveness of using concessional funds, and Section 12.5 examines issues and improvement measures for promoting private investment.

Based on the findings of the review and examination in the main part of this chapter, the case of Laos is cited at the end of the chapter as an example of export-oriented large-scale hydropower development in other country and will be used as a reference for this study.

## 12.2 CURRENT STATUS OF POWER PROJECT FINANCING IN NEPAL

### 12.2.1 Demand Side Information: Funding of Major Business Entities

This section summarizes information on the demand side of project finance and describes the findings of the JICA study team on the current state of financing for project investment for the core business operators implementing hydroelectric power projects (power generation and transmission) in Nepal. Specifically, this section describes the current state of financing for public business operators NEA, VUCL, RPGCL, and HIDCL, as well as private power business operators.

#### (1) NEA Financing (Power Generation and Transmission)

As a public power utility company, the Nepal Electricity Authority (NEA) is engaged in both power generation and transmission. Apart from its own funds, business investment funds are borrowed from outside sources, most of which are borrowed from the GoN. This also includes sub-lending of concessional loans from international development financial institutions. On the <sup>3</sup>other hand, the NEA also borrows from private financial institutions. In terms of how the government and private borrowings are used, the reality is that long-term funds for business investments are raised from the GoN, and short-term funds for business operating capital are raised from commercial banks<sup>4</sup>.

#### (2) VUCL financing (power generation business)

VUCL (Vidhyut Utpadan Company Limited) was established in 2006 as an entity to implement large-scale hydroelectric power generation projects through a public-private partnership method. Various public and private entities have invested in the company, among them MoEWRI holds 20% of the shares as the largest shareholder, and NEA holds 10%, making it a business entity with a strong public character. As of September 2022, VUCL has invested in six hydroelectric power plants, but none of them have yet started operation<sup>5</sup>. There is no revenue recorded from selling electricity, the company currently relies on borrowing from the GoN to raise funds for its business.

#### (3) RPGCL fundraising (power transmission business)

RPGCL (Rastriya Prasaran Grid Company Limited) was established in 2015 as a public entity responsible for grid development projects in Nepal. The shareholder structure is made up of MoEWRI as the largest shareholder, various government ministries of the GoN, and NEA. The company raises business funds through loans from the GoN.

#### (4) HIDCL Fund Raising (Power Generation Business Development)

Although the company does not directly engage power generation activity, Hydroelectricity Investment and Development Company Ltd. (HIDCL) acts for investing in the development of power generation projects. HIDCL was established in July 2011 under MoEWRI to attract domestic and international investors with the aim of enabling renewable power (including hydropower) projects' financing and promoting the development of large-scale hydroelectric power sources. It has two subsidiaries, Remit Hydro Limited and Simbuwa Remit Hydro Limited, and owns 100% of the shares of both companies. HIDCL's shareholders are the Government of Nepal and pension funds. HIDCL raises its own funds for business development, and provides

<sup>3</sup> This was confirmed through interviews with NEA officials. International development financial institutions include the World Bank, ADB, EIB, AIIB, and the Export-Import Bank of India.

<sup>4</sup> This statement is based on the results of a review of the NEA's Annual Report (each year).

<sup>5</sup> Based on interviews with NEA officials (as of June 2024). Therefore, VUCL has not yet generated any operating income.

loans to business developers<sup>6</sup>. HIDCL raises its own funds from its own funds, as well as from borrowings from the Government of Nepal (including long-term loans from development aid agencies)<sup>7</sup>.

**(5) Financing of private operators (IPP: Independent Power Producer)**

There are two types of IPP in Nepal: PPP cases involving government agencies and cases promoted only by private companies. In the PPP case involving government agencies, the relevant government agencies and private companies bear the risks and enjoy the profits, and a PDA (Project Development Agreement) is concluded<sup>8</sup>. On the other hand, in a private IPP-based hydropower project, the IPP builds, owns, operates, and transfers the hydropower project on its own. The involvement and role of the relevant government agencies is limited to project approval and issuance of power generation licenses<sup>9</sup>.

At present, private sector participation in Nepal is limited to power generation projects, and there is no evidence of participation in power transmission and distribution projects. According to interviews with MoEWRI and NEA officials, the possibility of private companies' participation in power transmission and distribution business in the future is not excluded. However, the specific time has not been announced. Therefore, it is fair to judge private sector participation in power transmission and distribution projects is currently at the conceptual level and is not a business area in which private companies are considering concrete investment.

Financing by private businesses (for investment in power generation projects), particularly debt, is done in the form of loans, and there has been no evidence of bond financing. Financing methods through loans for local and foreign companies can be summarized as shown in the table below.

**Table 12.2-1 Use of financing by private businesses (loans)**

	Commercial Banks	Policy banks/development banks/ export-import banks, etc.
Local Business	○	△
Foreign companies	○	○

Legend ○: Frequently used △ Used

Source: JICA Study Team

According to interviews conducted by the JICA study team, many local companies raise funds from commercial banks, and borrowing from government banks etc. is rare. The reason for this is that such domestic financial institutions are not yet fully developed in Nepal. On the other hand, foreign companies (for example, Indian companies) are actively utilizing funds from commercial banks and government banks etc.

As for financing methods, Upper Trishuli-1 (216MW) is an example of a project in which an SPC led by Korea Electric Power Corporation received PPP financing from ADB and IFC, using project

<sup>6</sup> For example, for projects of 25 MW or more, the loan limit is NPR 250 million, and for 15-25 MW, the loan limit is a maximum of NPR 200 million. In addition, for projects of 10-15 MW, the company also provides refinancing services such as improved interest rate schemes in cooperation with local banks.

<sup>7</sup> The company has provided NPR 11.5 billion to 13 projects, with a lead example being the provision of a World Bank IDA loan to the Kabeli A project. It has also provided equity as well as debt, and has signed an MOU to form a JV with Power China for the development of Madi Storage (156 MW) and Tamor Storage (156 MW).

<sup>8</sup> Through the PDA, government agencies and private businesses jointly bear risks such as contract termination, force majeure, and land acquisition.

<sup>9</sup> In addition, for hydroelectric power development projects of 200MW or more, an application for PDA negotiations will be made to IBN, and a PDA will be concluded between IBN and the government.

finance<sup>10</sup>. Although it has not been confirmed for other projects in which overseas companies have invested, corporate finance is used for projects in which local companies have invested and borrowed, and no cases applying project finance.

Fundraising methods of the five organizations (or classifications) are summarized in the following table.

**Table 12.2-2 Summary of current fund-raising status of major business entities**

	Business Field	Government Borrowing	Commercial banks, etc.	Policy banks, etc.
NEA	Power generation and transmission	○	○	—
VUCL	Power Generation	○	—	—
RPGCL	Power Transmission	○	—	—
HIDCL	Power Generation	○	○	—
Private businesses (local)	Power Generation	—	○	△
Private business operators (overseas)	Power Generation	—	○	○

Legend: ○: Frequently used △: Used —: Unconfirmed (N/A)

Source: JICA Study Team

## 12.2.2 Supply-side Information: Suppliers of Business Capital

This section summarizes information of the supply side of project finance, and the results of our investigation into the organizations supplying funds to hydropower projects in Nepal (excluding investments by project owners and project developers, as shown in the previous section). They can be broadly categorized into equity suppliers and debt suppliers.

### (1) Equity Suppliers

#### 1) Institutional investors in Nepal

There are cases where institutional investors such as pension funds in Nepal are investing in equity. Specifically, pension management organizations such as the Employee Provident Fund (EPF), CIT (Citizen Investment Trust) and RBS (Rastriya Beema Sansthan) are found as investors in hydropower projects. EPF is a pension management organization for federal government employees established under the Employees Provident Fund Act, 2019. CIT is mainly responsible for the management and operation of retirement benefits and pensions for military and police personnel. Rastriya Beema Sansthan is a general insurance company owned by the government.

<sup>10</sup> It is possible that project financing is being used for projects in which IFC, Indian companies, and Korean companies are investing and financing, but the specific details remain unconfirmed (as the information is not disclosed).

**Table 12.2-3 Hydropower-related investments by major institutional investors in Nepal**

Institutional investor name	Examples of involvement in hydroelectric power generation-related businesses
EPF	Betan Karnali Upper Tamakoshi Tamakoshi V Investment in VUCL and HIDCL
CIT	Sanigad Hydro (guarantee) Investment in VUCL and HIDCL
RBS	Investment in VUCL and HIDCL

Source: Company websites and HIDCL website

## 2) Nepalese private investors

Public investors are active in investing in domestic hydropower projects, often purchasing shares when development companies go public on the Nepal Stock Exchange, and according to IPPAN, IPOs are often oversubscribed. There is also a mechanism under which up to 10% of issued shares can be issued to residents in areas where hydropower projects are located (Securities Issue and Allotment Directive, 2017, 2074 4-(2)).

## 3) Overseas public entities

Foreign public sector entities are also interested in equity contributions. For example, NHPC (National Hydroelectric Power Corporation) and SJVN (Joint venture company jointly owned by the Union Government of India and the Government of Himachal Pradesh) are actively seeking to invest in development projects in Nepal. As India's decarbonization movement accelerates, these parties are highly potential investors in accelerating the development and procurement of hydroelectric power sources. At the same time, if the benefits of providing ODA include India, it<sup>11</sup> is<sup>12</sup> expected that the project itself will be positioned as development assistance to India, and consideration will be given to utilizing the country's credit line.

## (2) Debt providers

### 1) Local financial institutions

Nepal's local financial institutions are primarily responsible for debt lending to small to medium-scale hydropower projects. There are 20 commercial banks in Nepal classified as Class A that provide loans in local currency to IPP developers. However, loans are provided against personal guarantees, not against legal entities or projects. Many local financial institutions have a high loan-to-capital ratio. Attention should be paid to the lending capacity of these banks to meet the large-scale, long-term capital needs of large-scale hydropower projects, as described below.

### 2) Multilateral Development Banks

Many international development financial institutions also provide loans. The main ones are as follows:

- The World Bank and UK Department for International Development reviewed and assisted IBN in negotiating PDAs for large-scale hydropower projects with the intent of exporting electricity, which resulted in the development of two sites: Upper Karnali and Arun III.

<sup>11</sup> SJVN is a joint venture company jointly owned by the Union Government of India and the Government of Himachal Pradesh.

<sup>12</sup> Currently, NHPC is involved in the development of Phukot Karnali while SJVN is involved in the development of Arun 3.

- The World Bank is providing USD 20 million for technical design and bidding assistance for the Upper Arun project with multiple developing partners, and ADB has agreed to provide USD 60 million PPP loan for Trishuli (216 MW), co-financed the 144 MW Kali Gandaki “ A ” hydropower project with JICA in 2002, and implemented the 140 MW Tanahu hydropower project, a reservoir-type hydropower plant, co-financed by JICA, EIB, and the Abu Dhabi Fund for Development in 2013.
- EIB is providing a grant aid of EUR 5.5 million for the Tanahu project to cover the construction of the power plant, and is also providing € 25 Mil loan funding for development studies for the Chilime-Trishuli transmission line project with KfW (€14 Mil Grant)<sup>13</sup>.
- USAID has no history of directly investing in hydroelectric power generation projects, but its Nepal Energy Program includes providing advisory services on deregulation aimed at sector reform, strengthening the capabilities of the private sector, and improving systems for electricity imports and exports.

### 12.2.3 Situation of Project Finance in Nepal

This part summarizes the information collected regarding the current state of financing for hydroelectric power generation projects in Nepal by key elsewhere.

#### (1) Financing Methods

It is difficult to gather information on the specific financing methods for individual cases (because of commercial confidence), but based on interviews with private organizations such as IPPAN and international organizations such as the World Bank and ADB, it can be assumed that, at least for local companies, corporate financing is the most common financing method currently used. The reasons for this are thought to be as follows:

- The investment scale is not large enough to formulate project financing.
- Local companies have limited knowledge or experience regarding project finance.
- Local financial institutions have limited knowledge and experience in project finance.

#### (2) Debt-Equity Ratio

The debt-to-equity ratio (hereinafter referred to as the "DE ratio") that is considered when raising funds for hydroelectric power generation projects is generally around 20:80 to 40:60 worldwide. According to the survey conducted this time, it appears that in Nepal, the ratio of 70:30 is often applied<sup>14</sup>.

For equity investment, investors in large projects can choose from government organizations or neighboring power companies that will purchase electricity. For medium-sized and larger projects with excellent profitability, investment is often sought from investors in India, China, etc. As a result, domestic investors are focusing on the possibility of investing in small to medium-sized businesses, due in part to limited investment capital.

Regarding debt, local Nepalese financial institutions have limited capacity to lend long-term funds, making it difficult for them to lend to medium-sized or larger projects, and therefore local financial institutions are limited to minority participation in medium-sized or larger projects. Lenders for

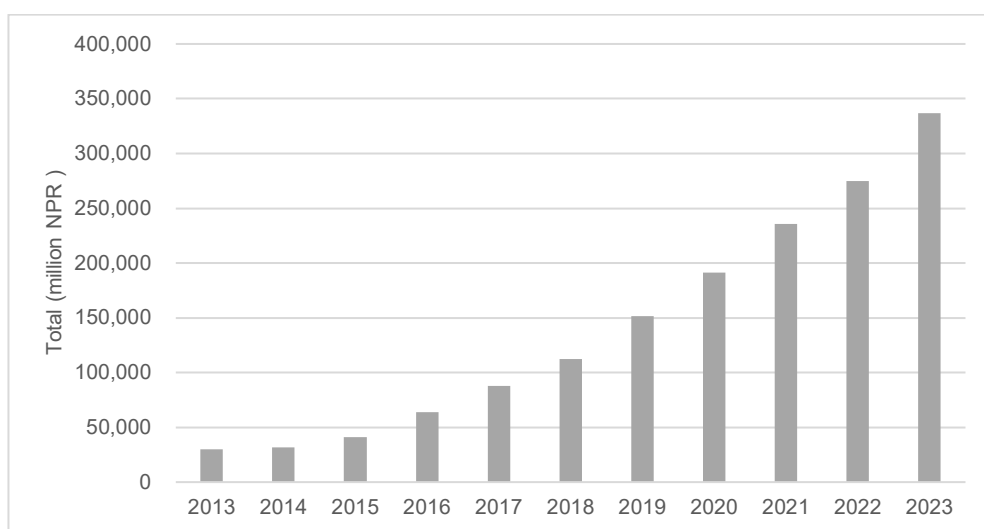
<sup>13</sup> “ Global Gateway: EU and Nepal launch new flagship to support electrification of rural areas”, 17 May 2024, European Commission

<sup>14</sup> This is based on various literature surveys and interviews with private business operators, including IPPAN. In addition, the financial analysis in Chapter 11 is based on these survey results and assumes that the business operator's debt/equity ratio is 70:30.

medium-sized or larger projects are limited to international commercial banks and international development financial institutions. Furthermore, some ECA providers, such as the Exim Bank of India, have provided institutional loans through credit guarantee schemes.

### (3) Lending capacity of local financial institutions

In Nepal, commercial banks and development banks are actively lending to hydropower projects. The following figure shows the <sup>15</sup>lending trends of commercial financial institutions to the infrastructure sector, including the energy sector, and the past lending trends to the sector have exceeded the overall increase in lending amount of these financial institutions. NRB is calling for a gradual increase in the proportion of lending to the power, gas and water sector, which remains at 5.45% of the total lending amount as of 2021, to more than 10% by 2023/24<sup>16</sup>. Figure 12.2-1 shows that the lending capacity of local financial institutions is on the rise.



Source: “Quarterly Economic Bulletin Mid-Oct 2023”, Nepal Rastra Bank

**Figure 12.2-1 Lending trends from commercial financial institutions**

## 12.2.4 Laws and Regulations related to Power Development

This article introduces the main laws and regulations related to hydropower project financing in Nepal.

### (1) Private Finance in Build and Operation of Infrastructure Act, 2063

This act, enacted in 2006, constitutes the legal framework for infrastructure construction by private capital in Nepal. The scope of application of this act also includes power generation projects. Based on this act, the Investment Board Act (2068) was enacted in 2011, and the IBN was established as an organization to improve the investment environment and centrally manage investments both in and out of Nepal.

### (2) The Public Private Partnership and Investment Act 2019

Aiming to attract private investment in the development of large-scale infrastructure, the PPP Policy was established in 2015, and the PPP and Investment Law came into effect in 2019. In

<sup>15</sup> In addition to the energy sector, this includes transport, communications and public services.

<sup>16</sup> Nepal Rastra Bank “Financial Stability Report 2019/20”

addition, the PPP and Investment Regulations were established as implementing rules in 2020. The PPP and Investment Law established a PPP Unit and an Investment Unit within IBN, and stipulated that the development of hydroelectric power generation projects with investment amounts exceeding NPR 6 billion or generating capacity exceeding 200 MW must be applied for to IBN. In addition, a one-stop service center was established to support projects implemented based on the PPP and Investment Law in obtaining approvals and licenses from various government agencies.

**(3) Hedging Related Regulations, 2075 (as amended in 2076)**

Hedging-related rules were enacted to promote financing for large-scale infrastructure projects based on the PPP and Investment Law. For hydroelectric power generation projects, a mechanism was established to provide foreign exchange hedge financing for hydroelectric power generation projects exceeding 100 MW and for the construction of transmission lines exceeding 30 km.

**(4) The Foreign Investment and Technology Transfer Act 2075**

The Foreign Investment and Technology Transfer Law was enacted in 1992 with the aim of promoting industrialization and encouraging foreign direct investment. The new law enacted in March 2019 allows for equity investment, reinvestment, and technology transfer, as well as the establishment of branches, lease financing, equity investment through venture capital, and fund raising through bond and securities issuance in overseas stock markets.

**(5) Foreign Exchange (Regulation) Act 2019**

Regarding foreign exchange transactions, the Foreign Exchange (Regulation) Act, 2019 was enacted in 1962, which gives the NRB full powers to formulate and implement foreign exchange policy and stipulates matters relating to foreign financing and foreign exchange.

## 12.3 BASIC CONSIDERATION ON FINANCING METHOD OF IPSPD

### 12.3.1 Overall IPSPD Investment Plan, Capital Needs and Business Financing Options

As mentioned at the beginning of this chapter, to realize the projects included in the IPSPD, it is necessary to raise funds for the business investments shown in the table below. The basic ideas and methods used to calculate the values shown in the table above are described below.

- The base figures are taken from Chapter 9 "Power Development Plan" and Scenario 3 of Chapter 11 "Grid Development Plan." Inflation is not taken into account.
- As for the power transmission and transformation business, currently there are no private companies involved. Although the possibility of private participation in the future cannot be denied, as there is currently no clear legal basis for this, we have provisionally assumed that the business will be entirely funded by government funds <sup>17</sup>.
- power generation projects as government (assumed)/private (assumed) was made by the JICA study team by confirming the proponent of each project, and projects that were clearly being promoted by the GoN were classified as "Investment by the Nepalese government (assumed)" and all other projects as "Investment by the private sector (assumed)." PPPs were classified as the latter.

**Table 12.3-1 Investment Plans and Capital Demand in IPSPD**

Unit: Million USD

Year	Investment by the Nepalese government (estimated)		Private investment in power generation business (estimated)	total
	Power Generation	Power Transmission and Transformation		
2022	228	404	1,003	1,635
2023	258	404	1,318	1,981
2024	208	404	1,280	1,892
2025	440	404	1,262	2,107
2026	509	553	1,379	2,441
2027	508	553	2,603	3,664
2028	977	553	3,007	4,536
2029	1,168	553	4,214	5,935
2030	1,538	553	3,378	5,469
2031	1,738	479	3,260	5,478
2032	1,614	479	2,624	4,718
2033	953	479	2,842	4,274
2034	968	479	1,797	3,244
2035	785	479	1,903	3,168
2036	1,226	543	1,570	3,339
2037	1,187	543	1,203	2,934
2038	1,187	543	866	2,597
2039	979	543	480	2,003
2040	787	543	9	1,340
total	17,261	9,496	35,999	62,756

Source: JICA Study Team

<sup>17</sup> Regarding private sector participation in the power transmission business, the government seems to be considering a certain degree of participation due to the revised Electricity Act. Although we had multiple discussions with Nepalese government officials on this topic during the implementation of this study, we were unable to obtain a clear answer regarding the form of private sector participation, demarcation with the NEA, and the timing when participation will be approved.

In addition, the following table summarizes the financing methods that can generally be used in power generation and transmission projects<sup>18</sup>. The following discussion will be based on this table.

**Table 12.3-2 Major Financing options in developing nations' power projects**

Business Classification	Government/Private Sector	Major Classification	Remarks
Power Generation Business	Government funding	- Domestic budget (Tax & Non-tax revenue, domestic borrowing) - Foreign borrowing	It is often used in projects with huge construction costs or low profitability.
	Private funding (PPP/IPP)	Equity Debt	It can be applied if the conditions are met in terms of business scale, risk, profitability, finance, etc.
Power Transmission Business	Government Business	- Domestic budget (Tax & Non-tax revenue, domestic borrowing) - Foreign borrowing	Generally, transmission projects are implemented as government projects.
	Private funding (PPP)	Equity Debt	Limited cases of application due to factors such as construction costs, land acquisition, and exclusivity.

Source: JICA Study Team

### 12.3.2 Considerations regarding Financing for Power Generation Projects

Power development projects are likely to have different investors and lenders depending on the scale of the project, profitability, and the composition of the participating parties. In hydroelectric power projects, the scale of the project determines the development period and required investment amount, so the composition of investors and lenders varies.

Small-scale usually refers to projects of less than 1MW, but in this section, investor procurement is set at 50MW, which is completed by investors (including state power companies, etc.) within Nepal or neighboring countries such as India. Medium scale refers broadly to projects up to 200MW that do not require IBN investment permission. Since hydroelectric power plants over 200MW in size are subject to IBN approval, in such cases, it can be interpreted that the GoN is determining investor eligibility through IBN approval.

The financing methods for hydroelectric power generation projects of each scale can be summarized as shown in the following table, considering the actual situation in Nepal and the experience of other countries.

**Table 12.3-3 Scale and Funding Methods of Hydropower projects**

Capacity	Fund raising methods
Small projects (less than 50MW)	• Corporate Finance
Medium-sized projects (50-200MW)	• Corporate Finance • Project Finance • Public support, including the use of ODA
Large-scale projects (over 200MW)	• Project Finance • Public support, including the use of ODA

Source: JICA Study Team

<sup>18</sup> The word "general" here means that it can be used not only in Nepal but in developing countries in general.

Following section explains the participating businesses (players) and their fundraising methods based on the classification of small, medium, and large scale, and then summarize the participating businesses and fundraising methods from the perspective of the profitability of the priority projects listed in the IPSDP.

### **(1) Small projects (less than 50MW)**

Regarding small-scale projects of 50MW or less, IPPAN, an organization of Nepalese IPPs, is of the opinion that there is an ardent desire to invest in hydroelectric power generation projects in Nepal, and that if procedures are made smoother, further development can be promoted. It is assumed that the basic form for small-scale projects will be for IPPs in Nepal to raise funds based on corporate finance and proceed with them.

HIDCL is particularly noteworthy as an organization that plays a role in promoting the development of small and medium-sized hydroelectric power plants. HIDCL is an organization under Ministry of Finance, but it also has technical support and consulting functions, and is expected to work on the technical aspects of accelerating medium-sized projects. HIDCL has a record of investing in stocks or providing funds (loans) in over 30 projects, and by strengthening its functions, it is conceivable that it could accelerate the development of small to medium-sized hydroelectric power projects.

As the climate change issue becomes more serious, the trend toward hydroelectric power generation as a source of energy that does not emit CO<sub>2</sub> will continue for the time being (until innovative technologies to reduce CO<sub>2</sub> emissions are developed and become commonplace). In fact, there are cases where operators of energy-intensive industries in India are not only procuring renewable energy-derived electricity from the market but are also proactively securing their own power sources and entering into off-site PPAs, so the appeal of hydroelectric power generation for energy-intensive industries is expected to remain for the time being.

### **(2) Medium-sized projects (50~200MW)**

IPPAN is actively promoting investment opportunities in Nepal at seminars and workshops in neighboring countries such as India, but it is expected that there will be some medium-scale projects where Nepali IPPs can raise funds on their own, and some where it will be difficult to raise funds on their own. In the latter case, it is expected that foreign investors, or a joint venture between a foreign investor and a Nepali IPP, will be the operator and raise funds. Even though various fund-raising methods are examined for projects of this scale, basically corporate finance are applied. The method to be used will be decided based on the operator's cash on hand, the characteristics of the project, and the lending policy and intentions of financial institutions.

### **(3) Large-scale projects (over 200MW)**

Projects over 200MW in size are expected to have strategic investors, including electricity buyers. Looking back at past investors, state power utilities in India, which are seeking to decarbonize from thermal power, are seen as major investors. In addition, for projects of this size, project financing is considered to be a common method of fundraising. However, for projects involving large-scale civil engineering works such as STO, private fundraising may not be sufficient to ensure profitability, and government support, such as the use of ODA, may be provided to compensate for this.

Many energy-intensive industries are located in India and neighboring countries, and it is expected that these multinational companies will become investors and off-takers. For example, data center

operators such as Infosys<sup>19</sup> and Amazon India<sup>20</sup>, as well as Tata Motors, are working to reduce their electricity consumption from fossil fuels by purchasing renewable energy through their affiliated companies<sup>21</sup>. The GoN is expected to take a leading role in encouraging these potential investors and off-takers to invest and is expected to involve not only the power sector but also organizations related to investment attraction such as IBN in appealing to multinational companies and exploring matching opportunities.

### 12.3.3 Considerations regarding Financing for Power Transmission and Distribution Businesses

Unlike power generation businesses, power transmission and distribution businesses must be operated as an entire power system, not as individual project development, and profitability varies project by project. In addition, because it is a business with a high degree of public interest, namely a stable supply of electricity to the people of Nepal, financing for the construction/operation of transmission lines tends to be primarily through public funds. The construction of the 132kV system, which RPGCL began, is being carried out with funds from the GoN. Using funds obtained from the World Bank, ADB, and AIIB, NEA is working on the construction of transmission lines and substation facilities, as shown in the following table.

*Table 12.3-4 NEA projects assisted by Development partners.*

Development partners	NEA Business
ADB	Rehabilitation of Sundarijal HEP as part of support for the maintenance of power plants with a generating capacity of less than 30MW
World Bank	Hetauda Dhalkebar Inaruwa 400kV Transmission Line Project
AIIB/EIB	Power distribution system renewal plan
EIB	Marsyangdi Corridor 220kV Transmission Line Project
ADB	Tanahu region electrification, network improvement
ADB	Strengthening of electricity distribution network in suburban areas of Lalitpur and Bhaktapur
ADB	Substation Automation
ADB	132kV Keraun Substation Project
Export-Import Bank of India	Raghuganga Hydropower
JICA	Urban Power Transmission and Distribution Network Development Project

Source: NEA Annual Report

The development of the domestic grid in Nepal has been conducted by the NEA or RPGCL using government budgets. However, upon an enactment of Electricity Act in the future will open transmission business open to the public and it is being considered to proceed with the development through blended finance including investment from the private sector. HIDCL also has set as its organizational objective to work on the development of transmission and distribution systems in cooperation with financial institutions, not just on power source development. One of HIDCL's investment made for PTCL (Power Transmission Company Limited), which is responsible for operating the interconnection line with India and is responsible for the construction of the Dhalkebar/Bittamond interconnection line.

<sup>19</sup> p50-51, Infosys Annual Reports, <https://www.infosys.com/investors/reports-filings/annual-report/annual/documents/2022-23/natural-capital.pdf>

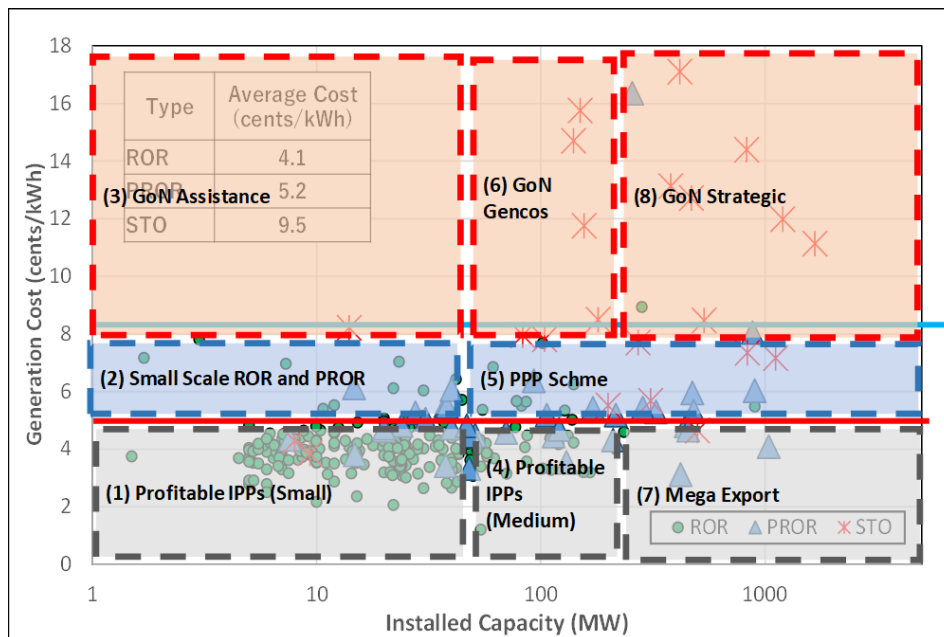
<sup>20</sup> "Amazon unveils 198-MW wind PPA in India's Maharashtra", *Renewable Now*, Nov.01, 2023, accessed 31 Dec. 2023

<sup>21</sup> Tata Power Press Release, 21 August 2023, <https://www.tatapower.com/media/PressReleaseDetails/2045/tata-power-renewable-energy-limited-signs-ppa-for-9-mwp-on-campus-solar-plant>

Because it is difficult to foresee the economic viability of transmission and distribution development projects, the GoN will likely take the lead in investing in them, and it is conceivable that such projects could be supported by loan schemes from international development financial institutions.

### 12.3.4 Basic considerations for realizing IPSDP financing

In this study, hydropower projects that were deemed to be given priority for development in the IPSDP were evaluated based on the axes of power generation cost and project scale (installed capacity), and were classified into eight categories as illustrated in Figure 12.3-1 and 12-3-4. Generation costs were assessed based on the Levelized Cost of Electricity (LCOE) described in Section 6.6.3. This analysis classifies projects with an LCOE of 5.0 cents/kWh or less into a category that is highly profitable and can be implemented with private funds, projects in the 5.0-8.0 cents/kWh category into a category that is moderately profitable and requires more preferential borrowing than the private sector, such as PPP loans, and projects with power generation costs of 8.0 cents/kWh or more into a category that is low profitable and requires loans from development aid agencies. The calculation of Equity IRR is based on the assumptions of an interest rate of 10% and a capital to debt ratio of 30:70. The installed capacity is based on the information collected in Table 12.3-3. The characteristics of projects included in each quadrant are described below.



Source: JICA Study Team

Figure 12.3-1 Priority Development Projects

**Table 12.3-5 Number of Sites, Output and Investment Amount by Category**

Category	Sites	Output (MW)	Investment Amount (USD Mil)
(1) Profitable IPP(Small)	493	5,915.4	8,975.2
(2) Small Scale POR/PROR	24	434.4	889.7
(3) GoN Assistance Projects	8	88.0	139.5
(4) Profitable IPPs (Medium)	60	5,614.1	8,652.0
(5) PPP Scheme	24	6,658.4	12,822.4
(6) GoN PROR/STO Projects	8	1,128.0	2,351.8
(7) Mega Export Projects	15	5,542.0	8,054.0
(8) GoN Strategic Projects	11	6,811.9	15,279.4
(9) Others	82	4,188.1	4,213.5
(10) Power System	-	-	9,496

Source: JICA Study Team

## &lt;Project categories with relatively high profitability&gt;

(1) For profitable IPPs (small) development is likely to proceed, if financing is possible within Nepal and the surrounding environment, such as access roads and grid connections, is in place. On the other hand, considering the implementation of appropriate approval processes by the government, it is not desirable to spend time and money on formulating and supporting projects for each development sites. For this reason, it is expected that the lending capacity of HIDCL, an organization supporting development, will be strengthened, new funds will be established to provide financing for multiple projects, and a bank specializing in small and medium-sized hydropower will be established or supported. Such support will likely include TSL and policy loans, which provide large amounts of capital to banks and government-affiliated funds.

(4) The situations are similar to for profitable IPPs (medium), but the number of businesses that can implement projects with a development scale of over USD 100 million in Nepal is limited due to financial scale. For this reason, measures are needed to encourage matching with domestic and foreign investors and businesses for projects that have been granted development rights but are not progressing. Financial support will include a mix of corporate finance and project finance, and overseas investment and financing is also expected.

(7) Mega Export is a large-scale, highly profitable project and an attractive investment opportunity. However, as it is a massive project worth over USD 400 million, the expected participants will be limited to an SPC consisting of government-affiliated businesses such as the NEA, major domestic conglomerates, major international development businesses, and Indian power companies.

<Moderate profitability project category><sup>22</sup>

(2) There are many small-scale ROR and PROR projects, but because the fixed costs are too large to be implemented through project financing like medium to large scale projects, it is expected that lump sum support will be provided through funds, or that government-affiliated businesses such as HIDCL will join in the support. In terms of the order of hydropower development, development of (1) will take priority, but it is expected that support will be

<sup>22</sup> For projects with medium profitability that are difficult to ensure profitability with the interest rates of Nepalese commercial banks (approximately 10-12%), it is necessary to supplement credit and ensure business viability through the provision of public funds and joint ventures with government-affiliated businesses.

necessary in the future.

(5) The PPP Scheme will be a joint support method for medium to large-scale projects. In addition to the various power generation formats of ROR, PROR, and STO, a variety of players are expected to participate in the development process, including medium to large-scale domestic and foreign developers, government-affiliated businesses, and Indian power companies. Since it is necessary to consider the composition of each project and the support methods are expected to be diverse, it is necessary to consider a flexible composition that combines support measures applicable to each player.

#### <Project categories with lower profitability><sup>23</sup>

Projects with generating costs above approximately 8 cents/kWh fall into this category.

There are few projects below 50 MW that fall under this category. Projects aimed at rural electrification or rural development, or projects developed without regard for profitability to utilize remaining head differentials, fall under (3) GoN Assistance. This is hardly the case for the IPSDP candidate projects. Examples of projects that are expected to be implemented include projects aimed at rural electrification or its development, and projects that utilize remaining head. Although the number of such projects is small overall, if the necessity of the project is recognized, it is expected that the project will be implemented using the government budget or support from various development aid agencies.

(6) GoN PROR/STO Projects envision the development of regulated power sources by government-affiliated companies in Nepal. Because project will be classified as a regulated power source, the scale of business development will be moderate, at 50 to 200 MW. However, because it will be a regulated power source, its operation will not be constant, making it less profitable, and it will be necessary to utilize loans from development aid agencies, such as ODA.

(8) The GoN Strategic Project is similar, but due to the large scale of development and mostly designed for export-oriented, project will be necessary to utilize funds not only from government-affiliated companies in Nepal, but also from overseas power companies, etc. In addition to utilizing support schemes such as EBF and overseas investment and loans, it will also be important to utilize ODA budgets not only for Nepal, but also for neighboring countries that are potential destinations for the electricity.

Based on the above considerations, the basic ideas regarding project categories and financing methods are summarized as follows:

#### **(1) Basic principles regarding financing for power generation projects**

Regarding the basic approach to financing for power generation projects, the consideration of financing entities in the previous section is summarized in Table 12.3-6, and the development scheme is summarized in Table 12.3-7. This will be the basis for the following considerations.

---

<sup>23</sup> Low-profit projects include regulated power sources such as STO. The business value of STO power sources is difficult to evaluate based on hourly value such as LCOE alone, and many locations do not show business feasibility or profitability through financial analysis, so development by government-affiliated businesses or joint development with IPPs is expected.

**Table 12.3-6 Basic Concepts of Project Categories and Financing Methods in IPSDP**

Relative profitability	Categories	Expected main financing entities	
		government	private
High	(1) Profitable IPPs (Small)	-	⊙
	(4) Profitable IPPs (Medium)	△	⊙
	(7) Mega Export	○	⊙
During ~	(2) Small Scale ROR and PROR	△	○
	(5) PPP Scheme	○	○
Low	(3) GoN Assistance	○	△
	(6) GoN PROR/STO Projects	⊙	-
	(8) GoN Strategic Project	⊙	-

Legend: ⊙: Consider as a prerequisite ○: Consider as a priority △: Consider necessity and possibility - : Not applicable

Source: JICA Study Team

## (2) Basic principles regarding financing for power transmission business

As described in Section 12.3.1 " Overall IPSDP Investment Plan, Capital Needs and Business Financing Options" the legal basis for private participation in the power transmission business (including substation business) is currently unclear, and there is no prospect of its realization. Therefore, the following approach will be taken as the basis for the financing method for the power transmission business.

- As the revised Electricity Act has not yet been enacted, it is assumed that financing for the electricity transmission business will be provided by the government.
- On the other hand, we cannot rule out the possibility that private participation in power transmission projects will be legally recognized in the future. There are plans to utilize private funds in the development of power transmission networks for international power exchange as an idea. Therefore, we reserve the option of utilizing private funds depending on the situation and developments.

Table 12.3-7 Summary of Development Scheme by Project Categorization

Item	Financial Performance							
	High		Moderate		Low			
<b>Scheme</b>	(1) Profitable IPPs (Small)	(4) Profitable IPPs (Medium)	(7) Mega Export Project	(2) Small Scale ROR and PROR	(5) PPP Scheme	(3) GoN Assistance Projects	(6) GoN PROR/STO Projects	(8) GoN Strategic Projects
<b>Project Size</b>	Small Scale (Upto 50MW)	Medium Scale (200MW – 50MW)	Large Scale (over 200MW))	Small Scale (Upto 50MW)	Medium and Large Scale (over 50MW)	Small Scale (Upto 50MW)	Medium Scale (200MW – 50MW)	Large Scale (over 200MW))
<b>Generation Cost</b>	Low		Moderate		High			
<b>Number</b>	Very much	Many	Few	Many	Many	Few	Few	Few
<b>Generation Type</b>	ROR	ROR, PROR and STO	ROR and PROR	ROR, PROR	ROR, PROR and STO	ROR, PROR and STO	PROR and STO	STO
<b>Developer</b>	Local Developers	Local/International Developers	Local/International Developers, GoN Gencos, Indian/Bangladesh States owned companies	Local Developers and/or HIDCL	Local/International Developers, GoN Gencos, Indian/Bangladesh States owned companies	Local Governments and/or HIDCL Own Fund	GoN Gencos	GoN Gencos, Indian/Bangladesh States owned companies
<b>Finance</b>	Corporate Finance and Own Fund	Corporate/Project Finance	Project Finance including EBF	Corporate Finance	Project Finance including EBF	Corporate Finance	Project Finance	Project Finance including EBF
<b>Lender</b>	Local Private Banks	Local/Indian/Bangladesh Banks and International Development Banks (PPP)	Local/Indian/Bangladesh Banks and International Development Banks (Private), Global Banks	Local Banks, Green Bond and/or HIDCL	Local Banks and International Development Banks (PPP and Sovereign Loan), Global banks	GoN Budget, Local Banks, Green Bond and/or HIDCL	Local Banks and International Development Bank (Sovereign Loan)	Local/Indian/Bangladesh Banks and International Development Banks (Sovereign Loan)
<b>Off-Taker</b>	NEA	NEA	NEA, Indian/Bangladesh DSOs	NEA	NEA, Indian/Bangladesh DSOs	NEA, Off Grid	NEA	NEA, Indian/Bangladesh DSOs and consumers

Source: JICA Study Team

## 12.4 ANALYSIS OF THE EFFECTIVENESS OF CONCESSIONAL FUNDING

There are 750 hydroelectric power projects expected to be developed under the IPSPDP, with large-scale projects including large-scale developments with an average investment exceeding USD 1,000 million. It seems difficult for the GoN, IPP operators, and Nepalese financial institutions to conclude the financing of such a large-scale hydroelectric power development project alone. International development financial institutions have participated to date and have provided grant and loan assistance and credit enhancement to make this possible.

**Table 12.4-1 Types of hydropower projects planned in IPSPDP**

Power Generation Capacity	Power Generation Capacity	number	Total investment amount (USD M)	Per item Average Investment Amount (USD M)
Developed by the GoN	Less than 50MW	31	771	twenty five
	50~200MW	20	3,865	193
	Over 200MW	13	14,313	1,101
Private IPP	Less than 50MW	573	9,997	17
	50~200MW	87	11,934	137
	Over 200MW	28	20,498	732

Source: JICA Study Team

In this section, this report analyzes the effectiveness of applying concessional funds from international development financial institutions, taking into account the characteristics of projects expected to be prioritized for development in the IPSPDP examined in Chapter 7. Concessional funds are loans in which the loan conditions (interest rates, repayment period, etc.) are set favorably for the recipient country. In this section, we examine the cases in which sovereign loans, investment loans for private entities, and EBF are applied to the projects and verify the effect of introducing concessional funds. Furthermore, since hydroelectric power development is being carried out in Nepal in anticipation of electricity exports, we analyze the possibility of development and fundraising by utilizing the creditworthiness of India, Bangladesh, and other countries that will be the destinations for electricity exports. Projects analyzed were selecting projects for which the results of feasibility studies necessary for financial analysis were available, and by setting scoring criteria to determine the projects. The study excluding projects that have high profitability given consider the nature of concessional loan's additionality. These projects are enabled to developed with private funds, and projects that are too small in scale to require concessional loans from donors and therefore are unlikely to produce support or development effects. Note that while this section will examine the feasibility of projects using concessional funds, it is not premised on support from JICA.

### 12.4.1 Selection of Target Projects

Here, we will select projects to analyze through the following three steps.

- Step 1: Consideration of categories for which concessional financing is desirable
  - Step 2: Selection process for projects to be analyzed and setting criteria
  - Step 3: Selection of projects to be analyzed.
- Step 1: Consideration of categories for which concessional loans are desirable

Figure 12.4-1 shows the hydropower priority projects mapped into the eight categories shown in Figure 12.3-1. After examining each category, it was found that projects classified as (1)

and (4) Profitable IPPs, which have lower power generation costs, and (7) Mega Export, do not require the application of concessional loans because the projects are sufficiently viable. In addition, (2) Small Scale ROR/PROR is excluded from consideration because its development impact is limited, and there are few projects classified as (3), so it will not be considered.

Projects that are expected to promote hydropower projects through the application of concessional loans are those located in the quadrants of (5) PPP Scheme, (6) GoN Gencos, and (8) GoN Strategic.

(6) GoN Gencos and (8) GoN Strategies: Projects in quadrants (6) and (8) include power generation methods with higher construction costs, such as reservoir-type power generation. Power generation methods such as reservoir-type plants are significant in terms of providing a balancing force in energy policy, but because the increase in revenue from them is not significant compared to the construction costs, they are not very viable as a business and fundraising tends to be difficult. These projects are highly significant in that they will use concessional loans to achieve their goal, while also bringing new revenue opportunities to the Nepalese economy through electricity exports, and that promoting the development of adjustable power sources will promote Nepal's socio-economic development. In addition, some of the projects are export-oriented, and the amount of concessional loans to Nepal is insufficient, so it is possible to utilize concessional loan facilities for India and Bangladesh, which are the destinations for electricity exports.

(5) PPP Scheme: Projects in this quadrant range in scale from medium to large, exceeding 1,000MW, and include a mixture of power generation methods such as ROR, PROR, and STO. There are many locations where power generation costs are distributed around the break-even point, and projects that are currently less profitable, so it is desirable to consider how to provide support through concessional loans. In PPP projects, the parties participating are diverse, including private businesses, government organizations in Nepal, and power companies in neighboring countries to which the electricity will be sold. Therefore, when providing concessional loans, the form of support needs to be considered individually.

## ■ Step 2: Selection process for projects to be analyzed and setting of criteria

Based on the analysis in the preceding paragraphs, for projects for which it was deemed appropriate to analyze the effects of introducing concessional loans, since it would be difficult to obtain comprehensive business feasibility studies from the perspective of confidentiality of individual projects, projects for which specific analysis work would be carried out were screened and selected based on certain conditions.

<b>Financial Performance</b> High Low	<b>(1) Profitable IPPs (Small)</b> Type :ROR Developer :Local Developers Finance :Corporate Finance and Own Fund Lender :Local Private Banks Off-taker :NEA	<b>(2) Profitable IPPs (Medium)</b> Type :ROR, PROR and STO Developer :Local/International Developers Finance :Corporate/Project Finance Lender :Local/Indian/Bangladesh Banks and International Development Banks (PPP) Off-taker :NEA Budhigandaki Prok (103MW)	<b>(3) Mega Export Project</b> Type :ROR, PROR Developer :Local/International Developers, GoN Gencos, Indian/Bangladesh States owned companies Finance :Project Finance Lender :Local/Indian/Bangladesh Banks and International Development Banks (Private), Global Banks Off-taker :NEA, Indian/Bangladesh DSOs Chaiपुर Seti (210MW), Betan Karmali (442MW), Upper Arun (1,061MW), Kimathanka (450MW) Bajhang Upper Seti (216MW), Budhi Gandaki Ka (226MW)
	<b>(4) Small Scale ROR and PROR</b> Type :ROR, PROR Developer :Local Developers and/or HIDCL Finance :Corporate Finance Lender :Local Banks, Green Bond and/or HIDCL Off-taker :NEA	<b>(5) PPP Scheme</b> Type :ROR, PROR and STO Developer :Local/International Developers, GoN Gencos, Indian/Bangladesh States owned companies Finance :Project Finance including EBF Lender :Local/Indian/Bangladesh Banks and International Development Banks (PPP and Sovereign Loan), Global banks Off-taker :NEA, Indian/Bangladesh DSOs Lower Seti (126W) Upper Marshagadhi (102MW)	<b>(6) GoN Assistance Projects</b> Type :ROR, PROR and STO Developer :Local Governments and/or HIDCLOWN Fund Finance :Corporate Finance Lender :GoN Budget, Local Banks, Green Bond and/or HIDCL Off-taker :NEA
	<b>(8) GoN Strategic Projects</b> Type :STO Developer :GoN Gencos, Indian/Bangladesh States owned companies Finance :Project Finance including EBF Lender :Local/Indian/Bangladesh Banks and International Development Banks (Sovereign Loan) Off-taker :NEA, Indian/Bangladesh DSOs and consumers Nalsayu Gad STO (417MW), Bhardhng STO (470MW) Sunkoshi 3 STO (680MW)	<b>(8) GoN Strategic Projects</b> Type :STO Developer :GoN Gencos, Indian/Bangladesh States owned companies Finance :Project Finance including EBF Lender :Local/Indian/Bangladesh Banks and International Development Banks (Sovereign Loan) Off-taker :NEA, Indian/Bangladesh DSOs and consumers Tamor STO (200MW), Phukot Karnali (480MW) Duhokoshi STO (635MW) Bheri 4 STO (271MW), Tila-1 (299MW), Tila-2 (257MW), SR-06 STO (309MW) Arun 3 (900MW), West Seti STO (750MW)	<b>Capacity :upto 50MW</b> <b>Capacity :200MW - 50MW</b> <b>Capacity :500MW - 200MW</b> <b>Capacity :over 500MW (Huge)</b>
	<b>Project Scale</b>		

Source: JICA Study Team

Figure 12.4-1 Mapping of Hydropower Priority Projects into Project Category

**Table 12.4-2 Evaluation criterion of projects applying concessional fund**

standard	Specific evaluation methods and criteria
Business scale	<ul style="list-style-type: none"> <li>● In cases where large-scale investments are required and it is difficult for the private sector alone to raise business funds, it is effective to utilize concessional loans.</li> <li>● We highly value projects with large total investment amounts.</li> </ul>
Economic efficiency	<ul style="list-style-type: none"> <li>● By providing concessional loans to projects with low feasibility, it is expected that economic viability will be improved, and development will be promoted and implemented.</li> <li>● Projects with an LCOE exceeding 7.0 cents compared to the NEA's wholesale unit price for consumers (7.0 cents/kWh) are less economical, so there is rationality in introducing concessional financing.</li> </ul>
Ease of implementation	<ul style="list-style-type: none"> <li>● When formulating projects and considering the provision of concessional loans, it is easier to support projects being developed by GoN entities than projects being developed solely by private sector entities.</li> <li>● Projects where the implementing entity is the GoN or a government agency such as VUCL will be highly evaluated.</li> </ul>
Involvement of other donors	<ul style="list-style-type: none"> <li>● In cases where assistance is already being considered by other donors, it is assumed that additional concessional loans will be received, so a high rating is given to projects where there is no visible donor involvement, and a low rating is given to projects where there is no sign of donor involvement.</li> </ul>

Source: JICA Study Team

■ Step 3: Selection of businesses to be analyzed

Based on the above evaluation, the 26 projects listed as priority projects were evaluated, with the results shown in the table below.

**Table 12.4-3 Screening evaluation results for priority projects**

Project <small>Note : * represents PROR type</small>	Name of Developer	FS Availability	Total Score	Business Scale	Economic Efficiency	Implementation	Other Donor's involvement
<b>Sunkoshi 3</b>	NEA	○	7	○	○	○	△
Dudhkoshi	NEA	○	7	○	△	○	○
<b>Upper Arun*</b>	Upper Arun Hydro Electric Ltd.	○	6	○	×	○	○
<b>Lower Seti</b>	Tanahu Hydropower Ltd.	○	5	△	△	○	△
Tanahu	Tanahu Hydropower Ltd.	○	4	○	○	—	—
Nalsyau gad	Nalgad Hydropower Co., Ltd	△	5	○	○	△	×
Bharbung	Not decided	△	4	○	○	×	×
<b>Phukot karnali*</b>	VUCL/NHPC India	△	4	○	△	△	×
Tila-1	S C Power Co. Ltd	×	5	△	○	×	○

Evaluate listed projects with respect to Business Scale, Economic Efficiency, implementation and Other Donor's Involvement were scored with ○ : 2points, △ : 1points, × : 0points

Critically negative aspects are highlighted with yellow

Nominated 3 projects for detailed analysis are highlights with red bold

Source: JICA Study Team

At present, Upper Arun is not included in the analysis because it is deemed that there is little need for concessional financing as sufficient economic viability is foreseen. In terms of type classification, Upper Arun is classified as the (7) Mega Export quadrant. In terms of type classification, Lower Seti is classified as (5) PPP Scheme, but in terms of business feasibility

it is closer to the (6) GoN Gencos classification, and it was determined that there is value in verifying the effects of concessional financing. In addition, Sunkoshi 3 is classified as (8) GoN Strategic (a project that is meaningful for the GoN to undertake strategically) in terms of type classification, and since it is premised on cross-border exports to India and Bangladesh, the development effect of concessional financing is high, and it was deemed that there is value in analyzing and verifying. Furthermore, the Phukot Karnali project is being developed as an export-oriented business, just like Sunkoshi 3. Although Indian investors are actively investing, the project is not currently economically viable, so we will consider the applicability of concessional funds and their contribution to improving the project's viability.

## 12.4.2 Consideration of Analytical Methods and Indicators

### (1) Summary review of concessional funding methods

The quantitative analysis of the project aimed to quantitatively grasp the improvement in profitability for investors by utilizing concessional funds from the perspective of promoting the introduction of private funds. For this analysis, a sensitivity analysis was conducted on the variables set using the equity IRR as an indicator. The types of concessional funds that could be applied to the projects analyzed are as shown in the table below. However, since the Lower Seti project, which is the subject of this calculation, assumes a concessional sovereign loan, the analysis of debt assumes direct financing of the project using concessional funds. On the other hand, in the analysis of Sunkoshi 3, a model was constructed that allows calculations assuming financing using investment loans for private entities. Regarding the analysis of equity, application of EBF was examined to the Lower Seti project to evaluate quantitative impacts of concessional loan application.

*Table 12.4-4 Types of concessional funds used in the analysis*

Type	overview
Sovereign loan	Concessional funds such as yen loans are provided directly to the government and afterwards injected into specific projects.
Private-sector direct investment and financing	In order to promote development in developing countries through the private sector, funds are provided in the form of investments and loans to development projects implemented by private companies and others.
Equity Back Finance (EBF) Loans	We will provide loans to developing country governments to cover capital investment in infrastructure development projects, etc., and promote PPP infrastructure development projects.
Two Step Loan (TSL)	In order to provide funds to the private end beneficiaries, the necessary funds are provided through a development bank (in the case of Nepal, this would be HIDCL, etc.).

Source: JICA Study Team

### (2) Indicators used in the analysis

This analysis conducted a sensitivity analysis of the equity IRR by changing conditions to see how the concessional financing would affect investor profitability. There are several types of internal rates of return, depending on the purpose of their use, since the objective of this assessment is to improve the profitability of the investing shareholders and attract private investors to participate in hydroelectric power generation projects in Nepal. Hence, we focused on the equity IRR, which indicates shareholder profitability, and used it as an indicator for the analysis.

**Table 12.4-5 Types of Internal Rate of Return Indicators**

	Types of Internal Rate of Return		
	Economic IRR	Project IRR	Equity IRR
Indicators the purpose	In public projects, it is often used to measure the degree of economic benefit a project will have on a country's economy.	It is often used to measure the profitability of the project itself.	It is often used by shareholders to measure the profitability of a project.
For index calculation Calculation elements used	Using economic benefits and economic costs	Use project revenues and expenditures, although development agencies may not consider principal and interest repayments as expenditures.	We use shareholder income (dividends to shareholders) and shareholder expenses (shareholder contributions).

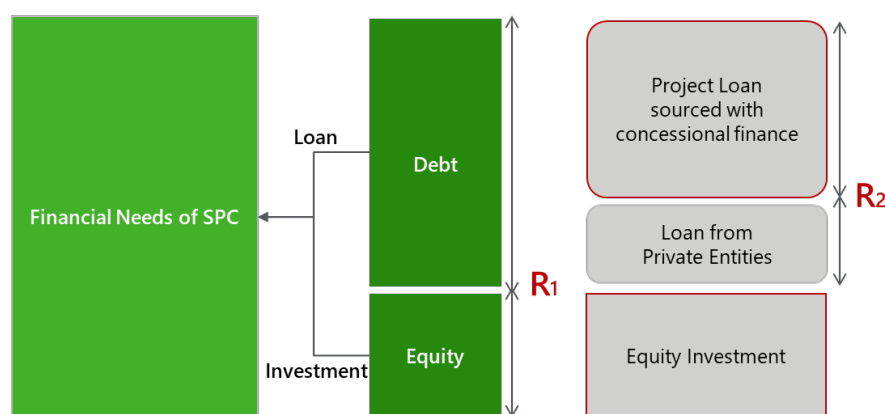
Source: JICA Study Team

### (3) Schemes Assessed

The analysis was conducted assuming a scheme in which concessional funds could be applied to both the debt and equity portions of the loan.

#### 1) Scheme for applying sovereign loan to debt portion

Sensitivity analysis of shareholder profitability conducts when concessional funds are injected into debt (in this analysis, direct lending of concessional funds is assumed). We assume that the interest rate of loans funded by concessional funds is 5% and that of commercial banks is 10% (Sunkoshi<sup>3</sup> also assumes loans funded by investment and loans for private entities (interest rate 7%)), and use the D/E ratio ( $R_1$  in the figure below) and the interest rate determined by the funds injected into debt ( $R_2$  in the figure below) as variables.

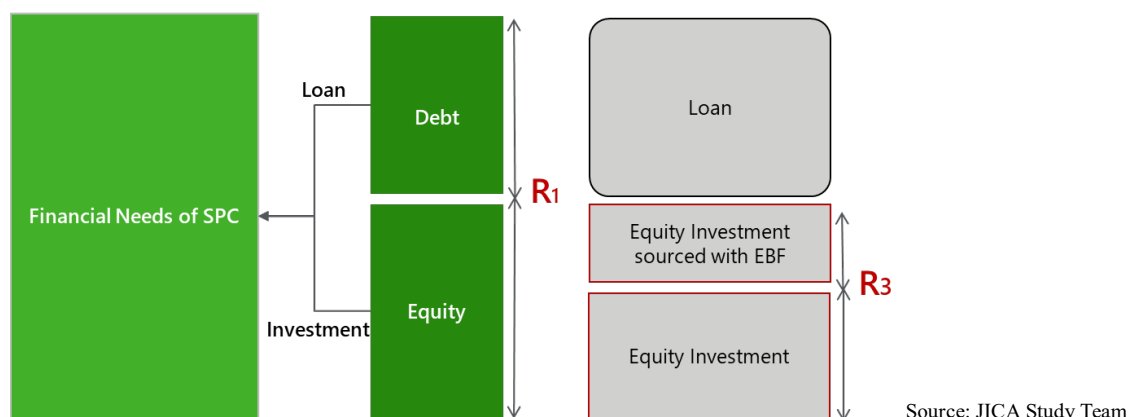


Source: JICA Study Team

**Figure 12.4-2 Cases where sovereign loans are applied to debt portion**

#### 2) EBF application scheme for equity portion

Sensitivity analysis of the profitability of private investors when concessional funds (EBF) are injected into equity. The variables used are the DE ratio ( $R_1$  in the figure below) and the proportion of EBF funds to concessional loans and equity ( $R_3$  in the figure below).



**Figure 12.4-3 Cases where EBF is applied to equity portion**

### 3) How to proceed with the analysis

In this analysis, we first perform a basic analysis: 1) 2) Sovereign loan application scheme for debt portion ( $R1 \times R2$ ) We will analyze the EBF application scheme ( $R1 \times R3$ ) for the equity portion and consider the appropriate development scheme and EBF applicability for the target business based on profitability.

Based on the results of the fundamental analysis, an IRR analysis will be carried out for a business structure assuming a specific equity developer and debt provider.

## 12.4.3 Analysis of the Effectiveness of the Lower Seti Concessional Fund Application

### (1) Fundamental Analysis of Lower Seti

**Table 12.4-6 Assumptions for Lower Seti Analysis**

Index	Assumptions
Period	<ul style="list-style-type: none"> <li>Construction period: 5 years, operation period: 30 years</li> </ul>
Revenues and expenses for calculating equity IRR	<ul style="list-style-type: none"> <li>Dividends paid to private shareholders are used as income for the purposes of calculating the IRR.</li> <li>Contributions from private shareholders are treated as expenditures for the purpose of calculating the IRR.</li> <li>If the EBF is included in the investment, the dividend ratio between the EBF's original funds and the private investment will be determined so as to provide favorable dividends to private shareholders (in this calculation, the ratio of EBF's original funds: private investment is assumed to be 2:3).</li> </ul>
Debt Interest Rate	<ul style="list-style-type: none"> <li>The interest rate for concessional sovereign loans is assumed to be 5%, and that of commercial banks is assumed to be 10%. (Figures from the IPSDP financial analysis are used.) The repayment period for concessional loans was set to 30 years (with a grace period of 10 years) while the period for commercial bank loans was set to 12 years (with a grace period of 5 years).</li> </ul>
Power plant construction costs	<ul style="list-style-type: none"> <li>USD224M</li> </ul>
Amount of electricity sold and unit price	<ul style="list-style-type: none"> <li>The amount of electricity sold is 520.78GWh/year, and the unit price is USD 0.060/kWh</li> <li>(All based on FS reports)</li> </ul>

Source: JICA Study Team

The Lower Seti project is classified as (5) PPP Scheme according to the classification of priority development projects shown in Figure 12.3-1. However, its LCOE is estimated at approximately 6.05 cents/kWh, and if the development costs are higher, it would be closer to the classification of (6) GoN Gencos. For this reason, we will consider whether it is possible to implement the project by mobilizing private funds using concessional loans. The assumptions for this analysis shown in Table 12.4-6.

■ Analysis 1: Effects of applying sovereign loans

From the following table, we can see that the equity IRR will increase by increasing the proportion of debt in the R1 ratio, and by increasing the proportion of concessional funds within that. If borrowing from a commercial bank is assumed, the repayment of principal and interest will be large, there will be periods when the cash balance will be negative, and it will be difficult to operate the business (marked with an "×" in the table). If the hurdle rate for the equity IRR is set at 9.0% from the perspective of the expected return of private investors, the only time the equity IRR will exceed this rate is when the interest rate is further lowered to 3.0% and the D/E ratio is set to 80:20.

**Table 12.4-7 Effects of sovereign loan application in Lower Seti (results of sensitivity analysis)**

		R1 (Debt/Equity Ratio)	
		80:20	70:30
R2 (Debt Interest)	Concessional Loan (Interest 3.0%)	13.3%	10.9%
	Concessional Loan (Interest 5.0%)	10.0%	8.8%
	Commercial Bank (Interest 10.0%)	×	×

Source: JICA Study Team

■ Analysis 2: Effects of applying EBF

If concessional funds with an interest rate of 5.0% and borrowing from commercial banks are assumed, a business plan using EBF would not be viable. This is because the project's profitability is low, and dividends to the NEA would not be sufficient, and the NEA would not be able to meet the EBF repayment schedule. If interest rates were further reduced and it were possible to borrow concessional funds with an interest rate of 3.0%, dividends would be possible to meet the EBF repayment schedule, and an equity IRR of over 9.0%, which was assumed as the hurdle rate, would be calculated.

**Table 12.4-8 Effect of EBF application in Lower Seti (results of sensitivity analysis)**

Debt Interest : 3.0%		R1 (Debt/Equity Ratio)	
		80:20	70:30
R3 (Percentage of EBF in Equity)	80%	15.7%	13.1%
	60%	15.0%	12.5%
	40%	14.4%	×
	20%	13.8%	×

Source: JICA Study Team

**(2) Detailed analysis of Lower Seti**

The Lower Seti project is located downstream of the Tanahu HEP (under construction, scheduled to start operation in 2026, STO 140MW), for which JICA provided financing together with ADB, and is expected to provide adjustment during the dry season through cascade operation. The access roads are also well developed, and there are few environmental issues. The three patterns were analyzed for the application of concessional loans, including methods involving an IPO for residents.

**Table 12.4-9 Conditions of Lower Seti project assessment**

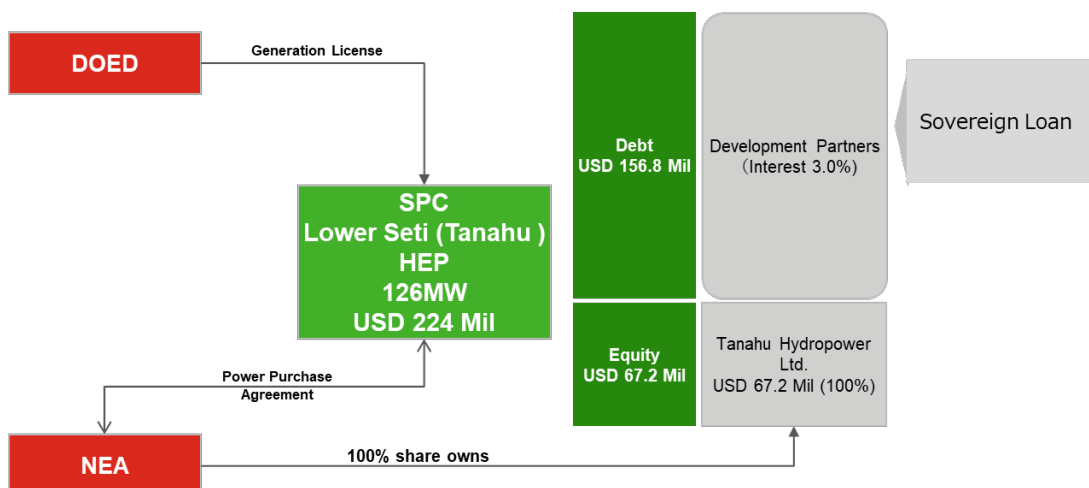
Case	Overview	Conditions	IRR	
Case A-1	Implementation as a concessional sovereign loan project by a public institution	Interest rate 3.0%, D/E ratio 70:30	Project IRR Equity IRR	8.0% 10.9%
Case A-2	Case A plus an IPO for residents	Ibid.	Project IRR Equity IRR	8.0% 10.9%
Case B	Utilizing private funds through EBF	Interest rate 3.0%, DE ratio 80:20, EBF equity ratio 40%	Project IRR Equity IRR	8.0% 14.4%

Source: JICA Study Team

Result of the analysis suggests ensuring the feasibility of the Lower Seti project application of concessional funds is vital. However, if profits were distributed using EBF via a public institution, it would be possible to achieve the equity IRR expected by private investors, leading to the attraction of private investment. The results of each analysis are shown below.

**1) Case A-1: Implementation as a concessional loan project by a public institution**

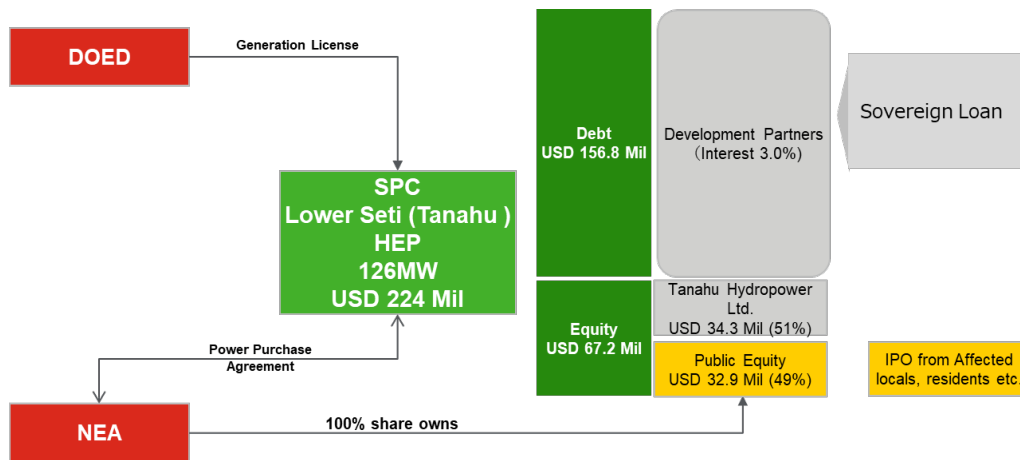
It is assumed that the project will be funded by a Japanese ODA loan through investment by Tanahu Hydropower Ltd., a wholly owned subsidiary of NEA. The interest rate conditions applied are 3.0% and DE ratio is 70:30. In accordance with this scheme, the project IRR will reach 8.0% and the equity IRR will reach 10.9%. This is an established financing scheme; it is important to implement the project as quickly as possible.



Source: JICA Study Team

**Figure 12.4-4 Lower Seti Project Case A-1 Scheme diagram**

2) [Reference] Case A-2: Public institutions provide concessional loans and implement an IPO for residents



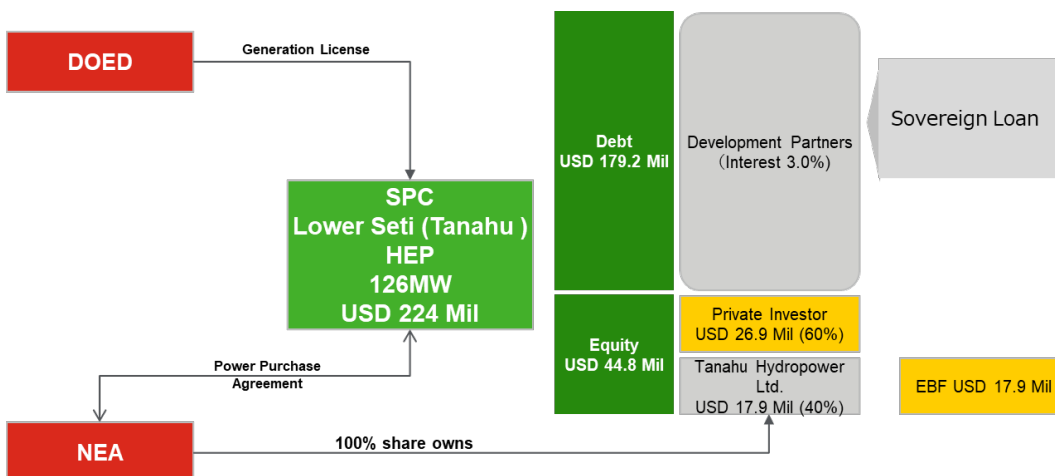
Source: JICA Study Team

Figure 12.4-5 Lower Seti Project Case A-2 Scheme diagram

Tanahu Hydropower Ltd will invest 51% and will conduct an IPO to allocate 49% of the shares to residents who will be affected around the project site. The DE ratio will be 70:30, and the interest rate conditions of the sovereign loan used for the debt portion will be 3.0%. Applying this condition, the project IRR will be 8.0% and the equity IRR will be 10.9%, the same figures as Case A-1.

The resident IPO, also referred to as public equity, is a system established by the Securities Registration and Issue Rules enacted in 2016 and the Securities Registration, Issue and Allotment Rules and Regulations enacted in 2017, and is used in the Upper Tamakoshi project, aiming to compensating local communities through hydroelectric power generation projects. This system allows private funds to be introduced into projects and also makes it possible to distribute dividends to meet the level required for an IPO. It should be noted that, there are mixed opinions on the Nepalese side regarding the effectiveness of the resident IPO system in accelerating hydroelectric power development projects, and careful consideration is needed.

3) Case B: Utilizing private funds through EBF



Source: JICA Study Team

Figure 12.4-6 Lower Seti Project Case B Scheme diagram

The debt-to-equity ratio is set at 70:30, and a sovereign loan (USD 179.2M) with an interest rate of 3.0% is applied to the debt side, while 40% of the equity (USD 17.9M) is injected as EBF to Tanahu Hydropower. As a result, the equity IRR reaches 14.4%, making it possible to utilize private funds. In this case, although the public institution does not contribute its own funds, there is no business profit, and Tanahu Hydropower Ltd must carefully consider whether it can accept investment. In addition, injecting 87.9% of concessional funds into a project with a project IRR of 8.0% and deliberately encouraging private companies to participate is not an efficient way of utilizing concessional funds, and therefore EBF is not appropriate for this project.

#### 12.4.4 Analysis of the Effectiveness of Sunkoshi 3 Concessional Funding

##### (1) Fundamental Analysis of Sunkoshi 3

Assumptions applied for this analysis are as follows:

*Table 12.4-10 Sunkoshi 3 Analysis Assumptions*

Index	Assumptions
period	<ul style="list-style-type: none"> <li>Construction period: 7 years, operation period: 30 years</li> </ul>
Revenues and expenses for calculating equity IRR	<ul style="list-style-type: none"> <li>Dividends paid to private shareholders are used as income for the purposes of calculating the IRR.</li> <li>Contributions from private shareholders are treated as expenditures for the purpose of calculating the IRR.</li> <li>If the EBF is included in the investment, the dividend ratio between the EBF's original funds and the private investment will be determined so as to provide favorable dividends to private shareholders (in this calculation, we have assumed a ratio of EBF's original funds: private investment = 2:3).</li> </ul>
Debt Interest Rate	<ul style="list-style-type: none"> <li>The interest rate for concessional financing (yen loans, etc.) is assumed to be 5%, and the repayment period is assumed to be 30 years (including a 10-year grace period).</li> <li>The interest rate on investment loans for private entities is assumed to be 10%, with a repayment period of 20 years (including a grace period of 7 years during the construction period).</li> <li>The interest rate on borrowing from commercial banks was assumed to be 10%, with a repayment period of 15 years (including a grace period of 7 years during the construction period).</li> </ul>
EBF Repayment Terms	<ul style="list-style-type: none"> <li>Assume that the original capital is 5% interest, and the repayment period is 30 years (10 of which is a grace period). The repayment is conducted with dividends from the project.</li> </ul>
Power plant construction costs	<ul style="list-style-type: none"> <li>USD1,331M (based on FS report)</li> </ul>
Amount of electricity sold and unit price	<ul style="list-style-type: none"> <li>The amount of electricity sold is 2,356.27GWh/year, and the unit price is USD 0.060/kWh</li> <li>(All based on FS reports)</li> </ul>

Source: JICA Study Team

A summary of the fundamental analysis is provided below.

- ① In case of sovereign loan application  
Since the repayment funds obtained from business activities are small, repayment of principal and interest will be difficult, and if borrowing is done with a D/E ratio of 70:30, the borrowing plan using investment loans for private entities or commercial bank loans with an interest rate

of 5% will not be viable, and the interest rate will need to be lowered to 5%. Assuming that the expected rate of return for private investors is 9%, the domestic electricity selling price needs to be set at USD 0.083/kWh (assuming a D/E ratio of 70:30 and the use of concessional loans with an interest rate of 5% for debt).

② When EBF is applied:

Due to the small amount of dividends obtained from business activities, NEA is unable to meet the repayment schedule of the EBF. Even if concessional funds with an interest rate of 5% were used for 100% of the debt, it would be difficult to meet the repayment conditions, making it difficult to carry out business using the EBF.

The details of the analysis results are presented below.

■ Analysis 1: Effects of applying sovereign loans

The D/E ratio of 70:30, which is prevalently used for hydroelectric power generation projects in Nepal, is used to calculate Equity IRR this time. In addition to 70:30, the ratio of 80:20 is also applied. The project is not profitable (project IRR is 6.0%), and the amount of cash that can be obtained from business activities is small to begin with. The repayment of principal and interest will result in a negative cash balance, so it is difficult to borrow and repay with a D/E ratio of 70:30 when the loan is based on investment loans for private entities or commercial bank loans with an interest rate of 10%. If concessional funds with an interest rate of 5% are used, borrowing and repayment with a D/E ratio of 70:30 becomes possible, and the equity IRR reaches 6.9%. However, if the hurdle rate for the equity IRR is set at 9% from the perspective of the expected return of private investors, none of the calculated equity IRRs reach that level.

Table 12.4-11 Sovereign Loan Application in Sunkoshi 3 (Sensitivity Analysis Results)

		R1 (Debt/Equity Ratio)	
		80:20	70:30
R2 (Debt Interest)	Concessional Loan (5.0%)	7.5%	6.9%
	Oversea Investment Loan (10.0%)	×	×
	Commercial Bank (10.0%)	×	×

Source: JICA Study Team

■ Analysis 2: Effects of applying EBF

Because the dividend resources obtained from business activities are small, even if concessional funds are used for 100% of the debt, the repayment conditions cannot be met and a business using EBF is difficult to implement. Although there was limited room for the use of EBF in Lower Seti, in the case of Sunkoshi 3, even if concessional funds (interest rates of 5%) were used for 100% of the debt, a business using EBF would be difficult and the business plan was not viable.

Projects that are already seeking funding seek concessional financing because the use of concessional financing by project investors or project promoters has the following effects:

First, the use of concessional financing is expected to complement private financing in terms of risk reduction, making it easier to carry out projects, including infrastructure development, in the business environments of emerging countries, which are generally considered to be high-risk.

Second, the addition of development financial institutions and development aid agencies that provide concessional financing signals to investors that project risks have eased, and they will be more proactive in considering lending. An increase in the number of fund providers means that fundraising conditions will be relaxed for business operators planning projects, and it will also serve as a catalyst for an increase in business operators working on similar projects.

Third, the provision of concessional financing for social infrastructure development in developing countries, where it is difficult to expect development to proceed autonomously through economic efficiency alone, is expected to encourage appropriate fiscal discipline management through monitoring opportunities from the loan provider side. Without concessional financing, developing country governments would refrain from excessive infrastructure spending that disrupts fiscal discipline, and miss opportunities for economic development, so it can be said that concessional financing is effective in achieving economic development while maintaining fiscal balance.

Even with the above-mentioned effects of concessional financing in mind, it is still important to improve the profitability of the project, so we conducted a more detailed analysis of the electricity export pattern planned by the Sunkoshi 3 project to explore possibilities for improving profitability.

## **(2) Detailed analysis of Case 2 (Sunkoshi 3)**

### **1) Basic analysis results of the Sunkoshi 3 projects**

Sunkoshi 3 is a site planned for exporting electricity to India and Bangladesh, and is a reservoir-type hydroelectric power plant that is relatively economical and close to the main grid. In January 2024, NEA issued an EOI for D/D consulting for development. Although the design needs to be reviewed, the project is highly important as a trilateral project between Nepal, India, and Bangladesh, and is expected to be a development site that would be meaningful for support from development financial institutions, including JICA.

After obtaining the Sunkoshi 3 FS documents and analyzing the D/E ratio, we obtained the following results. The project IRR for the Sunkoshi 3 project is 6.0%, and if concessional financing (D/E ratio 80:20, interest rate 5.0%) is used for this, the equity IRR will be 7.5%, which is below the target of 9%. In addition, even if part of the equity is planned as public funds using EBF, it is found that the business plan is not viable because the repayment conditions cannot be met.

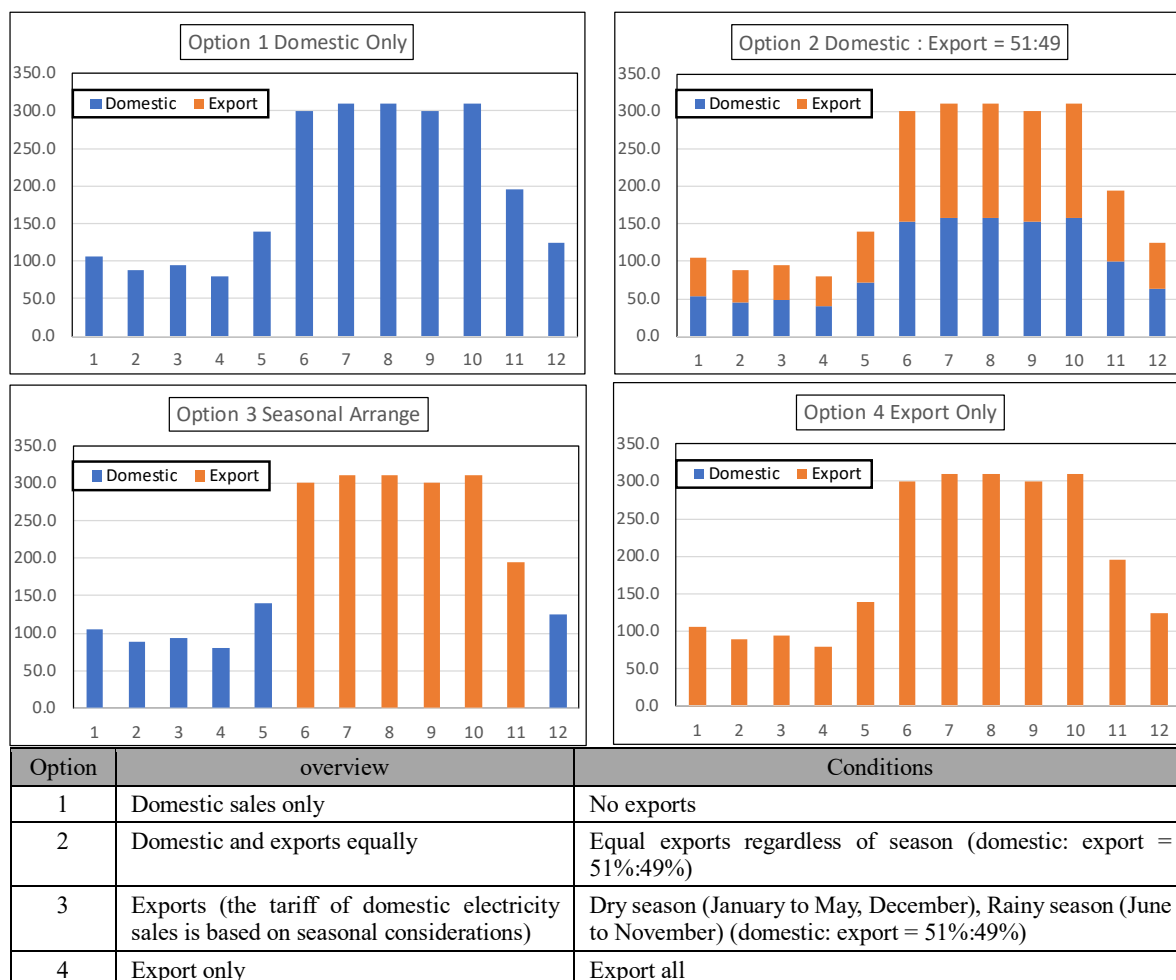
As a result of the above fundamental analysis, it was realized that in order to make the Sunkoshi 3 project a reality, it was necessary to find ways to improve profitability other than through a financing scheme. For this reason, we conducted a more detailed analysis of the electricity export pattern envisaged by the Sunkoshi 3 project and explored the possibility of improving profitability.

### **2) Measures to improve profitability of Sunkoshi 3 projects through electricity exports.**

The Sunkoshi 3 project plans to export electricity and intends to sell it across borders to India and Bangladesh in addition to domestically (NEA). Therefore, if electricity is exported, it is

expected that profits will improve, and the application of concessional funds will improve profits. Based on this assumption, the variation of electricity export can be assumed as shown below. We assumed that electricity would be sold domestically (NEA) and for export (India, Bangladesh), and for electricity prices, we took into account the price difference due to the season (rainy season/dry season) and the difference between peak and off-peak, and set the peak operation time to 6 hours (off-peak time is 18 hours).

**Table 12.4-12 Sunkoshi 3 business analysis**



Source: JICA Study Team

The electricity prices for this analysis are set as shown in the table below.

**Table 12.4-13 Prices used in the analysis of profitability improvement**

Dry season	Peak	10.6 NPR/kWh
	Off-peak	8.4NPR/kWh
Wet season	Peak/off-peak	4.8NPR/kWh
See NEA PROR peak operation tariffs		
Power Export	<ul style="list-style-type: none"> <li>• Calculated based on IEX electricity market performance in 2023</li> <li>• Based on the data on the average electricity selling price for each region for the year, the electricity selling price for each month (Ave. 8.80NPR/kWh) and the peak (Ave. 12.70 NPR/kWh) and off-peak prices (Ave. 7.60 NPR/kWh) are calculated (Table)</li> </ul>	

Source: JICA Study Team

When looking at the seasonality of the electricity supply and demand relationship between Nepal and the assumed export destinations, India and Bangladesh, securing supply capacity is important in Nepal during the dry season when hydroelectric power output is low, whereas in India and Bangladesh demand increases during the rainy season when temperatures rise, and electricity demand expands. As a result, a mutually complementary relationship is established in the electricity demand between Nepal and India/Bangladesh and selecting the optimal electricity sales destination between Nepal and export destinations while taking seasonality into consideration will be beneficial for both Nepal and India/Bangladesh.

In the following analysis, we analyzed the contribution of the application of concessional funds to improving profitability in Option 3 (Exports (the tariff of domestic electricity sales is based on seasonal considerations)): whether or not to distinguish between peak and off-peak periods for exports (taking into account seasonality).

Fundamental analysis showed that the Sunkoshi 3 project would be more profitable if electricity exports were taken into consideration, and that the introduction of concessional financing would increase the project's feasibility.

In Case D analyzed below (electricity export considering seasonality), if peak and off-peak are distinguished, and if a concessional loan with an interest rate of 5.0% is applied with a DE ratio of 70:30, the equity IRR will reach 11.9%. This exceeds the hurdle rate (9.0%) set in this analysis from the perspective of private investors' expected returns. However, since the interest rate of 5.0% on the concessional funds at this time is only applicable to operators in Nepal, it will be difficult to utilize concessional funds if the three countries including India and Bangladesh are included.

Based on the above analysis, the following three concessional funding application schemes were considered.

**Table 12.4-14 Conditions of Sunkoshi 3 project assessment**

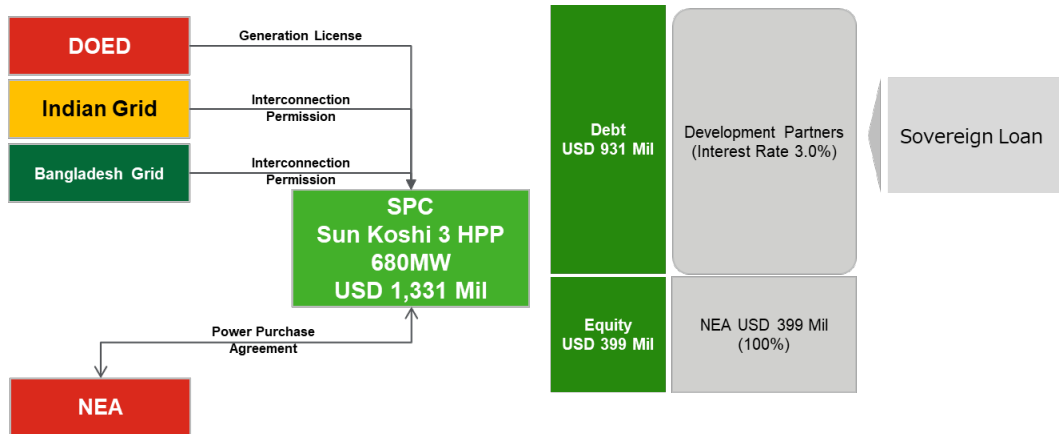
Case	Overview	Conditions	IRR
Case C	Implementation as a loan project by a public institution	Interest rate 5.0%, D/E ratio 70:30	Project IRR 6.0% Equity IRR 6.9%
Case D	Implementation as a loan project by a public institution with electricity export	Interest rate 5.0%, D/E ratio 70:30 Power export	Project IRR 8.5% Equity IRR 11.2%
Case E	Using investment and financing for private entities by public institutions involving electricity exports	Interest rate 3.0% (concessional loan) and 7.0 (investment loan for private entities), DE ratio 80:20, EBF equity ratio 29% Power export	Project IRR 8.5% Equity IRR 12.4%

Source: JICA Study Team

### 3) Case C: Implementation as a concessional loan project by a public institution

Although a sovereign loan will be injected into the debt portion, the equity IRR will remain at 6.9%, below the hurdle rate. In order to secure the debt portion equivalent to USD 931 million (70% of the total cost), financial assistance will be required from multiple development aid agencies, and NEA will also need to secure USD 339 million (30% of the total cost) of its own funds for the equity portion.

In this case, Project IRR and Equity IRR remain at 6.0% and 6.9%, respectively.

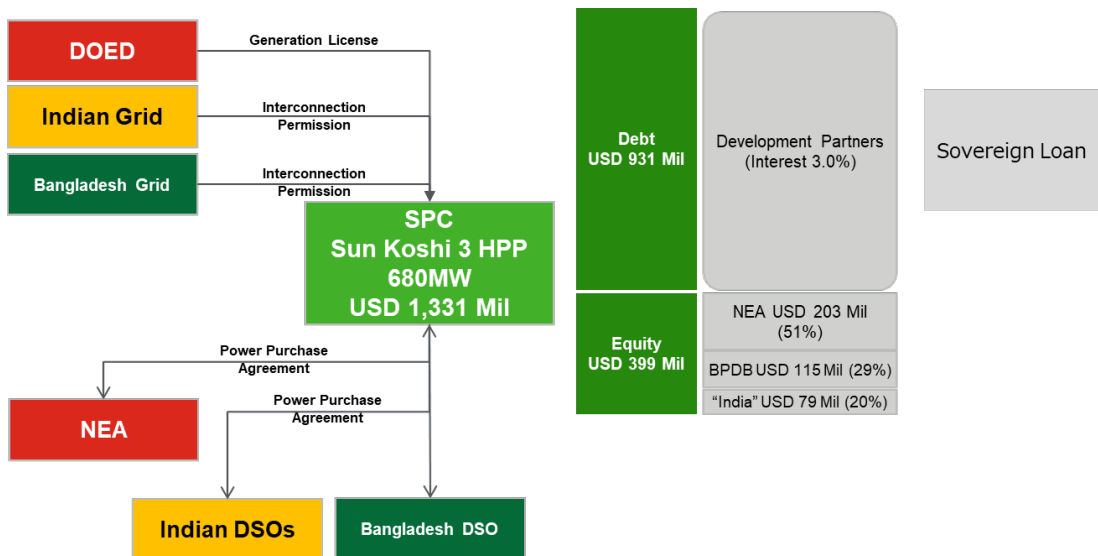


Source: JICA Study Team

Figure 12.4-7 Sunkoshi 3 Project: Case C Scheme Diagram

4) Case D: Implementation as a concessional loan project by a public institution with electricity export

By providing a sovereign loan and exporting electricity, it is possible to create a business with an equity IRR of 11.2%, which exceeds the hurdle rate of 9.0%. However, it is difficult for Nepal alone to secure a sovereign loan of USD 931 million because it is an enormous amount, and fundraising through multiple development aid agencies will be more viable when India and Bangladesh join this project along with Nepal.



Source: JICA Study Team

Figure 12.4-8 Sunkoshi 3 Project: Case D Scheme Diagram

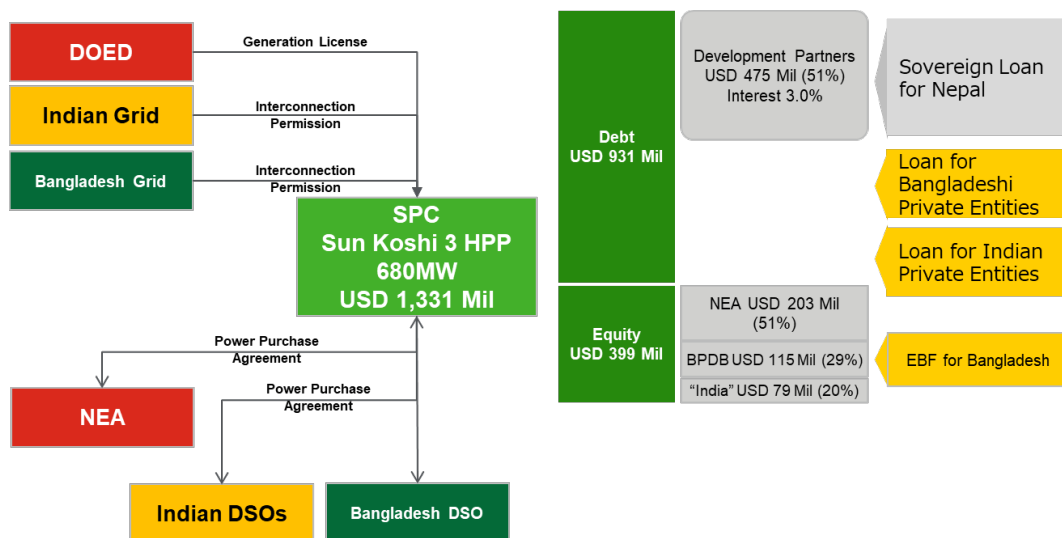
5) Case E: Private Sector Investment Finance was applied to concessional loans provided by public institutions with electricity exports

If the interest rate for concessional funds is 5.0% and the interest rate for investment loans for private entities is 10.0%, the burden of interest payments is heavy, making it difficult to use EBF. If the interest rates were lowered to 3.0% for concessional funds (the same applies to loans made from concessional funds that are the basis of EBF) and 7.0% for investment loans for private entities, and this scheme was used with the assumption of issuing common stocks

without preferential dividends while using EBF, the equity IRR improved to 12.4%, exceeding the hurdle rate.

In addition to sovereign loans, we will utilize the investment and financing for private entities framework for India and Bangladesh, which are the destinations for electricity exports, and provide EBF to the Bangladesh Power Development Board (BPDB), an organization responsible for power development in Bangladesh, as an investor. We assume that investment and financing for Bangladesh private entities will be equivalent to 29% of the debt (USD 270 million), and investment and financing for Indian private entities will be 20% (USD 186 million), and the analysis was conducted using the prescribed interest rate for investment and financing for private entities of 7.0%. By utilizing the financing framework for both India and Bangladesh, we can avoid placing an excessive burden on the financing framework for Nepal.

On the other hand, commercial terms of electricity sales to India and Bangladesh, such as applied currency of the PPA are unknown. If it is difficult to settle the condition with US dollars, Nepalese party should have support for negotiating on the terms of the PPA. Currency hedging schemes in Nepal is other contentious issue. Foreign investors are seeking usable hedging scheme in Nepal to mitigate exchange risks.



Source: JICA Study Team

Figure 12.4-9 Sunkoshi 3 Project: Case E Scheme Diagram

### 12.4.5 Analysis of the effectiveness of Phukot Karnali Concessional Funding

#### (1) Fundamental Analysis of Sunkoshi 3

Assumptions applied for this analysis are as follows:

**Table 12.4-15 Phukot Karnali Analysis Assumptions**

Index	Assumptions
period	<ul style="list-style-type: none"> <li>• Construction period: 7 years, operation period: 30 years</li> </ul>
Revenues and expenses for calculating equity IRR	<ul style="list-style-type: none"> <li>• Dividends paid to private shareholders are used as income for the purposes of calculating the IRR.</li> <li>• Contributions from private shareholders are treated as expenditures for the purpose of calculating the IRR.</li> <li>• If the EBF is included in the investment, the dividend ratio between the EBF's original funds and the private investment will be determined so as to provide favorable dividends to private shareholders (in this calculation, we have assumed a ratio of EBF's original funds: private investment = 2:3).</li> <li>• When concessional funds are invested in the equity portion, if the investors are public institutions, there is no dividend priority and the dividend ratio is 1:1.</li> </ul>
Debt Interest Rate	<ul style="list-style-type: none"> <li>• The interest rate for concessional financing (yen loans, etc.) is assumed to be 5%, and the repayment period is assumed to be 30 years (including a 10-year grace period).</li> <li>• The interest rate on investment loans for private entities is assumed to be 10%, with a repayment period of 20 years (including a grace period of 7 years during the construction period).</li> <li>• The interest rate on borrowing from commercial banks was assumed to be 10%, with a repayment period of 15 years (including a grace period of 7 years during the construction period).</li> </ul>
EBF Repayment Terms	<ul style="list-style-type: none"> <li>• Assume that the original capital is 5% interest, and the repayment period is 30 years (10 of which is a grace period). The repayment is conducted with dividends from the project.</li> </ul>
Power plant construction costs	<ul style="list-style-type: none"> <li>• USD617M (based on FS report)</li> </ul>
Amount of electricity sold and unit price	<ul style="list-style-type: none"> <li>• The amount of electricity sold is 2,447.88GWh/year, and the unit price is USD 0.050/kWh</li> <li>• (All based on FS reports)</li> </ul>

Source: JICA Study Team

A summary of the fundamental analysis is provided below.

<p>① In case of sovereign loan application Because the project itself is highly profitable (project IRR 15.0%), borrowing plans can often be secured without running out of cash to repay the loan and interest, whether through concessional financing, foreign investment loans, or commercial bank loans.</p> <p>② When EBF is applied: Because the project itself is highly profitable, it is possible to repay the original capital through dividends, even when concessional financing or a combination of investment financing for private entities and EBF is used. However, when using loans from commercial banks, there may be cases where there is not enough cash left to allocate to dividends after paying principal and interest, and a financing plan using EBF cannot be implemented.</p>
---

■ Analysis 1: Effects of applying sovereign loans

Because the project itself is highly profitable, unless borrowing from a commercial bank with a DE ratio of 80:20, the company will not run out of cash even after repaying the principal and interest, and will be able to enjoy the leverage effect of borrowing.

**Table 12.4-16 Sovereign Loan Application in Phukot Karnali (Sensitivity Analysis Results)**

		R1 (Debt/Equity Ratio)	
		80:20	70:30
R2 (Debt Interest)	Concessional Loan (5.0%)	23.9%	19.8%
	Oversea Investment Loan (10.0%)	19.0%	16.7%
	Commercial Bank (10.0%)	×	15.6%

Source: JICA Study Team

■ Analysis 2: Effects of applying EBF

Because the project itself is highly profitable, unlike Sunkoshi 3, a financing plan combining investment financing for private entities and EBF is possible (the dividend ratio is calculated as public institution investment: private investment = 2:3).

**Table 12.4-17 Effect of EBF application in Phukot Karnali (results of sensitivity analysis)**

Debt Interest : 10.0% (Overseas Investment Loan)		R1 (Debt/Equity Ratio)	
		80:20	70:30
R3 (Percentage of EBF in Equity)	80%	22.0%	19.5%
	60%	21.1%	18.7%
	40%	20.3%	18.0%
	20%	19.6%	17.3%

Source: JICA Study Team

**(2) Detailed analysis of Phukot Karnali**

Based on the results of the fundamental analysis of Phukot Karnali, we present possible financing schemes. As mentioned above, NHPC, an Indian government-affiliated operator, is considered to participate in Phukot Karnali with a capital ratio of 51% or more, and we will examine a scheme for foreign capital participation using concessional funds. Below, we will first consider a conventional scheme carried out by a single country (Case F), in which VUCL and the Nepalese government are the development implementation bodies. Next, we will consider an export-oriented scheme led by NHPC (Case G). Note that for Case G, we will also consider EBF support for VUCL, which is short of its own funds.

**1) Case F: Investment loans for private entities and commercial bank loans are combined**

Based on the results of the fundamental analysis, it is believed possible to construct a financing scheme that is profitable for investors through investment loans for private entities and loans from commercial banks, without using concessional funds with an interest rate of 5.0%. The figure below shows a financing scheme using investment loans for private entities and loans from commercial banks, and the equity IRR calculated based on this scheme is 16.6%, which

exceeds the expected rate of return of 9.0%.

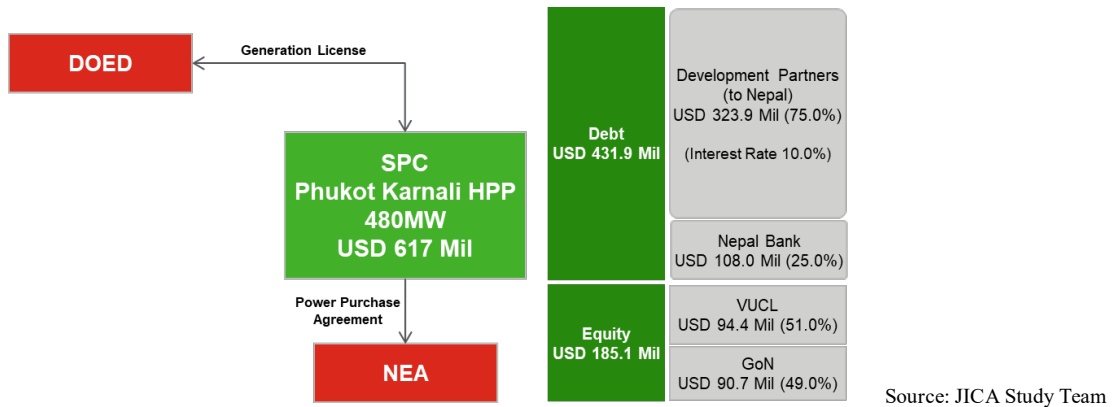


Figure 12.4-10 Phukot Karnali Project: Case F Scheme Diagram

2) Case G: Investment Loans for Private Entities, Commercial Bank Loans, and EBF are combined

We present a financing scheme that incorporates NHPC's involvement in Phukot Karnali. In this case, we assume that investment loans for private entities will be utilized not only for Nepal but also for India, in addition to loans from commercial banks. In addition, to supplement the investment capital, VUCL will invest in equity using EBF as capital. Note that NHPC is also a state-owned enterprise, and the dividend ratio is set at 1:1, with no difference in dividends to VUCL and NHPC. The above assumptions are illustrated in the figure below, and the equity IRR in this case is 16.3%. This case also exceeds the expected rate of return of 9.0%.

In this scheme, the debt burden on the Nepalese side is reduced through the participation of NHPC, and the use of EBF also contributes to solving VUCL's fundraising issues.

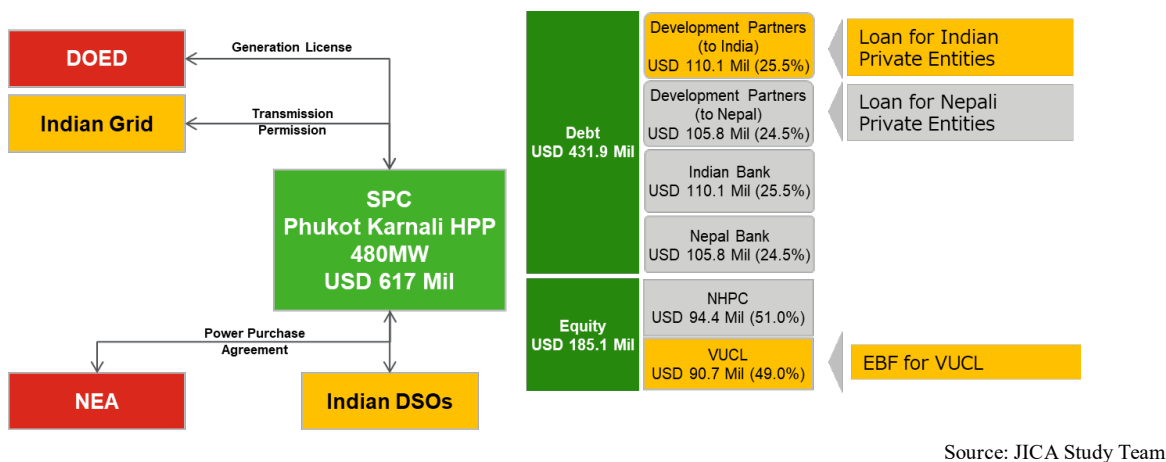


Figure 12.4-11 Phukot Karnali Project: Case G Scheme Diagram

## 12.4.6 Implications from the Analysis

Through the analysis of the above two projects, the following observations were made:

- In particular, in the case of Sunkoshi 3, there is a high possibility that the repayment of principal and interest will result in a cash flow shortfall. Even if low-interest concessional loans are used, it is desirable to reduce the reliance on loans and increase investment from investors' own capital, etc. to avoiding shortage of finance.
- In particular, in the case of Sunkoshi 3, both the project IRR and equity IRR are low, and rather than relying on private investment, from the perspective of prioritizing public interest, having a public institution provide capital as the main investor will increase the feasibility of the project and fundraising.

Next, the following points can be noted as suggestions obtained from a somewhat generalized perspective of introducing concessional financing into power generation projects.

- Assuming that dividends are paid in line with the repayment schedule, if dividends to EBFs cannot be paid due to low profits caused by cash outflows for repayment of borrowing principal and interest, or the burden of interest payments and depreciation expenses, then business consideration using EBFs would not be viable. Therefore, if it were permitted to set a longer grace period, such as freezing EBF dividends during the borrowing principal and interest repayment period, the feasibility of using EBFs would be enhanced.
- When investing in concessional funds in debt, the lower the interest rate of the concessional loan, the more profits that can be distributed to investors, making it a desirable condition for private investors. Therefore, when financing the project itself, it is important to consider to what extent "concessional" can be maintained, such as how low the interest rate spread can be kept when sub-lending to the SPC.
- It was found that while it is possible to improve the equity IRR and increase the profitability of private investors by injecting concessional funds, if the profitability of the project itself is low, there is a limit to how much concessional funds can be used to increase the profitability of private investors. In the case of a highly profitable project like Phukot Karnali, it is possible to implement the project even with the borrowing conditions of a commercial bank. On the other hand, considering the amount of debt procurement in Nepal and the amount of equity that developers can invest, as mentioned in Section 12.3, the participation of foreign companies is necessary for projects above a certain size. In this case, it is expected that the use of concessional funds with favorable borrowing conditions will improve the profitability of the project and the reliability will be improved through the involvement of donors. It is expected that this will attract investment from foreign companies and promote the development of projects that would be difficult to implement on a scale by Nepal alone.

## **12.5 FUNDING PLAN FOR IPSDP IMPLEMENTATION**

This section examines the outlook for financing for projects designated as priority projects under the IPSDP based on the characteristics of the projects and the characteristics of the lenders, and shows the outlook for capital needs and financing during the IPSDP period.

### **12.5.1 Methodology**

Based on the distribution and characteristics of the projects shown in Figure 12.3-1 and Table 12.3-5, a model of the investor and lender for the project was assumed, and the investor and lender were allocated based on the model. In this case, the debt/equity ratio was set at 70:30. In addition, when considering the investor and lender, the investor and lender were considered based on the considerations in 12.2 and 12.3. The investment and lending ratio for each classification is as shown in Table 12.5-1, which is the premise of the procurement ratio from each organization at the time of fundraising.

Based on the investment and lending ratio assumed for each investor attribute, the required amount for each classification per year was calculated. The calculation results were summed up for each organization, and the amount required over the IPSDP planning period from 2022 to 20240 was tabulated to give Table 12.5-2, the IPSDP Funding Plan by Funding Source (draft).

Table 12.5-1 Funding assumption for each categories and source of finance

	Country	Organization	(1) Profitable IPPs (Small)	(2) Small Scale ROR and PROR	(3) GoN Assistance Projects	(4) Profitable IPPs (Medium)	(5) PPP Scheme	(6) GoN PROR/STO Projects	(7) Mega Export Project	(8) GoN Strategic Projects	(9) Others	(10) Power System	
Equity	Nepal	Gov't & SOE			100%		30%	80%	30%	50%		100%	
		Gov't Fin. Institutions											
	Neighboring Countries	Private IPP	50%	100%		40%	20%	20%	20%	5%	40%	100%	
		Gov't & SOE						30%	20%	30%			
		Gov't Fin. Institutions											
	Dev't Partners	Private IPP	40%			40%		10%		15%			
		MNEs											
	Private Co.	Int'l Inv. Banks	10%			20%		10%		20%			
		Sovereign											
	Debt	Nepal	Sovereign					20%	60%	10%	40%		80%
PPP									15%				
Two Step Loan													
Gov't Fin. Institutions		20%	50%	100%	20%	20%	20%	20%	5%	10%	20%	20%	
Private Fin. Institutions		30%	50%		20%				5%		80%		
Neighboring Countries	Sovereign								5%				
	PPP						30%	15%	25%	40%			
	Two Step Loan												
Global	Gov't Fin. Institutions	20%			20%	20%	10%	5%	10%	10%			
	Private Fin. Institutions	20%			20%				5%				
	PPP				20%		10%		10%				
		Int'l Inv. Banks	10%						10%				

Source: JICA Study Team

Table 12.5-2 IPSPD Funding Plan by source

Country	Organization	Year																		
		2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Equity+Debt		1,699	2,137	2,249	2,417	2,918	4,195	4,691	6,035	5,569	5,628	4,918	4,474	3,444	3,368	3,544	3,141	2,804	2,208	1,440
Nepal	Government & SOE	184	194	222	244	298	351	450	544	575	594	557	471	451	445	497	433	411	341	281
	Gov't Finance Institutions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Private IPP	154	208	237	226	291	427	349	415	315	316	280	291	163	144	127	123	103	89	31
	Government & SOE	31	39	53	67	74	106	185	254	273	300	292	225	213	214	248	195	178	134	94
	Gov't Finance Institutions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Private IPP	89	124	97	102	112	214	236	303	221	220	156	172	81	76	59	59	37	21	1
	Government & SOE	12	16	17	25	28	40	61	98	105	103	94	76	61	63	73	62	57	43	24
	Gov't Finance Institutions	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Private IPP	0	2	2	5	6	9	6	12	13	10	4	5	5	7	7	9	8	5	0
	Partners	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MNE	MNEs	39	58	47	57	67	112	120	184	169	145	92	101	58	62	54	62	47	30	0
	Int'l Investment Banks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Year Total		510	641	675	725	876	1,258	1,407	1,811	1,671	1,688	1,475	1,342	1,033	1,010	1,063	942	841	662	432
Nepal	Sovereign	327	336	388	410	502	566	762	879	932	984	963	801	792	774	872	738	704	595	525
	PPP	29	42	36	59	69	98	97	196	216	169	115	112	63	71	71	88	80	57	0
	TSL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gov't Finance Institutions	255	294	302	305	371	528	576	722	639	637	570	536	362	335	338	299	266	221	147
	Private Commercial Banks	178	267	345	323	432	621	429	440	288	333	305	329	218	194	175	173	149	128	58
	Sovereign	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PPP	69	87	108	142	157	224	364	529	570	598	565	444	398	402	461	375	342	258	165
	TSL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gov't Finance Institutions	122	162	140	147	161	290	369	474	386	409	343	321	206	198	197	161	129	92	56
	Private Commercial Banks	90	130	102	105	117	233	250	298	196	208	138	163	81	76	56	56	32	12	1
Bangladesh	Sovereign	0	4	4	11	13	21	15	28	31	24	9	12	12	15	15	21	19	11	0
	PPP	29	34	36	47	52	73	127	200	215	216	211	166	130	133	154	123	113	90	55
	TSL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Gov't Finance Institutions	0	4	4	11	13	21	15	28	31	24	9	12	12	15	15	21	19	11	0
Global	Private Commercial Banks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	PPP	63	90	74	79	101	147	183	309	316	251	158	175	103	111	95	101	73	46	0
Year Total		1,189	1,496	1,574	1,692	2,043	2,936	3,284	4,225	3,898	3,940	3,443	3,132	2,411	2,358	2,481	2,199	1,963	1,545	1,008

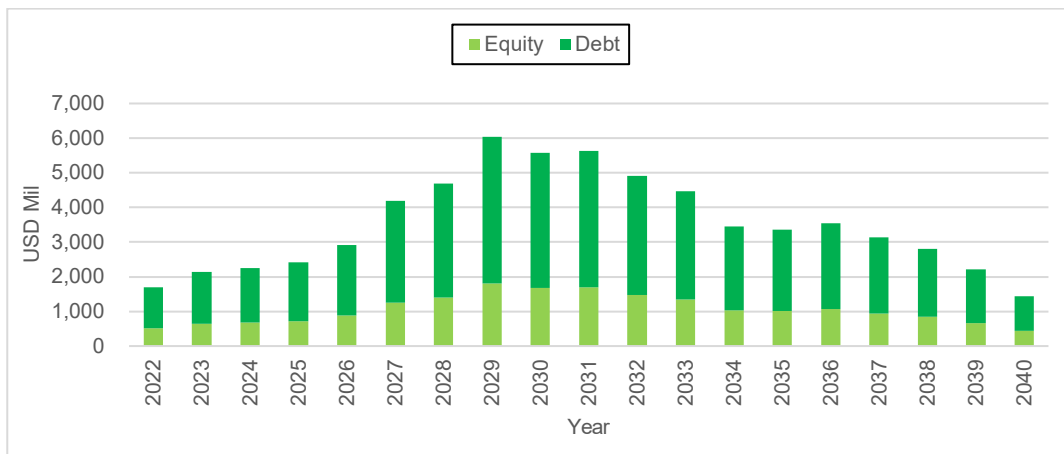
Source: JICA Study Team

### 12.5.2 Analysis

The trend of debt and equity procurement by country and organization during the period is illustrated in Figure 12.5-1. Capital demand will peak in 2029 (USD 6,035 million in total debt and equity), then gradually decrease, reaching around USD 3,500 million per year from 2034 to 2036, after which it will begin to decline. Note that while this study includes demand for development up to 2040, it does not include the cost of power plants scheduled to start operation after 2041.

During this period, Nepal will bear 53-72% of the equity investment by government organizations and private developers in total (see Figure 12.5-2 Capital Demand Outlook Based on Funding). However, the equity investment ratio by government organizations and private developers in Nepal will fall to about 53% of the total equity investment from 2029 to 2031, when the total equity demand will peak. This is because, in addition to increased investment from India and Bangladesh, increased investment from international developers is expected.

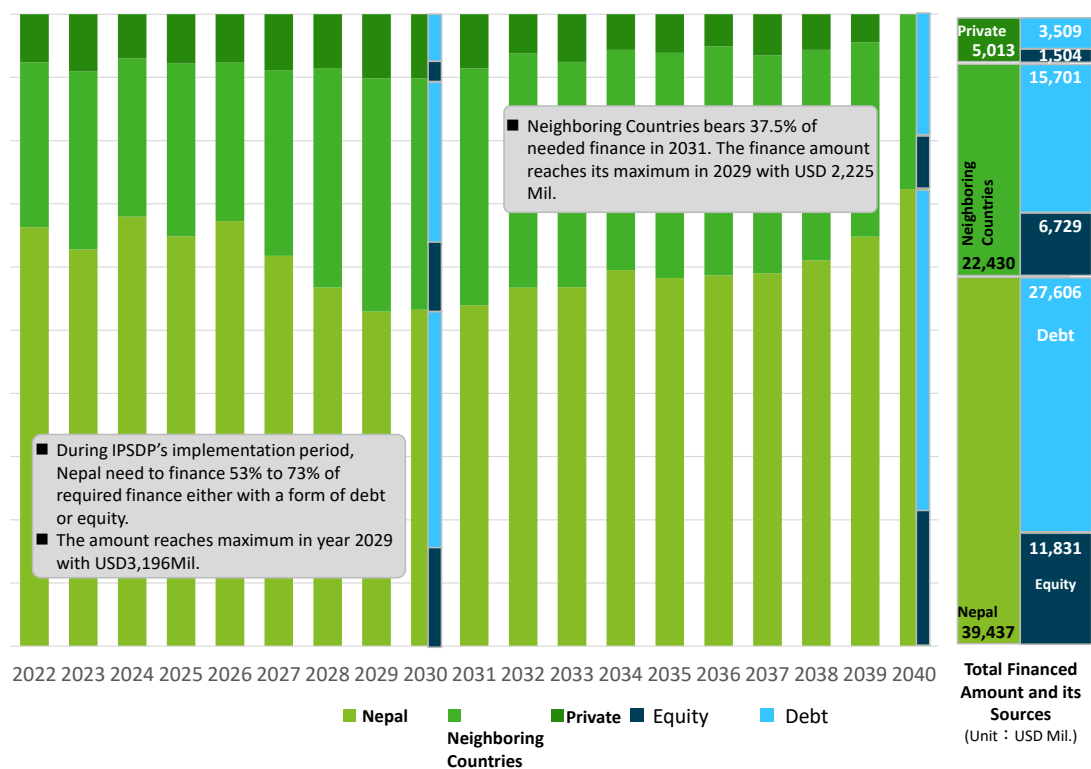
Debt will also peak at USD 4,225 million in 2029, then decrease to USD 2,411 million by 2034, increase to USD 2,481 million in 2036, and gradually decrease thereafter (see Figure 12.5-2 Trends in Debt Procurement). The proportion of total debt borne by the Nepalese government, government-affiliated financial institutions, private banks, and PPP schemes will trend at a similar rate to equity. Nepal's share will also decline from 2029 to 2031 and will remain at 57-72% from 2032 onwards.



Source: JICA Study Team

**Figure 12.5-1 Capital demand forecast**

As shown in Figure 12.5-2 and Table 12.5-3, capital demand during the IPSDP period will peak between 2029 and 2032, when construction of many projects will be concentrated, and then gradually decline. This forecast covers hydropower projects currently captured in the IPSDP, and it is expected that trends up to around 2030 will attract private sector investment. It should be noted that this figure does not show the inflow of private sector investment outside of the IPSDP plan. There are also areas that need improvement in order to more smoothly invest in hydropower projects in Nepal, and these are discussed in Chapter 15.



Source: JICA Study Team

Figure 12.5-2 Proportional trend and Source of Finance

Table 12.5-3 Trend of Finances by Sources during IPSDP period

	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Nepal	5,194	5,992	6,185	6,498	7,427	9,785	10,675	13,207	12,353	12,405	11,077	10,286	8,314	8,166	8,470	7,763	7,151	6,070	4,635
Neighboring Countries	978	1,381	1,371	1,562	1,833	2,914	3,362	4,651	4,271	4,248	3,524	3,222	2,348	2,357	2,451	2,185	1,873	1,363	678
Private	217	301	251	267	295	549	639	805	617	645	497	501	307	296	277	245	186	123	480

(Unit : USD Mil)

Source: JICA Study Team

## Reference: Examples of financial schemes in other countries

In this section, we will look for examples from other countries regarding the financing required for Nepal to build an export-oriented hydroelectric power project, and point out the points that Nepal should pay attention to when procuring financing for a hydroelectric power project and when developing an export-oriented hydroelectric power project. In this paper, we look for an example in the Nam Theun 2 project in Laos, and refer to the background of project formation and the financing scheme.

### (1) Construction History of the Nam Theun 2 Project

Laos is a landlocked country on the Indochina Peninsula, with the Mekong River running through the country, but it has not been actively used as a source of power. In 1993, the Mekong Development Commission 24(MRC) estimated that the hydroelectric potential that can be developed in Laos is over 18,000 MW, and recommended that the development be divided into domestic and export-oriented hydroelectric power. Based on this estimate, the Laotian government began concrete consideration of development, with the premise that export-oriented hydroelectric power would be developed mainly with foreign capital.

The Nam Theun 2 project was first studied in 1994. A 39m-high dam is constructed on the Nam Theun River, which flows through the mountainous region of central Laos, and 1,075MW of electricity is generated by pumping water (with an effective head of 348m) to a power plant in the plains. From the start, the project was designed with the aim of exporting electricity, with nearly 90% of the generating capacity being sold to the Electricity Generating Authority of Thailand (EGAT).

Consortia from Japan, France, and Thailand participated in the construction, with full-scale construction work commencing in 2005. In 2003, operation of the project was transferred to the project company, the IPP Nam Theun 2 Power Co. (NTPC). After that, flooding began in 2008, and the plant began full operation and transmission of electricity in 2010.

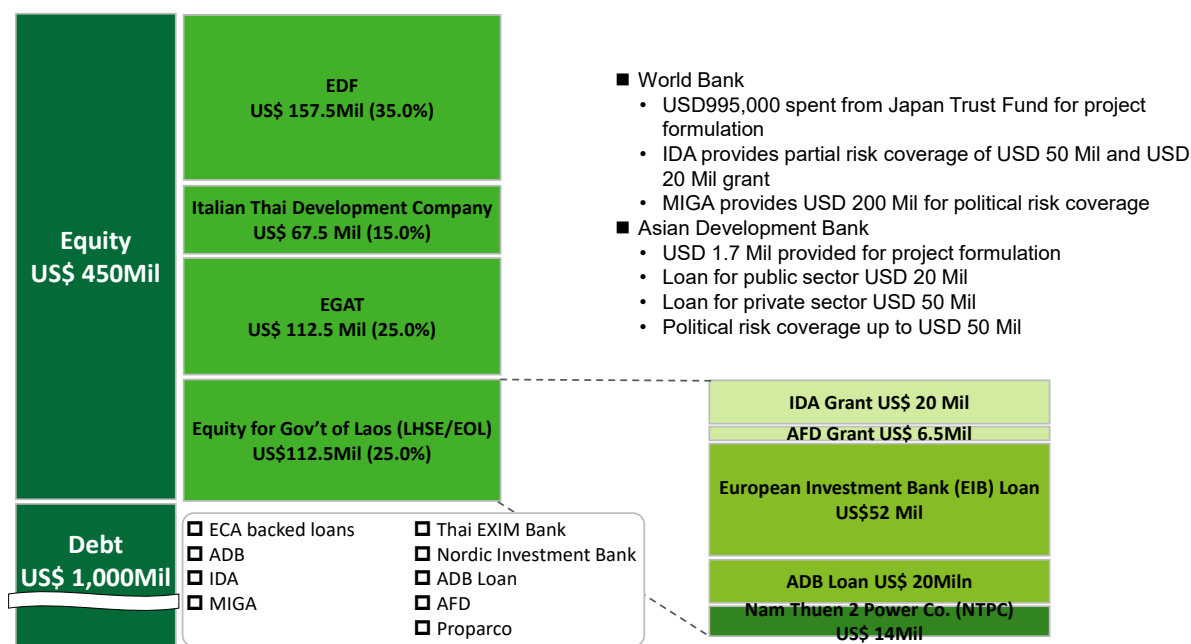
### (2) Project Financing Scheme

The total cost of the project is USD 1.45B, of which USD 0.45B was raised through equity and USD 1.0B through debt. 27 banks are said to have participated in the debt syndicate. The equity portion is roughly divided into four parts, with EDF (Électricité de France) investing 35%, followed by EGAT, the main purchaser of electricity, with 25%, Italthai, which will be responsible for the construction work, investing 15%, and the remaining 25% being held by the Lao government. The Lao government's equity holding is supported by funds from donors.

Under this scheme, the World Bank and the Asian Development Bank are providing credit and risk guarantees through their affiliated organizations.

---

<sup>24</sup> There are various names for the committee, such as the Interim Mekong Committee, but as this is beyond the scope of this article, we will refer to it as the Mekong River Committee.



Source: Project Performance Assessment Report, World Bank, December 2000

Figure 12.A.1 Nam Theun 2 Project Financing and Capital Structure

(3) Terms of transaction

The power purchase agreement concluded between EGAT and the Nam Theun 2 project, which was developed as an export-oriented project, had unfavorable terms for the Lao side, which ultimately affected the finances of the Electricite de Laos, which participated in the project.

The initial contract terms for the project, as shown in the diagram below, were favorable to EGAT, the export destination, and even taking into account exchange rates, EDL was structured in a way that would prevent it from suffering losses. Although the terms were subsequently revised, the unfavorable trade terms for EDL have not been resolved. The Lao government has attempted to provide credit guarantees, such as borrowing funds from overseas and sub-lending them to State Owned Enterprises, including EDL, but the business situation has not improved, and EDL has refrained from disclosing its financial situation since 2018, and as of 2022, EDL has been behind in repaying principal and interest to the government.

PPA (September 2003)		
	Export	Import
Peak	THB/kWh 1.22	Export Price + USD/kWh 0.50
Off-Peak	THB/kWh 1.1924	Export Price + USD/kWh 0.50

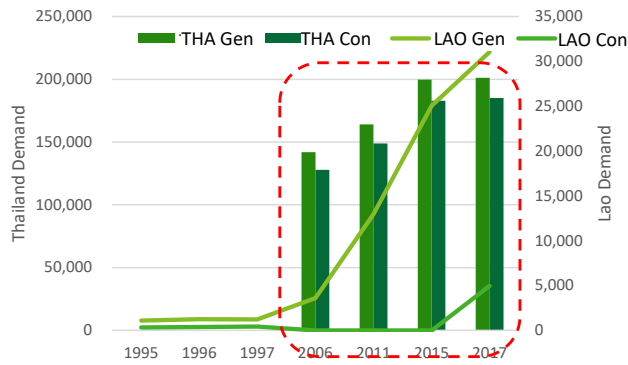
Revised PPA (March 2019)		
	Export	Import
Peak	THB/kWh 1.80	THB/kWh 1.90
Off-Peak	THB/kWh 1.53	THB/kWh 1.63

Source: JICA Study Team

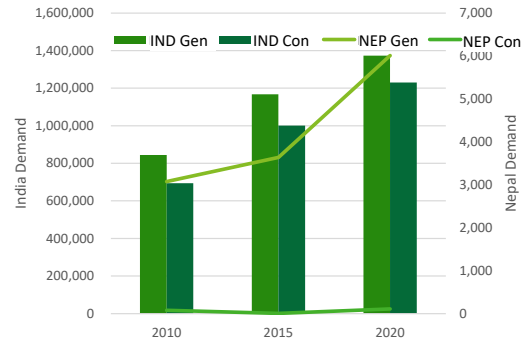
Figure 12.A.2 Changes in contract terms

#### (4) Background of Nam Theun 2 Project Development

This paper focuses on the electricity situation in Laos and Thailand at the time of the formation and start of operation of the Nam Theun 2 project and attempts to compare it with the background to Nepal's export-oriented efforts to develop hydroelectric power generation.



Source: JICA Study Team



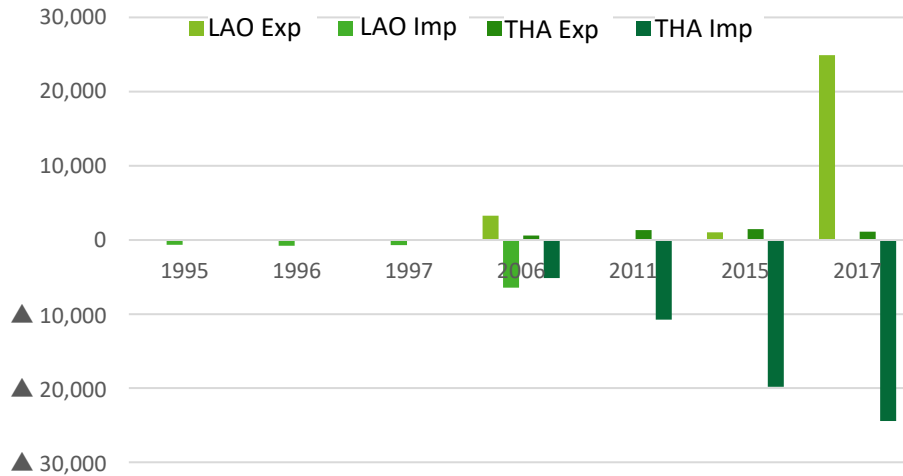
Source: JICA Study Team

**Figure 12.7.3 Electricity supply and demand trends in Thailand and Laos**

**Figure 12.7.4 Electricity supply and demand trends in India and Nepal**

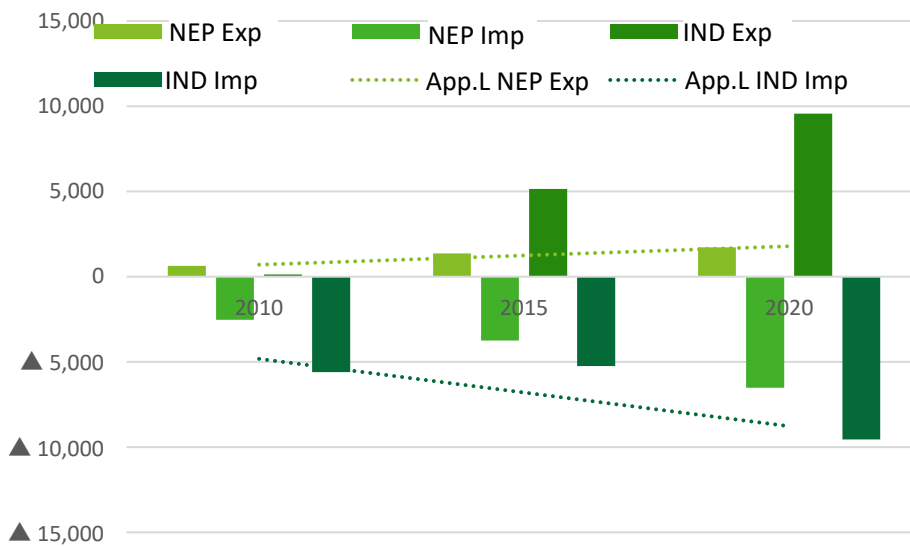
As shown in the graph above, Thailand's electricity demand has grown at a robust pace, while Laos' demand has grown at a relatively slow pace. The Mekong Development Committee's 1993 "Development Policy" was created with this supply-demand situation in mind. Looking at the period when Nam Theun 2 began operation, Thailand's domestic electricity demand has continued to grow, and the supply-demand gap has remained at roughly the same level. Comparing this trend with the situation in Nepal and India, the graphs show a similar shape, and in light of the example of Laos, it can be said that working to sell electricity to India, an electricity export destination, through the development of new power sources to meet growing demand is a rational approach.

Next, comparing the relationship between the increase in electricity imports and the development of supply capacity, we can see that between Laos and Thailand, supply development has been carried out in Laos that is comparable to the trend of increasing electricity imports by Thailand, as shown in the following figure. Comparing the current trends of Nepal and India, we can see that while India's electricity imports have increased between 2010 and 2020, the increase in Nepal's electricity exports has only been gradual and is not meeting India's demand for imported electricity. If India's import trend continues in the future, strengthening Nepal's supply capacity would be consistent with meeting India's increased electricity imports.



Source: JICA Study Team

**Figure 12.A.5 Electricity exports and imports between Thailand and Laos**



Source: JICA Study Team

**Figure 12.7.6 Power export and import between India and Nepal**

## (5) Implications for hydropower development and investment promotion in Nepal

### 1) Participation of international development financial institutions

In financing the Nam Theun 2 project, a wide range of investments and loans are being provided, including not only international development financial institutions and bilateral aid agencies, but also off-takers and operators contracted to carry out facility construction work. To realize the latter private investment, the World Bank (IDA, MIGA) is providing a political risk guarantee. In order to increase the private investment that Nepal is aiming for, it is first necessary for international development financial institutions and development aid agencies to provide credit enhancement measures to cover risks that private operators cannot bear as part of improving the investment environment. After the risks of the environment surrounding the project, such as political risks and riot risks, are proposed, measures to guarantee the risks associated with the project will be provided.

### 2) Impact of transaction terms

When the power buyer becomes an investor in export-oriented hydropower development, it is necessary to consider the impact on the terms of the transaction. It is necessary to devise ways to avoid situations such as unreasonable differences or conditions being set in the import and export amounts, or unfavorable import prices being set when Nepal imports electricity. In addition, looking at the current business development situation, it is not rare for the off-taker to invest in hydropower projects in Nepal, so when negotiating PPAs in this type of business, it is necessary to be aware of the conflict of interest between the position of the project investor and the position of the power buyer.



## **ANNEX 13**

# **CONSIDERATIONS ON UTILIZATION OF SURPLUS ELECTRICITY**



<b>Annex 13</b>	<b>Considerations on Utilization of Surplus Electricity.....</b>	<b>13-1</b>
13.1	The Energy Chain focused on Green Hydrogen .....	13-1
13.2	Initiatives related to Energy Transition in Nepal .....	13-3
13.2.1	Green Hydrogen Policy .....	13-3
13.2.2	Summary of Existing Studies on Green Hydrogen in Nepal .....	13-5
13.2.3	Lessons from Previous Initiatives and Considerations for the Future .....	13-12
13.3	Estimation of Surplus Electricity up to 2040.....	13-14
13.3.1	Estimation of Surplus Electricity .....	13-14
13.3.2	Potential for Heat Demand and Hydrogen Production Utilizing Surplus Electricity.....	13-17
13.4	Considerations for a Carbon-neutral Approach Utilizing Surplus Electricity in Nepal ..	13-22
13.4.1	Potential for Heat and Green Hydrogen Production from Surplus Electricity ...	13-22
13.4.2	Comparison with Nepal's Primary Energy Consumption in 2022/23 .....	13-22
13.4.3	Comparison with Green Hydrogen Demand in Previous Studies .....	13-24
13.4.4	Considerations on the Utilization of Surplus Electricity in Nepal .....	13-24



## ANNEX 13 CONSIDERATIONS ON UTILIZATION OF SURPLUS ELECTRICITY

This chapter examines the feasibility of introducing CN (Carbon-Neutral) fuels, particularly green hydrogen produced from renewable energy, from the perspective of utilizing surplus electricity in Nepal's power development plans as a consideration for energy transition. First, the global trends on CN fuels in recent energy transitions are organized. Then, Nepal's legal system and previous research related to carbon neutrality are organized, extracting lessons from past initiatives and future policies. By organizing the possible supply output (MW) and electricity volume (GWh) of surplus electricity based on the results of power development plans, the potential for utilizing available electricity, heat, and hydrogen production is clarified. Based on these considerations, the utilization of surplus electricity in Nepal's energy transition is discussed.

### 13.1 THE ENERGY CHAIN FOCUSED ON GREEN HYDROGEN

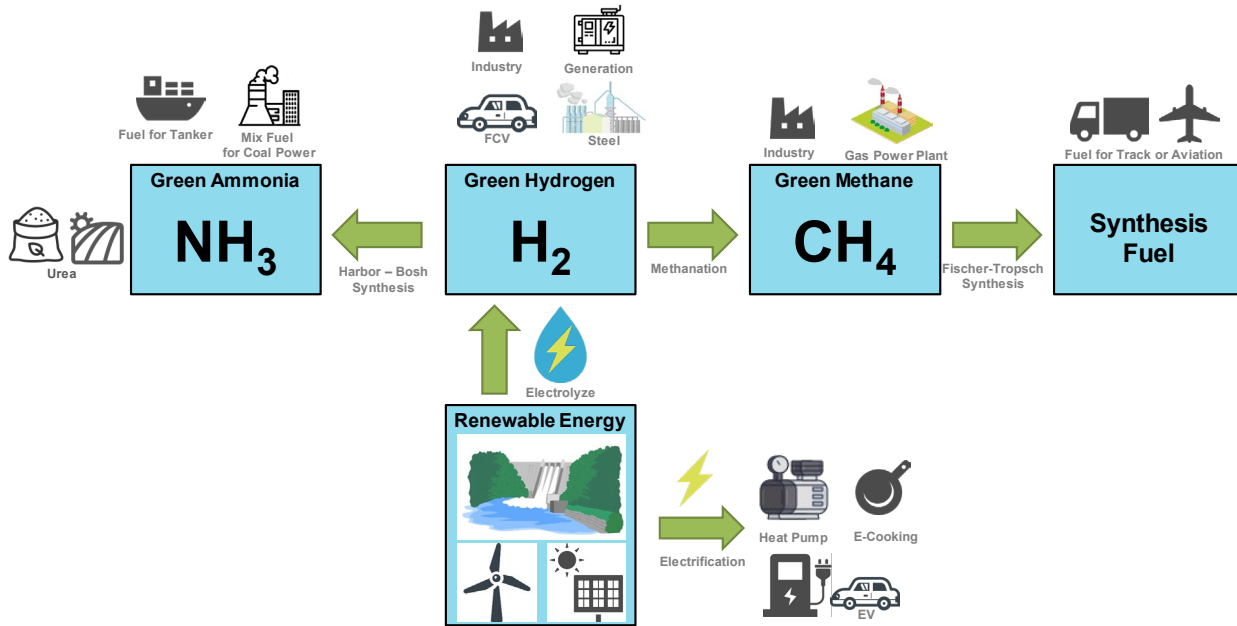
This section organizes the global trends in synthetic fuels including ammonia, methane, methanol, and e-fuels, which play an essential role in the energy chain focused on hydrogen as CN fuel.

Efforts towards climate change by countries around the world have accelerated since the carbon neutral declaration in 2020, leading to various analyses and examinations. Renewable energy and hydrogen are particularly considered as new sources of energy sources under climate change. Because renewable energy and hydrogen each have their challenges, synthetic fuels such as ammonia, methane, methylcyclohexane, and e-fuels are being considered as energy carriers. Their production methods and applications are organized in Table 13.1-1. Research, pilot trials, and new business regarding the energy chain around the green hydrogen continue worldwide, with the applicable scope of each CN fuel becoming clearer and generally settling into the relationship shown in Figure 13.1-1.

**Table 13.1-1 Renewable Energy and Carbon Neutral Fuel**

Item	Manufacturing Method	Application	Distribution Infrastructure
Electrification by Renewable Energy	Hydropower, Solar, Wind, Geothermal	EV, E-cooking, Heat pumps for heating demand	Power grid available, EV charging stations under development
Green Hydrogen	Water electrolysis powered by renewable energy sources	Ammonia, e-fuel precursor, FCV, usage in redox iron, various industrial uses	Not yet established
Green Ammonia	Synthesis Process using Green Hydrogen	Hydrogen carrier, Coal co-firing, Marine fuel, Fertilizer manufacturing	Existing infrastructure can be utilized
Green Methane & Methanol	Methanation using Green Hydrogen	Raw material for synthetic fuels, Application to general gas demand	Existing infrastructure can be utilized
Synthetic Fuels	Manufactured using the FT process with Green Methane	Fuel for buses, heavy machinery, airplanes, Application to general fuel demand	Existing infrastructure can be utilized

Source: JICA Study Team



Source: JICA Study Team

**Figure 13.1-1 Energy Chain surrounding Green Hydrogen**

Electrification, including renewable energy, can address the needs of EV (Electric Vehicle), household E-cooking, and heat demand (up to 120 degrees) through heat pumps. On the other hand, heavy-duty vehicles such as trucks, construction machinery, ships, and aircrafts are thought to be difficult to electrify. Various discussions are being held about carbon neutrality in these transportation sectors. Green hydrogen is considered technically feasible as an extension of current internal combustion engine technologies due to its high thermal efficiency. However, there are challenges such as distribution costs for storage and transport, related infrastructure development, and production costs of fuel cells.

In this context, green ammonia, green methane, and synthetic fuels are mentioned as energy carriers for hydrogen. Despite the high production costs of these fuels, they are already widely used in society, and the related infrastructure, technology, and legal systems have been established. Therefore, it is expected that these CN fuels will be utilized for demands that are difficult to meet with electrification and green hydrogen.

However, as of 2024, these CN fuels face commercial and technical challenges, and further technological innovation is needed to reach the practical stage. Under this recognition, it is important to implement technologies realized as of 2024 in the short term, to conduct pilot projects for future knowledge accumulation, to prepare the necessary legal systems and, in the medium to long term, to clarify and implement measures for each fuel anticipating future technological innovations.

## **13.2 INITIATIVES RELATED TO ENERGY TRANSITION IN NEPAL**

### **13.2.1 Green Hydrogen Policy**

Regarding the legal system related to energy transition in Nepal, although the EPR 2020 (Environmental Protection Rules 2020) and the National Climate Change Policy, 2020, formulated in 2020, mention green hydrogen, no policy with specific guidelines or strategies had been established. In February 2024, MoEWRI (Ministry of Energy, Water Resources and Irrigation) formulated the Green Hydrogen Policy, which outlines long-term guidelines and goals after organizing the situation surrounding green hydrogen in Nepal, stating five objectives and seven strategies to achieve them. This item presents an overview of the policy.

#### **(1) Background**

Hydrogen has long been considered the future of energy, and recent technological advancements have moved hydrogen production and consumption into a new phase. Among these, green hydrogen derived from renewable energy is expected to play a significant role in Nepal's efforts to achieve carbon neutrality in the international community.

Green hydrogen has the potential to make a significant contribution to clean energy production, with hydropower playing a central role in its production in Nepal. Hydropower has seasonal variations, especially generating surplus electricity during the rainy season, which can be utilized to reduce the use of fossil fuels in industries and transportation. Nepal, with its abundant hydropower potential, can aid in foreign currency earnings through the production of green hydrogen and its use in chemical fertilizers and other by-products. India, China, and the United States are already working on hydrogen production, creating future roadmaps, and advancing plans for independent hydrogen production and consumption.

Nepal relies almost entirely on imports for chemical fertilizers and petroleum products, posing a challenge of foreign currency outflow. As a countermeasure, it is important to formulate policies related to green hydrogen and advance its production and consumption. The cultivation of hydrogen-related industries requires more electricity usage, and an increase in supply through future power development by NEA (Nepal Electricity Authority) and IPP (Independent Power Producer) is expected.

#### **(2) The situation in Nepal**

Imports of petroleum products in Nepal account for 10% of the country's GDP (Gross Domestic Product) and 13% of the annual total trade deficit. Thus, the production and consumption of green hydrogen can substitute for the import of petroleum products, contributing to improved energy security. Similarly, the country's main industry, agriculture, relies on imports for essential chemical fertilizers, spending 21 billion NPR annually, necessitating countermeasures.

Nepal, with its rich hydropower potential, currently has development plans for about 20,000MW. Utilizing these hydropower resources for green hydrogen production to substitute for imports of petroleum products and chemical fertilizers is considered feasible. The production and consumption of green hydrogen are expected to substitute for coal, LPG (Liquefied Petroleum Gas) gas, and petroleum product imports, making the economy stronger, safer, and more self-reliant.

#### **(3) Challenges in Green Hydrogen Production and Consumption, and the Need for Policy**

The issues in the production and consumption of green hydrogen primarily include the high cost

of green hydrogen production, hydrogen consumption, the establishment of a safe and reliable supply infrastructure, legal systems including environmental measures, technology for storage facilities, and efforts to promote awareness and attract investment. The immediate challenge is considered to be the high cost of green hydrogen production, but it is necessary to be aware that foreign currency is flowing out for the import of petroleum products and chemical fertilizers. Therefore, the domestic utilization of domestically produced hydropower energy and the creation of new industries based on hydrogen energy are expected to contribute to Nepal's development and lead to job creation. This recognition underscores the need for policies related to green hydrogen production.

This policy is formulated for the production, storage, and consumption of green hydrogen, noting the need to establish regulatory bodies for effective project implementation, ensure the use of appropriate technologies, and prevent green hydrogen development from adversely affecting human life, property, and the environment.

#### (4) Overview of the Policy

The long-term vision, objectives, purposes, and strategies for achieving the Green Hydrogen Policy are organized in Table 13.2-1.

**Table 13.2-1 Outline of Green Hydrogen Policy**

Item	Contents
Long term vision	Economic prosperity by the use of green hydrogen that has been produced from the utilization of renewable energy sources where hydrogen is used alternative to existing energy sources that will help to achieve carbon neutral state with energy security and sustainable economic development.
Goal	To make country's economy viable, secured and independent by promoting the production and use hydrogen through renewable energy sources.
Objectives	<ol style="list-style-type: none"> <li>1. To minimize the effects of climate change by promoting the production and use of hydrogen that will be produced by renewable energy sources including hydropower.</li> <li>2. To create an economy that is carbon neutral and reduce dependency on petroleum products</li> <li>3. To make provision for the use and storage of green hydrogen and its sub products</li> <li>4. To promote industrialization inside country and production of chemical fertilizer by using green hydrogen and its sub products</li> <li>5. To promote research and studies for the commercial use of green hydrogen and its sub products</li> </ol>
Strategy	<ol style="list-style-type: none"> <li>i. Necessary law will be made for production of green hydrogen and its sub products</li> <li>ii. To make special provision in relevant laws to provide concession facility based on necessity and relevance to attract investment in industries that are based on green hydrogen and its sub-products.</li> <li>iii. To promote carbon trade by minimizing carbon emission from the use of green hydrogen and its sub products</li> <li>iv. To construct environment friendly infrastructure for the production, storage, transport and use of green hydrogen</li> <li>v. To establish and promote plant to produce chemical fertilizer by using green hydrogen and its sub products</li> <li>vi. To construct and promote relevant and necessary infrastructure necessary for the use of green hydrogen or its sub products</li> <li>vii. To promote research and studies for the use and application of green hydrogen and its sub products.</li> </ol>

Source: Prepared Based on Green Hydrogen Policy, MoEWRI

### 13.2.2 Summary of Existing Studies on Green Hydrogen in Nepal

Recent studies on the utilization of green hydrogen are organized in Table 13.2-2.

**Table 13.2-2 Studies and Research related to Green Hydrogen in Nepal**

Item	Agency	Year
Hydrogen and Sub-products Generation from Hydropower	Tribhuvan University and Western Michigan University	2009
Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower	Asian Development Bank	2021
Report on the Production and Use of Green Hydrogen in Nepal	WECS	2022
Expert Group Report on the Potential for Chemical Fertilizer Production Using Green Hydrogen in Nepal	MoEWRI	2022
Data collection survey for energy transition and carbon neutral society	JICA	2022
Green Hydrogen for Development in Nepal	Kathmandu University	2023

Source: Prepared Based on Green Hydrogen Policy, MoEWRI

This section organizes the findings from previous studies related to green hydrogen production in Nepal, specifically focusing on the initiatives towards the practical use of green hydrogen as outlined in "Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower, ADB" and "Green Hydrogen for Development in Nepal, Kathmandu University."

#### (1) Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower, ADB

ADB (Asian Development Bank) report examines scenarios for hydrogen production and consumption using Nepal's surplus electricity during the rainy season, targeting the year 2025. The report is composed of 10 chapters, summarizing IX. POTENTIALS OF "HYDROPOWER-TO-X" IN NEPAL and X. CONCLUDING REMARKS AND NEXT STEPS, which consider hydrogen production and demand in Nepal in 2025.

- I. INTRODUCTION
- II. ELECTRICITY SECTOR OF NEPAL
- III. ENERGY CONSUMPTION BY SECTOR
- IV. TRANSPORT SECTOR OF NEPAL
- V. HYDROGEN AS A POTENTIAL OPTION
- VI. POSSIBLE HYDROGEN PRODUCTION IN NEPAL
- VII. POTENTIAL HYDROGEN VALUE CHAIN IN NEPAL
- VIII. COST ANALYSIS OF HYDROGEN VALUE CHAIN
- IX. POTENTIALS OF "HYDROPOWER-TO-X" IN NEPAL
- X. CONCLUDING REMARKS AND NEXT STEPS

At the end of FY2019, Nepal's total installed capacity for hydropower was 1,113.48 MW, with an annual total generation of 4,738.16 GWh and a capacity factor of about 48%. Considering the White Paper issued by the GoN in 2018 and the current delays in progress, the total installed capacity for hydropower by 2025 is assumed to be 3 GW, and by 2030, 8 GW.

To forecast the surplus electricity available for hydrogen production, a comprehensive analysis based on the Power Development Plan is necessary. However, the objective of this study is to verify the feasibility of using hydrogen, exceeding the scope of consideration. Therefore, a simplified approach was adopted, utilizing literature related to output restrictions of existing

hydropower.

The model developed by existing research assumes capacity factors of 49% and 34% for hydropower plants under base case and high build case scenarios with output curtailment, respectively. The results without output curtailment were 62% and 61%.

This study defines scenarios assuming a capacity factor of 60% for hydropower plants from 2025 to 2030 without output curtailment and envisages scenarios with 20%, 30%, and 40% output curtailment. The content of the scenario settings is shown in Table 13.2-3.

**Table 13.2-3 Setting of the Scenarios between Curtail 20% - 40%**

	Variable	2025	2026	2027	2028	2029	2030
A	Total installed capacity (GW)	3	4	5	6	7	8
B	Capacity factor without curtailment (%)			60%			
C1	Curtailment—Scenario 1			20%			
C2	Curtailment—Scenario 2			30%			
C3	Curtailment—Scenario 3			40%			
D	Hydrogen production efficiency (kWh/kgH <sub>2</sub> )			50			
E1	Hydrogen production—Scenario 1 (MtH <sub>2</sub> )	0.06	0.08	0.11	0.13	0.15	0.17
E2	Hydrogen production—Scenario 2 (MtH <sub>2</sub> )	0.10	0.13	0.16	0.19	0.22	0.25
E3	Hydrogen production—Scenario 3 (MtH <sub>2</sub> )	0.13	0.17	0.21	0.25	0.29	0.34

GW = gigawatt, kgH<sub>2</sub> = kilogram of hydrogen, kWh = kilowatt hour, MtH<sub>2</sub> = million tons of hydrogen.

Source; Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower, ADB

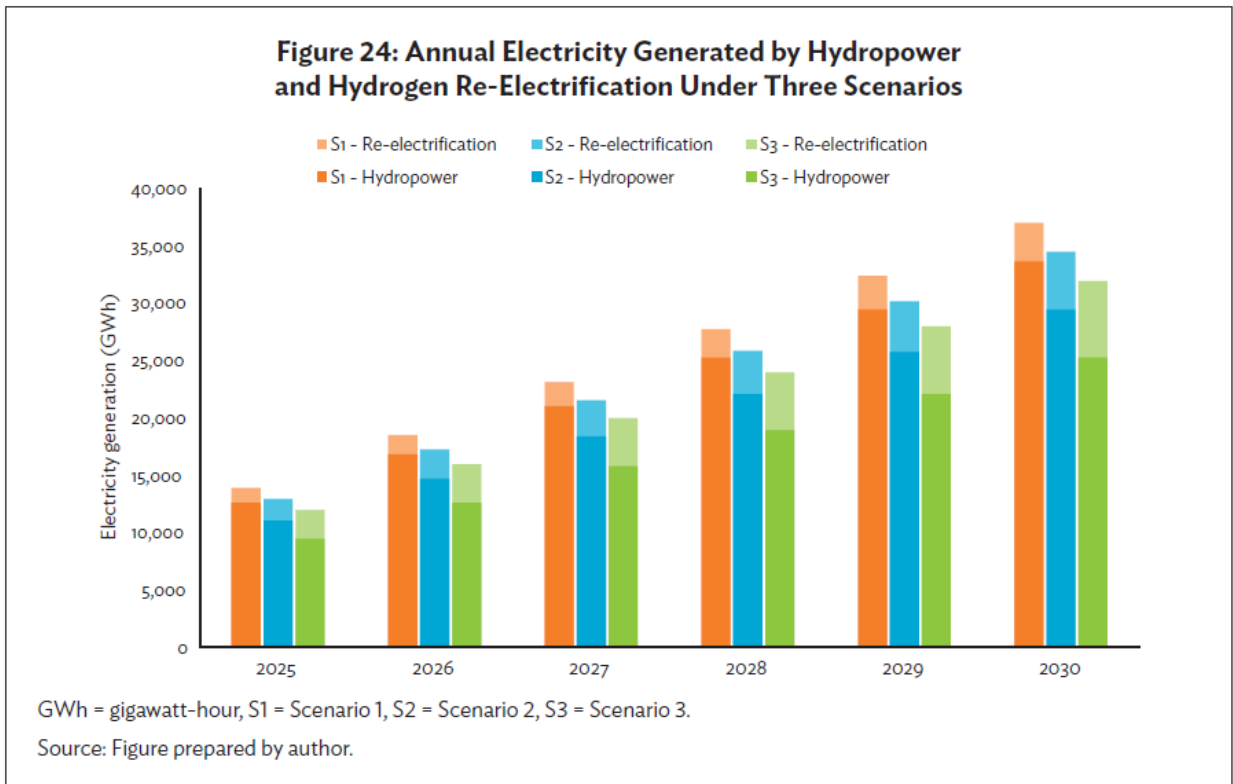
For each scenario, the amount of surplus hydropower available from 2025 to 2030 is calculated. Furthermore, the hydrogen production was estimated from the annual available surplus hydropower generation. This production efficiency is assumed to be 50 kWh/kgH<sub>2</sub> for 2025 and is assumed to be constant for simplicity.

The hydrogen produced annually from surplus generation is assumed to be utilized for power generation within the year through CCGT (Combined Cycle Gas Turbine) or fuel cells. As a result, the annual power generation from hydrogen was expected to range from 1,261 GWh to 3,364 GWh in Scenario 1 (20% suppression), and reach 5,000 GWh by 2028 in Scenario 3 (40% suppression). On the other hand, an increase in output curtailment in a specific year is associated with a decrease in hydropower generation. Scenario 2 produces 12.5% less than Scenario 1, and Scenario 3 produces 25% less than Scenario 1.

When using hydrogen produced through output curtailment for power generation during the dry season, it is estimated that in Scenario 3 by 2030, the electricity generated from hydrogen would correspond to about 20% of the power demand forecast. This suggests that "Hydropower to Power" has significant potential to produce a considerable amount of electricity and meet part of Nepal's power demand during the dry season.

The potential for "Hydropower to Mobility" is then discussed in this report. Hydrogen produced from surplus hydropower can be used as a fuel for FCV (Fuel Cell Vehicle). Previous studies have indicated that the fuel efficiency of FCVs is 0.01 kgH<sub>2</sub>/km for general vehicles and 0.08 kgH<sub>2</sub>/km for buses. According to official statistics from GoN (Government of Nepal), at the end of FY2018, there were a total of 154,433 vehicles and 12,617 buses in Nepal. Assuming an annual mileage of 15,000 km for cars and 30,000 km for buses, and hypothetically converting all vehicles and buses in Nepal to FCVs by 2025 and assuming they consume hydrogen, the total demand for hydrogen in 2025 would be about 0.053 MtH<sub>2</sub>, accounting for 84% of the total hydrogen available under Scenario 1.

While it is unclear when and to what extent hydrogen will be used as a vehicle fuel source in Nepal, it is considered rational and feasible to pursue the "Hydropower to Power" and "Hydropower to Mobility" pathways concurrently. The latter also aims to ensure a minimum demand for hydrogen.



Source: Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower, ADB

**Figure 13.2-1 Generation by Hydropower and Hydrogen Combustion in Three Scenarios**

## (2) Green Hydrogen for Development in Nepal

### 1) Report Summary

This report examines the methods of utilizing green hydrogen in Nepal, considering a wide range of applications including fertilizer production, domestic and industrial heating, power generation and supply stabilization, the transportation sector, and industrial use, based on concrete examples. The report also investigates the actual pilot plants and future commercialization of green ammonia and fertilizer production. These examination items are shown in Table 13.2-4.

**Table 13.2-4 Study Fields and Items on Green Hydrogen for Development in Nepal**

Field	Study Item
Chemical Process	Pilot Scale Production of Green Ammonia Pilot Scale Production of Green Urea
Clean cooking and Heating	Biogas Upgradation by Methanation Using Green Hydrogen Green Methane for the Energy Transition in Industrial Zones
Re-electrification Fuel	Cell CHP System for the Replacement of Diesel Generators Energy Storage System to Balance Wet to Dry Season Hydroelectricity Variation Hydrogen based Intelligent Power Management System (IPMS) for Maintaining Grid Quality and Reliability
Transportation	Hydrogen and Battery Hybrid System for Retrofitting Heavy-Duty Vehicles in Nepal Retrofitting of Safa Tempo with Hydrogen Fuel Cell System Installation of Hydrogen Refueling Stations for Vehicle Fleet
Industrial Process Applications	Production of Green Steel from the Local Iron Ore Piloting Green Hydrogen in The Cement Production Industry Decarbonizing Industrial Boilers: A Case Study of Kattha Factory

Source: Green Hydrogen for Development in Nepal, Kathmandu University

In Nepal, green hydrogen can be utilized to produce several derivatives such as ammonia, urea, and green methane. Green ammonia, manufactured from green hydrogen, can be used not only as a raw material for the chemical fertilizer urea but also as an energy carrier for long-term storage and as fuel for ships. Green methane or synthetic natural gas, produced using carbon dioxide captured from the cement industry and green hydrogen, can be used as a fuel for industrial applications, addressing high-temperature heat demand. Due to its high energy density of 140MJ/kg, green hydrogen also holds potential for seasonal energy storage and electricity backup applications.

By storing surplus electricity from the rainy season's hydropower in green hydrogen storage and power generators, it is possible to generate electricity during the dry season, facilitating inter-seasonal load balancing. Furthermore, fuel cell-based combined heat and power systems can be used to ensure continuous power supply to critical loads such as hospitals. In the transportation sector, green hydrogen can be utilized in vehicles with significant weight, such as trucks and large buses, where electrification is challenging, serving as an alternative to diesel fuel.

Green hydrogen is also applicable as an industrial raw material and for heat demand. In the steel industry, it can be used in reduction reactions as an industrial raw material, and in the cement industry, hydrogen can be used to meet the high-temperature heat demand for clinker production. The following introduces two pilot projects for the proposed use of green ammonia in Nepal.

## 2) Green ammonia production and urea production.

The environment surrounding ammonia in Nepal: Ammonia (NH<sub>3</sub>) is produced both naturally and synthetically from a combination of nitrogen (N<sub>2</sub>) and hydrogen (H<sub>2</sub>). The most common method for ammonia production is the Haber-Bosch process, which uses natural gas or coal gas, but green ammonia production involves hydrogen production through electrolysis units, nitrogen separation units, and ammonia synthesis loops. Ammonia accounts for about 2% of the world's final energy consumption, making it the second-largest chemical product by volume. The ammonia market was valued at \$67.01 billion in 2020, with an expected growth rate of 6.4% until 2028. Between 2000 and 2020, the market price for ammonia ranged from

\$100 to \$600 per ton, but in 2021, due to natural gas shortages, it exceeded \$1,000 per ton. Eighty percent of ammonia is used in agriculture as fertilizers such as urea and DAP. Recently, green ammonia has also gained attention as fuel for ships and as co-firing fuel for coal-fired power plants. Nepal lacks domestic ammonia production facilities to meet demand, and ammonia and chemical fertilizers are imported.

According to government statistics, the annual import volume of ammonia in the 2021/2022 fiscal year was a record high of 491.25 tons, totaling 24 million NPR (approximately \$390.8 per ton at 1 USD = 125 NPR). Urea was imported at 274 thousand tons for 13 billion NPR (\$379.6 per ton), and DAP at 155 thousand tons for 7 billion NPR (\$361.3 per ton). Fertilizer usage per hectare in Nepal is only 87 kg, less than half of neighboring agricultural countries such as India (175 kg), Bangladesh (319 kg), and Pakistan (156 kg). Nepal's reliance on fertilizer imports from neighboring countries results in shortages and delayed application times during the harvest season.

### 3) Pilot Project 1: Pilot Project for Green Ammonia Production

Pilot projects related to the utilization of green ammonia in Nepal: The projects aim to explore appropriate and sustainable business models and manufacturing scales for green ammonia in Nepal, utilizing domestic surplus electricity for green fertilizer production. These pilot projects are categorized into three stages as outlined in Table 13.2-5.

**Table 13.2-5 Three (3) Development Phases of the Pilot Project for Green Ammonia**

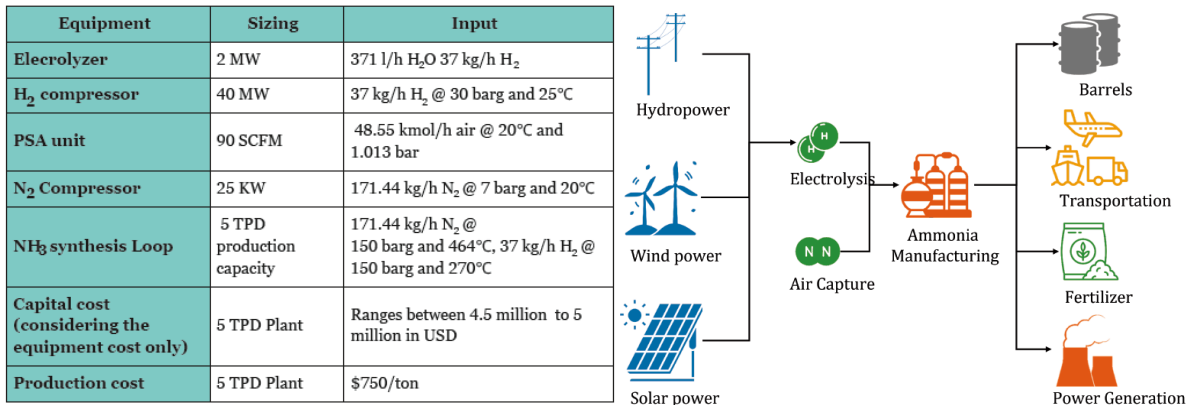
Phase	Contents
Phase 1: F/S	The first stage of the project, the technical and economic feasibility of producing green ammonia using surplus hydropower in Nepal was assessed. This study, supported by the NEA, analyzed factors such as hydropower resources, market demand, equipment specifications, and legal frameworks.
Phase 2: Commercialization	The focus shifts to the commercialization of green ammonia production in Nepal. This stage requires securing investments, necessary equipment, infrastructure development, and examining the production process. It may also include cooperation with local and international stakeholders such as investors, government agencies, equipment suppliers, and market partners to ensure the commercialization of the project.
Phase 3: Establishment of Pilot Project	The third stage of the project, envisages the implementation of pilot projects to demonstrate the feasibility and sustainability of the green ammonia production process in Nepal. These pilot projects are small-scale operations intended to validate the technical practice and economic viability of green ammonia production, taking into account the local market size and stakeholder involvement. Lessons learned from these pilot projects will be used to optimize the production process and provide feedback for scaling up to commercial production.

The most basic facilities for green ammonia production include the production of green hydrogen through an electrolyze and the production of nitrogen from the air. The latter is categorized into cryogenic air separation for large-scale production ( $\geq 500$  TPD N<sub>2</sub>) or pressure swing adsorption for small-scale production ( $\leq 500$  TPD N<sub>2</sub>) based on the manufacturing tons per day (TPD). The analysis was conducted under the following conditions:

- Plant life: 25 years
- Operational days per year: 330
- Electrolyze efficiency: 70%
- Electricity cost: 3 NPR (0.024 USD)/kWh [subsidized price]

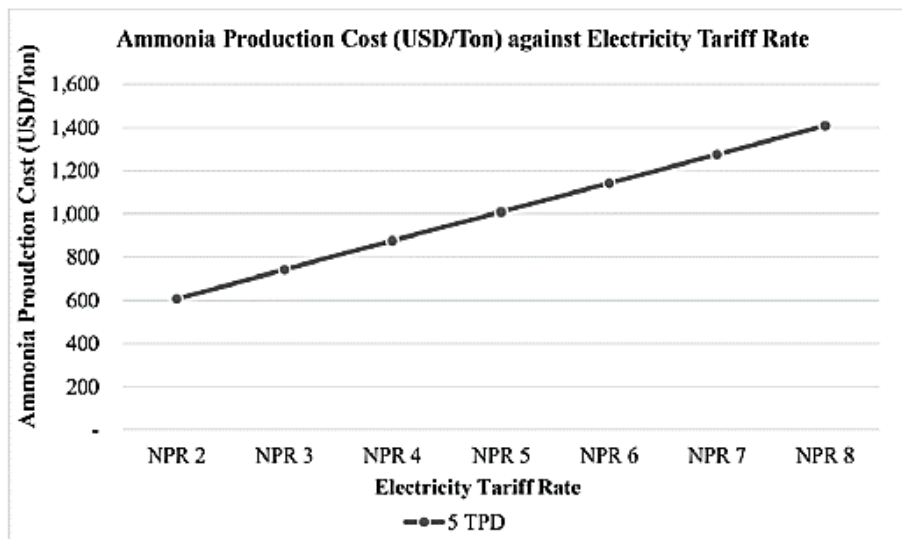
The effects of scale on production costs were significant, with the cost expected to decrease

from approximately \$750 at pilot plant scale to a maximum of \$500 for a 500 TPD plant. However, these scale benefits are assumed to be attainable up to about 1000 TPD.



Source: Green Hydrogen for Development in Nepal, Kathmandu University

**Figure 13.2-2 Image of Green Ammonia Production**



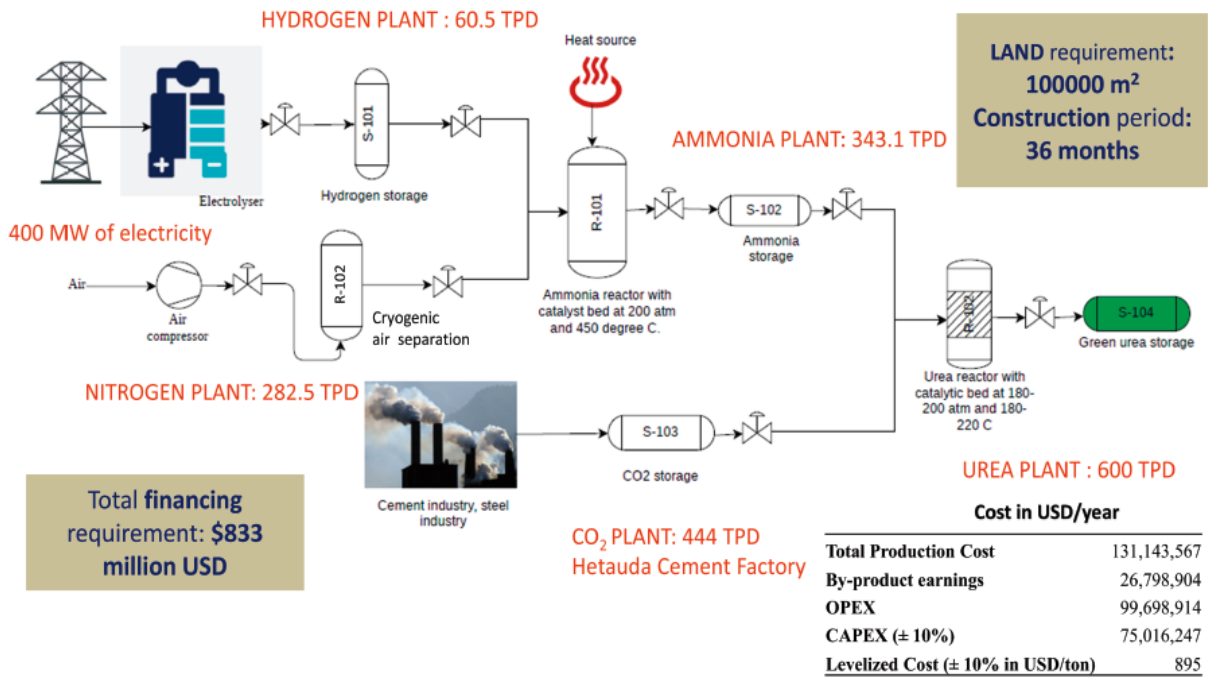
Source: Green Hydrogen for Development in Nepal, Kathmandu University

**Figure 13.2-3 Variation of Ammonia Production Cost by Electricity Tariff**

As previously mentioned, the pilot project was set to a scale of 5 TPD. The most significant parameter affecting price is the electricity cost, which nearly doubles the price of ammonia from 3 NPR/kWh to 8 NPR/kWh.

#### 4) Pilot Project 2: Chemical Fertilizer (Urea)

For the urea (chemical fertilizer) production feasibility study, an overview related to the urea manufacturing plant utilizing green ammonia in Bagmati province is presented below.



Source: Green Hydrogen for Development in Nepal, Kathmandu University

**Figure 13.2-4 Image of Urea Plant in Bagmati Province using Green Ammonia**

The plant, envisioned for construction in Hetauda, requires a land area of 100,000m<sup>2</sup> and is divided into units for electrolysis, air separation, ammonia synthesis, carbon capture, and urea synthesis and granulation, assuming a plant life of 25 years, 330 operational days per year, and a discount rate of 10%.

The daily production capacity is 600 TPD, allowing for an annual urea production of approximately 200,000 tons. The input power to the electrolyze is 400MW, and nitrogen production employs the cryogenic air separation method. The total project cost is estimated at 833 million USD with a construction period of 36 months. The cost of urea production per ton is 637 USD/ton at 3 NPR/kWh and 895 USD/ton at current electricity rates.

### 5) Considerations Regarding This Report

The production costs of green ammonia and fertilizer in the pilot project study are 750 USD/ton and 637 USD/ton, respectively (assuming an electricity price of 3 NPR/kWh). The import prices from abroad in the fiscal year 2021/2022 were 390.8 USD/ton and 361.3 USD/ton, respectively, with price differences of 1.92 times and 1.76 times. This study assumes an electricity price of 3 NPR/kWh for hydrogen production, which is cheaper compared to the wholesale electricity price of approximately 9.0 NPR/kWh for consumers. If the electricity price were 0 NPR/kWh, it is assumed that it would be at the same level as the import price from India. Therefore, judging from simple economics, the feasibility of the project as a business is considered low.

On the other hand, since ammonia and fertilizers rely on imports from India, it is necessary to consider not only economic factors but also quality, supply timing, and supply stability. The urea production volume of the Hetauda Urea Pilot Project is 200,000 tons per year, which is 73% of the urea import volume of 274,000 tons in 2021/2022. The power demand of the plant is assumed to be 400 MW, but considering the power demand of 11,500 MW and power development capacity of 32.2 GW in 2040, there is a possibility of utilizing it as an additional demand for policy consideration (Policy Intervention). The introduction feasibility of these

pilot projects is expected to be considered from a policy perspective, including economic viability and food security.

### 13.2.3 Lessons from Previous Initiatives and Considerations for the Future

#### (1) Lessons from Previous Initiatives

Past research and studies have explored the potential for hydrogen production in Nepal using multiple approaches. The lessons learned from these initiatives, considering the situation in Nepal as of February 2024, are organized below:

- The production of green hydrogen in Nepal is expected to leverage the country's abundant untapped hydropower, especially the surplus electricity during the rainy season that was subject to output curtailment.
- Possible applications for green hydrogen include the production of green ammonia, fuel cells in the transportation sector, thermal use in the industrial sector, and seasonal adjustment of electricity supply through hydrogen storage and generation. The possibility of manufacturing essential chemical fertilizers for the country's key industry, agriculture, is particularly anticipated.
- The costs for green ammonia and fertilizer production in pilot projects are estimated at \$750/ton and \$637/ton, respectively, assuming an electricity rate of 3 NPR/kWh. However, the import prices for these products in the fiscal year 2021/2022 were \$390.8/ton and \$361.3/ton, respectively, indicating a price gap.
- The significance of producing green hydrogen in Nepal includes not only achieving carbon neutrality but also improving energy and food security by reducing reliance on imported fossil fuels and fertilizers.
- Currently, the use of hydrogen in Nepal is limited, necessitating the need to stimulate demand. Moreover, a complete supply chain from infrastructure development for hydrogen production to distribution needs to be established.
- A systematic legal framework encompassing hydrogen storage, transport, business licensing, and retail is lacking. In particular, establishing rules for the technically challenging aspects of storage and transport is crucial for commercialization.

#### (2) Considerations for Future Energy Transition

Based on the lessons learned from previous initiatives, two key considerations for the energy transition are outlined:

- 1) The change in added value of surplus electricity during the rainy season.
- 2) The available output (MW) and the electricity generation (GWh).

##### 1) Change in the Added Value of Surplus Electricity during the Rainy Season

Although the lessons mentioned in the previous section are assumed to remain key points of focus going forward, it's important to recognize that the premise regarding the utilization of surplus electricity during the rainy season has significantly changed as of 2024. Initially, the surplus electricity during the rainy season, explored in studies prior to 2022, was not guaranteed for export to India, and considerations were made for handling this surplus through

output curtailment. Hence, the utilization of green hydrogen focused on how to utilize this surplus electricity, which, under the assumption, had no wholesale buyers and was considered low-value electricity.

However, with the cooperation between the governments of Nepal and India, avenues for exporting electricity to India and Bangladesh during the rainy season are opening, and from 2022 to 2023, NEA has been profiting from electricity exports. Thus, the surplus electricity during the rainy season, previously considered of low value, has started to generate value, albeit market-dependent, for exports to India at 6 – 8 cents/kWh. This development suggests a need to reconsider the narrative of utilizing surplus electricity without buyers during the rainy season.

Specifically, it's necessary to evaluate the economics of green hydrogen production, which previously assumed electricity costs to be of no value or cheap, compared to the export rates to India of 6 – 8 cents/kWh. If the electricity cost is to be kept low, it essentially represents a form of subsidy by setting the value obtained lower than potential.

It is also crucial to understand that this value exchange is merely a transfer of goods within Nepal and does not diminish the economic value of the country as a whole. Nepal's reliance on imports from India for fossil fuels and chemical fertilizers represented a transfer of goods that led to an outflow of foreign currency. However, the domestic production and consumption of green hydrogen would be a local transaction, potentially preventing foreign currency outflow and contributing to enhanced security. It's important to note that the manufacturing of green hydrogen should be evaluated not only for its financial viability but also for its contribution to economic value in terms of enhancing security.

## **2) Available Output (MW) and Electricity Generation (GWh)**

The consideration of surplus electricity in past studies was not based on the power development plan, and thus, the seasonal availability of power (MW) and electricity generation (GWh) were not taken into account. These pieces of information are crucial input conditions for assuming the scale and operation rate of hydrogen production plants. IPSDP (Integrated Power System Development Plan) also organizes the foundation data for considering green hydrogen, making it possible to examine the available surplus electricity on a monthly and annual basis.

### 13.3 ESTIMATION OF SURPLUS ELECTRICITY UP TO 2040

This section estimates the monthly available surplus power (MW) and electricity generation (GWh) up to 2040, based on the results of the power development plan analysis from Chapter 7. The surplus electricity is accounted for by subtracting domestic demand (GWh) from the total generated electricity (GWh).

As the methods for utilizing surplus electricity, such as electricity export and electrification, vary in demand each month, supply must be adjusted according to demand. While green hydrogen can also be stored, its production quantity depends on the supply capacity of surplus electricity. However, as is known, Nepal mainly relies on hydropower, leading to a significant difference between the dry and rainy seasons. According to the power development plan results, the total electricity generated during the dry season tends to drop to about one-third of that during the rainy season, leading to an even smaller surplus. Therefore, when considering the utilization of surplus electricity, it is important to estimate the base supply available throughout the year and the peak outputs and electricity quantities focused on the rainy season.

The forecast of surplus electricity will serve as foundational information for future considerations of electricity export, electrification, and CN fuels centered on green hydrogen. Specifically, in green hydrogen production, the electricity cost constitutes a significant portion of the expenses. Additionally, the capacity (MW) and operational rate (%) of water electrolysis plants have a considerable impact on the costs. The operational rate is calculated based on the relationship between capacity (MW) and the amount of electricity supplied (GWh), making the available surplus electricity's output (MW) and quantity (GWh) crucial for evaluating the manufacturing cost of green hydrogen.

#### 13.3.1 Estimation of Surplus Electricity

##### (1) Monthly Average Available Output and Electricity Generation

Table 13.3-1 shows the average available output (MW) and electricity generation (GWh) for each month, calculated based on the performance data from 2022 and 2023, as well as the results of the power development plan. This average available output assumes a 24-hour supply capability, with the potential for increased output during peak operation.

Until 2028, surplus electricity will not occur during the dry season, as the supply capacity falls below domestic demand, necessitating electricity imports. From 2029 onwards, surplus electricity is generally expected to occur throughout the year, except in February. Between 2033 and 2036, surplus electricity is anticipated to be available throughout the year, achieving self-sufficiency in electricity. It should be noted that from 2037 onwards, minimal imports during the daytime peak in February will be the most cost-effective operation. From 2039 to 2040, due to limited hydropower development capacity compared to the growth in demand, surplus electricity will slightly decrease, but for the rest of the period, surplus electricity is expected to increase annually.

Until 2028, the difference between seasons regarding the surplus electricity will be almost exclusively limited to the rainy season, as no surplus electricity is generated during the dry season. From 2029 onwards, surplus electricity during the dry season will gradually increase, but compared to the rainy season, the electricity generation is very small. Even in 2033, when electricity self-sufficiency is achieved, the electricity generation in February (the lowest) is 232 GWh, and in March (the next lowest) is 1,030 GWh, whereas in August (the highest) it is 7,797 GWh, making the dry/rainy season ratio approximately 3.6% and 13.4%, respectively.

As mentioned, Nepal's reliance on hydropower results in a significant disparity in electricity

quantities between the dry and rainy seasons, with generation dropping to about one-third of the rainy season's output during the dry season. When estimating surplus electricity, domestic demand must be further subtracted from this figure, resulting in an available electricity generation in the dry season that is only a few percent to just over 10% of that during the rainy season.

**Table 13.3-1 Monthly Available Surplus Output (MW) and Power Generation (GWh) until 2040**

Year	Item	1	2	3	4	5	6	7	8	9	10	11	12	Total
2022	Exp. (GWh)	0	0	0	0	91	207	210	202	164	122	1	1	999
	Imp. (GWh)	-514	-674	-520	-322	0	0	0	0	0	0	-249	-374	-2,654
	Cap. (MW)	0	0	0	0	125	284	288	277	224	167	1	1	-
2023	Exp. (GWh)	0	0	0	5	386	568	571	559	517	438	1	1	3,047
	Imp. (GWh)	-456	-643	-461	-189	0	0	0	0	0	0	-71	-260	-2,080
	Cap. (MW)	0	0	0	7	529	778	782	766	708	600	2	2	-
2024	Exp. (GWh)	0	0	0	15	550	770	789	774	728	634	5	5	4,270
	Imp. (GWh)	-462	-673	-463	-143	0	0	0	0	0	0	0	-234	-1,976
	Cap. (MW)	0	0	0	20	753	1,055	1,081	1,061	998	869	6	6	-
2025	Exp. (GWh)	2	0	9	186	1,104	1,509	1,518	1,591	1,525	1,376	468	98	9,385
	Imp. (GWh)	-241	-491	-243	0	0	0	0	0	0	0	0	0	-975
	Cap. (MW)	3	0	13	254	1,512	2,067	2,079	2,179	2,088	1,885	641	135	-
2026	Exp. (GWh)	0	0	0	209	1,290	1,767	1,762	1,826	1,757	1,570	481	58	10,719
	Imp. (GWh)	-306	-623	-301	0	0	0	0	0	0	0	0	0	-1,229
	Cap. (MW)	0	0	0	286	1,767	2,421	2,413	2,501	2,407	2,151	659	80	-
2027	Exp. (GWh)	0	0	0	370	1,586	2,118	2,118	2,187	2,107	1,877	651	176	13,190
	Imp. (GWh)	-226	-588	-195	0	0	0	0	0	0	0	0	0	-1,009
	Cap. (MW)	0	0	0	507	2,172	2,902	2,902	2,995	2,886	2,571	892	242	-
2028	Exp. (GWh)	142	0	4	589	2,051	2,912	2,930	3,001	2,892	2,657	1,124	484	18,786
	Imp. (GWh)	-143	-443	0	0	0	0	0	0	0	0	0	0	-586
	Cap. (MW)	195	0	5	807	2,810	3,989	4,013	4,111	3,961	3,639	1,540	664	-
2029	Exp. (GWh)	83	0	74	771	2,485	3,462	3,472	3,548	3,422	3,131	1,421	645	22,514
	Imp. (GWh)	0	-418	0	0	0	0	0	0	0	0	0	0	-418
	Cap. (MW)	114	0	101	1,056	3,403	4,743	4,756	4,861	4,688	4,289	1,947	884	-
2030	Exp. (GWh)	187	0	181	962	2,892	3,836	3,864	4,157	4,050	3,662	1,642	818	26,252
	Imp. (GWh)	0	-394	0	0	0	0	0	0	0	0	0	0	-394
	Cap. (MW)	257	0	248	1,318	3,961	5,255	5,293	5,695	5,548	5,016	2,250	1,121	-
2031	Exp. (GWh)	629	201	588	1,486	3,884	5,134	5,203	5,808	5,724	5,119	2,530	1,412	37,720
	Imp. (GWh)	0	-255	0	0	0	0	0	0	0	0	0	0	-255
	Cap. (MW)	862	276	806	2,036	5,320	7,033	7,127	7,956	7,841	7,013	3,466	1,934	-
2032	Exp. (GWh)	641	122	601	1,528	4,042	5,277	5,351	6,068	6,004	5,339	2,562	1,471	39,006
	Imp. (GWh)	0	-229	0	0	0	0	0	0	0	0	0	0	-229
	Cap. (MW)	878	167	823	2,093	5,537	7,229	7,331	8,312	8,225	7,314	3,510	2,015	-
2033	Exp. (GWh)	1,062	232	1,030	2,075	4,922	6,373	6,503	7,710	7,797	6,678	3,184	1,981	49,547
	Imp. (GWh)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cap. (MW)	1,455	318	1,411	2,843	6,742	8,730	8,908	10,562	10,681	9,148	4,361	2,714	-
2034	Exp. (GWh)	1,115	230	1,111	2,265	5,285	6,593	6,746	8,259	8,343	7,155	3,320	2,089	52,510
	Imp. (GWh)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cap. (MW)	1,528	314	1,521	3,103	7,239	9,031	9,242	11,313	11,429	9,802	4,548	2,861	-
2035	Exp. (GWh)	1,168	213	1,170	2,392	5,563	6,793	6,968	8,815	8,972	7,545	3,444	2,189	55,233
	Imp. (GWh)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cap. (MW)	1,600	292	1,603	3,276	7,620	9,305	9,546	12,076	12,291	10,336	4,718	2,999	-
2036	Exp. (GWh)	1,108	93	1,124	2,386	5,626	6,665	6,866	9,123	9,388	7,694	3,363	2,163	55,599
	Imp. (GWh)	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cap. (MW)	1,518	127	1,540	3,269	7,707	9,131	9,405	12,497	12,860	10,539	4,607	2,963	-
2037	Exp. (GWh)	1,015	7	1,044	2,372	5,788	6,780	6,972	9,308	9,590	7,824	3,286	2,095	56,082
	Imp. (GWh)	0	-98	0	0	0	0	0	0	0	0	0	0	-98
	Cap. (MW)	1,391	10	1,430	3,249	7,929	9,288	9,551	12,751	13,137	10,718	4,501	2,870	-
2038	Exp. (GWh)	994	0	1,019	2,381	5,971	7,068	7,260	9,591	9,946	8,206	3,455	2,141	58,034
	Imp. (GWh)	0	-204	0	0	0	0	0	0	0	0	0	0	-204
	Cap. (MW)	1,362	0	1,395	3,261	8,180	9,683	9,945	13,139	13,625	11,241	4,733	2,933	-
2039	Exp. (GWh)	999	0	1,007	2,420	6,360	7,747	7,948	10,268	10,592	8,907	3,703	2,255	62,205
	Imp. (GWh)	0	-313	0	0	0	0	0	0	0	0	0	0	-313
	Cap. (MW)	1,368	0	1,380	3,315	8,712	10,612	10,887	14,066	14,510	12,201	5,072	3,089	-
2040	Exp. (GWh)	844	23	874	2,354	6,365	7,403	7,640	10,638	11,147	9,016	3,496	2,142	61,943
	Imp. (GWh)	0	-573	0	0	0	0	0	0	0	0	0	0	-573
	Cap. (MW)	1,156	32	1,197	3,225	8,719	10,141	10,466	14,573	15,269	12,351	4,789	2,934	-

Source: Prepared by the JICA Study Team

## (2) Utilization of Surplus Electricity Based on Output and Electricity Generation

Based on the estimation results of surplus electricity supply in the previous section, this part discusses the utilization policy based on output and electricity generation. The results from Table 12.3-1 can be categorized into the following two options:

Option 1: Electricity that can be supplied as a base throughout the year, tailored to the dry season

Option 2: Electricity matching the peak during the rainy season

Here, the output and electricity generation for Option 1 (Base), Option 2 (Peak), and the total up to 2040 are calculated. The average possible output for Option 1 is based on March, as the output in February, being the lowest, results in a very low value. Option 2 assumes that all surplus electricity is utilized. The total is accounted for by adding Option 1 and Option 2. These estimated results are shown in Table 13.3-2.

**Table 13.3-2 Available Output (MW) and Power Generation (GWh) in Base and Peak**

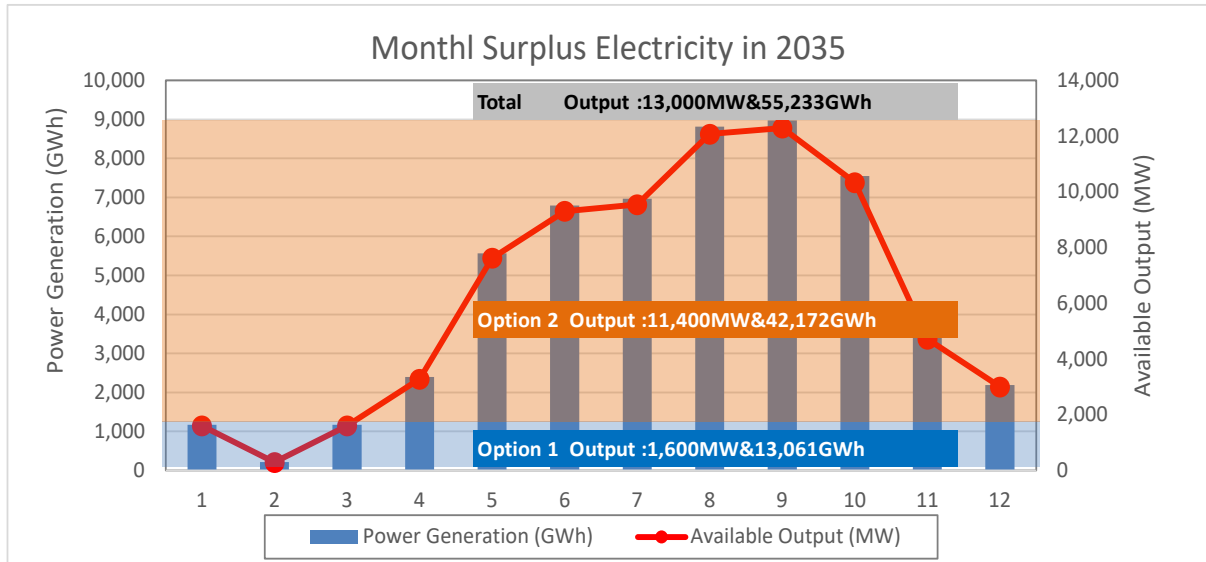
Year	Option	Output (MW)	Surplus Generation (GWh)												Total	Usage Factor (%)		
			1	2	3	4	5	6	7	8	9	10	11	12				
2022	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	1,000	0	0	0	0	91	207	210	202	164	122	1	1	1	1	999	11.4%
	Total	1,000	0	0	0	0	91	207	210	202	164	122	1	1	1	1	999	11.4%
2023	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	1,000	0	0	0	5	386	568	571	559	517	438	1	1	1	1	3,047	34.8%
	Total	1,000	0	0	0	5	386	568	571	559	517	438	1	1	1	1	3,047	34.8%
2024	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	2,000	0	0	0	15	550	770	789	774	728	634	5	5	5	5	4,270	24.4%
	Total	2,000	0	0	0	15	550	770	789	774	728	634	5	5	5	5	4,270	24.4%
2025	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	3,000	2	0	9	186	1,104	1,509	1,518	1,591	1,525	1,376	468	98	98	98	9,385	35.7%
	Total	3,000	2	0	9	186	1,104	1,509	1,518	1,591	1,525	1,376	468	98	98	98	9,385	35.7%
2026	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	3,000	0	0	0	209	1,290	1,767	1,762	1,826	1,757	1,570	481	58	58	58	10,719	40.8%
	Total	3,000	0	0	0	209	1,290	1,767	1,762	1,826	1,757	1,570	481	58	58	58	10,719	40.8%
2027	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	3,000	0	0	0	370	1,586	2,118	2,118	2,187	2,107	1,877	651	176	176	176	13,190	50.2%
	Total	3,000	0	0	0	370	1,586	2,118	2,118	2,187	2,107	1,877	651	176	176	176	13,190	50.2%
2028	Option 1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	#DIV/0!
	Option 2	5,000	142	0	4	589	2,051	2,912	2,930	3,001	2,892	2,657	1,124	484	484	484	18,786	42.9%
	Total	5,000	142	0	4	589	2,051	2,912	2,930	3,001	2,892	2,657	1,124	484	484	484	18,786	42.9%
2029	Option 1	100	73	0	73	73	73	73	73	73	73	73	73	73	73	73	803	91.7%
	Option 2	4,900	10	0	1	698	2,412	3,389	3,399	3,475	3,349	3,058	1,348	572	572	572	21,711	50.6%
	Total	5,000	83	0	74	771	2,485	3,462	3,472	3,548	3,422	3,131	1,421	645	645	645	22,514	51.4%
2030	Option 1	200	146	0	146	146	146	146	146	146	146	146	146	146	146	146	1,606	91.7%
	Option 2	5,800	41	0	35	816	2,746	3,690	3,718	4,011	3,904	3,516	1,496	672	672	672	24,646	48.5%
	Total	6,000	187	0	181	962	2,892	3,836	3,864	4,157	4,050	3,662	1,642	818	818	818	26,252	49.9%
2031	Option 1	800	584	201	584	584	584	584	584	584	584	584	584	584	584	584	6,625	94.5%
	Option 2	7,200	45	0	4	902	3,300	4,550	4,619	5,224	5,140	4,535	1,946	828	828	828	31,094	49.3%
	Total	8,000	629	201	588	1,486	3,884	5,134	5,203	5,808	5,724	5,119	2,530	1,412	1,412	1,412	37,720	53.8%
2032	Option 1	800	584	122	584	584	584	584	584	584	584	584	584	584	584	584	6,546	93.4%
	Option 2	8,200	57	0	17	944	3,458	4,693	4,767	5,484	5,420	4,755	1,978	887	887	887	32,460	45.2%
	Total	9,000	641	122	601	1,528	4,042	5,277	5,351	6,068	6,004	5,339	2,562	1,471	1,471	1,471	39,006	49.5%
2033	Option 1	1,400	1,022	232	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	11,474	93.6%
	Option 2	9,600	40	0	8	1,053	3,900	5,351	5,481	6,688	6,775	5,656	2,162	959	959	959	38,073	45.3%
	Total	11,000	1,062	232	1,030	2,075	4,922	6,373	6,503	7,710	7,797	6,678	3,184	1,981	1,981	1,981	49,547	51.4%
2034	Option 1	1,500	1,095	230	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	12,275	93.4%
	Option 2	10,500	20	0	16	1,170	4,190	5,498	5,651	7,164	7,248	6,060	2,225	994	994	994	40,236	43.7%
	Total	12,000	1,115	230	1,111	2,265	5,285	6,593	6,746	8,259	8,343	7,155	3,320	2,089	2,089	2,089	52,510	50.0%
2035	Option 1	1,600	1,168	213	1,168	1,168	1,168	1,168	1,168	1,168	1,168	1,168	1,168	1,168	1,168	1,168	13,061	93.2%
	Option 2	11,400	0	0	2	1,224	4,395	5,625	5,800	7,647	7,804	6,377	2,276	1,021	1,021	1,021	42,172	42.2%
	Total	13,000	1,168	213	1,170	2,392	5,563	6,793	6,968	8,815	8,972	7,545	3,444	2,189	2,189	2,189	55,233	48.5%
2036	Option 1	1,500	1,095	93	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	1,095	12,138	92.4%
	Option 2	11,500	13	0	29	1,291	4,531	5,570	5,771	8,028	8,293	6,599	2,268	1,068	1,068	1,068	43,462	43.1%
	Total	13,000	1,108	93	1,124	2,386	5,626	6,665	6,866	9,123	9,388	7,694	3,363	2,163	2,163	2,163	55,599	48.8%
2037	Option 1	1,400	1,015	7	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	11,243	91.7%
	Option 2	12,600	0	0	22	1,350	4,766	5,758	5,950	8,286	8,568	6,802	2,264	1,073	1,073	1,073	44,840	40.6%
	Total	14,000	1,015	7	1,044	2,372	5,788	6,780	6,972	9,308	9,590	7,824	3,286	2,095	2,095	2,095	56,082	45.7%
2038	Option 1	1,400	994	0	1,019	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	11,211	91.4%
	Option 2	12,600	0	0	0	1,359	4,949	6,046	6,238	8,569	8,924	7,184	2,433	1,119	1,119	1,119	46,823	42.4%
	Total	14,000	994	0	1,019	2,381	5,971	7,068	7,260	9,591	9,946	8,206	3,455	2,141	2,141	2,141	58,034	47.3%
2039	Option 1	1,400	999	0	1,007	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	1,022	11,204	91.4%
	Option 2	13,600	0	0	0	1,398	5,338	6,725	6,926	9,246	9,570	7,885	2,681	1,233	1,233	1,233	51,001	42.8%
	Total	15,000	999	0	1,007	2,420	6,360	7,747	7,948	10,268	10,592	8,907	3,703	2,255	2,255	2,255	62,205	47.3%
2040	Option 1	1,200	844	23	874	876	876	876	876	876	876	876	876	876	876	876	9,625	91.6%
	Option 2	14,800	0	0	0	1,478	5,489	6,527	6,764	9,762	10,271	8,140	2,620	1,266	1,266	1,266	52,318	40.4%
	Total	16,000	844	23	874	2,354	6,365	7,403	7,640	10,638	11,147	9,016	3,496	2,142	2,142	2,142	61,943	44.2%

Source: Prepared by the JICA Study Team

For the base usage in Option 1, 100MW becomes available in 2029, 200MW in 2030, 800MW from 2031 to 2032, and then fluctuates between 1,200MW and 1,600MW from 2033 onwards. For the peak usage in Option 2, the capacity gradually increases in line with hydropower development:

3,000MW in 2025, 5,800MW in 2030, 11,400MW in 2035, and 14,800MW in 2040.

A capacity setting example for 2035, the target year of the MoEWRI's energy development roadmap and work plan, is illustrated in Figure 13.3-1.



Source: Prepared by the JICA Study Team

**Figure 13.3-1 Example of Available Output and Generation in 2035**

For Option 1, the supply capability is 1,600MW with a surplus electricity generation of 13,061GWh, and for Option 2, the figures are 11,400MW and 42,172GWh, respectively. The total supply capacity is 13,000MW and 55,233GWh. The annual utilization rate for these surplus electricity is 93.2% for Option 1, 42.2% for Option 2, and 48.5% overall.

### (3) Considerations on the Utilization of Surplus Electricity

Considering the estimated results of surplus electricity, there are two suggested directions for its utilization: focusing on the base throughout the year and emphasizing the peak during the rainy season. As of 2024, all surplus electricity is utilized for electricity exports to India, which can be considered a strategy focusing on the peak as per Option 2. The production of green hydrogen, as shown in Nepal's previous initiatives, fundamentally aligns with this concept.

Once surplus electricity begins to emerge even during the dry season from 2029 onwards, its use as a base in Option 1 becomes feasible. In this case, options such as promoting new year-round electrification demands with heat pumps or stable green hydrogen production throughout the year become viable.

### 13.3.2 Potential for Heat Demand and Hydrogen Production Utilizing Surplus Electricity

This section discusses the conversion of the surplus electricity available until 2040 into heat demand (GJ) and hydrogen production (million Ton), examining the maximum amounts that can be produced and realistically supplied. The potentials are calculated under the following conditions:

- Heat potential and hydrogen production potential are calculated based on Table 13.3-2.
- Alkaline water electrolysis is assumed for the conversion from electricity to hydrogen, with a conversion efficiency of 52.40kWh/kg.

- The calorific value of hydrogen is based on the LHV (Lower Heating Value) standard at 120MJ/kg.
- The heat efficiency from electricity is set at 3600kJ/kWh.
- The heat potential (GJ), hydrogen production potential (million Ton), and heat potential converted to hydrogen for each month until 2040 are presented in Table 13.3-3, Table 13.3-4, and Table 13.3-5 respectively.

**Table 13.3-3 Conversion of Surplus Electricity to Heat Potential in Base and Peak (PJ)**

Year	Option	Output (MW)	Potential of Heat (GJ)												Total	
			1	2	3	4	5	6	7	8	9	10	11	12		
2022	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	1,000	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.8	0.7	0.6	0.4	0.0	0.0	3.6
	Total	1,000	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.8	0.7	0.6	0.4	0.0	0.0	3.6
2023	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	1,000	0.0	0.0	0.0	0.0	0.0	1.4	2.0	2.1	2.0	1.9	1.6	0.0	0.0	11.0
	Total	1,000	0.0	0.0	0.0	0.0	0.0	1.4	2.0	2.1	2.0	1.9	1.6	0.0	0.0	11.0
2024	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	2,000	0.0	0.0	0.0	0.1	2.0	2.8	2.8	2.8	2.6	2.3	0.0	0.0	0.0	15.4
	Total	2,000	0.0	0.0	0.0	0.1	2.0	2.8	2.8	2.8	2.6	2.3	0.0	0.0	0.0	15.4
2025	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.0	0.7	4.0	5.4	5.5	5.7	5.5	5.0	1.7	0.4	0.4	33.8
	Total	3,000	0.0	0.0	0.0	0.7	4.0	5.4	5.5	5.7	5.5	5.0	1.7	0.4	0.4	33.8
2026	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.0	0.8	4.6	6.4	6.3	6.6	6.3	5.7	1.7	0.2	0.2	38.6
	Total	3,000	0.0	0.0	0.0	0.8	4.6	6.4	6.3	6.6	6.3	5.7	1.7	0.2	0.2	38.6
2027	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.0	1.3	5.7	7.6	7.6	7.9	7.6	6.8	2.3	0.6	0.6	47.5
	Total	3,000	0.0	0.0	0.0	1.3	5.7	7.6	7.6	7.9	7.6	6.8	2.3	0.6	0.6	47.5
2028	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	5,000	0.5	0.0	0.0	2.1	7.4	10.5	10.5	10.8	10.4	9.6	4.0	1.7	1.7	67.6
	Total	5,000	0.5	0.0	0.0	2.1	7.4	10.5	10.5	10.8	10.4	9.6	4.0	1.7	1.7	67.6
2029	Option 1:	100	0.3	0.0	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	2.9
	Option 2:	4,900	0.0	0.0	0.0	2.5	8.7	12.2	12.2	12.5	12.1	11.0	4.9	2.1	2.1	78.2
	Total	5,000	0.3	0.0	0.3	2.8	8.9	12.5	12.5	12.8	12.3	11.3	5.1	2.3	2.3	81.1
2030	Option 1:	200	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	5.8
	Option 2:	5,800	0.1	0.0	0.1	2.9	9.9	13.3	13.4	14.4	14.1	12.7	5.4	2.4	2.4	88.7
	Total	6,000	0.7	0.0	0.7	3.5	10.4	13.8	13.9	15.0	14.6	13.2	5.9	2.9	2.9	94.5
2031	Option 1:	800	2.1	0.7	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	23.9
	Option 2:	7,200	0.2	0.0	0.0	3.2	11.9	16.4	16.6	18.8	18.5	16.3	7.0	3.0	3.0	111.9
	Total	8,000	2.3	0.7	2.1	5.4	14.0	18.5	18.7	20.9	20.6	18.4	9.1	5.1	5.1	135.8
2032	Option 1:	800	2.1	0.4	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	23.6
	Option 2:	8,200	0.2	0.0	0.1	3.4	12.4	16.9	17.2	19.7	19.5	17.1	7.1	3.2	3.2	116.9
	Total	9,000	2.3	0.4	2.2	5.5	14.6	19.0	19.3	21.8	21.6	19.2	9.2	5.3	5.3	140.4
2033	Option 1:	1,400	3.7	0.8	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	41.3
	Option 2:	9,600	0.1	0.0	0.0	3.8	14.0	19.3	19.7	24.1	24.4	20.4	7.8	3.5	3.5	137.1
	Total	11,000	3.8	0.8	3.7	7.5	17.7	22.9	23.4	27.8	28.1	24.0	11.5	7.1	7.1	178.4
2034	Option 1:	1,500	3.9	0.8	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	44.2
	Option 2:	10,500	0.1	0.0	0.1	4.2	15.1	19.8	20.3	25.8	26.1	21.8	8.0	3.6	3.6	144.8
	Total	12,000	4.0	0.8	4.0	8.2	19.0	23.7	24.3	29.7	30.0	25.8	12.0	7.5	7.5	189.0
2035	Option 1:	1,600	4.2	0.8	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	47.0
	Option 2:	11,400	0.0	0.0	0.0	4.4	15.8	20.2	20.9	27.5	28.1	23.0	8.2	3.7	3.7	151.8
	Total	13,000	4.2	0.8	4.2	8.6	20.0	24.5	25.1	31.7	32.3	27.2	12.4	7.9	7.9	198.8
2036	Option 1:	1,500	3.9	0.3	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	43.7
	Option 2:	11,500	0.0	0.0	0.1	4.6	16.3	20.1	20.8	28.9	29.9	23.8	8.2	3.8	3.8	156.5
	Total	13,000	4.0	0.3	4.0	8.6	20.3	24.0	24.7	32.8	33.8	27.7	12.1	7.8	7.8	200.2
2037	Option 1:	1,400	3.7	0.0	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	40.5
	Option 2:	12,600	0.0	0.0	0.1	4.9	17.2	20.7	21.4	29.8	30.8	24.5	8.1	3.9	3.9	161.4
	Total	14,000	3.7	0.0	3.8	8.5	20.8	24.4	25.1	33.5	34.5	28.2	11.8	7.5	7.5	201.9
2038	Option 1:	1,400	3.6	0.0	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	40.4
	Option 2:	12,600	0.0	0.0	0.0	4.9	17.8	21.8	22.5	30.9	32.1	25.9	8.8	4.0	4.0	168.6
	Total	14,000	3.6	0.0	3.7	8.6	21.5	25.4	26.1	34.5	35.8	29.5	12.4	7.7	7.7	208.9
2039	Option 1:	1,400	3.6	0.0	3.6	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	3.7	40.3
	Option 2:	13,600	0.0	0.0	0.0	5.0	19.2	24.2	24.9	33.3	34.5	28.4	9.7	4.4	4.4	183.6
	Total	15,000	3.6	0.0	3.6	8.7	22.9	27.9	28.6	37.0	38.1	32.1	13.3	8.1	8.1	223.9
2040	Option 1:	1,200	3.0	0.1	3.1	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	34.7
	Option 2:	14,800	0.0	0.0	0.0	5.3	19.8	23.5	24.4	35.1	37.0	29.3	9.4	4.6	4.6	188.3
	Total	16,000	3.0	0.1	3.1	8.5	22.9	26.7	27.5	38.3	40.1	32.5	12.6	7.7	7.7	223.0

Source: Prepared by the JICA Study Team

**Table 13.3-4 Conversion of Surplus Electricity to Hydrogen Potential in Base and Peak  
(Thousands Ton)**

Year	Option	Output (MW)	Potential of Hydrogen Production (Thousand Ton)												Total	
			1	2	3	4	5	6	7	8	9	10	11	12		
2022	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	1,000	0.0	0.0	0.0	0.0	0.0	1.8	4.1	4.2	4.0	3.3	2.4	0.0	0.0	20.0
	Total	1,000	0.0	0.0	0.0	0.0	0.0	1.8	4.1	4.2	4.0	3.3	2.4	0.0	0.0	20.0
2023	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	1,000	0.0	0.0	0.0	0.1	7.7	11.4	11.4	11.2	10.3	8.8	0.0	0.0	0.0	60.9
	Total	1,000	0.0	0.0	0.0	0.1	7.7	11.4	11.4	11.2	10.3	8.8	0.0	0.0	0.0	60.9
2024	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	2,000	0.0	0.0	0.0	0.3	11.0	15.4	15.8	15.5	14.6	12.7	0.1	0.1	0.1	85.4
	Total	2,000	0.0	0.0	0.0	0.3	11.0	15.4	15.8	15.5	14.6	12.7	0.1	0.1	0.1	85.4
2025	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.2	3.7	22.1	30.2	30.4	31.8	30.5	27.5	9.4	2.0	2.0	187.7
	Total	3,000	0.0	0.0	0.2	3.7	22.1	30.2	30.4	31.8	30.5	27.5	9.4	2.0	2.0	187.7
2026	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.0	4.2	25.8	35.3	35.2	36.5	35.1	31.4	9.6	1.2	1.2	214.4
	Total	3,000	0.0	0.0	0.0	4.2	25.8	35.3	35.2	36.5	35.1	31.4	9.6	1.2	1.2	214.4
2027	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	3,000	0.0	0.0	0.0	7.4	31.7	42.4	42.4	43.7	42.1	37.5	13.0	3.5	3.5	263.8
	Total	3,000	0.0	0.0	0.0	7.4	31.7	42.4	42.4	43.7	42.1	37.5	13.0	3.5	3.5	263.8
2028	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	5,000	2.8	0.0	0.1	11.8	41.0	58.2	58.6	60.0	57.8	53.1	22.5	9.7	9.7	375.7
	Total	5,000	2.8	0.0	0.1	11.8	41.0	58.2	58.6	60.0	57.8	53.1	22.5	9.7	9.7	375.7
2029	Option 1:	100	1.5	0.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	16.1
	Option 2:	4,900	0.2	0.0	0.0	14.0	48.2	67.8	68.0	69.5	67.0	61.2	27.0	11.4	11.4	434.2
	Total	5,000	1.7	0.0	1.5	15.4	49.7	69.2	69.4	71.0	68.4	62.6	28.4	12.9	12.9	450.3
2030	Option 1:	200	2.9	0.0	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	32.1
	Option 2:	5,800	0.8	0.0	0.7	16.3	54.9	73.8	74.4	80.2	78.1	70.3	29.9	13.4	13.4	492.9
	Total	6,000	3.7	0.0	3.6	19.2	57.8	76.7	77.3	83.1	81.0	73.2	32.8	16.4	16.4	525.0
2031	Option 1:	800	11.7	4.0	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	132.5
	Option 2:	7,200	0.9	0.0	0.1	18.0	66.0	91.0	92.4	104.5	102.8	90.7	38.9	16.6	16.6	621.9
	Total	8,000	12.6	4.0	11.8	29.7	77.7	102.7	104.1	116.2	114.5	102.4	50.6	28.2	28.2	754.4
2032	Option 1:	800	11.7	2.4	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	11.7	130.9
	Option 2:	8,200	1.1	0.0	0.3	18.9	69.2	93.9	95.3	109.7	108.4	95.1	39.6	17.7	17.7	649.2
	Total	9,000	12.8	2.4	12.0	30.6	80.8	105.5	107.0	121.4	120.1	106.8	51.2	29.4	29.4	780.1
2033	Option 1:	1,400	20.4	4.6	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	229.5
	Option 2:	9,600	0.8	0.0	0.2	21.1	78.0	107.0	109.6	133.8	135.5	113.1	43.2	19.2	19.2	761.5
	Total	11,000	21.2	4.6	20.6	41.5	98.4	127.5	130.1	154.2	155.9	133.6	63.7	39.6	39.6	990.9
2034	Option 1:	1,500	21.9	4.6	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	245.5
	Option 2:	10,500	0.4	0.0	0.3	23.4	83.8	110.0	113.0	143.3	145.0	121.2	44.5	19.9	19.9	804.7
	Total	12,000	22.3	4.6	22.2	45.3	105.7	131.9	134.9	165.2	166.9	143.1	66.4	41.8	41.8	1,050.2
2035	Option 1:	1,600	23.4	4.3	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	23.4	261.2
	Option 2:	11,400	0.0	0.0	0.0	24.5	87.9	112.5	116.0	152.9	156.1	127.5	45.5	20.4	20.4	843.4
	Total	13,000	23.4	4.3	23.4	47.8	111.3	135.9	139.4	176.3	179.4	150.9	68.9	43.8	43.8	1,104.7
2036	Option 1:	1,500	21.9	1.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9	242.8
	Option 2:	11,500	0.3	0.0	0.6	25.8	90.6	111.4	115.4	160.6	165.9	132.0	45.4	21.4	21.4	869.2
	Total	13,000	22.2	1.9	22.5	47.7	112.5	133.3	137.3	182.5	187.8	153.9	67.3	43.3	43.3	1,112.0
2037	Option 1:	1,400	20.3	0.1	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	224.9
	Option 2:	12,600	0.0	0.0	0.4	27.0	95.3	115.2	119.0	165.7	171.4	136.0	45.3	21.5	21.5	896.8
	Total	14,000	20.3	0.1	20.9	47.4	115.8	135.6	139.4	186.2	191.8	156.5	65.7	41.9	41.9	1,121.6
2038	Option 1:	1,400	19.9	0.0	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	224.2
	Option 2:	12,600	0.0	0.0	0.0	27.2	99.0	120.9	124.8	171.4	178.5	143.7	48.7	22.4	22.4	936.5
	Total	14,000	19.9	0.0	20.4	47.6	119.4	141.4	145.2	191.8	198.9	164.1	69.1	42.8	42.8	1,160.7
2039	Option 1:	1,400	20.0	0.0	20.1	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.4	224.1
	Option 2:	13,600	0.0	0.0	0.0	28.0	106.8	134.5	138.5	184.9	191.4	157.7	53.6	24.7	24.7	1,020.0
	Total	15,000	20.0	0.0	20.1	48.4	127.2	154.9	159.0	205.4	211.8	178.1	74.1	45.1	45.1	1,244.1
2040	Option 1:	1,200	16.9	0.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	192.5
	Option 2:	14,800	0.0	0.0	0.0	29.6	109.8	130.5	135.3	195.2	205.4	162.8	52.4	25.3	25.3	1,046.4
	Total	16,000	16.9	0.5	17.5	47.1	127.3	148.1	152.8	212.8	222.9	180.3	69.9	42.8	42.8	1,238.9

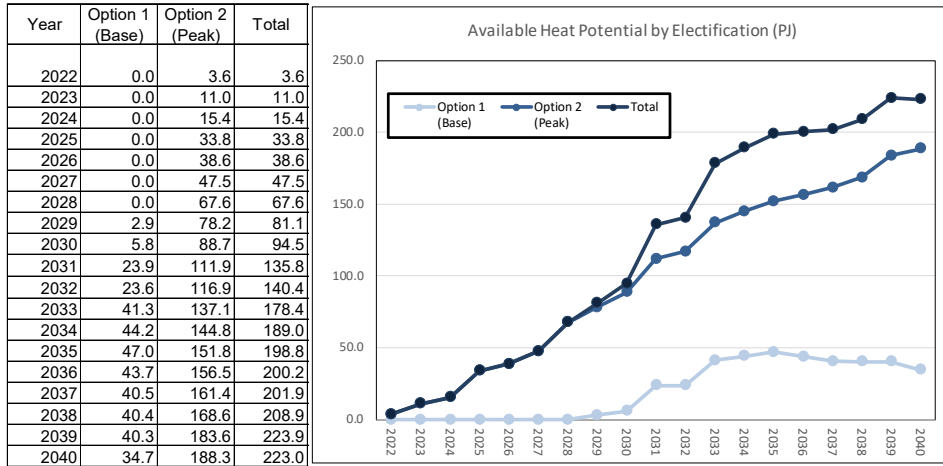
Source: Prepared by the JICA Study Team

**Table 13.3-5 Conversion of Surplus Electricity to Hydrogen Potential in Base and Peak (PJ)**

Year	Option	Output (MW)	Potential of Heat (GJ)												Total	
			1	2	3	4	5	6	7	8	9	10	11	12		
2022	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Option 2:	1,000	0.0	0.0	0.0	0.0	0.2	0.5	0.5	0.5	0.4	0.3	0.0	0.0	0.0	
	Total	1,000	0.0	0.0	0.0	0.0	0.2	0.5	0.5	0.5	0.4	0.3	0.0	0.0	0.0	
2023	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	1,000	0.0	0.0	0.0	0.0	0.9	1.4	1.4	1.3	1.2	1.1	0.0	0.0	0.0	
	Total	1,000	0.0	0.0	0.0	0.0	0.9	1.4	1.4	1.3	1.2	1.1	0.0	0.0	0.0	
2024	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	2,000	0.0	0.0	0.0	0.0	1.3	1.8	1.9	1.9	1.7	1.5	0.0	0.0	0.0	
	Total	2,000	0.0	0.0	0.0	0.0	1.3	1.8	1.9	1.9	1.7	1.5	0.0	0.0	0.0	
2025	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	3,000	0.0	0.0	0.0	0.4	2.6	3.6	3.6	3.8	3.7	3.3	1.1	0.2	22.5	
	Total	3,000	0.0	0.0	0.0	0.4	2.6	3.6	3.6	3.8	3.7	3.3	1.1	0.2	22.5	
2026	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	3,000	0.0	0.0	0.0	0.5	3.1	4.2	4.2	4.4	4.2	3.8	1.2	0.1	25.7	
	Total	3,000	0.0	0.0	0.0	0.5	3.1	4.2	4.2	4.4	4.2	3.8	1.2	0.1	25.7	
2027	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	3,000	0.0	0.0	0.0	0.9	3.8	5.1	5.1	5.2	5.1	4.5	1.6	0.4	31.7	
	Total	3,000	0.0	0.0	0.0	0.9	3.8	5.1	5.1	5.2	5.1	4.5	1.6	0.4	31.7	
2028	Option 1:	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Option 2:	5,000	0.3	0.0	0.0	1.4	4.9	7.0	7.0	7.2	6.9	6.4	2.7	1.2	45.1	
	Total	5,000	0.3	0.0	0.0	1.4	4.9	7.0	7.0	7.2	6.9	6.4	2.7	1.2	45.1	
2029	Option 1:	100	0.2	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	1.9	
	Option 2:	4,900	0.0	0.0	0.0	1.7	5.8	8.1	8.2	8.3	8.0	7.3	3.2	1.4	52.1	
	Total	5,000	0.2	0.0	0.2	1.9	6.0	8.3	8.3	8.5	8.2	7.5	3.4	1.5	54.0	
2030	Option 1:	200	0.4	0.0	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	3.9	
	Option 2:	5,800	0.1	0.0	0.1	2.0	6.6	8.9	8.9	9.6	9.4	8.4	3.6	1.6	59.2	
	Total	6,000	0.4	0.0	0.4	2.3	6.9	9.2	9.3	10.0	9.7	8.8	3.9	2.0	63.0	
2031	Option 1:	800	1.4	0.5	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	15.9	
	Option 2:	7,200	0.1	0.0	0.0	2.2	7.9	10.9	11.1	12.5	12.3	10.9	4.7	2.0	74.6	
	Total	8,000	1.5	0.5	1.4	3.6	9.3	12.3	12.5	13.9	13.7	12.3	6.1	3.4	90.5	
2032	Option 1:	800	1.4	0.3	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	15.7	
	Option 2:	8,200	0.1	0.0	0.0	2.3	8.3	11.3	11.4	13.2	13.0	11.4	4.7	2.1	77.9	
	Total	9,000	1.5	0.3	1.4	3.7	9.7	12.7	12.8	14.6	14.4	12.8	6.1	3.5	93.6	
2033	Option 1:	1,400	2.5	0.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	27.5	
	Option 2:	9,600	0.1	0.0	0.0	2.5	9.4	12.8	13.2	16.1	16.3	13.6	5.2	2.3	91.4	
	Total	11,000	2.5	0.6	2.5	5.0	11.8	15.3	15.6	18.5	18.7	16.0	7.6	4.8	118.9	
2034	Option 1:	1,500	2.6	0.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	29.5	
	Option 2:	10,500	0.0	0.0	0.0	2.8	10.1	13.2	13.6	17.2	17.4	14.5	5.3	2.4	96.6	
	Total	12,000	2.7	0.6	2.7	5.4	12.7	15.8	16.2	19.8	20.0	17.2	8.0	5.0	126.0	
2035	Option 1:	1,600	2.8	0.5	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	31.3	
	Option 2:	11,400	0.0	0.0	0.0	2.9	10.5	13.5	13.9	18.4	18.7	15.3	5.5	2.5	101.2	
	Total	13,000	2.8	0.5	2.8	5.7	13.4	16.3	16.7	21.2	21.5	18.1	8.3	5.3	132.6	
2036	Option 1:	1,500	2.6	0.2	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	29.1	
	Option 2:	11,500	0.0	0.0	0.1	3.1	10.9	13.4	13.8	19.3	19.9	15.8	5.4	2.6	104.3	
	Total	13,000	2.7	0.2	2.7	5.7	13.5	16.0	16.5	21.9	22.5	18.5	8.1	5.2	133.4	
2037	Option 1:	1,400	2.4	0.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	27.0	
	Option 2:	12,600	0.0	0.0	0.1	3.2	11.4	13.8	14.3	19.9	20.6	16.3	5.4	2.6	107.6	
	Total	14,000	2.4	0.0	2.5	5.7	13.9	16.3	16.7	22.3	23.0	18.8	7.9	5.0	134.6	
2038	Option 1:	1,400	2.4	0.0	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	26.9	
	Option 2:	12,600	0.0	0.0	0.0	3.3	11.9	14.5	15.0	20.6	21.4	17.2	5.8	2.7	112.4	
	Total	14,000	2.4	0.0	2.4	5.7	14.3	17.0	17.4	23.0	23.9	19.7	8.3	5.1	139.3	
2039	Option 1:	1,400	2.4	0.0	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	26.9	
	Option 2:	13,600	0.0	0.0	0.0	3.4	12.8	16.1	16.6	22.2	23.0	18.9	6.4	3.0	122.4	
	Total	15,000	2.4	0.0	2.4	5.8	15.3	18.6	19.1	24.6	25.4	21.4	8.9	5.4	149.3	
2040	Option 1:	1,200	2.0	0.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	23.1	
	Option 2:	14,800	0.0	0.0	0.0	3.5	13.2	15.7	16.2	23.4	24.6	19.5	6.3	3.0	125.6	
	Total	16,000	2.0	0.1	2.1	5.7	15.3	17.8	18.3	25.5	26.8	21.6	8.4	5.1	148.7	

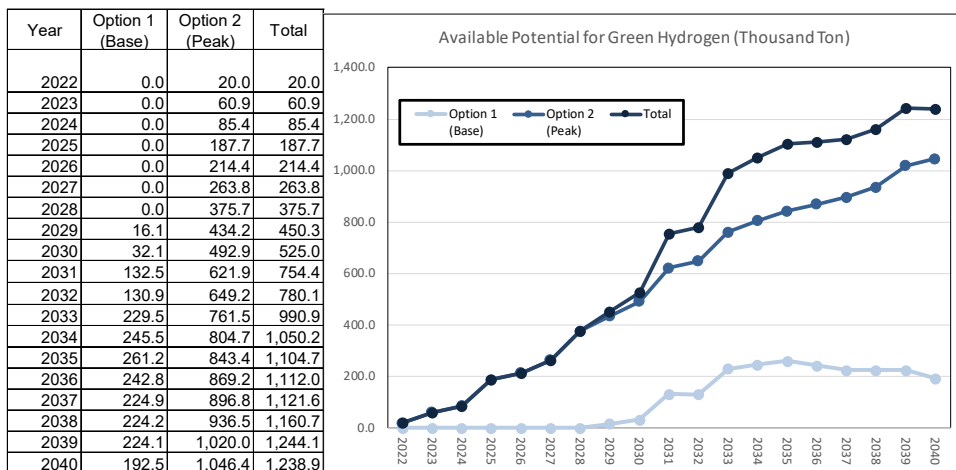
Source: Prepared by the JICA Study Team

Subsequently, the heat potential (GJ), hydrogen production potential (million Ton), and heat potential converted to hydrogen for each year until 2040 are illustrated in Figure 13.3-2, Figure 13.3-3, and Figure 13.3-4 respectively.



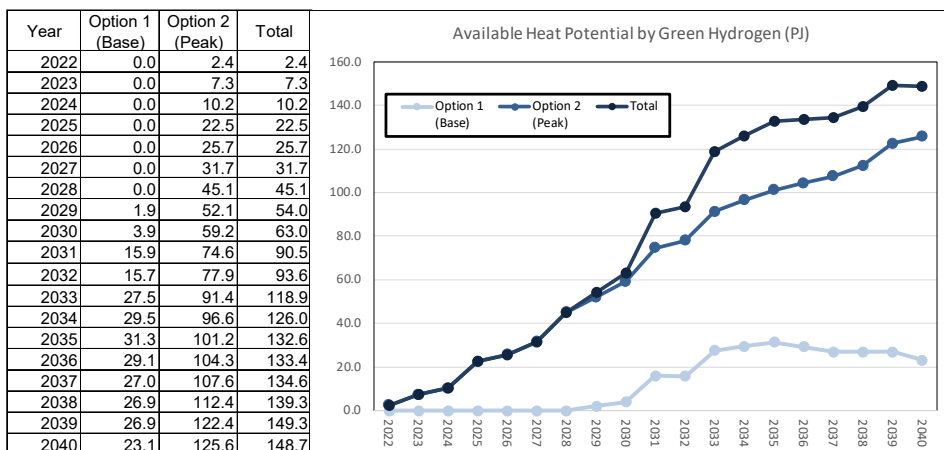
Source: Prepared by the JICA Study Team

Figure 13.3-2 Heat Potential by Electrification until 2040 (PJ)



Source: Prepared by the JICA Study Team

Figure 13.3-3 Green Hydrogen Production Potential until 2040 (Thousands ton)



Source: Prepared by the JICA Study Team

Figure 13.3-4 Green Hydrogen Production Potential until 2040 (PJ)

### 13.4 CONSIDERATIONS FOR A CARBON-NEUTRAL APPROACH UTILIZING SURPLUS ELECTRICITY IN NEPAL

This section discusses the direction of Nepal's energy transition and CN fuel utilization from the perspective of utilizing surplus electricity. It should be noted that, although Sections 13.4.2 and 13.4.3 limit the comparison to the potential for production through surplus electricity against demand size, practical application requires consideration of economic viability and usage patterns.

#### 13.4.1 Potential for Heat and Green Hydrogen Production from Surplus Electricity

The potential for heat and green hydrogen production from surplus electricity until 2040, discussed in Section 13.3, is summarized in Table 13.4-1.

**Table 13.4-1 Potential for Surplus Electricity, Heat, and Green Hydrogen Production until 2040**

Year	Power Generation (GWh)			Electrification (PJ)			Green Hydrogen (Thousand Ton)			Green Hydrogen (PJ)		
	Option 1 (Base)	Option 2 (Peak)	Total	Option 1 (Base)	Option 2 (Peak)	Total	Option 1 (Base)	Option 2 (Peak)	Total	Option 1 (Base)	Option 2 (Peak)	Total
2022	0.0	998.8	998.8	0.0	3.6	3.6	0.0	20.0	20.0	0.0	2.4	2.4
2023	0.0	3,047.0	3,047.0	0.0	11.0	11.0	0.0	60.9	60.9	0.0	7.3	7.3
2024	0.0	4,270.0	4,270.0	0.0	15.4	15.4	0.0	85.4	85.4	0.0	10.2	10.2
2025	0.0	9,385.3	9,385.3	0.0	33.8	33.8	0.0	187.7	187.7	0.0	22.5	22.5
2026	0.0	10,719.1	10,719.1	0.0	38.6	38.6	0.0	214.4	214.4	0.0	25.7	25.7
2027	0.0	13,189.8	13,189.8	0.0	47.5	47.5	0.0	263.8	263.8	0.0	31.7	31.7
2028	0.0	18,786.2	18,786.2	0.0	67.6	67.6	0.0	375.7	375.7	0.0	45.1	45.1
2029	803.0	21,711.1	22,514.1	2.9	78.2	81.1	16.1	434.2	450.3	1.9	52.1	54.0
2030	1,606.0	24,646.2	26,252.2	5.8	88.7	94.5	32.1	492.9	525.0	3.9	59.2	63.0
2031	6,625.3	31,094.3	37,719.6	23.9	111.9	135.8	132.5	621.9	754.4	15.9	74.6	90.5
2032	6,545.6	32,460.5	39,006.1	23.6	116.9	140.4	130.9	649.2	780.1	15.7	77.9	93.6
2033	11,474.2	38,072.8	49,547.0	41.3	137.1	178.4	229.5	761.5	990.9	27.5	91.4	118.9
2034	12,274.5	40,235.9	52,510.4	44.2	144.8	189.0	245.5	804.7	1,050.2	29.5	96.6	126.0
2035	13,061.0	42,171.8	55,232.8	47.0	151.8	198.8	261.2	843.4	1,104.7	31.3	101.2	132.6
2036	12,137.5	43,461.7	55,599.2	43.7	156.5	200.2	242.8	869.2	1,112.0	29.1	104.3	133.4
2037	11,242.5	44,840.0	56,082.5	40.5	161.4	201.9	224.9	896.8	1,121.6	27.0	107.6	134.6
2038	11,211.1	46,823.0	58,034.1	40.4	168.6	208.9	224.2	936.5	1,160.7	26.9	112.4	139.3
2039	11,203.8	51,001.0	62,204.8	40.3	183.6	223.9	224.1	1,020.0	1,244.1	26.9	122.4	149.3
2040	9,625.3	52,317.8	61,943.1	34.7	188.3	223.0	192.5	1,046.4	1,238.9	23.1	125.6	148.7

Source: Prepared by the JICA Study Team

The utilization of surplus electricity is expected to focus mainly on peak-oriented Option 2 until 2028. From 2029 onwards, if surplus electricity becomes available even during the dry season, it will be possible to utilize the base of Option 1, which aims to meet year-round demand. In this case, options such as meeting new electrification demand with heat pumps throughout the year or stable green hydrogen production throughout the year become viable options.

#### 13.4.2 Comparison with Nepal's Primary Energy Consumption in 2022/23

This section discusses the scale of surplus electricity, heat, and hydrogen production potential in comparison with the domestic primary energy consumption in Nepal in 2022/23, as shown in Table 13.4-2.

**Table 13.4-2 Primary Energy Consumption in Nepal in 2022/23**

Category	Fuel Type	FY 2078/79				Growth Rate from previous FY
		Energy (000 GJ)	000 TOE	GWh	% of National Total	
Traditional	Firewood	374,562.95	8,946.28	104,877.63	58.53%	-0.85%
	Agricultural Residues	17,965.50	429.10	5,030.34	2.81%	-4.35%
	Animal Waste	18,150.14	433.51	5,082.04	2.84%	1.02%
	<b>Total</b>	<b>410,678.59</b>	<b>9,808.89</b>	<b>114,990.01</b>	<b>64.17%</b>	<b>-0.93%</b>
Commercial	Coal	58,148.22	1,388.85	16,281.50	9.09%	-0.51%
	Petrol	24,653.98	588.85	6,903.11	3.85%	26.04%
	Diesel	66,079.60	1,578.28	18,502.29	10.33%	4.12%
	Kerosene	640.68	15.30	179.39	0.10%	-22.91%
	LPG	24,657.27	588.93	6,904.04	3.85%	13.09%
	ATF	5,392.72	128.80	1,509.96	0.84%	143.10%
	Furnace Oil	1,834.45	43.82	513.65	0.29%	-46.03%
	<b>Total</b>	<b>181,406.91</b>	<b>4,332.83</b>	<b>50,793.94</b>	<b>28.35%</b>	<b>6.88%</b>
	<b>Grid Electricity</b>	<b>31,766.40</b>	<b>758.73</b>	<b>8,894.59</b>	<b>4.96%</b>	<b>20.45%</b>
Renewable	Biogas	10488.72	250.52	2,936.84	1.64%	7.50%
	Wind	1.87	0.04	0.52	0.0003%	0.00%
	Micro/Pico Hydro	539.97	12.90	151.19	0.08%	4.86%
	Solar	5083.32	121.41	1,423.33	0.79%	6.80%
	<b>Total</b>	<b>16113.88</b>	<b>384.87</b>	<b>4,511.89</b>	<b>2.52%</b>	<b>7.19%</b>
<b>Total</b>		<b>639,965.79</b>	<b>15,285.32</b>	<b>179,190.42</b>	<b>100%</b>	<b>2.28%</b>

Source: Energy Synopsis Report 2023, WECS

Primary energy consumption in Nepal in 2022/23 was 640.0 PJ, with the composition being Traditional at 410.1 PJ (64.2%), Commercial at 181.4 PJ (28.4%), System Power at 31.8 PJ (4.9%), and Renewables at 16.1 PJ (2.5%). Of these, Traditional, mainly biomass for cooking, is not the main target of the energy transition. The main focus is assumed to be on the Commercial heat demand of 181.4 PJ, of which coal accounts for 58.1 PJ, gasoline 24.7 PJ, diesel 66.1 PJ, kerosene 0.6 PJ, LPG 24.6 PJ, and other 7.2 PJ.

The total calorific value converted from surplus electricity for electrification or hydrogen production is estimated to be 33.8 PJ and 22.5 PJ in 2025, 94.5 PJ and 63.0 PJ in 2030, 198.8 PJ and 132.8 PJ in 2035, and 223.0 PJ and 148.7 PJ in 2040, respectively. For example, the calorific value of hydrogen in 2040, at 148.7 PJ, corresponds to about 82% of the Commercial primary energy in 2023, allowing for the substitution equivalent to coal, diesel, and LPG in terms of calorific value.

Although these utilizations need to be decided based on a comprehensive assessment of the economics compared to existing energy and the cost of establishing hydrogen infrastructure, there is a potential of a certain scale from a simple energy generation perspective.

### 13.4.3 Comparison with Green Hydrogen Demand in Previous Studies

The demand for green hydrogen in previous studies mentioned in Section 13.2 is summarized in Table 13.4-3. It should be noted that the values for the annual hydrogen demand are reference figures estimated by the JICA Study Team.

**Table 13.4-3 Green Hydrogen Demand in Previous Studies**

Application		Annual Demand of Hydrogen (Thousand Ton)	References
Green Ammonia	Demonstration Plant	0.29	Ammonia production: 5 ton/day, Fertilizer factory annual: 198,000 ton
	Pilot Project	20.07	Urea production: 600 ton/day, Electrolysis: 400MW
	Potential Demand (2020)	81.09	Urea production: 2,424 ton/day, Electrolysis: 1,616MW
Industry*2	Cement, Bricks, Concrete Manufacturing	77.5 (2030)	
		201.4 (2035)	
		419.3 (2040)	
	Chemical Products, Rubber, Glass, Plastic Manufacturing	15.5 (2030)	
		39.75 (2035)	
		81.75 (2040)	
Transportation*3	Cars	23.16 (2018)	FCV fuel efficiency 0.01kgH2/km, 154,433 cars and 15,000km/year
	Buses	30.28 (2018)	FCV fuel efficiency 0.08kgH2/km, 12,617 cars and 30,000km/year

\*1: Green Hydrogen for Development in Nepal, Kathmandu University, \*2: Report on the Production and Use of Green Hydrogen in Nepal, WECS, \*3: Study on the Possibility of Producing Hydrogen in Nepal Using Hydropower, ADB

Regarding the demand for green hydrogen in “Green Hydrogen for Development in Nepal”, the hydrogen demand for an ammonia demonstration plant is very small, with a negligible amount of required electricity generation (GWh), which is assumed not to impact supply and demand. The demand for a fertilizer plant pilot project is 20.07 thousand ton, which can be supplied by the base surplus electricity from 2030 onward. Similarly, the potential demand for fertilizer within Nepal, estimated at 800,000 ton/year, requires approximately 81.09 thousand ton of hydrogen, which can be supplied by the base from 2031 onward. Utilizing the peak during the rainy season, if storage is possible, early supply by advancing production is feasible for ammonia and fertilizers.

For the use in boilers for cement, brick, and concrete production, supply is possible on the base from 2033 to 2035, but in other years, peak hydrogen production is also needed. However, by 2040, with a demand of 419.3 thousand ton and a hydrogen production potential of 1,238.9 thousand ton, year-round supply is feasible. Chemical products, rubber, glass, and plastic manufacturing are within the range that can be supplied by the base from 2030 onward.

Hydrogen demand for the transport sector is an estimate based on the number of vehicles in 2018, but passenger cars and buses together can be supplied by the base from 2031 onward. FCVs are assumed to store hydrogen over a period due to their usage pattern, peak utilization is also possible.

### 13.4.4 Considerations on the Utilization of Surplus Electricity in Nepal

This section examines the potential for surplus electricity, heat, and green hydrogen production in the IPSPDP's power development plan, as well as the energy consumption and hydrogen demand in Nepal from previous studies. Key findings include:

- Until 2028, the utilization of surplus electricity, heat, and green hydrogen will mainly occur during peaks, but from 2029 onwards the base supply gradually increase, and from 2031 onward, it will be possible to meet both base and peak demand.
- It is estimated that surplus of electricity, heat, and green hydrogen in Nepal can enable a significant energy transition compared to primary energy consumption.
- The potential is sufficient when compared to future hydrogen demand in previous studies.

On the other hand, when considering the kWh value of these surplus electricity sources, the value of electrifying heat demand followed by exporting electricity to India is high. As of 2024, the business feasibility of green hydrogen in Nepal without subsidies or carbon credits has not been reached. Therefore, it is essential to enhance the financial value of green hydrogen through an increase in the market value of green hydrogen, establishment of various preferential systems, and reduction in manufacturing costs through the development of new technology.

From an energy efficiency perspective, the most efficient utilization of electricity is for direct use as a power source for EVs, E-cooking, and heat demand. As already mentioned in Chapter 5, the Nepal government has set ambitious targets for EV and E-cooking. It is therefore important to promote these existing initiatives and stimulate new demand through heat pumps is considered important.

Exporting electricity also contributes to the energy transition from the perspective of CO<sub>2</sub> reduction in neighboring countries and is assumed to be a necessary measure for Nepal to earn valuable foreign exchange. It is therefore important to focus on electrification and electricity exports, which offer superior financial value.

While the practical use of CN fuels, including green hydrogen, is advancing in some developed countries, the full-scale social implementation is still at the exploratory stage worldwide, and it is assumed that Nepal is no exception. Therefore, for the time being, it is important to prioritize domestic economic value from the perspectives of technology dissemination, establishment of related systems, energy and food security, and preventing the outflow of foreign currency.

In particular, there is a clear market demand for ammonia produced from green hydrogen as fertilizer for agriculture in Nepal. Although it is less competitive in price than fertilizers imported from India, which are made from natural gas, it is preferable to proceed from the perspectives of a stable supply of fertilizers and food security. Furthermore, using CO<sub>2</sub> emitted from cement clinker production as a raw material for urea production can contribute to reducing emissions in carbon neutrality. However, the business is likely to be rely on subsidies in the short term. Therefore, it is advisable to carefully consider the production scale to avoid impacting the finances of related businesses and the Government of Nepal.



# **ANNEX 14**

## **STRENGTHENING POWER SECTOR GOVERNANCE MECHANISM**

---



---

<b>Annex 14</b>	<b>Strengthening Power Sector Governance Mechanism</b>	<b>14-1</b>
14.1	Purpose of the Chapter and Methodology	14-1
14.2	Concerning the Establishment of a Vision for the Power Sector	14-3
14.2.1	Result of the Study by the JICA Study Team and Considerations	14-3
14.2.2	Necessary Capacities to realize the Vision	14-5
14.3	Issues relating to the Current Governance Mechanism and Considerations on their Mitigation and Resolution	14-6
14.3.1	Overview of the Sector Governance	14-6
14.3.2	Development of Interorganizational Communication Platform and Protocol	14-7
14.3.3	Investment Climate Improvement	14-7
14.3.4	Clarification of Processes concerning License Issuance for IPP and Screening Standards, and Discussions with the Private Sector	14-9
14.3.5	New Electricity Act and the unbundling of the NEA	14-10
14.3.6	Strengthening Collaboration between Donors	14-11
14.3.7	Summary of key Issues on Power Sector Governance of Nepal	14-11
14.4	Examining the Energy Development Roadmap and action plans	14-13
14.5	Development Partner / Considerations on the Direction of Aid by ODA Donors	14-17

---



## ANNEX 14 STRENGTHENING POWER SECTOR GOVERNANCE MECHANISM

### 14.1 PURPOSE OF THE CHAPTER AND METHODOLOGY

In this chapter, the challenges to the power sector from a governance perspective will be discussed based on current organizational structure, legal systems, and policies outlined in Part 1, Chapter 2 “Current Status of the Power Sector in Nepal” as well as results from relevant studies touched upon in other chapters. Specifically, the chapter begins with an explanation on the importance of clarifying the vision for the power sector as part of Nepal’s national policy, followed by a discussion on the 5 challenges as below and the actions needed to mitigate or resolve them.

- Establishment of communication platform/protocol among relevant government agencies
- Improvement of investment environment through cooperation with other government agencies
- Improvement of clarification of process and standard of issuing IPP license and dialogue with private sector
- Establishment of new electricity law and unbundling of NEA
- Strengthening cooperation among development partners

Next, the contents and, more importantly, action plans laid out in the Energy Development Road Map and Action Plan created by Nepal in 2023 will be analyzed, from which the JICA study team will provide its opinion on implementation methodologies, points of concern, and means by which to improve the effectiveness the action plans from the perspective of the project at hand.

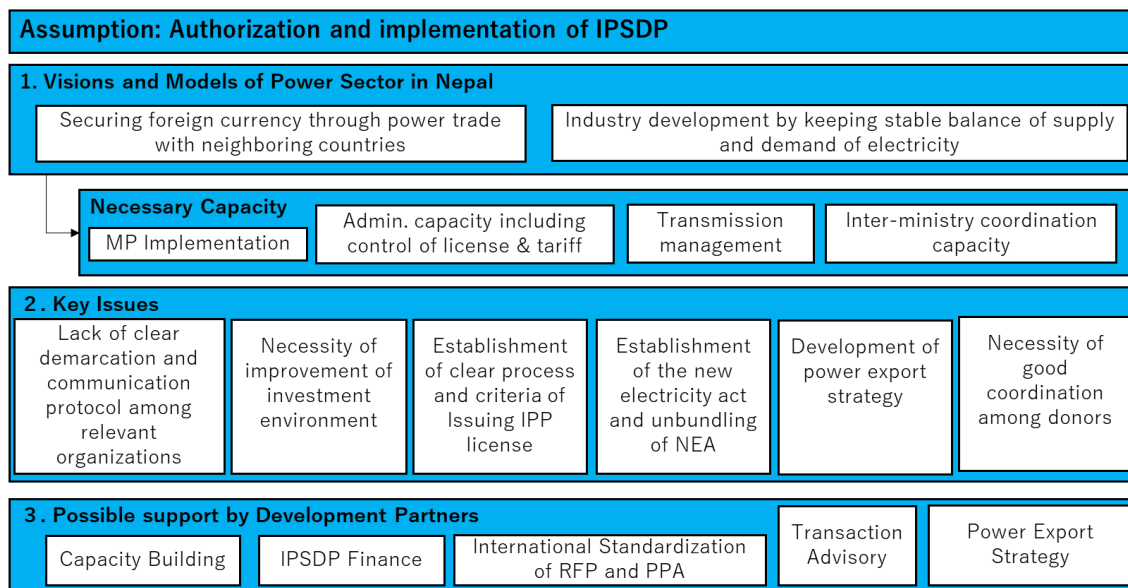
Based on the above findings, we present the direction of support that development partners, including JICA, can take to help the Government of Nepal mitigate and resolve the various issues related to power sector governance.

Figure 14.1-1 shows the framework for considering power sector governance<sup>1</sup>. Note that this assumes that the IPSDP is properly positioned within the Government of Nepal and is implemented appropriately.

In addition, Section 14.2 discusses the vision that should be clearly positioned as a basis for strengthening the governance of the power sector in Nepal. In Section 14.3, we present the current situation regarding the five issues mentioned above and discuss measures to mitigate and resolve them. Based on the above considerations, Section 14.4 examines the contents of the energy development roadmap and action plan, and Section 14.5 examines the direction of support by development partners.

---

<sup>1</sup> This diagram was discussed and compiled in multiple meetings with senior officials of the Nepalese government, such as DoED and ERC, and senior officials of the NEA. In that sense, it can be understood that the structure and contents of the diagram have been agreed upon in principle, albeit unofficially.



Source: JICA Study Team

**Figure 14.1-1 Key issues and structure of the chapter**

The data collected and considerations made in the chapters are based on data collected, analyzed, and deliberated upon by the study team as well as discussions with the entities listed below.

- Relevant line ministries of the government of Nepal (The project’s JCC, governance working group, leaders and managers who participated in discussions during their invitation to Japan)
- IPPAN and investors who have had experience in investing or are planning to invest in the hydropower industry in Nepal, and related private entities
- Legal firm lawyer expert in Nepal’s power sectors
- The World Bank, ADB, USAID, and other Development Partners
- Power trade market players in India and relevant members

## 14.2 CONCERNING THE ESTABLISHMENT OF A VISION FOR THE POWER SECTOR

### 14.2.1 Result of the Study by the JICA Study Team and Considerations

The document that forms the core foundation on discussing the strengthening of governance in Nepal's power sector is the Energy Development Road Map and Action Plan created by MoEWRI in 2023. This document, as explained in Chapter 7 as well as other chapters of this report, first describes the current status of the energy sector in Nepal, followed by an analysis of energy demand and evaluation of energy demand forecast and international power exchange, and finally culminates in establishing a 2035 target with relevant road maps and actions to be taken<sup>2</sup>.

However, this road map and action plan only shows the policy direction of the MoEWRI and does not describe the overall strategy or vision of the government of Nepal. Consequently, the document does not necessarily clarify how the power sector and the road map would be positioned in Nepal's socioeconomic structure. Moreover, the way in which the document is written limits the application of the action plan to the MoEWRI (and relevant ministries and agencies in the power sector).

Based on the above, the vision that the power sector should show from the perspective of the entire socio-economy of Nepal and organize it as a recommendation to the Nepalese government shall be considered. This will be the "ideal state or direction that the power sector in Nepal should aim for" as considered by the JICA study team in this study, and will serve as the basis for considering and proposing measures to further improve governance.

The basic idea is to create domestic electricity demand, build a system that can supply electricity stably to that demand, ensure energy security for Nepal, and then export surplus electricity to neighboring countries. This is a common and rational idea<sup>3</sup>.

According to the electricity demand forecast in Chapter 5, the electricity sales volume in Nepal in 2022 will be 9,000 GWh, broken down as follows: 42% for households and 39% for industry<sup>4</sup>. Domestic demand alone is expected to grow by about 20%, and as industry continues to develop, electricity demand is expected to increase. First of all, it is necessary to respond appropriately to this increase in domestic electricity demand. As the electrification rate is set to reach 93% in 2021, it is considered important to increase and respond to industrial demand, especially in industry.

Regarding industrial demand, Chapter 5 examines the growth of domestic electricity demand and its main sectors (domestic, industrial, and commercial) and their components<sup>5</sup>. Furthermore, the spread of electric vehicles, electrification of cooking, introduction of smart street lighting, introduction of electric railways, operation of steel plants, and development of industrial zones and special economic zones are cited as areas where government intervention is likely. Of these, industrial development is expected to be the biggest driver of a dramatic increase in domestic demand, which is thought to have a major impact on future electricity demand.

From the above, as premise to improving governance in Nepal's power sector, the JICA study team considers clearly defining the following visions to be important.

---

<sup>2</sup> It is important to note that the target year is different from that of the IPSDP (the target year for the IPSDP is 2040).

<sup>3</sup> This content has been compiled based on discussions with senior Nepalese government officials on such occasions as the JCC, the Governance Working Group, and during visits to Japan.

<sup>4</sup> See Chapter 5, Section 5.1, "Electricity Demand Performance."

<sup>5</sup> For more details, see Chapter 5, Section 5.4, "Electricity Demand Forecast."

**Table 14.2-1 Top 5 Export Products of Nepal (2022)**

Product	Amount
Zinc Sheet	Rs. 7.97 bn
Polyestel Yarn & Thread	Rs. 7.15 bn
Woolenn Carpert	Rs. 6.93 bn
Cardamom	Rs. 5.29 bn
Juice	Rs. 5.17 bn

Source: "the HRM (2024) Vol.3 Issue 7"

Of course, industrial promotion is outside the direct jurisdiction of MoEWRI, and in order to achieve it, collaboration with the Department of Industry (DoI), which is in charge of industrial development, and the Investment Board of Nepal (IBN), which is in charge of investment promotion, is essential. Thus, MoEWRI is required to strategically and balancedly generate electricity demand and increase electricity supply capacity while strengthening collaboration with other ministries and related institutions<sup>6</sup>.

In relation to investment promotion throughout Nepal, the Nepal Investment Summit 2024 was held in April 2024 with the aim of encouraging investment promotion both domestically and internationally. An overview of this summit is provided at the end of this chapter.

It goes without saying that another pillar of the vision for Nepal's power sector is to earn foreign currency through electricity exports. To put it simply, Nepal's trade balance is in a severe state. According to a survey by the Embassy of Japan in Nepal<sup>7</sup>, Nepal's trade volume in 2021/22 is 1.92 trillion rupees for exports of 200 billion rupees, or 9.6 times the amount of imports compared to exports<sup>8</sup>. For reference, the import value of electricity in 2021/22 is 22 billion rupees. This trade deficit has been expanding in recent years, and if it continues, Nepal's balance of payments may continue to deteriorate.

On the other hand, Nepal's electricity exports (to India) are expected to be about 12 billion rupees in 2022/2023 and 13.2 billion rupees in 2023/2024<sup>9</sup>. Thus, electricity exports to India are on the rise. It is also a notable point that Nepal, India, and Bangladesh have reached a basic agreement on electricity exports from Nepal to Bangladesh<sup>10</sup>. If the current export amount could be doubled, the net electricity trade balance could be turned from a deficit to a surplus. It would also account for a large proportion of Nepal's total exports. Thus, electricity exports could have a significant impact on the macroeconomy of Nepal.

According to the economic and financial analysis conducted in Chapter 11, if electricity exports grow smoothly based on Scenario 3, Nepal's electricity exports will reach 100 billion rupees in 2026-2027<sup>11</sup>. It is expected to reach 200 billion rupees in 2029, which is equivalent to the current export amount of Nepal. In addition, if investment and electricity exports proceed according to the IPSPD scenario, it is estimated that in 2040, export value will increase by approximately 7.5 times on a nominal basis, and the trade deficit will shrink to 0.16 times<sup>12</sup>. This shows how electricity exports will have a significant impact on Nepal's trade balance and the finances of the Nepalese government.

<sup>6</sup> For the relationship between the IBN and the DoI, please refer to the section on IBN in Chapter 2, Section 2.1 "Organizational Structure of the Electricity Sector."

<sup>7</sup> Based on the Embassy of Japan in Nepal's Illustrated Guide to the Nepalese Economy 2023 (February 2023).

<sup>8</sup> For reference, the current main export items are soybean oil, yarn, wool carpets, jute products, cardamom, etc.

<sup>9</sup> The above figures are from the NEA Annual Report.

<sup>10</sup> For more details, see Chapter 8, "Current Status of Power Trade between Nepal and Neighboring Countries"

<sup>11</sup> For more information, see Chapter 11, Section 11.3, "Financial Analysis."

<sup>12</sup> For more details, see Chapter 11, Section 11.8 "Impact Analysis and Financial Analysis of Nepal's Macroeconomy."

In light of the above, the JICA study team believes that it is important to clearly set the following vision as a prerequisite for improving governance in Nepal's power sector.

First, promote industry through appropriate collaboration between ministries and agencies within the country, generate electricity demand, and build a power supply system to meet that demand.

Second, export surplus electricity to neighboring countries, bringing about a positive impact on the country's trade balance and national finances.

#### 14.2.2 Necessary Capacities to realize the Vision

The above points were basically agreed upon in interviews with senior government officials and other relevant parties in the governance field conducted during the course of this study. However, many opinions were heard that in order to achieve this, it will be necessary to develop and improve the organizational and human capacity of relevant government agencies in Nepal.

Through exchanges of opinions with relevant parties, the following four points were identified as the main points (mainly, but not limited to, governance-related) that require capacity building in the future. These points will also be useful for development partners such as JICA to consider future support measures for Nepal.

- Capacity to implement IPSDP: Ability to position IPSDP as a practical master plan and realize its contents
- Capacity to form and implement power projects: Ability to carry out project operations such as issuing licenses<sup>13</sup> for power generation projects and setting and changing tariffs<sup>14</sup> for power generation, transmission, and distribution
- Capacity to manage the grid: Ability to appropriately manage the grid under the expected future introduction of a domestic wheeling system and expansion of power exchange with neighboring countries<sup>15</sup>
- Capacity to coordinate among ministries: To realize the contents of IPSDP, DoED needs to collaborate with multiple ministries and local governments such as the Ministry of Finance, IBN, and the Ministry of Industry, but it has the ability to coordinate them<sup>16</sup>

Based on the above, the following sections will present the results of the survey and examination of the main issues in the power sector of Nepal identified through this survey and the measures to alleviate and resolve them.

---

<sup>13</sup> For more information on licensing issues, see Chapter 2, Section 2.2.5, "IPP Permitting and Approval Processes."

<sup>14</sup> For more details on issues relating to setting and changing tariffs, see Chapter 2, Section 2.4.2, "Electricity Tariff System."

<sup>15</sup> For more details on the challenges of grid management, see the section on the Asian Development Bank in Chapter 2, Section 2.7, "Assistance of Development Assistance Agencies in the Power Sector."

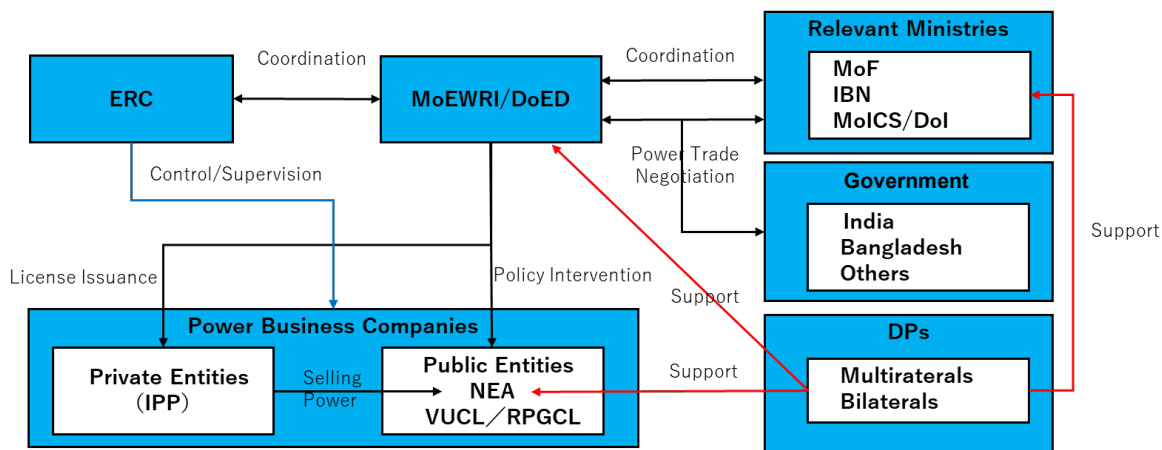
<sup>16</sup> For more information on the major players in the power sector, see Chapter 2, Section 2.1, "Institutional Structure of the Power S

### 14.3 ISSUES RELATING TO THE CURRENT GOVERNANCE MECHANISM AND CONSIDERATIONS ON THEIR MITIGATION AND RESOLUTION

#### 14.3.1 Overview of the Sector Governance

The current status of power sector governance in Nepal is summarized in the following figure.

The central role in power governance is played by the DoED. The organization works with the ERC, the Ministry of Finance (MoF), and the Board of Investment of Nepal (IBN) to implement various power policies and projects. In terms of industrial development, cooperation with the Department of Industry (MoICS/DoI) of the Ministry of Industry, Commerce and Supply is expected, but at present there are no policies or measures in which the two ministries work together. In terms of promoting investment by domestic and foreign private companies, cooperation between the MoEWRI/DoED and the Ministry of Finance/IBN is expected, but the development and improvement of the investment environment is essentially left to the latter<sup>17</sup>.



Source: JICA Study Team

Figure 14.3-1 Overview of Power Sector in Nepal

The main points of focus regarding governance are as follows.

The main organization of the power business is the NEA, and while it receives a certain amount of intervention from the Nepalese government, it is primarily responsible for power generation and transmission. Depending on the new electricity law currently being discussed in the National Diet, there is a possibility that the transmission and distribution functions will be separated<sup>18</sup>. In addition, there is a related issue of merger or separation with VUCL and PRGCL. In other words, the new Electricity Act may have a significant impact on the governance of the power sector.

MoEWRI is in a position to issue licenses for power generation projects to private operators (basically IPP operators). Private operators have requested improvements to the procedures and standards for issuing licenses, which will be discussed later. Once a license is issued, there seems to be little public intervention.

- Regarding the power trade negotiations with neighboring countries such as India and Bangladesh, various reports have confirmed that the Prime Minister of Nepal and other government officials are participating in the negotiating team. In the future, it will be necessary

<sup>17</sup> Based on interviews with various Nepalese government officials including MoEWRI and IBN.

<sup>18</sup> There is no clear description in the current bill but according to interview to some senior officers of MoEWRI and NEA, it is expected that the relevant discussion will resume once the law is officially in place.

to determine the price negotiations and the volume, timing, and detailed conditions of power exchange, and it is important to ensure that there is strategy and consistency in this.<sup>19</sup>

- From the perspective of improving governance capacity (including, in part, improving the investment environment), the role of development partners (DPs) is important. In fact, as shown in Chapter 2, major organizations such as the World Bank, ADB, and USAID are implementing technical cooperation. However, information sharing, collaboration, and coordination between DPs is not necessarily being carried out appropriately, and there is some overlap in the content of support (resulting in inefficiency), so in that sense there is room for improvement.

Based on the above, the following provides a concrete confirmation of individual issues and the results of an investigation into measures to improve them.

### 14.3.2 Development of Interorganizational Communication Platform and Protocol

Currently, it can be observed that the policies and measures implemented in Nepal's power sector have been strictly limited to the sector. In order to achieve the IPSDP based on the visions outlined above, collaboration with the departments and ministries listed below is essential from the perspective of industrial development and promotion of private investment. However, the current status suggests that governance in this area is not effective.

- Ministry of Finance, IBN: procurement of funding for power plants and transmission and distribution grids as well as related discussions and assessments
- Ministry of Industry, Commerce, and Supplies: assessment and discussion concerning industrial development policy (particularly from the perspective of electricity supply)
- Local governments assessment and discussion on land purchase and the maintenance and operation of transmission and distribution lines
- Private entities: exchange of information and ideas with investors who in particular develop power plants as IPP, private proprietors and business owners, and commercial banks

It is important to clarify communication protocol to ensure unimpeded communication between ministries and departments and strengthen governance for inter-ministerial collaboration. The items below may be considered as what may be done specifically for this.

- Creation of a communication platform (conference) and secretariat
- Holding periodic and ad hoc meetings
- Communication methods (face-to-face meetings, online meetings, etc.)
- Planning and holding regular events
- Preparation of manuals and guidelines concerning the above

### 14.3.3 Investment Climate Improvement

In order to achieve the IPSDP, business investment by private firms is absolutely crucial, and this is evident from the result of the financial analysis and finance procurement analysis in Part 1 Chapter 11 of this report. Additionally, this kind of investment would be difficult to entice only from domestic firms considering limited resources available for investment, thus necessitating investment from foreign investors.

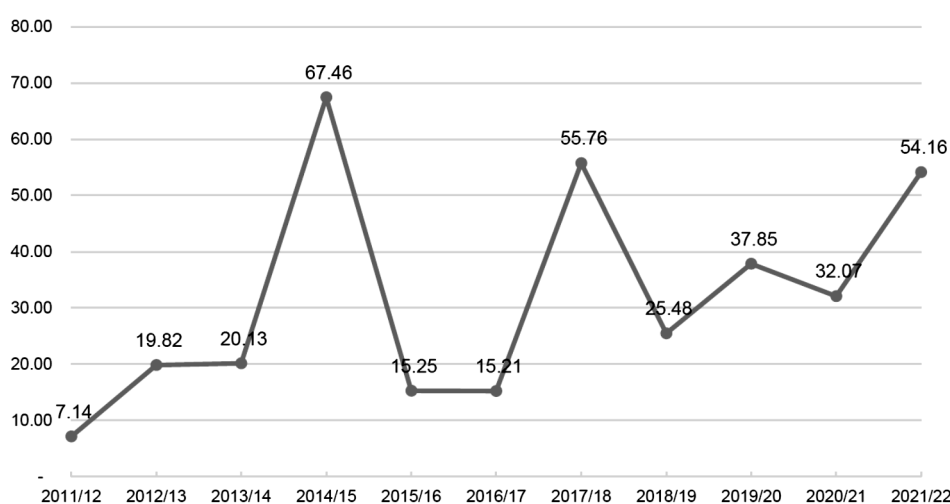
---

<sup>19</sup> Based on interview surveys of private power generation companies such as MoEWRI and IPPAN

FDI to Nepal over the past 10 years is as shown in the graph below and is on a rising trend.

Of the sectors targeted for FDI, the energy sector is the largest and comprises 31.1%. Additionally, the countries of origin of the FDI consists largely of investment from China at 51.67% followed by India at 24.10% (both data are proportions derived from cumulative investment value between 1989/90-2021/22)<sup>20</sup>.

Although the amount of FDI is on a rising trend in recent years as shown, according to the result of the financial analysis and fund procurement method evaluation, an additional 2,000-7,000 million USD of private investment (both domestic and FDI) would be needed annually in the future. Considering that the approved FDI amount (total amount not limited to the energy sector) in 2020-2021 was 54.2 billion NPR (approximately 4,000 million USD), the current measures in place to entice FDI is insufficient. Unwavering determination to steadily increase FDI by effectively utilizing a more robust governance is required.



Source: Embassy of Japan in Nepal “Illustrated Nepal Economy 2023” / DoI (Industrial Statistics 2021/22)

**Figure 14.3-2 Changes in FDI to Nepal (authorized amount)**

Generally, the conditions listed below are needed to attract investment from countries and firms; however, attracting investment to Nepal have been made challenging by certain issues that counter each of those conditions.

- Government stability (ministerial and departmental leadership): changes in positions held by high-ranking officials is frequent, resulting in the lack of clarity in leadership and responsibility.<sup>21</sup>
- The state of legal system and process development: the amended Electricity Act is pending, and existing administrative and legal processes are subject to frequent changes<sup>22</sup>.
- Risk sharing when making contracts: The contents of contracts, particularly for IPP, may be difficult to agree to from the perspective of foreign investors.
- Foreign investors may be feeling that they cannot cover every possible risk owing to the

<sup>20</sup> Embassy of Japan in Nepal “Illustrated Nepal Economy 2023”

<sup>21</sup> Political instability was also pointed out at length at the aforementioned Nepal Investment Summit 2024.

<sup>22</sup> For an overview of the amended Electricity Act and its current status, refer to Chapter 2 “2.2.1 Legal system concerning the entire power industry” of this report.

insufficient in development legal systems that would ensure the protection of their rights.<sup>23</sup>

- Procurement of business finance: It is difficult, at least in Nepal, to procure finance at competitive conditions from public or urban financial institutions, which necessitates foreign investors to turn to foreign financial institutions for funding. Naturally, foreign financial institutions are also wary of financing projects in Nepal.

Although the items above are all crucial, there are not many courses of action available for line ministries involved in the power sector, particularly the DoED. Consequently, these are issues that must be addressed by the government of Nepal as part of its national policy, led as an initiative from the top and put into action with collaboration between relevant ministries such as the Ministry of Finance and IBN.

#### 14.3.4 Clarification of Processes concerning License Issuance for IPP and Screening Standards, and Discussions with the Private Sector

To attract private investment and particularly foreign capital for development in the power sector, improving the IPP licensing and approval processes is necessary<sup>24</sup>. One important function of the DoED is to act as the one-stop window for the application and screen for matters relating to the power sector. However, as discussed in “2.1.1 Key administrative entities involved in the power business” of this report, it must coordinate with multiple ministries and departments as part of this.

In the implementation phase of this study, USAID, which supports Nepal in the energy sector, pointed out that the acquisition of land and application for licenses and approvals were labor intensive and time consuming<sup>25</sup>, while IPPAN also identified the complexity and high cost of processes, especially in consideration of climate-friendly societies, as being issues<sup>26</sup>. Additionally, private businesses found it burdensome how laws, regulations, and processes frequently change and how regulations differ between ministries due to the lack of collaboration<sup>27</sup>.

Moreover, IPPAN and other parties have also pointed out that the standard used for the issuance of licenses to investors is unclear. In fact, as discussed in Chapter 2 “2.2.5 IPP licensing and approval process” of this report, they noted that many construction projects seemed to never begin even though years had passed since their licenses had been issued. Some attribute this situation to the substandard screening during the license application process (uncontrolled and haphazard issuance of construction licensing for IPP) rather than delays to construction caused by problems that arose after the issuance of the license. Regardless of the validity of this viewpoint, the fact that such opinions exist suggest that it may cause significant setback to promoting investment from private entities, including foreign investors.

In addition to the above, the current method for IPP license issuance is done for proposals from private entities on a first-come-first-served basis and thus is implemented under a business approval or private sector-led unsolicited business method. In other words, Competitive bidding for IPP projects led by the government is not done. This is also thought to be one of the causes of the lack of transparency in the license issuance processes by the government.

The evaluation of the current license issuance process differed greatly between the government

---

<sup>23</sup> This may require the credit guarantee of NEA as an off-taker.

<sup>24</sup> There are various financial issues that should be resolved such as addressing foreign exchange risk and procuring long-term finance., However, this section will be limited to discussions on issues concerning governance.

<sup>25</sup> Based on hearing conducted with USAID (March 2022)

<sup>26</sup> Based on hearing conducted with IPPAN (June 2022)

<sup>27</sup> Based on hearing conducted with IPPAN (June 2022)

and private sector entities<sup>28</sup>. While it is true that the government is reviewing and revising process and other matters, which merits appropriate evaluation, it is also true that the private sector has been complaining and raising concerns from the perspective of simplicity, transparency, and fairness of these processes and screening standards. In a sense, this is evidence that critical governance is lacking to address the crux of power sector development, which is to promote investment from private entities and materialize projects.

Based on the above, it is necessary to again review and clarify processes and screening standards concerning the issuance of licenses. In doing so, the burden felt by private firms may be lessened. At the same time, more private investment may be raised by improving the transparency of processes and evaluation standard. Additionally, in making these improvements, it is also vital to hold discussions as needed with private entities, heed their opinions, and incorporate them as needed into plans and actions.

On the other hand, particularly for future projects, there should be plans to freeze or revitalize “mothballed” projects such as cancelling licenses if tangible progress has not been achieved after a certain duration, even for licenses that have already been issued<sup>29</sup>.

### 14.3.5 New Electricity Act and the unbundling of the NEA

As stated in Chapter 2 of this report, the amended Electricity Act, 2075 was submitted to Congress in July 2020. However, the amended law has not passed as of February 2024, and there is no prospect of this happening. A scanning of the amendment bill reveals that it includes the unbundling of the NEA, the introduction of the competitive principle to the implementation of government-led projects, introduction of a consignment system domestically, open access to the grid, participation of private entities to transmission and distributions projects, and other crucial elements. Nonetheless, any concrete discourse on such matters would not occur unless the amendment passes.

Similarly, the unbundling of the NEA did not reach any meaningful discussions during the meetings with members from the government of Nepal, at least during the implementation of this project. Looking at similar examples in other countries, the separation of generation and transmission/distribution may be one example to refer to. However, in identifying a model that suits Nepal’s power sector the best, the country’s needs and situation should be discussed independently from cases used by other countries. In particular, Nepal has existing public organizations such as the VUCL and RPGCL, and the demarcation between the NEA and their functions would also need to be considered at some point.

As for the governance relating to the passage of the amendment, this is an issue that stems from the Nepali Congress and government and thus cannot be said to be an issue stemming from the individual ministries. Consequently, this study also concludes that providing comments and advice to specific ministries is not feasible. In any case, it is a fact that the structural reform (or preliminary discussions for this) of Nepal’s power sector have been halted or delayed as a result of the unbundling of the NEA put on hold for a number of years, and thus it must be stressed again that this is a key issue that needs to be addressed.

---

<sup>28</sup> For example, during the workshop to which parties from both the government and the private sector were invited, many private sector attendants voiced their concern about the license application and issuance process.

<sup>29</sup> Concerning specific projects for which no real progress could be observed between the end of 2022 and 2023, refer to the following URL (<https://myrepublica.nagariknetwork.com/news/energy-ministry-initiates-review-of-non-operational-hydropower-projects-mulls-revoking-licenses>)

### 14.3.6 Strengthening Collaboration between Donors

As discussed in “2.7 Aid from development agencies for the power sector” of this report, international organizations such as the World Bank, ADB, and AIIB and many other bilateral development agencies have designed and implemented projects in Nepal’s power sector (or energy sector). The aid provided are not necessarily coordinated and, on the surface, seem to overlap in places. The following items are of particular importance.

- Electricity demand forecast in Nepal
- Assessment concerning power trade with neighboring countries
- Assessment concerning the state of Strategic Environmental Assessment (SEA)
- Assessment concerning the promotion of private funding utilization

With regard to these overlapping areas, although a certain degree of overlap (based on cursory review) in some areas may be unavoidable, some risks may arise that any discrepancy or contradiction would not be properly managed and dealt with should they arise between donors. To prevent this, coordination between donors is important.

In particular, during the implementation of this project (the design of the IPSDP), the team actively communicated and exchanged information with the World Bank, ADB, and USAID. Through this, it learned that there always were few overlapping areas of aid, such as between this project and the aid provided by USAID. One obvious example of this in the forecasting of electricity demand in Nepal, the state of power trade with neighboring countries, and assessment concerning the development of relevant transmission and distribution grids.

These unavoidable overlaps are issues that stem from the Nepali side but also from the assisting donors. In fact, although meetings for information exchange and coordination of aid in the power sector are held among donors, the team could not substantiate in conducting this study that these meetings were necessarily effective.

In any case, with the existence of the above overlapping aid, there is a high probability that these would result in wastage and confusion. Consequently, strengthening governance for inter-donor coordination is another important issue to address. Put differently, if the information exchange and coordination mechanism between relevant agencies function, this may allow for the provision of more efficient aid and create synergy between donors. For this reason, it is desirable to strengthen the capacity for inter-donor coordination by putting effort into creating a forum for information exchange and coordination, by both the government of Nepal and donors.

### 14.3.7 Summary of key Issues on Power Sector Governance of Nepal

The following table summarizes the themes/systems of the issues mentioned above, the current situation and issues with their implementation, and actions required for improvement.

**Table 14.3-1 Summary of Issues related with Governance**

Theme/System	Current status and issues	Actions Required
Platform for communication between related organizations	There is a tendency for discussions and actions to be limited to MoEWRI. The action plan mentions other ministries and agencies, but their ability to implement is unclear.	The communication platform between related organizations needs to be strengthened and electricity demand and supply needs to be steadily increased.
Improvement of investment environment	In particular, in the power generation business, improvements to the investment environment are required to attract private investment from both within and outside of Japan, but this is not directly under MoEWRI's jurisdiction.	MoEWRI needs to proactively engage in dialogue with the private sector while strengthening its appeal to the Ministry of Finance and IBN.
Process for issuing licenses for IPPs	The private sector has pointed out that there are some unclear aspects of the current process. In addition, expiration procedures have not been carried out properly.	The new procedures are detailed in the new Electricity Bill. The passage and implementation of the new Electricity Bill is awaited first.
Establishment of new electricity law and unbundling of NEA	There has been no thorough discussion within the government about unbundling the NEA (especially the separation of transmission and distribution functions).	The passage of the new Electricity Bill is required to start discussions on the unbundling of NEA. The passage and implementation of the new Electricity Bill is awaited first.
Collaboration between donors	Although various donors are supporting Nepal's power/energy sector, cooperation is not always good and some inefficiencies are observed.	The sharing and coordination itself should be done between donors, but MoEWRI is also expected to proactively share information and take the lead in coordination.

Source: JICA Study Team

## 14.4 EXAMINING THE ENERGY DEVELOPMENT ROADMAP AND ACTION PLANS

This section will examine 85 action plans contained in the Energy Development Roadmap created in 2023 by MOEWI from the perspective of IPSDP governance and comment on its consistency, limitations, etc.

The action plans are comprised of the following 4 parts. Of these, A and B are highly relevant from a governance perspective.

- A) Legal and Policy Improvement: 29 items
- B) Institutional and Administrative reform: 17 items
- C) Infrastructure Development: 24 items
- D) Power trade and market management: 15 items

Additionally, these 85 actions come with additional information such as “Deadline Main”, “Responsible body”, “Assisted by”, and “Estimated cost for government”. The following table shows the result of the JICA study team’s analysis.

**Table 14.4-1 Action plan analysis result**

No.	Action	Comment from the JICA study team
<b>A) Legal and Policy Improvement</b>		
2	To appoint a separate institution for the operation, expansion and management of National transmission grid	For matters relating to grid operation, etc., the plan mentions that the government will appoint a separate institution. While this is relevant to the unbundling of the NEA, details could not be confirmed from the document.
3	In order to ascertain investment in hydropower Projects, for RoR or PROR projects above 100 MW to which PPA has been signed but financial closure is remaining and for the projects that are signing PPA from now, the provision of having upper limit of 17% RoE on equity party will be removed.	Abolishing the current ceiling of ROE17% applied to private entities is effective from the perspective of promoting private investment. In addition to this, considerations on private investment promotion plans (e.g., guarantees, protection of rights, policy-based finance, etc.) should be done simultaneously.
4	In order to make Electricity generation, transmission, distribution and trading time relevant and to supply clean, stable, dependable, quality and safe electricity, a new electricity act will be promulgated	As discussed in this report, the amended electricity Act is pivotal to power sector reforms. There are some actions that cannot be taken because the amendment has not been passed. Consequently, the earliest passage of this law is anticipated.
9	Make necessary arrangements to issue Power trading license to private sector	This action clearly lays out the government’s understanding on the need for discussions and coordination with private entities for the issuance of licenses in private electricity trading. Moving forward, a detailed review on matters such as the revision of existing regulations and publication of information and communication with private entities and making necessary changes would be anticipated.
10	For clean energy transition, utilize the country's available vast potential of generating green Hydrogen by issuing Green Hydrogen policy	The introduction of hydrogen as new energy is included in the action plans, which is noteworthy. Moving forward, additional evaluation and research on the use of hydrogen are anticipated. The team is also hopeful that there will also be evaluation and research on the use of ammonia.
11	In order to attract private investment for the rapid development of transmission	This action plan touches on private investment for grid development. While the intended objective is noteworthy, there

No.	Action	Comment from the JICA study team
	infrastructure, Tariff Based Competitive Bidding (TBCB) regulations will be issued	should also be the creation of a specific business scheme and development of matters concerning the arrangement of government contracts (such as the drafting of RFP and PPA templates from an international perspective).
15	Renewable energy and Energy efficiency act will be issued	The aim of issuing this act could not be determined from the document. The team believes there is particular need to extensively deliberate the amended Electricity Act and matters relating to it.
16	Formulate "National Energy security policy"	From the point of presenting a national vision as recommended in this report, the importance of establishing a policy cannot be overstated.
17	Dedicated laws (Sunset law) will be issued in order to solve the problems that come while developing the HEP and escalate the process of construction	Additional confirmation is needed for the purpose and contents of the law, but its passage may be effective in terms of strengthening governance in the power sector if it includes provisions for cancelling licenses that have already been issued.
18	Power trade guidelines to be issued for the domestic and cross boarder power trade after taking into consideration the neighboring countries policy and tradition in power trade	This action may be very important from the perspective of revitalizing power trade with neighboring countries. However, additional confirmation is needed to ascertain whether the guideline suggested is only applicable in Nepal or usable internationally.
24	Arrangements to be made to issue bank loan against the collateral of the private land that falls under the Right of way of electricity transmission line	Accounting for the needs of financial institutions is important from the perspective of promoting private investment, and consequently actions like this are crucial. However, the implementing entities of this action are stated as MoF/Nepal Rastra Bank, meaning that MoEWRI will be tested on how well it can conduct inter-ministerial coordination.
27	Make provision in policy to implement innovative Financial instruments like quasi equity, Mezzanine financing to attract investment in hydro power projects.	Same as above.
28	Remove duplication of work jurisdiction among MoEWRI, Department of Industry and IBN while developing a hydro power project	An appropriate review of the functions and responsibilities of the MoEWRI and IBN is necessary. However, the implementing entities of this action are stated as the Nepal government / MoF/ Nepal Rastra Bank, meaning that the MoEWRI may face difficulty in taking appropriate actions. The government will be tested on how it will assert initiative for this.
<b>B) Institutional and Administrative reform</b>		
30	Nepal Power trade company will be appointed and brought into operation as Nodal agency for Nepal's power trade	A nodal agency is to be appointed to conduct power trade. The team hopes that more specific deliberations will be held in future in consideration of the existence of the NEA.
31	For the integrated approach towards the development of HPP, projects developers will be encouraged to work in integrated development of access road, transmission line and other related task.	It is important to appropriately divide responsibilities with private entities for developing the power sector. However, it is also important to remember to not force too many responsibilities or risks onto them.
38	Promote NEA to function on the business trading norms to manage the funds required to build the infrastructure to increase the domestic power demand and cross boarder power trading.	While the action states that the NEA's function will be strengthened, what this entails and what the action aims for cannot be determined owing to the ambiguity of the text. The text of the action should be revised to clearly state the objective of the action.

No.	Action	Comment from the JICA study team
39	To further activate WECS to be able to update the master plan related to generation/transmission/distribution and also update Power demand forecast and Assessment of Energy consumption.	The further strengthening of WECS is necessary for the appropriate implementation (and regular review) of the IPSDP. It may also be valuable to evaluate the possibility of receiving technical aid through international aid agencies as necessary.
40	To motivate non resident Nepali to invest in power bond, Debenture and other related financial instruments so as to generate funds for the development of energy sector	It is interesting that this is an investment promotion action aimed solely at non-resident Nepali. However, there should also be assessments on investment promotion policy to more broadly include foreign investors, not limited to Nepali.
41	To unbundle NEA and make separate organization for Energy generation, transmission and distribution	This action states clearly that the NEA unbundling will be implemented and that separate organizations for generation, transmission, and distribution will be established. Concerns and comments on this point have been previously stated.
42	Restructure and Capacity buildup of HIDCL	While the strengthening of the HIDCL is an important issue, the more specific issue is on how to procure the funding and resources for this. In that respect, it is also important to reassess the role of the HIDCL in promoting private investment.
43	Carry out innovative financing like Power Bond/ Debenture to manage the financial resources for the development of Energy sector.	The diversification of finance procurement method is an important theme and more discussions on the matter are expected to follow. However, only the HIDCL is stated as the implementing entity in the action plan, and evaluation and actions that concern only this organization may not be enough to achieve the plan. It is thus important to involve the Ministry of Finance, IBN, and other financial institutions.
46	To conduct relevant and updated training and study opportunity for the capacity development of employees and organizations related to energy sector	As mentioned previously, from the point of achieving the IPSDP, it is important to carry out the continuous capacity building of government officials and staff.
<b>C) Infrastructure Development</b>		
Because this section refers to specific and technological actions needed for the development of projects, the team has no comments to make from a governance perspective.		
<b>D) Power trade and market management</b>		
74	To expand the energy infrastructure up to the area of Chemical fertilizer plant, Special economic zone and industrial area.	This is pretty much the only item in this action plan that refers to industrial growth. Moving forward, it is anticipated that discussions and evaluation will take place among relevant ministries on how the power sector will contribute to industrial growth or more specific plans on how to bring this about. This deliberation may lead to helping materialize specific projects.
83	NEA to continue Take or Pay PPA principle of different HPP by taking into account the market risk and investment required in HPP	The continued application of the “Take or Pay” PPA principle currently implemented by the NED may be effective from the perspective of promoting private investment. Additionally, although it is the only de facto power off-taker, it is also important to consider diversification and relevant policies.

Source: JICA Study Team

Based on the above, the JICA study team’s comments (which, in this chapter, are limited to items relating to governance) can be summarized as follows.

- The action plans are very comprehensive and agrees with the contents of the IPSDP.
- If actions to be taken by the DoED and NEA were to be added to the action plans, they would

pertain to matters such as the development of a Standard Operation Procedure (SOP) for both intra- and inter-ministerial applications and communication. In particular, considering the limitations in staffing (in terms of number) in the government of Nepal, the development of an SOP, guideline, or manual would be conducive to effectively conducting administrative functions.

- While the action plans mention using IPP and strengthening the collaboration with private entities, it should also incorporate actions pertaining to the government increasing opportunities for discussion, thus deepening understanding between both parties, and taking necessary measures to promote private investment. Additionally, strengthening finance is to be the purview of the MoF and IBN, and ensuring their capacity for implementation is key.
- The plans acknowledge that the current IPP is done basically on a non-competitive basis (based on proposals from private entities). However, there is need to consciously introduce the competitive principle for large-scale projects and IPP. Actions for this may be incorporated into the plans. In line with this, it is also vital to prepare RFP and PPA templates according to international standards.
- It is somewhat disappointing that the action plans hardly mention industrial development and power generation development. As mentioned previously in this chapter, industrial development in Nepal is a matter of utmost importance, and there should be discussions on whether the issue can be approached by addressing the power sector, the result of which should be reflected in specific actions to be taken.
- The action plans do not mention anything about ODA donors. The inclusion of donors is important (in a sense vital), whether through financial aid such as loans and grants, technical assistance, supply of investment funds to businesses (non-sovereign base). The action plans would benefit from mentioning specific actions pertaining to the effective utilization of aid and coordination mechanism to prevent aid from overlapping or contradicting.

## **14.5 DEVELOPMENT PARTNER / CONSIDERATIONS ON THE DIRECTION OF AID BY ODA DONORS**

Based on the above considerations and observations, this section will discuss the JICA study team's opinions on possible aid that development partners and ODA donors may consider (not limited to JICA).

### **(1) Capacity Building**

While the steady implementation of the IPSDP is to be hoped for moving forward, it is also true that the government of Nepal is limited on staffing. To achieve this efficiently and effectively, building the capacity of relevant ministries and staff (resource) is needed. A capacity of particular importance would be one that was specified by Nepal and discussed in "1.2.2 Strengthening capacity to materialize the above visions: Nepal-side opinions" of this chapter. Addressing this through aid such as technical assistance would be very important.

### **(2) Financing the IPSDP project**

Of the projects described in the IPSDP, it is effective to provide finance through highly concessional facilities, in particular large-scale generators and grid development. Loans provided by development partners and ODA donors would be of high utility value.

### **(3) Development of RFP / PPA template according to international standards**

From the perspective attracting foreign investors, the creation of RFP and PPA equipped with conditions acceptable to them would be needed. The NEA currently has a PPA template, although its contents do not necessarily reflect the perspectives or opinions of foreign investors. It is possible for development partners and ODA donors to develop these documents through aid such as technical assistance.

### **(4) Provision of Transaction Advisor Service (TAS)**

TAS refers to development partners and ODA donors supporting the procurement (bidding) process of a government ministry-implemented project from preparation to implementation. IFC and ADB have extensive experience in this globally, and JICA also has experience in providing a similar service for a Waste-to-Energy project overseas (Indonesia). The previous points mentioned capacity building and creation of RFP/PPA to international standards but implementing an OJT could be said to be the most efficient way forward. Packaging these elements into one and providing aid in the form of technical assistance may be very effective.

### **(5) Supporting the development of an electricity export strategy**

For Nepal, exporting electricity to neighboring countries such as India and Bangladesh could be considered to be its lifeline. Thus, preparing a long-term strategy for this is crucial. However, when considering the experience and position of the staff of the government of Nepal and adding to this communication, discussions, and deliberations with foreign governments, developing a strategy for this may be challenging to do for the staff on their own. From the perspective of bolstering them and covering the challenges, it may be meaningful for development partners and ODA donors to provide support for the development of Nepal's electricity export strategy.



## **ANNEX 15**

# **MILESTONES AND FUTURE OUTLOOK FOR THE POWER SECTOR TOWARDS THE REALIZATION OF IPSDP**



---

<b>Annex 15</b>	<b>Milestones and Future Outlook for the Power Sector towards the Realization of IPSDP .....</b>	<b>15-1</b>
15.1	Development Milestones and Pathways towards 2040 in IPSDP .....	15-1
15.1.1	Development Milestones in IPSDP .....	15-1
15.1.2	Pathways to IPSDP .....	15-3
15.2	Challenges of IPSDP .....	15-4
15.2.1	Clean Export .....	15-5
15.2.2	Expansion of Nepal Power System .....	15-7
15.2.3	Business Structure of Power Sector .....	15-11
15.2.4	Finance / Private Investment .....	15-13
15.2.5	Energy Transition .....	15-14
15.3	Required Transformations and Future Outlook for IPSDP .....	15-16
15.3.1	Current Power Business Structure .....	15-16
15.3.2	Five Transformations Needed for IPSDP .....	15-17
15.3.3	Future Business Structure for IPSDP .....	15-18
15.4	Recommendations for IPSDP .....	15-20
15.4.1	Power Trade .....	15-20
15.4.2	Promotion of Pioneer of Hydropower Project in River Basin .....	15-22
15.4.3	Scaling Up the Power Sector Industry .....	15-25
15.4.4	Matching the Demand and Needs for Project Financing .....	15-26
15.4.5	Energy Transition .....	15-27
15.5	Proposal of Pilot Projects for IPSDP .....	15-28
15.5.1	Sunkoshi-3 HPP .....	15-30
15.5.2	Phukot Karnali HPP .....	15-35
15.5.3	Transaction Advisory Service .....	15-40
15.5.4	Strengthening the Financing Capacity of HIDCL and Domestic Financial Institutions .....	15-40
15.5.5	Implementation of Pilot Projects for Energy Transition .....	15-42

---



## ANNEX 15 MILESTONES AND FUTURE OUTLOOK FOR THE POWER SECTOR TOWARDS THE REALIZATION OF IPSDP

In order to achieve the development sector outlined in IPSDP (Integrated Power System Development Plan), it is crucial for Nepal to transform the power sector itself significantly in power infrastructure, business structures, power trade, finance and legal frameworks. These elements are closely related among various fields such as power generation, power system, environment and finance. Thus, it is necessary to involve diverse stakeholders and to proceed the development from comprehensive perspective. This Chapter organizes the results from Chapters 1 to 14 cross-sectionally, presents the milestones and pathway towards realizing IPSDP and indicates the necessary transformations and future outlook of power sector. Finally, challenges and recommendations to carry out IPSDP are summarized.

### 15.1 DEVELOPMENT MILESTONES AND PATHWAYS TOWARDS 2040 IN IPSDP

Table 15.1-1 and Figure 15.1-1 summarize the installed capacity, domestic demand, power trade and major milestones towards 2040 in IPSDP. Development milestones of IPSDP are; achieving net-zero in power trade (2025), commencement of operation of power generation projects currently under survey (2027), achieving self-sufficiency through a year (2033), meeting government targets in roadmap (2035) and contributing to stable power supply to domestic and neighboring countries (2040).

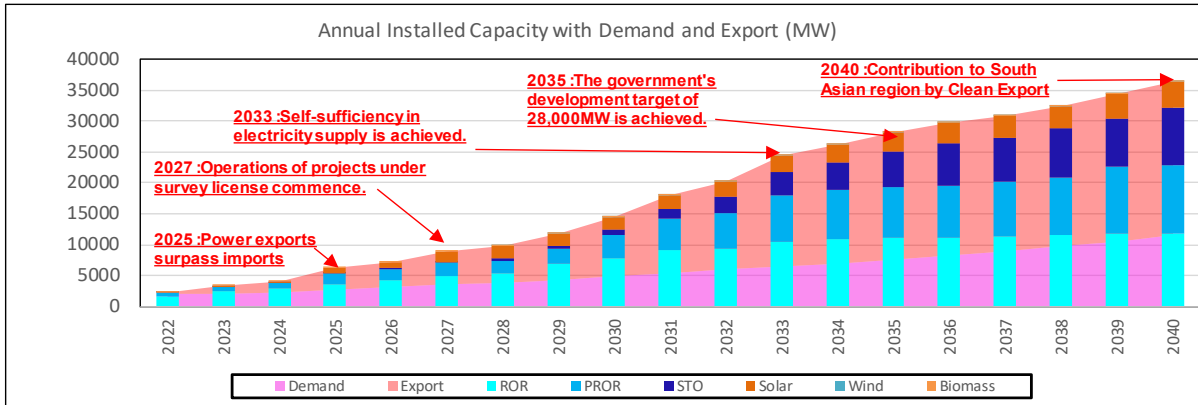
*Table 15.1-1 Milestones towards 2040*

Year	Milestone
2025	Power exports surpass imports.
2027	Commencement of operation of currently surveyed power projects, accelerating power exports.
2033	Achieving power self-sufficiency including the dry season and advancing energy transition.
2035	Commencement of large scale STO HPPs, achieving the energy development roadmap target of 28,000 MW.
2040	Contributing to stable power supply to Nepal and neighboring countries.

Source: Prepared by JICA Study Team

#### 15.1.1 Development Milestones in IPSDP

From 2023 to 2025, 4,110.2MW of installed capacity will have been developed. It is important to steadily implement the projects currently under construction that have already obtained a Construction License. This requires proper and smooth monitoring, quick reviews and approval of necessary permits and interconnection between power system and plants. Hydropower development includes projects such as Rasuwagadhi and Madhya Bhotekoshi by NEA (Nepal Electricity Authority) subsidiaries and large IPP (Independent Power Producer) projects like Upper Trishuli-1 and Arun 3. Development of power system focuses on 400kV interconnection line at New Butwal and 400kV backbone system connecting major domestic cities from New Butwal to Ratmate, Hetauda and Dhalkebar.



Item	~2025	2026 - 2030	2031 - 2035	2036 - 2040	
Generation	GoN Entities	Rasuwagadhi (111MW), Sanjen (42.5MW), Upper Modi A (42MW), Rahughat (40MW), Upper Trishuli 3B (37MW), Madhya Bhotekoshi (102MW)	Tanahu HEP (140MW), Tamor Storage (200MW), Madi Storage HEP (156MW)	Lower Seti(126MW), Uttarganga STO (828MW), Phukot Karnali (480MW), Nalsyau Gad STO (417MW), Upper Arun (1061MW), Chainpur Seti (210MW), Dudhkoshi STO (635MW), Sunkoshi 3 STO (680MW)	Betan Karnali (442MW) Kimathanka Arun (450MW), Bhabung (470MW), Mugu Karnali STO (1670MW)
	IPPs	Upper Trishuli-1 (216MW), Arun 3 (900MW)	Manang Marsyangdi (282MW), Budhi Gandaki Ka (226MW), Bheri 4 HEP (271MW), Tila-1 (299MW), Tila-2 (297MW)	Lower Badigad STO (380MW), Budhi Gandaki (340MW), Upper Marsyangdi - 2 (327MW), Dudh Koshi-IV (350MW), Upper Tamor (285MW), Bheri-2 (270MW), West Seti STO (750MW), SR-06 STO (309MW), Tamakoshi 3 (650MW), Khimti Shivalaya STO (396MW)	Bajhang Upper Seti (216MW), Naumure STO (218MW), Upper Mugu Karnali (240MW), Bheri-1 (270MW), Humla Karnali-Cascade (637MW)
	RE	800.2MW (823MUSD)	1355.6MW (1363MUSD)	900MW (950MUSD)	1025MW (925MUSD)
Technical Studies	Planning for Cascade Operation utilizing STO Considerations of access road for hydropower corridors	Introduction of pumped storage Innovation of generation planning considering export			
Construction	1) HPPs in Construction Licenses				
	2) HPPs in Survey Licenses			3) HPPs in GoN categories	
Power System	400kV Bulk Power System	NEW BUTWAL - NEW DAMAULI - RATMATE - LAPSI PHEDI, RATMATE - HETAUDA - DHALKEBAR - INARUWA	LUMKI - KOHALPUR - LAMAHI - NEW BUTWAL, DHALKEBAR - NEW KHIMTI - DUDHKOSHI, DHALKEBAR - DUDHKOSHI - ARUN	ATTARIA - LUMKI, NALSING GADH - NEW DAMAULI, LAPSI PHEDI - NEW KHIMTI	CHAINPUR - ATTARIA, PURKOT - LUMKI, NALSING GADH - KOHALPUR, PHILIM - RATMATE - CHILIME HUB, ARUN - INARUWA - ANARMANI
	Interconnection Lines	NEW BUTWAL - GORAKHPUR	LUMKI - BAREILY, INARUWA - PURNEA	DHALKEBAR 2 - MUZAFFARPUR	KOHALPUR - LUCKNOW
	Major Cities Demand	Kathmandu 506 MW (LAPSI PHEDI, RATMATE) Birgunj 302 MW (HETAUDA) Pokhara 195 MW (NEW DAMAULI) Dhalkebar 126 MW (DHALKEBAR)	Kathmandu 935 MW (LAPSI PHEDI, RATMATE) Birgunj 570 MW (HETAUDA) Pokhara 371 MW (NEW DAMAULI) Dhalkebar 368 MW (DHALKEBAR) Lumbini 637 MW (NEW BUTWAL)	Kathmandu 1,329 MW (LAPSI PHEDI, RATMATE) Birgunj 873 MW (HETAUDA) Pokhara 403 MW (NEW DAMAULI) Dhalkebar 564 MW (DHALKEBAR) Lumbini 975 MW (NEW BUTWAL)	Kathmandu 2017 MW (LAPSI PHEDI, RATMATE) Birgunj 1,326 MW (HETAUDA) Pokhara 612 MW (NEW DAMAULI) Dhalkebar 856MW (DHALKEBAR) Lumbini 1,481 MW (NEW BUTWAL)
	Cost	1213MUSD	2765MUSD	2397MUSD	2717MUSD
	Technical Studies	Power system operation planning with power trade Interconnection studies with neighboring countries	Harmonization between power system and VRE Power System Planning for Western Province		
	Construction	Reinforcement of Interconnection Lines and Domestic Bulk Power System		Establishment of 400kV Bulk Power System	Operation of Transmission Lines for Direct Export
Developer	Matching between domestic HPPs and potential developers Facilitation of involvement of foreign developers	Establishment of SPCs			
Finance	Enhancing the finance capacity of domestic finance	Involvement of Indian/Bangladesh Investors Utilization of Sovereign or PPP loans for Nepal, India and Bangladesh			
Rule & Regulation	Establishment of modality of power trade in PPA, grid interconnection and related regulations				
Capacity Development	Restructuring the Power Sector	Scale-up of governmental entities in quantity and quality			
Energy Transition	Facilitation of electrification by EV, E-cooking or Heat pumps Research and development for green hydrogen or ammonia		Energy transition by utilizing surplus electricity		

Source: Prepared by JICA Study Team

Figure 15.1-1 Development Milestones and Pathways in IPSDP

From 2026 to 2030, 8,250.6MW of installed capacity will have been developed. The projects currently under construction are expected to commence operations between 2026 and 2027. From 2028 onwards, projects currently with a Survey License or identified by GoN (Government of Nepal) will also start operations. Hydropower development will focus on medium and small-scale projects up to 200MW such as Tanahu STO (Storage) in this period. Although scale of individual HPPs are not huge, total amount of capacity addition is a significant increase. Solar projects around Terai plains are also expected to be developed by mainly IPPs. As power exports increase owed to rapid capacity addition, power system will also be developed in new 400kV interconnection lines at Lumki and Inaruwa, as well as the 400kV backbone system connecting western regions to New Butwal and Koshi basin to Dhalkebar. Active participation from international developers, investors, and banks including those from India and Bangladesh is facilitated.

From 2031 to 2035, 13,669.0MW of installed capacity will have been developed. Development will shift from small and medium ROR (Run of River) to large-scale PROR (Peaking Run of River) and STO projects over 200MW. In this period, commencement of major projects under Survey License will reach the peak of development, achieving power self-sufficiency including the dry season by 2033. Hydropower development will focus on new river basins such as Karnali, Bheri, Kaligandaki, and Tamor. The power system development will extend the 400kV backbone system in the far west and develop the 2<sup>nd</sup> eastern-western backbone along the northern route. As surplus electricity is available through the year after 2030, energy transition initiatives will advance the utilization of low-carbon fuels like hydrogen and ammonia. These continuous efforts will lead the achievement of development target indicated in the Energy Development Roadmap and Work Plan 2035 by MoEWRI (Ministry of Energy, Water Resources and Irrigation).

From 2036 to 2040, 8,112.0MW of installed capacity will have been developed. Large-scale STO HPPs and development of upstream areas in each river basin will progress. As domestic power supply is stable year-round, new power sources will be developed for direct export to neighboring countries.

### 15.1.2 Pathways to IPSDP

Achieving the milestones shown in the previous section requires the implementation of various measures, including technical considerations, finance, institutional and regulatory frameworks, and human resource development. Considering the timeline and the progress of each project, it is assumed that projects currently under construction with a Construction License will be required to commence operations by 2027. Ensuring the steady execution and progress monitoring of these projects is essential.

Conversely, numerous projects with a Survey License and GoN projects need to be proceeded towards commercialization. To achieve the MoEWRI development target of 28GW by 2035, these projects need to commence operations between 2031 and 2035. Therefore, construction works of them are required to start by 2026-2030. This means that it is necessary to complete organization of SPC (Special Purpose Company), financing, PPA (Power Purchase Agreement) negotiations and obtaining Construction License by 2026-2030. Similarly, preparation for the development of international interconnection lines and domestic backbone systems targeting 2031-2035 is necessary.

Various tasks are addressed including technical considerations for power generation and system operation aimed at the power trade, financing for each project, establishing a mechanism of Clean Export, enhancing safeguards and strengthening the power sector's capacity. These are urgent issues to be carried out involving not only the power sector but also other sectors.

## 15.2 CHALLENGES OF IPSDP

To realize IPSDP, it is crucial to steadily execute the currently ongoing projects by 2026. From 2027 onwards, it will be necessary to develop the currently surveyed projects. Many of these new developments lack established implementation structures and financing. Feedback from local private and government operators indicates that it is difficult for individual license-holding developers to undertake large-scale projects alone. Meanwhile, domestic resources are already being utilized, making the promotion of participation by foreign developers, investors, banks, and development aid agencies an urgent task. To achieve development post-2027, issues such as integrated river basin development, access road development, securing transmission routes, and promoting power trade must be addressed. Additionally, enhancing the capacity of government organizations and the entire power sector is also necessary.

Many of these challenges need to be addressed promptly to achieve development post-2028. However, as the various fields are closely related, it is difficult to solve them through the efforts of individual government organizations alone. Inter-organizational cooperation is crucial. For instance, while NEA's risk in expanding power trade does not directly affect the technical considerations of power sources and systems as an electrical phenomenon, it is closely related to financial aspects, such as who bears the financial risk in power trade, institutional aspects, such as whether organizations other than NEA will be involved in the power trade, and governance aspects, such as adjusting interests among various stakeholders, including neighboring countries.

This section organizes the major challenges, summarizing knowledge and experiences of JICA Study Team through IPSDP studies and comments obtained from various stakeholders. Although issues of power sector are closely related each other, these are classified into the following five categories;

- (1) Clean export
- (2) Expansion of the Nepal power system
- (3) Business structure of power sector
- (4) Finance / Private Investment
- (5) Energy Transition

Major topics and relation with generation, power system, finance, legal framework and governance are integrated in Table 15.2-1.

**Table 15.2-1 Challenges in the Five Necessary Transformations in the Nepalese Power Sector**

Item	Generation	Power System	Finance	Institutional / Legal	Governance
<b>1.Clean Export</b>					
Concentration of risks on NEA for expansion of clean export	✓	✓	✓	✓	✓
Securement of power supply reliability for domestic demand	✓	✓		✓	✓
Technical issues on expansion of power trade		✓			
Development scheme on interconnection lines		✓		✓	✓
Issues on legal framework for power trade	✓	✓		✓	
Insufficient experiences on export oriented hydropower projects by Nepalese developers	✓	✓	✓	✓	
<b>2.Expansion of the Nepal Power System</b>					
Necessary adaptation measures against climate change risks.	✓	✓		✓	
Necessity of integrated river basin development	✓			✓	✓
Capacity development on tunnel design and construction	✓			✓	
Need to improve system planning capabilities.		✓		✓	
Interconnection of VRE		✓		✓	
Mitigation of environmental and social impacts	✓	✓	✓	✓	
<b>3.Business Structure of Power Sector</b>					
Necessity of capacity development of GoN	✓	✓		✓	
Clarification of role of government organizations and sector reforms.	✓	✓		✓	✓
Shortage of domestic contractors	✓	✓		✓	
Necessity of international standard PPA	✓			✓	✓
<b>4.Finance/Private Investment</b>					
Finance from domestic investors or lenders	✓	✓	✓	✓	
Necessity of promotion of FDI	✓	✓	✓	✓	
Enhancement of assistance by development partners	✓	✓	✓	✓	
<b>5.Energy Transition</b>					
Promotion of electrification	✓	✓	✓	✓	
Establishment of legal framework and supply chain in Green Hydrogen	✓	✓	✓	✓	

Source: Prepared by JICA Study Team

## 15.2.1 Clean Export

### (1) NEA's Risk in Expanding Power Trade

Regarding power exports to India, there has been progress in negotiations since 2023, with India setting exchange volumes and purchase periods of 5-10 years, but long-term prospects remain uncertain. When NEA, as a single buyer, purchases power from IPPs and trades it with India, the lack of long-term guaranteed buyers can pose significant financial risks. Additionally, while Bangladesh has started receiving 40MW and future expansion is expected, transmission is primarily via the Indian grid, raising concerns about country risk if relations with India deteriorate.

Under the current business structure, NEA bears all risks related to power trade. To mitigate these risks, establishing a business model where power plants directly wholesale to distribution companies or large consumers in other countries or the Exchange Market, bypassing NEA, is necessary. This direct transaction model is expected to involve developers or financiers from India and Bangladesh, contributing to stable power supply in the South Asian region, with each stakeholder benefiting from Clean Export.

### (2) Ensuring Domestic Supply Capacity in Nepal

The examination of power development plans and the utilization of surplus power includes considerations of power exports, electrification of heat demand, and the production of green hydrogen and ammonia. From 2029 onwards, surplus power is expected even during the dry season, which could drive Nepal's economic growth. When considering the utilization of surplus power,

the government and NEA's role in the power sector is to ensure stable domestic power supply first. However, as demand and economic viability for export power and green hydrogen grow, there is a concern that private operators might focus on overseas projects, potentially jeopardizing domestic supply.

Currently, NEA handles domestic power supply, but as power exports expand, it is crucial to establish mechanisms to ensure domestic demand-supply balance and operational systems that flexibly combine exports and imports.

### **(3) Technical Challenges in Expanding Power Trade**

#### **1) Technical Considerations for International Interconnection Lines**

Future power trade with India, particularly for international interconnection lines beyond New Butwal, such as Lumki, Koharpur, and Inaruwa, will require considerations for optimizing transmission capacity, controlling power flow and faults on the interconnection lines, frequency adjustment, synchronization, interconnection regulations, and connection points to the Indian backbone system. These considerations will primarily be addressed within the existing framework of the Joint Technical Study Team. However, NEA also needs to enhance its capability to carry out these technical studies, necessitating capacity building in the Power System Department.

#### **2) Understanding the Power Trade Volume in Power Supply-Demand Operation**

Power licenses need to be granted in alignment with the progress of transmission line development, but there are frequent comments about the lack of coordination between power and transmission line developers. Specific issues include scenarios where transmission line development is ahead but power generation is delayed, or vice versa. Coordination is principally managed by NEA's Generation Control Department, which needs to collaborate with DoED (Department of Electricity Development) and hydropower developers. However, there are also comments about insufficient coordination and frequent plan changes. Both NEA and DoED recognize these coordination and project management issues, emphasizing the need for smooth project advancement.

In the coming years, NEA will continue commissioning its hydropower plants, and power trade volumes with India are expected to increase. If NEA fails to control power trade volumes as per the contracts, it will incur penalties under the DSM (Deviation Settlement Mechanism) with India. Therefore, enhancing NEA's supply-demand adjustment capabilities is also crucial as power trade volumes increase.

#### **3) Seasonal Discrepancies in Generation and Optimization of Generation Plans for Power Export**

Nepal's power generation primarily relies on hydropower, excluding some thermal and renewable energy sources. Consequently, there is a significant seasonal variation in power generation, with high output during the rainy season (May to October) and low output during the dry season (November to April). This necessitates power imports from India during the dry season despite ample generation during the rainy season. Nepal is addressing this seasonal generation discrepancy through the development of reservoir-based hydropower plants, but only the Tanahu Hydropower Project is in the construction stage. As mentioned in Chapter 6, even with the development of reservoir-based hydropower, seasonal discrepancies will persist.

Existing project plans primarily focus on domestic supply, with generation plans targeting high

purchase rates during the dry season. However, as power exports to overseas markets increase, generation plans must also consider the high-power demand period in India and Bangladesh, which corresponds to rainy season in Nepal. These export-oriented generation plans require optimization of supply-demand operation plans and individual generation plans for exportable power across the entire system.

#### **(4) Development Schemes for International Interconnection Lines for Power Trade**

For each international interconnection line, the burden of development costs and O&M costs is determined through consultation. This process can be time-consuming, potentially delaying the development of interconnection lines as planned. Thus, establishing a scheme for developing international interconnection lines is necessary. Currently, NEA bears the development costs, and it is essential to assess the profitability of power trade costs, including those of the international interconnection lines, and reflect them in the power development plan.

#### **(5) Institutional Challenges in Expanding Power Trade**

Under current regulations, only electricity generated by power plants approved by the Indian side can be traded with India. This raises concerns about the inability to expand power trade volumes if power plants constructed on the Nepalese side do not receive approval from the Indian side. Going forward, it would be beneficial to negotiate with the Indian side to obtain approval for the total exportable power volume from Nepal rather than individual power plants.

### **15.2.2 Expansion of Nepal Power System**

#### **(1) Development of Access Roads and Transmission Lines in Major River Basins**

##### **1) Cost Burden of Access Road Construction**

In the development of hydropower and transmission lines within Nepal, the construction of access roads to project sites is crucial. Hydropower development requires roads capable of transporting heavy equipment, such as construction machinery, turbines, and transformers. These routes often run along river valleys, characterized by steep slopes prone to landslides, and are frequently remote and lengthy. Considering the needs and safety of local residents, multiple routes may be necessary. The costs of these constructions are often borne by the developers of the leading projects in each river basin, which can be a heavy financial burden when considering the project's individual profitability.

##### **2) Securing Transmission Line Routes**

For transmission line development in Nepal, lines connecting hydropower plants to the backbone system are often built along north-south routes following the rivers. As with access roads, these river valleys are steep, limiting suitable locations for constructing transmission lines. If these locations are occupied by lines from smaller, easier-to-develop hydropower plants, securing routes for future 400kV, 220kV, and 132kV transmission lines becomes challenging. To avoid overlapping transmission routes, a transmission plan considering the integrated development of river basins is necessary.

##### **3) Development of Access Roads and Transmission Line Routes by the Public Sector**

In river basins where development is currently concentrated, such as the Trishuli, Marshyangdi, Likhu, and Bhotekoshi rivers, existing hydropower plants have ensured the necessary road and transmission line routes. However, securing access roads and transmission line routes remains

a common challenge in river basins with abundant hydropower potential but less development, such as the West Seti, Karnali, Bheri, Kaligandaki, Dudhkoshi, and Tamor rivers.

The construction of access roads and transmission lines in major river basins also has public works aspects, contributing to regional development. Therefore, measures such as preferential treatment for pioneering developers, incorporation of costs into tariffs, or development by the public sector are necessary.

## **(2) Need for Integrated River Basin Development\*\***

### **1) Application of the Integrated River Basin Development Concept**

Nepal's rivers originate from the Himalayas and flow into the Terai plains. These lower basins are expected to develop into granaries but also frequently experience flooding. Integrated river basin development is crucial in water resource development and management plans to maximize societal benefits from power generation, water use, and irrigation. However, single-project developments tend to decide project scale and generation plans based on individual site economics. Integrated river basin development, which maximizes each river's hydropower potential through coordinated operation, such as cascade operation contributing to peak generation, is necessary. Additionally, sedimentation and flood control are critical issues in dam and reservoir operations.

In this context, WECS (Water and Energy Commission Secretariat), with WB (World Bank) support, is formulating "Preparation of River Basin Plans and Hydropower Development Master Plans and Strategic Environmental and Social Assessment." It is desirable to pursue integrated river basin development based on such comprehensive plans.

### **2) Acquisition Status of Development Licenses**

Small-scale hydropower developments sometimes hinder reservoir-based hydropower projects. For example, the Tamor Storage Project (762MW) in the Tamor River basin is impeded by earlier developments like Lower Hewa (7.3MW) and Kabeli A (37.6MW), which affect reservoir capacity. There are concerns about the licensing issue, where promising sites are preemptively occupied through survey licenses. Although measures like license expiration are in place, an integrated river basin development plan is needed.

### **3) Sedimentation Issues**

Sedimentation is a significant challenge in hydropower development in Nepal. Despite steep river slopes, many riverbeds have thick sediment layers. Sedimentation increases construction costs due to higher excavation volumes and dam heights, reduces effective reservoir capacity, decreases generated power, and raises maintenance costs due to turbine wear. Sedimentation management, including annual desilting, is particularly crucial for smaller reservoir-based plants. However, there is insufficient research on sedimentation volume and monitoring, and the status of reservoir sedimentation in existing plants is not well understood. Analyzing landslide potential and sediment sources in watersheds is also lacking. These sedimentation issues require integrated watershed management, including soil conservation and coordinated desilting, which is currently not adequately analyzed.

### **4) Climate Change Measures in Hydropower Development**

Nepalese rivers originate from Himalayan glaciers, with ICIMOD (International Centre for Integrated Mountain Development) highlighting the risks of glacier melt due to climate change. In February 2021, a flood in the Dhauliganga River, attributed to glacier melt, resulted in 200

deaths. Nepal lacks a technical committee to address such development risks related to climate change, necessitating assessments like GLOF (Glacial Lake Outburst Flood) and Dam Break Analysis in hydropower projects.

Climate change also impacts snowmelt and precipitation patterns, affecting river flow and reducing power generation during droughts. These risks should be considered on a river basin level rather than individual projects.

### **(3) Enhancing Tunnel Planning, Design, and Construction Capabilities**

Many ROR and PROR projects in Nepal involve constructing water conveyance tunnels, given the high-altitude, steep river sites. Additionally, projects like the Dudhkoshi Storage HPP (Hydro Power Plant) and Bharbhung HPP plan to secure head using diversion tunnels. However, as previously mentioned, Nepal's mountainous geology includes weak layers, making tunnel construction challenging. Besides water tunnels, access road tunnels are also necessary in mountainous terrain.

Enhancing "quality" and "quantity" capabilities in planning, designing, and constructing tunnels is essential.

### **(4) Enhancing System Planning Capabilities**

Nepal's hydropower plants are distributed across various river basins, while major demand centers like Kathmandu, Pokhara, and New Butwal are centrally located, causing voltage rise at power generation points. Plans include a grid of east-west 400kV transmission routes and north-south routes in each river basin, necessitating phased voltage increase operation considerations. Some northern routes and 400kV substations might become redundant. One example is the potential reduction in the transmission capacity from remote areas to demand centers such as Kathmandu, due to changes in the power generation development situation. The roles of 220kV (power lines) and 132kV (current backbone system) voltage levels need reevaluation. For example, regarding the demand system, the voltage levels will be structured in three stages: 400 kV / 132 kV / 33 kV or 11 kV, and the existing 220 kV and 66 kV will not be increased beyond the current levels. This approach will reduce the number of transformers needed and help stabilize the voltage. Urban centers with high demand, like Kathmandu, require individual system planning.

### **(5) Integration of Renewable Energy into the Grid**

The development of renewable energy in Nepal is concentrated in the southern Terai plains, with significant progress expected post-2023. These areas currently have 132kV or 66kV systems, and solar power plants are expected to connect to these systems. However, there are concerns about local grid instability due to the rapid output fluctuations of solar power in some concentrated development areas. Future system planning must consider these impacts and implement appropriate measures.

### **(6) Need for Mitigation Measures for Environmental and Social Impacts Accompanying Development**

At the stages following the Feasibility Study (F/S), it is desirable to appropriately conduct environmental and social considerations in accordance with local laws such as EPA 2019, EPR 2020, and good practices, taking into account the following points:

#### **1) Cumulative Impact Assessment for the Entire Basin**

Since the current local laws and regulations in Nepal (EPA (Environmental Protection Act)

2019, EPR (Environmental Protection Rules) 2020, etc.) do not specifically require cumulative impact assessment, there are cases that cumulative impacts from the entire watersheds' viewpoints are not taken into account during impact assessments and mitigation measures development. Due to the varying progress of development plans in each river basin in Nepal, it is necessary to evaluate cumulative impacts<sup>1</sup> in each basin and consider appropriate mitigation measures from a watershed management perspective. This is especially important in basins with concentrated development plans, such as the Gandaki River Basin, which has many existing power plants and is close to demand centers. Early-stage development considering cumulative impacts is desirable.

## **2) Impact on Ecosystems**

Hydropower projects can alter river flow and water levels due to water intake, storage, and release, potentially affecting aquatic life and water birds. The construction of dams and intake weirs can also disrupt river continuity, hindering the migration of fish species, which are the issues in Nepal. Where these impacts are expected, it is necessary to assess the effects on environmental flow and ecosystems and incorporate them into environmental management and monitoring plans. Additionally, it is essential to recognize and plan for risks associated with climate change, such as Glacial Lake Outburst Floods (GLOF).

## **3) Appropriate Compensation and Benefit Distribution for Land Acquisition and Resettlement**

One of the challenges in hydropower development in Nepal is the compensation and benefit-sharing for land acquisition and resettlement, which has occasionally led to criticism from NGOs (Non-Governmental Organizations) and complaints from residents. It is desirable to develop and implement a resettlement plan, including compensation payments based on the reacquisition price. Particularly in projects involving significant resettlement due to reservoir-based hydropower plants or transmission lines, enough budget and implementation systems must be secured. Moreover, benefits from power development, such as those from power projects and power trade with neighboring countries, often concentrate in urban areas like Kathmandu and Pokhara, while the directly impacted areas are around the project sites. It is also important to consider correcting these benefit disparities.

## **4) Consideration for Indigenous Peoples**

The "National Foundation for Development of Indigenous Nationalities Act" in Nepal designates 59 ethnic groups as indigenous peoples, with many residing in mountainous areas where hydropower projects are planned. Nepal has also ratified ILO (International Labor Organization) Indigenous and Tribal Peoples Convention, 1989 (No. 169). However, there are still few cases where FPIC (Free, Prior and Informed Consent) are obtained in the planning of hydropower projects. It is recommended to conduct meaningful consultations with the affected indigenous peoples from the early stages of planning and obtain agreement based on the principles of FPIC.

---

<sup>1</sup> Impacts caused by concentration of multiple similar projects in a certain area. For example, cumulative impact of multiple hydropower projects being developed in the same river basin should be evaluated from the perspective of river basin management; and the impacts on river flow and migratory fish should be appropriately managed and monitored.

### 15.2.3 Business Structure of Power Sector

#### (1) Strengthening Government Organizational Structure in the Power Sector

Nepal's total installed capacity was 2,684 MW as of 2023 but is expected to reach 35,591 MW by 2040. Progresses in power source and system development are anticipated from 2025 upto 2030, calls for efficient conduct of surveys, design, and construction. The Nepalese government need to handle approvals, control progress management, and execute administrative processes for power development in efficient manner. Human resource development within government organizations involved in power development is therefore an urgent topic. The following describes the specific needs for NEA, VUCL (Vidhyut Utpadan Co., Ltd.), and other institutions:

##### 1) NEA

NEA owns development rights of projects like Lower Seti (126 MW), Dudhkoshi Storage HPP (835 MW), Uttarganga Storage HPP (828 MW), and Chainpur Seti HPP (210 MW) in addition to several ongoing projects such as Upper Trishuli 3B (37 MW) and Tanahu (140 MW) with its subsidiaries. Additionally, new developments like Sunkoshi-3 HPP (680 MW) and Syarpu Lake Pump Storage (334 MW) are under discussion.

System development requires the establishment of 400 kV, 220 kV, and 132 kV backbone systems and distribution networks. International interconnection for power trade will also be integral. NEA needs the capability to execute these projects without fail.

##### 2) VUCL

VUCL is progressing with the development of projects like Phukot Karnali, Mugu Karnali, Nalgad, and Jagdulla. However, VUCL heavily relies on external consultants for F/S implementation. VUCL is a relatively new organization compared to NEA, with few experienced engineers for projects in the construction phase, which is a concern.

##### 3) Other Institutions

Other than developers, institutions like DoED, managing licenses, and ERC (Electricity Regulatory Commission), overseeing legal frameworks including PPAs, are in need to fortify staff when power and system development expands. Strengthening capabilities in technical fields such as hydropower and transmission, as well as in financial and legal fields related to PPAs and contractor agreements, is an essential.

#### (2) Clarifying Roles and Restructuring Government Enterprises

Several organizations within the government, such as MoEWRI (including DoED and ERC) and IBN (Investment Board of Nepal), and power generation companies like NEA and VUCL, and transmission companies like NEA and RPGCL (Rastriya Prasaran Grid Co. Ltd.), are overlapping their roles and results in inefficiencies. The 2019 PPP Investment Act designates IBN as the primary interface for projects over 200 MW, but IBN faces a shortage of technical staff involved in power development hence requires collaboration with MoEWRI. However, the specifics of this collaboration are unclear. Similarly, the role demarcation between NEA and VUCL/RPGCL is not well-defined, often decided on a case-by-case basis.

The revised Electricity Act, currently under parliamentary review, includes provisions for the separation of NEA's transmission and distribution functions. Following the enactment of this law, once it happens, discussions on the separation or integration of NEA, VUCL, and RPGCL are expected to accelerate. On the other hand, the role distribution and collaboration between

MoEWRI and IBN are not currently under consideration, possibly due to the lack of relevant projects. Implementing pilot projects defining respective roles and collaboration methods between these organizations might be a viable approach.

### **(3) Shortage of Private Sector Developers in the Power Sector**

#### **1) Hydropower Developers**

The shortage of private developers investing in hydropower projects, elaborated in Ch.12.2 and 12.3, is a concern, particularly for mid-to-large-scale projects requiring strong financing partners. While existing projects under construction or under survey have developers, finding local or attractive international partners for new large-scale projects remains challenging. Local private companies are already involved in various projects, making additional investments difficult, while local government companies face uncertainties in role distribution with NEA. Attracting international developers, especially for export-focused projects, requires creating and improving a conducive investment environment.

#### **2) Contractors**

A shortage of contractors is also anticipated. It is expected that the shortage of construction companies, as well as financial institutions and hydropower developers, will become apparent in the future. The construction industry's share of the total GDP will remain at around 5.1% as of fiscal 2021, which is somewhat lower than in other countries. However, the development costs expected for power development in Nepal are expected to be at the same scale as they are now. Meeting construction demand of power project, project developer needs to securing a large sum of workforce, from skilled to general laborers, with improved wages and working conditions.

### **(4) Need for PPA Development**

Hydropower development requires significant investment, making it difficult for the Nepalese government alone to secure the necessary funds, highlighting the need for private investment. Efforts to attract private investment include the revision of NEA's PPA standards in 2017 and the establishment of new PPA conditions by ERC in October 2019. However, risks from the perspective of international investors remain, hindering significant growth in hydropower investments. These risks include:

- Uncertainty in the legal framework
- Mechanisms for determining and revising purchase prices
- Implementation of take-or-pay provisions (and government guarantees for purchases)
- Protection of foreign investors' rights (development rights, land use rights, access to various infrastructures, collateral rights, etc.)

Additionally, the 2019 PPP Investment Act designates IBN as the point of contact for IPP development rights over 200 MW, adopting a bidding method based on developer proposals (Swiss Challenge). This increases the risk of losing bids for developers, reducing development incentives. Although a currency hedge method was implemented in 2022, it has seen limited application.

Alongside these general IPP-related legal risks, the development of reservoir-based hydropower projects by private investment also poses specific risks. Reservoir-based projects capable of annual adjustment require NEA, as the system operator, to direct power generation based on supply-demand balance. However, private developers cannot guarantee their generation volume, making it difficult to secure a stable financial base. To promote private investment, introducing payment

methods based on capacity (kW) rather than energy (kWh) is desirable. Additionally, given the large total project costs for reservoir-based hydropower, considering development schemes like the vertical separation model proposed in previous PPP studies is necessary.

## 15.2.4 Finance / Private Investment

### (1) Domestic Fundraising

The required investment amounts (CAPEX and OPEX) for realizing IPSDP are estimated as follows:

**Table 15.2-2 Required Investment Amount for Realizing IPSDP**

Category	Total	Government	Private
CAPEX	USD 80,195 Mil.	USD 31,119 Mil.	USD 49,076 Mil.
OPEX	USD 18,998 Mil.	USD 5,563 Mil.	USD 13,435 Mil.

Source: Prepared by JICA Study Team

Funding for the realization of the IPSDP based on the above table is being undertaken both domestically and internationally. The following describes the challenges each of these efforts faces, from the perspective of domestic and international fundraising, and assistance from development aid agencies.

Nepal has 20 commercial banks (Class A) and 17 development banks (Class B), but current credit capacity of these banks, cannot cover the required amounts. Although development licenses have been granted for many projects, many of them have been unable to raise funds and are effectively stranded. If lending to IPPs is based on project finance basis, the number of financial institutions executing these roles is limited. Hence, enhancing the capacity of local financial institutions to supply funding to projects are essential to realize IPSDP.

In addition, hydropower development in Nepal relies heavily on imports for civil engineering materials and equipment such as concrete and construction machinery, in addition to electrical equipment. Even in development funded by IPPs, the power purchase fee for the foreign currency investment must be paid in foreign currency. For this reason, in order to realize the IPSDP scenario, it is necessary to secure sufficient foreign currency to cover these payments. This issue involves a result-oriented or project-environment oriented issues. Given Nepal's limited foreign currency reserves, a practical approach in the short term is to leverage international aid (sovereign and non-sovereign loans) while promoting power exports and foreign currency acquisition.

### (2) Need to Promote Overseas Financing

As noted, the primary requirement for realizing IPSDP is to increase business investment by local companies and enhance domestic fundraising capabilities. However, the annual investment required for IPSDP is more than three folds of current levels (2022-2023), making it practically impossible to meet these needs domestically. Therefore, attracting foreign investors is critically important for realizing IPSDP.

As of 2024, most development rights for hydropower are held by Nepalese developers, with a few Indian companies. Projects over 50 MW require at least USD 80 million, and many are stalled due to financing issues. Major infrastructure development groups in Nepal can raise substantial funds, but overall financing is still insufficient.

Challenges for foreign investors and financial institutions considering investments in Nepal's power sector include:

- **Political Stability:** Frequent changes in senior officials make leadership and accountability unclear.
- **Legal and Procedural Frameworks:** The pending revised Electricity Act and frequent changes to procedures lack clarity and transparency.
- **Contractual Risk Allocation:** IPP contract terms may be unacceptable from the perspective of foreign investors.
- **Protection of Foreign Investors:** Insufficient legal frameworks to protect the rights of foreign investors, including development rights, land use rights, and access to infrastructure.
- **Project Financing:** Nepalese financial institutions struggle to offer competitive financing, forcing foreign investors to rely on international financial institutions, which are cautious about lending to Nepalese projects.

To accelerate foreign investment, it is essential to address listed issues individually and improve the investment environment.

### **(3) Support from Development Aid Agencies**

Collaboration with development aid agencies is crucial for realizing IPSPDP. Nepal's power sector already receives support from multiple agencies such as JICA (Japan International Cooperation Agency), World Bank, ADB (Asian Development Bank), and USAID (United States Agency for International Development). Effective utilization of these supports to enhance funding capabilities and develop government officials' skills is essential. The support includes:

- **Financial Cooperation:** Program loans, project loans, and two-step loans.
- **Overseas Investment and Lending:** Investments without government guarantees for private companies and financial institutions.
- **Technical Cooperation:** Execution support for IPSPDP, capacity building, and transaction advisory.
- **Expert Dispatch:** Providing advice to MoEWRI, NEA, and IBN.

It is vital to avoid inefficiencies or contradictions caused by overlapping support from different international agencies. Thus, active involvement and comprehensive management by the Nepalese government, along with strengthened information sharing and coordination among development aid agencies, are critical.

## **15.2.5 Energy Transition**

### **(1) Promoting Domestic Electrification**

The power demand forecast in IPSPDP includes policies for electrification such as EVs (Electric Vehicles) and E-cooking, presenting achievable figures. Given the characteristics of hydropower, the development capacity significantly exceeds demand, planning for export. Further demand stimulation, such as industrial promotion utilizing cheap electricity, is desirable.

**Table 15.2-3 Power Demand Forecast for EV and E-Cooking**

Policy / Year	2025	2030	2035	2040
EV[GWh]	190	724	1,464	2,233
Electric cooking [GWh]	904	2,649	3,146	3,649

Source: Prepared by JICA Study Team

By 2040, power demand from EVs and E-cooking will reach 2,233 GWh (3.6% of total) and 3,649 GWh (5.8% of total) respectively, which is significant. Promoting electrification reduces fossil fuel consumption, contributing to CO<sub>2</sub> reduction, improving energy self-sufficiency, and preventing foreign currency outflows.

As shown in Section 7.2.1, the primary energy supply in 2021, excluding traditional biomass, consisted of hydropower at 34,321 TJ (16%), renewable energy at 5,403 TJ (3%), coal at 49,970 TJ (23%), and petroleum products at 122,738 TJ (58%). More than 98% of the coal and all petroleum products were supplied through imports from India.

For Nepal, which relies on India for fossil fuel procurement, promoting electrification, including replacing boiler-based heat demand with heat pumps, is crucial.

## **(2) Legal Framework and Supply Chain for Green Hydrogen Production**

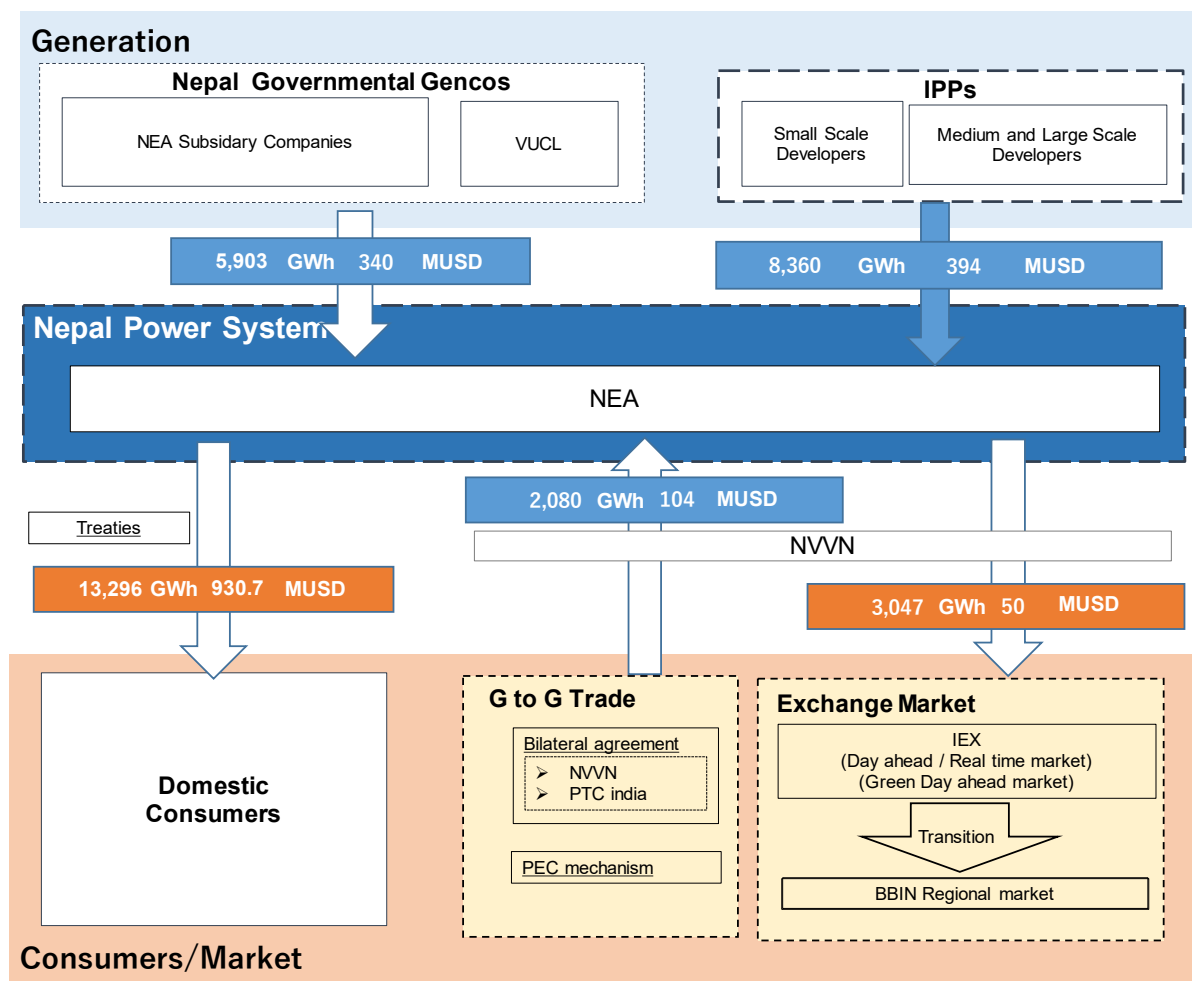
Nepal has significant potential for producing green hydrogen and other CN (Carbon-Neutral) fuels due to its abundant hydropower resources. However, a supply chain for hydrogen use is not yet established. Although MoEWRI formulated a Green Hydrogen Policy in 2024, preferential measures are yet to be developed. Further examination of these measures is necessary.

### 15.3 REQUIRED TRANSFORMATIONS AND FUTURE OUTLOOK FOR IPSDP

This Section clarify the current business structure of power sector based on recognition of challenges and considers required transformations and future outlook for IPSDP.

#### 15.3.1 Current Power Business Structure

Figure 15.3-1 illustrates the current business structure of power sector in 2023. NEA, the vertically integrated power company, functions as a single buyer, purchases power from generation companies and handles domestic and export power sales.



Source: Prepared by JICA Study Team

**Figure 15.3-1 Business Structure of the Power Sector in 2023**

Based on challenges described in previous section, the vulnerabilities of this business structure are consolidated below;

- Financial risk is concentrated in NEA, as it functions as the single buyer.
- NEA's dual roles in generation and transmission/distribution lack transparency in decision-making processes and financial performance.
- There is unclear role distribution between NEA and historical public power entities like VUCL and RPGCL, potentially leading to operational inefficiencies.

- NEA's near-monopoly in transmission/distribution results in a lack of competition, potentially increasing costs.
- With anticipated activation of power trade with India and Bangladesh, a strategic and speedy decision-making organizational structure is required.

### 15.3.2 Five Transformations Needed for IPSDP

As of 2024, the power sector has achieved stable power supply and better financial conditions owed to development over the past decade. However, to achieve the development outlined in IPSDP, it is necessary to solve issues shown in previous section. Following five transformations are proposed for realization of IPSDP:

- (1) Expansion of Clean Export
- (2) Significant Scale Expansion of the Power System
- (3) Reform of the Power Sector
- (4) Expansion of Finance/Private Investment
- (5) Energy Transition

#### (1) Expansion of Clean Export

As a nature of outputs from hydropower, surplus electricity during the rainy season is unavoidable. By 2030, approximately half of the annual generated power will be supplied for domestic demand and the other half for export. Hence, development of power sector is synonymous with expansion of Clean Export. The MoEWRI Roadmap and Workplan targets 15GW of exports by 2035.

The current business structure concentrates power purchases in NEA which contains various risks related to export expansion. Reduction of these risks involves establishing commercial flow through Power Trading Companies and allowing IPPs to engage in PPAs with distribution companies or consumers in India and Bangladesh to sell electricity to them directly. NEA can collect wheeling charges for transmission lines which can recover investment costs of power system while avoiding purchase risks. Such direct trade would also attract new players, increase foreign currency inflows and contribute to expand the business in power sector.

#### (2) Significant Scale Expansion of the Power System

Between 2023 and 2040, the power system in Nepal will achieve significant expansion. Domestic power demand (GWh) will increase 6.7 times, generation capacity (MW) ;16.2 times, and the length of 400kV backbone transmission lines (km) ;262.5 times. Cumulative investment in the power system will reach 61,750MUSD by 2040 with an annual average of 3,632MUSD.

Developing the power system will promote economic growth and navigate Clean Export to a pillar of the export industry. As it is insufficient not only to utilized existing resources but also to strong initiatives as the growing industry of Nepal and attraction of vast foreign investment.

#### (3) Reform of the Power Sector

To implement IPSDP and achieve its goals, power sector reform is essential. Specific considerations include:

- Strengthening ERC functions
- Unbundling NEA's generation, transmission, and distribution functions and introducing competition

- Determining the structure of public entities like VUCL and RPGCL post-NEA unbundling
- Segregating NEA's generation business from private IPPs
- Introducing open access and transmission systems in transmission business
- Operationalizing NPTCL (Nepal Power Trading Company Limited) for domestic and international power trade

These reforms require further capacity development of government officials.

#### **(4) Expansion of Finance/Private Investment\*\***

Sustainable development of Nepal's power sector requires robust foreign investment and financing. Hydropower development as per IPSDP involves substantial capital, necessitating active attraction of foreign investors. Potential sources include loans from international aid agencies like ADB and investments from private investors.

Essential conditions for attracting private investment include:

- Stability of government finances and macroeconomics
- Legal frameworks
- Protection of foreign investors' rights
- Standardized RFPs (Request for Proposals) and PPAs
- Enhanced financing options for private developers
- Strengthened project formation and implementation capabilities of government officials
- Ensuring competitiveness, transparency, and fairness

Government efforts to create a conducive investment environment, coupled with seed projects led by international aid agencies, will foster private investment, realizing large-scale hydropower development as envisioned in the master plan.

#### **(5) Energy Transition**

Achieving Net Zero 2045 is an important mission for the power sector. Nepal has significant potential to contribute to CO<sub>2</sub> reduction domestically and in neighboring countries with its abundant hydropower resources. Promoting electrification policies, such as EV and E-Cooking, and utilizing carbon-neutral fuels like hydrogen is essential.

Reducing fossil fuel use will enhance energy security by decreasing dependency on primary energy from India. Production of CN fuels like green ammonia offer potential for fertilizer procurement and exports to India for combustion of thermal power plants. It is important to utilize surplus electricity for CN purposes by 2040.

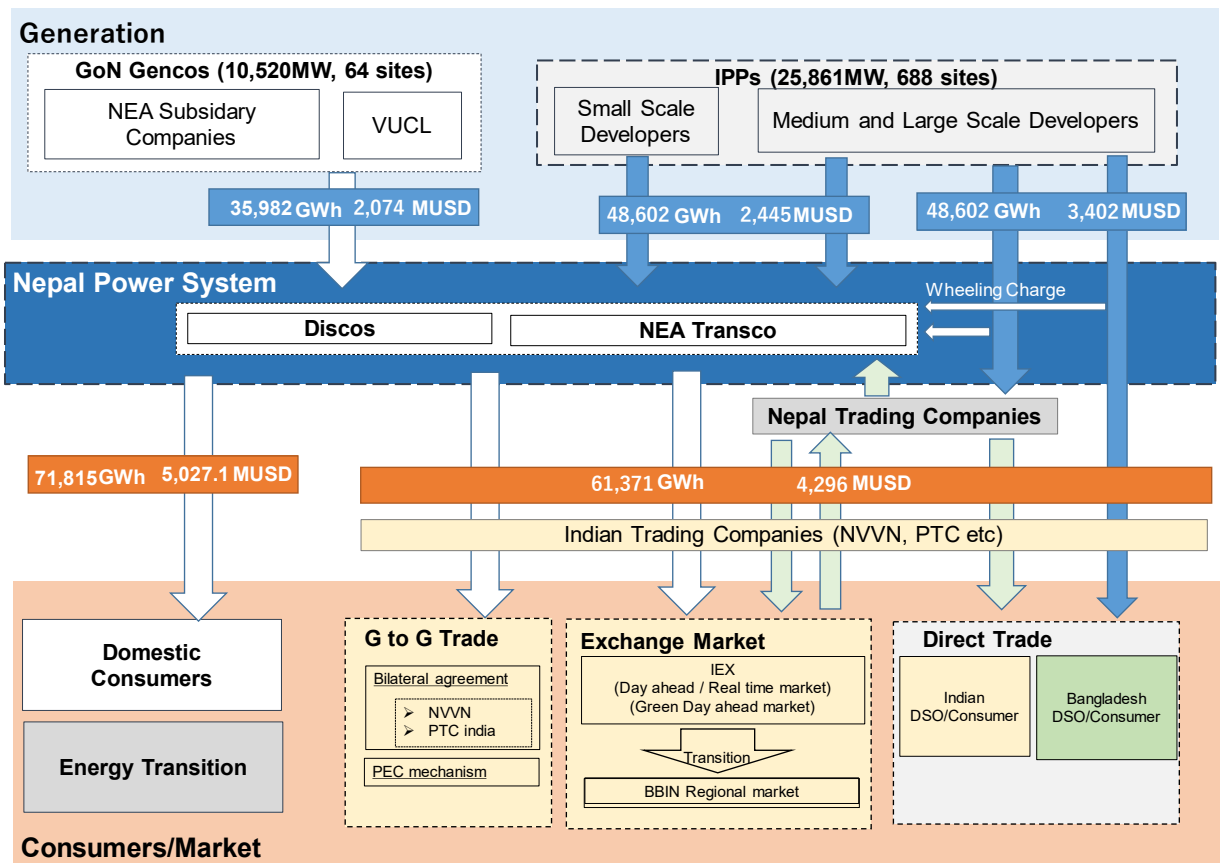
### **15.3.3 Future Business Structure for IPSDP**

Figure 15.3-2 illustrates the envisioned business structure of the power sector in 2035, reflecting the five required transformations.

In 2035, power sector in Nepal will see dramatic expansion in terms of supply-demand scale, clean export, institutional structure and cash flow. The installed capacity and number of power plant sites will be 7,497 MW and 58 sites for government entities such as NEA and VUCL, and 20,718 MW and 654 sites for IPPs. The power system will have a 400 kV backbone transmission lines from east to west across the country with a total length of 1,818 km and six 400 kV international interconnection lines.

The amount of power market business and sales revenue will also increase significantly. Domestic consumption will be 39,966 GWh (44.3%) with a revenue of 3,311 MUSD and Clean Export will be 50,259 GWh (55.7%) with a revenue of 3,518 MUSD, out of the total sales volume of 90,224 GWh. Clean Export will particularly account for 6% of the national GDP (Gross Domestic Product), developing into an export industry that would earn foreign currency. The institutional structure of power sector will also be significantly transformed with the establishment of power trading companies alongside the unbundling of generation, transmission, and distribution.

Nepal has substantial potential for energy transition including CO<sub>2</sub> reduction in neighboring countries through Clean Export. It is also expected to promote electrification of energy derived from fossil fuels and the utilization of green hydrogen and ammonia.



Source: Prepared by JICA Study Team

Figure 15.3-2 Future Outlook for the Power Sector in 2035

## 15.4 RECOMMENDATIONS FOR IPSDP

This Section propose recommendations for power sector in short and middle terms.

The milestones and pathways presented in Section 15.1 suggest that technical studies for Clean Export, strengthening and attracting IPPs, securing domestic and international financing, power system planning and capacity development of human resources must be completed within the next few years to achieve large-scale development beyond 2030. In other words, immediate actions are required to realize massive expansion of power sector. It is critical to deal with these issues but these tasks involve various fields and domestic and international agencies, making it challenging to achieve solely through the activities of individual agencies and requiring various adjustments.

Considering the limited resources of relevant agencies such as MoEWRI, DoED, ERC, NEA, and development partners, it is also important to focus on priority issues that Nepal must address urgently. As comprehensive topics have been covered by “Energy Development Roadmap and Work Plan in 2035 (MoEWRI)”, important issues are highlighted in recommendations for IPSDP.

### 15.4.1 Power Trade

Extensive concentration of sales and purchase trade on NEA is a significant issue for IPSDP because NEA is forced to shoulder a lot of risks in power trade. It is also important to establish institutional arrangements such as establishing distribution channel between power trading companies and IPPs and power companies/customers in India and Bangladesh, granting preferential treatment for clean energy, and applying for power grid connection in each country in order to mitigate the concentration of wholesale to NEA.

#### (1) Wholesale scheme of electricity from the viewpoint of power generators

Table 15.4-1 and Table 15.4-2 show the possible future power trade scheme and a comparison of each scheme of wholesaling from the viewpoint of power generators. 1) is a conventional trade and 2), 3) are new trading schemes assuming power exports.

**Table 15.4-1 Wholesale suppliers of electricity from the viewpoint of power generators**

Wholesale customer	Content
1) NEA	This is a conventional scheme of trading that is completed through domestic transactions with NEA. Since NEA distributes the purchased power to the domestic retail market and the surplus to India, the generators are not directly involved in power trade. Although the purchase price will be lower for the generator, it is assumed that this will continue to be the mainstream scheme for small and medium-sized power generation projects in Nepal, as it does not require any administrative procedures such as grid connection applications or PPAs with customers in other countries.
2) Power trading company	This is a scheme through power trading companies. In the future, Nepal's Electricity Act will be amended to allow power trading business, and it is expected that the function of power distribution, which NEA is responsible for, will be partially transferred to Nepal Trading Companies. NEA has established Nepal Power Trading Company Ltd. (NPTCL), the first trading company in Nepal, in 2021, and NPTCL is expected to operate this trading business for the time being. The power generation companies will be able to choose whether to use the PPA with the power trading companies as the price at which they sell electricity, or whether the price will be linked to the market.
3) Direct trade with DISCO/Customer in India/Bangladesh	This is a scheme in which power generation companies deal directly with power distribution companies and major customers in India and Bangladesh, and it offers economies of scale in structuring project financing with the participation of investors from various countries.

Source: Prepared by JICA Study Team

**Table 15.4-2 Comparison of Electricity Suppliers from the Power Generator's Perspective**

Scheme	1) NEA	2) Trading Company	3) Direct Trade
Purchaser	NEA	Trading Company	Large consumers in overseas
Selling Price	PPA with NEA	PPA with Trading Company Market Price	PPA with Consumers
Pros	<ul style="list-style-type: none"> <li>- Purchase volume and price are secured.</li> <li>- There are transmission costs only with Nepal.</li> </ul>	<PPA> <ul style="list-style-type: none"> <li>- Purchase volume and price are secured.</li> </ul> <Market> <ul style="list-style-type: none"> <li>- Electricity can be sold when surplus power is generated.</li> </ul>	<ul style="list-style-type: none"> <li>- Purchase volume and price are secured.</li> <li>- IPP can chose the customer with the best contract conditions by themselves.</li> </ul>
Cons	<ul style="list-style-type: none"> <li>- Limited amount of NEA purchases.</li> </ul>	<ul style="list-style-type: none"> <li>- The purpose and function of the Trading Company has not yet been determined.</li> </ul>	<ul style="list-style-type: none"> <li>- IPPs need to secure their own customers</li> <li>- Transmission costs are incurred outside of the Nepal in addition to within Nepal</li> </ul>

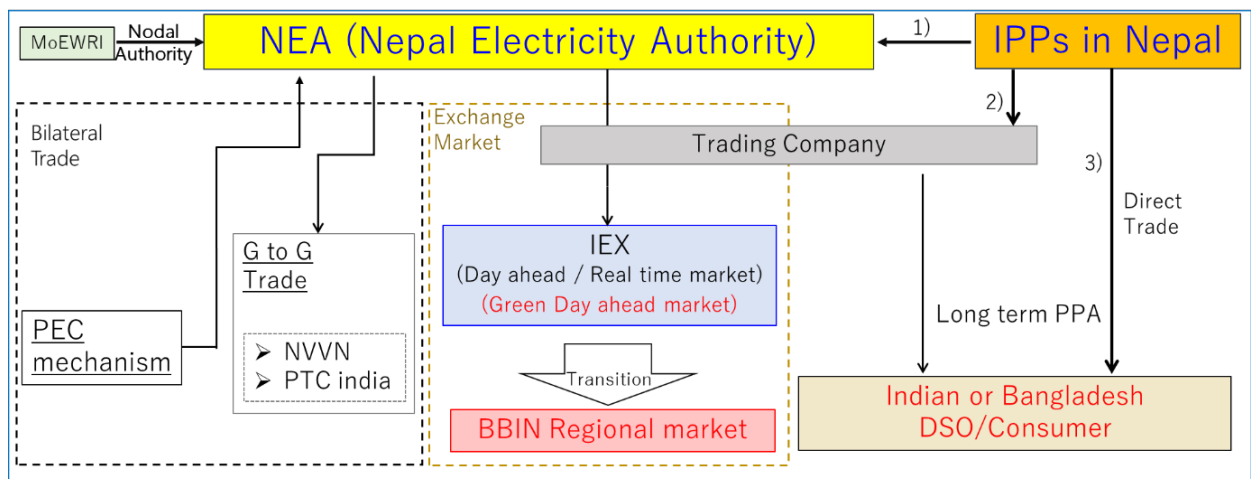
Source: Prepared by JICA Study Team

When looking at power trade from the perspective of a power generator, wholesale customers and the wholesale price are important factors in considering business feasibility. PPA's electricity selling price is 5.68 NRs/kWh (4.4 cents/kWh) on average in 2023/24 for NEA domestic trade, and 8.77 NRs/kWh (6.6 cents/kWh) for export, with the latter being higher. It is desirable for power generators to have a scheme that allows them to consider both domestic trading and exports as wholesale customers. There is no restriction on each power generator to choose only one form of trading for these 1), 2), and 3), and flexible combinations are expected to be possible.

For example, during the dry season, power could be sold to Nepal through NEA in the scheme of 1), and during the rainy season, power could be sold to India and Bangladesh in the scheme of 2) and 3). If this type of trade is possible, the power generation plans required, especially for medium to large scale projects, are expected to change.

**(2) Proposed power trading scheme**

Figure 15.4-1 shows the proposed trading scheme from the perspective of both the NEA and the power generator.



Source: Prepared by JICA Study Team

**Figure 15.4-1 Proposed power trading scheme**

As mentioned above, the diversification of wholesale customers for power generators is expected to reduce NEA's financial risk and promote the participation of Indian and Bangladesh generators.

It is also expected to add value to hydropower, a clean energy source. IEX (Indian Energy Exchange Limited) also has a green market for renewable energy, which is traded at about 10% higher than the regular market. If NEA can conclude an agreement with the Indian government to participate in the green market, it will lead to increase earnings for NEA. As mentioned above, India plans to increase its procurement of electricity derived from renewable energy sources, and the market is expected to expand in the future. In addition to IEX, it will also be necessary to conclude long-term relative contracts (PPAs) with power distribution companies and large customers in India and Bangladesh in order to secure long-term stable power export.

In addition, the proposal to build an interconnection line directly between Nepal and Bangladesh and the proposal for Bangladesh to participate in IEX, as India foresees a potential of IEX's development as a broad-based power exchange market in South Asia, would contribute to increasing the volume of electricity trade between Nepal and Bangladesh.

However, in order to ensure the supply of electricity to the domestic market, it will also be necessary to require a certain amount of domestic supply throughout the year when granting licenses to power generators. This will require improvement of NEA's capacity to plan for supply and demand, coordination with the DoED, which issues development rights, or the ERC, which evaluates PPAs, as well as coordination with power generators and trading companies.

#### **15.4.2 Promotion of Pioneer of Hydropower Project in River Basin**

This Section suggests the promotion of future development of hydropower projects from the aspect of progress of implementation in each river basin.

##### **(1) Organization of Hydropower Development Sites and Progress in IPSDP**

Table 15.4-3 organizes the installed capacity and progress of hydropower development sites in each river basins listed in IPSDP. Status is categorized based on DoED classifications into: a) Operation, b) Construction (Construction License, Application for Construction License), c) Survey (Survey License, Application for Survey License), and d) GoN (Government of Nepal). The gray hatch indicates over 50% completion in categories a) + b), highlighting river systems with substantial progress in operation and construction. It shall be noted that Tila Nadi in the Karnali basin and Tamor in the Koshi basin have seen no actual progress due to the expiration of Construction Licenses or project suspensions.

Among the three major rivers, development have been relatively advanced in Gandaki and Koshi rivers. Particularly, Gandaki River with Seti, Marshandhi, and Trishuli has many sites under construction. Conversely, there are many river systems undeveloped such as Karnali River, West Seti River, Bheri River, Dudhkoshi River and Tamor River despite having abundant hydropower potential. These underdeveloped river basin account for 53% of the total development capacity and it is an important and urgent issue to realize the development outlined in IPSDP.

##### **(2) Development of Pioneer of Hydropower Projects in River Basin**

The main reasons for the lack of development in these river basins are assumed to be supply risk and insufficient related infrastructure.

For the former, potential sites in these river basins are relatively larger in scale compared to domestic power demand, raising concerns about supply risk during the rainy season when power

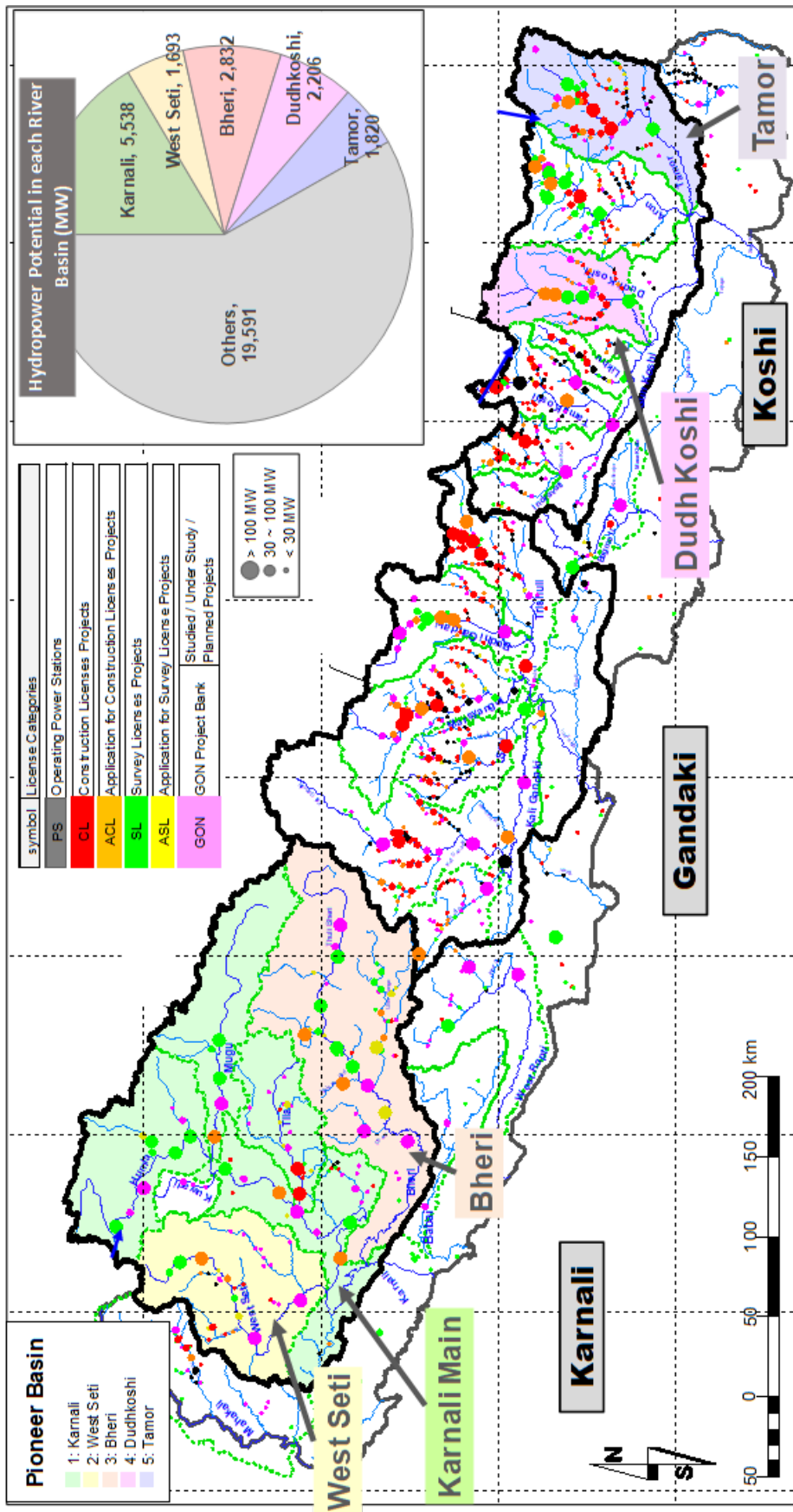
generation may exceed domestic power demand. In fact, without secured power export to India, medium- to large-scale hydropower projects have not been well progressed except for Arun 3 and Upper Karnali involving Indian developers. However, India is positive to import electricity from Nepal now and it is also possible to select the option to export electricity to India via interconnections in case of delays in developing domestic 400kV power system. Mitigation of this risk is expected to motivate IPPs to develop hydropower potentials in these undeveloped river basins.

**Table 15.4-3 Capacity of Hydropower Development Sites by River System and Progress in IPSDP (MW)**

River		a) Existing (Operation)		b) Committed (Construction)		c) Prioritized (Survey)		d) Optimized (GON)		Total
Karnali	Karnali	11.9	0.2%	1,068.4	22.3%	2,888.5	60.3%	821.1	17.1%	4,789.9
	Tiala Nadi	0.0	0.0%	621.7	83.1%	126.6	16.9%	0.0	0.0%	748.3
	Seti	12.0	0.7%	385.5	22.8%	236.4	14.0%	1,059.0	62.6%	1,692.9
	Bheri	0.0	0.0%	644.3	22.7%	1,569.1	55.4%	618.8	21.8%	2,832.1
Gandaki	Kali Gandaki	217.5	20.8%	819.0	78.5%	6.7	0.6%	0.0	0.0%	1,043.2
	Modi Khola	45.0	20.1%	175.0	78.2%	3.8	1.7%	0.0	0.0%	223.8
	Badigad Khola	7.5	0.6%	898.1	68.0%	35.0	2.7%	380.3	28.8%	1,321.0
	Myagdi Khola	0.0	0.0%	250.7	86.1%	40.4	13.9%	0.0	0.0%	291.0
	Seti Gandaki	94.5	10.0%	621.5	66.0%	225.1	23.9%	0.0	0.0%	941.1
	Marshandi	255.3	13.4%	1,509.8	79.3%	139.7	7.3%	0.0	0.0%	1,904.8
	Budhi Gandaki	13.5	0.6%	950.4	40.6%	174.6	7.5%	1,200.0	51.3%	2,338.4
	Trishuli	134.5	10.1%	1,075.0	80.6%	123.5	9.3%	0.0	0.0%	1,333.0
	Other Tributaries	76.4	76.2%	7.0	7.0%	16.8	16.8%	0.0	0.0%	100.2
Koshi	Sun Koshi	17.5	2.3%	38.5	5.1%	19.3	2.6%	680.0	90.0%	755.3
	Indrawati Nadi	10.5	20.8%	29.1	57.6%	10.9	21.6%	0.0	0.0%	50.4
	Balephi Khola	4.2	1.2%	307.7	89.8%	30.8	9.0%	0.0	0.0%	342.7
	Bhote Koshi	89.3	27.3%	233.4	71.5%	3.7	1.1%	0.0	0.0%	326.3
	Likhu Khola	131.8	33.9%	239.0	61.5%	18.0	4.6%	0.0	0.0%	388.8
	Tama Koshi	603.4	26.2%	1,249.2	54.3%	51.0	2.2%	396.5	17.2%	2,300.0
	Dudh Koshi	27.1	1.2%	857.8	38.9%	971.1	44.0%	350.0	15.9%	2,206.0
	Arun	33.2	1.0%	1,915.9	55.1%	1,525.9	43.9%	0.0	0.0%	3,475.1
	Tamor	95.3	5.2%	1,331.9	73.2%	392.9	21.6%	0.0	0.0%	1,820.2
	Koshi DS	155.5	28.3%	59.3	10.8%	335.0	60.9%	0.0	0.0%	549.8
Other Rivers	173.6	9.1%	309.7	16.3%	1,088.6	57.1%	334.0	17.5%	1,905.9	
Total	2,209.5	6.6%	15,597.8	46.3%	10,033.4	29.8%	5,839.7	17.3%	33,680.4	

Source: Prepared by JICA Study Team

Considering the current situation, the main issues in undeveloped river basins are assumed to be the lack of access road and transmission lines. Development of related infrastructure and interconnection to power system is shouldered by first developers in the river basin who need to be responsible for the costs and various procedural applications. It becomes big burdens for developers to hesitate accelerating the development. On the other hand, examples from rivers like Tamakoshi, Arun, Likhu, and Solu suggest that once one project advances, subsequent projects are accelerated. Thus, developing access roads and transmission lines and ensuring grid interconnection can promote hydropower development in each river system. Based on this understanding, IPSDP proposes the Pioneer of Hydropower Project in River Basin as a hydropower development promotion plan. The candidate river basins and projects are summarized in Figure 15.4-2 and Table 15.4-4.



Source: Prepared by JICA Study Team

Figure 15.4-2 Location of Undeveloped River Basins

**Table 15.4-4 Candidate Sites for Pioneer of Hydropower Project in River Basin**

River Basin	Major River	Installed Capacity	Candidates for Pioneer
Karnali Basin	Karnali, Humla Karnali and Tila	5,538 MW	Phukot Karnali HEP
West Seti Basin	Seti	1,693 MW	Chainpur Seti HEP, West Seti Storage HPP, SR-06 Storage
Bheri Basins	Bheri, Sano Bheri, Nalgad and Jadulla	2,832 MW	Nalsyau Gad Storage HEP, Jagdulla HEP
Dudhokoshi Basins	Dudhokoshi	2,206 MW	Dudhokoshi Storage HEP
Tamor Basins	Tamor and Kabeli	1,820 MW	Tamor Storage

Source: Prepared by JICA Study Team

As previously mentioned, constructing access roads and transmission lines also serves as public works. Therefore, the development of these projects is desirable through GoN entities with support from development partners such as JICA, WB, and ADB or by utilizing PPP scheme. For this reason, priority is put on hydropower projects which licenses are handled by NEA and VUCL and which progress are relatively advanced. Finally, candidate sites for pioneer are selected in each river basin.

### 15.4.3 Scaling Up the Power Sector Industry

Steady implementation of IPSDP needs to be supported by power sector with an appropriate industry scale. Nepal's power industry should have its blueprint for power infrastructure developments, which includes power plants, transmission/substation facilities, and distribution facilities. Industry also equip with an organizational strengthening and human resource development to realize IPSDP.

From an organizational perspective, the strengthening private sector is important in addition to capacity enhancement of government and related departments. During the plant construction, supporting services, such as survey companies, design firms, consultants, service contractors, and equipment and material suppliers are important. Of its operational phase, companies operating the plants and catering operation and maintenance capabilities are in need. In case projects are implemented as private IPP projects, the engineering consultancy, legal, and financial professionals in addition to financial institutions that provide loans to projects, are essential.

As many of the projects will be implemented in rural areas in the future, there will be a need to ensure the supply capacity of organizations and human resources to provide these services and technologies. Impact of these change will extend beyond urban areas such as Kathmandu. The direct effects of developing and operating project facilities are significant, and the expansion of supporting infrastructure (roads, electricity, water, and housing) is also necessary. As a result, scaling up of the power sector will significantly impact rural areas in terms of employment and capacity development.

As mentioned above, in order to develop the power sector as an industry, it is necessary for MoEWRI to strengthen collaboration with other government ministries and agencies (e.g. MOF, DOI, IBN, public financial institutions, etc.) and local governments. It is also expected that there will be dialogue with the private sector (for example, the Nepal Chamber of Commerce) and that various policies will be developed based on this dialogue. Furthermore, in order to strengthen human resources, in addition to the Nepalese government's own efforts, it is also possible to consider utilizing international development aid agencies to dispatch experts and provide technical cooperation.

#### 15.4.4 Matching the Demand and Needs for Project Financing

The scale and participation methods of power development projects will likely vary depending on the characteristics of investors.

##### (1) Improvement of the investment environment

Foreign investors participating in hydroelectric power projects in Nepal are mostly from India and China, and there is a lack of expansion. The biggest obstacle is that payments to the NEA, the off taker for the time being, are limited to Nepalese rupees. With the revision of the hedging-related regulations of the PPP/Investment Act in 2019, foreign investors are required to hedge their exchange rate risk in accordance with the mechanism set by the GoN, but discussions are ongoing regarding the detailed methodology. For this reason, Indian and Chinese investors are currently investing on the premise that they will accept the exchange rate risk.

Requesting international development financial institutions to cover the exchange risk of the Nepalese rupee is considered to be an essential measure from the perspective of reducing business risks, but it is urgently necessary for the GoN to establish a specific mechanism for reducing exchange risk. If the off taker is an Indian electricity consumer, it may be possible to consider structuring the business in a currency with many established hedging methods, such as making payments from India in Indian rupees.

##### (2) Negotiating electricity sales amounts and terms with off-takers in neighboring countries

Nepal's hydroelectric power generation projects are planned with the sale of electricity not only in the domestic market but also in the markets of neighboring countries such as India. In this case, the following three mechanisms are considered: 1) the NEA becomes the electricity buyer (off-taker), 2) a PPA is concluded with overseas consumers, or 3) the electricity is sold through a market mechanism such as IEX. On the other hand, if price fluctuations at IEX are taken into account when developing the project, option 3 is the option, but electricity that is price-competitive enough to be sold across borders to India will require a certain degree of business scale, and it is expected that price fluctuations will be suppressed in terms of fundraising, and stable income will be obtained. Therefore, from the perspective of reducing risk, direct sales to market mechanisms may be difficult.

As a result, PPAs will be concluded with NEAs or overseas consumers. In such cases, care must be taken to ensure that PPA terms are not significantly subordinated. The price of renewable energy-derived electricity currently used as a benchmark in the Indian market (approximately NPR 5.00) may fall further in the future as renewable energy sources become more widespread.

In India, the main export destination of Nepal's hydroelectric power generation, the State Electricity Regulatory Commission (SERC) of each state imposes a Renewable Energy Purchase Obligation (RPO) on power companies. The RPO came into force in 2016 and made the purchase of renewable energy, including wind and solar power, mandatory, but a review in 2018 showed that actual purchases did not reach the target, and each state is setting higher introduction targets.

In order to accelerate the development of hydroelectric power generation projects, it is necessary to develop exchange rate risk hedging methods as part of the improvement of the investment environment in Nepal, with the aim of inviting the participation of private funds or IPP operators. At the same time, considering that the development of hydroelectric power generation projects based on the premise of electricity export will be the main focus in the future, it is desirable from the perspective of improving the investment environment for operators and investors for the GoN to take the lead in establishing a certain degree of standards for the electricity sales conditions and

prices exchanged between Nepalese operators and export destinations.

### **(3) Strengthening the capacity of local financial institutions**

It is expected that the project development will be promoted by improving the lending capacity of local Nepalese financial institutions, which are currently only involved in small to medium-sized hydropower projects. In terms of financing, it is expected that leading banks will be selected from among the Nepalese financial institutions that rely on short-term loans, and their lending capacity will be strengthened by providing TSL. At the same time, it is necessary to develop the lending capacity of financial institutions so that they can lend to corporate or project loans, instead of lending to individuals at present. In the short and medium term, it is necessary to provide support to local financial institutions and develop their appraisal capacity for corporate loans, while cultivating the appraisal capacity for project financing for hydropower projects, which is the target.

## **15.4.5 Energy Transition**

Until 2028, the surplus electricity will mainly be available during rainy season but the base supply in dry season gradually increase from 2029 onwards and it will be possible to meet both rainy and dry season from 2031 onward.

On the other hand, when considering the kWh value of these surplus electricity sources, the value of electrifying heat demand followed by exporting electricity to India is high. As of 2024, the business feasibility of green hydrogen in Nepal without subsidies or carbon credits has not been reached. Therefore, it is essential to enhance the financial value of green hydrogen through an increase in the market value of green hydrogen, establishment of various preferential systems, and reduction in manufacturing costs through the development of new technology.

From an energy efficiency perspective, the most efficient utilization of electricity is for direct use as a power source for EVs, E-cooking, and heat demand. As already mentioned in Chapter 5, the Nepal government has set ambitious targets for EV and E-cooking. It is therefore important to promote these existing initiatives and stimulate new demand through heat pumps is considerably important.

Exporting electricity also contributes to the energy transition from the perspective of CO<sub>2</sub> reduction in neighboring countries and is assumed to be a necessary measure for Nepal to earn valuable foreign exchange. It is therefore important to focus on electrification and electricity exports, which offer superior financial value.

While the practical use of CN fuels, including green hydrogen, is advancing in some developed countries, the full-scale social implementation is still at the exploratory stage worldwide, and it is assumed that Nepal is no exception. Therefore, for the time being, it is important to prioritize domestic economic value from the perspectives of technology dissemination, establishment of related systems, energy and food security, and preventing the outflow of foreign currency.

In particular, there is a clear market demand for ammonia produced from green hydrogen as fertilizer for agriculture in Nepal. Although it is less competitive in price than fertilizers imported from India, which are made from natural gas, it is preferable to proceed from the perspectives of a stable supply of fertilizers and food security. Furthermore, using CO<sub>2</sub> emitted from cement clinker production as a raw material for urea production can contribute to reducing emissions in carbon neutrality. However, the business is likely to be rely on subsidies in the short term. Therefore, it is advisable to carefully consider the production scale to avoid impacting the finances of related businesses and the Government of Nepal.

## 15.5 PROPOSAL OF PILOT PROJECTS FOR IPSDP

It is critical to carry out recommendations and to deal with challenges but these tasks involve various fields and domestic stakeholders and international agencies. It seems to be challenging to achieve solely through the activities of individual agencies and requiring various adjustments.

To resolve these situations, implementation of pilot projects is expected to be effective, encompassing many of the identified key issues. Once pilot projects indicate solution of these issues such as PPA, interconnection with foreign grid, setting of transmission wheeling charge or physical infrastructure development, these could be good benchmarks for subsequent projects. As these pilot projects are required to explore various new fields with a lot of issues or unforeseeable risks, it supposed to be challenging for IPPs or private sector to deal with these pilot projects. Therefore, it might be reasonable to select GoN entities such as NEA or VUCL as implementing agencies and to execute these pilot projects under the assistance from GoN and development partners.

Based on these understandings, following five (5) pilot projects which can be the key driver for further development are proposed.

- Sunkoshi-3 HPP
- Phukot Karnali HPP
- Transaction Advisory Service
- Two Step Loan through HIDCL
- Promotion of Pilot Projects for Energy Transition

Based on understandings above, issues and recommendation of pilot projects are summarized in Table 15.5-1.

Table 15.5-1 Challenges and Recommendations on IPSDP

Item	Sunkoshi-3 HPP	Phukot Karnali HPP	Transactional Advisory Service	Enhancement of HDCL	Energy Transition
<b>1. Expansion of Clean Export</b>					
Concentration of risks on NEA for expansion of clean export	Establish direct trade scheme with India and BFDDB				
Securement of power supply reliability for domestic demand	Improve dry season supply capacity	Improve dry season supply capacity			
Technical issues on expansion of power trade	Review and establish generation plans considering three-country interconnection	Promote development of Lumki-Bareilly interconnection line			
Development scheme on interconnection lines	Establish and operate three-country interconnection				
Issues on legal framework for power trade	Facilitate smooth expansion of power trade by involving India and BFDDB				
Insufficient experiences on export oriented hydropower projects by Nepalese developers	Project implementation by NEA	Participation of VUCL	Advisory support for NEA and/or VUCL		
<b>2. Significant Expansion of the Nepalese Power System</b>					
Necessary adaptation measures against climate change risks	Develop 400kV substations and transmission lines in Sunkoshi basin	Develop access roads in Surkhet to Karnali basin			
Necessity of integrated river basin development		Phukot - Lumki 400kV T/L			
Capacity development on tunnel design and construction		Promote development of Karnali main river and Tila river basin			
Need to improve system planning capabilities	Develop three-country interconnection plan	Undertake the first large-scale tunnel construction in Karnali basins			
Interconnection of VRE	Implement study of international standards including transmission lines	Develop power system plan for western area			
Mitigation of environmental and social impacts					
<b>3. Reforming the Electricity Sector</b>					
Necessity of capacity development of CoN	Improve NEA's capabilities	Improve VUCL's capabilities	Strengthen organizational structure of the power sector and coordination with other ministries		
Clarification of role of government organizations and sector reforms			Promote organizational restructuring along with power law revision		
Shortage of domestic contractors	Involve Indian developers and BFDDB	Involve NHPC	Expand the sector to include contractors, equipment suppliers, construction consultants, legal advisors		
Necessity of international standard PPA	Consider PPAs with India and Bangladesh	Consider PPAs with India			
<b>4. Expanding Finance/Private investment</b>					
Finance from domestic investors or lenders				Strengthen HDCL and private banks	
Necessity of promotion of FDI	Encourage entry of developers and financial institutions from India and Bangladesh	Promote financing by NHPC		Matchmaking between foreign and domestic businesses on India and Bangladesh	
Enhancement of assistance by development partners	Ensure cross-regional involvement of development partners including India and Bangladesh	Support VUCL		Expand clean energy use in energy-intensive industries	
<b>5. Energy Transition</b>				Propose finance promotion measures such as loans, PPPs, sector loans, TSLs"	
Promotion of electrification					Propose new electrification promotion measures such as heat pumps
Establishment of legal framework and supply chain in Green Hydrogen					Propose pilot projects for green hydrogen and ammonia

Source: Prepared by JICA Study Team

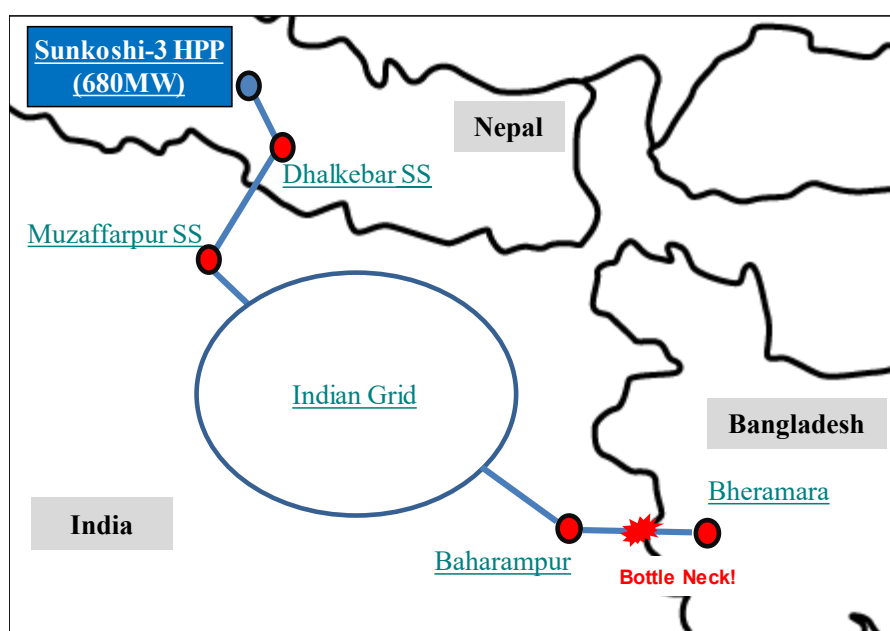
### 15.5.1 Sunkoshi-3 HPP

While expanding Clean Export is essential for the future development of the power sector, it is necessary to resolve various issues such as legal frameworks, development schemes, financing, and the construction of physical infrastructures. As these issues are related each other and difficult to solve by only one organization, it is effective to deal with these issues through the implementation for pilot projects under the mutual collaboration with related agencies and development partners.

Under this recognition, IPSDP proposes Sunkoshi-3 Hydropower Project (680MW) agreed for development between Nepal and Bangladesh as a pilot project to accelerate Clean Export expansion. This site is planned to be developed by a JV between NEA and BPDB (Bangladesh Power Development Board), with the prospect of attracting Indian developers as well.

#### (1) Interconnection of Sunkoshi-3 HPP through Three Countries

The concept of interconnection from Sunkoshi-3 to India and Bangladesh is show in Figure 15.5-1.



Source: Prepared by JICA Study Team

**Figure 15.5-1 International Interconnection from Sunkoshi-3 to India and Bangladesh**

The "Guidelines for Import Export Cross Border of Electricity 2018 India" formulated in 2018 allows for power trade to third countries via the Indian grid. Therefore, it is envisaged that Sunkoshi-3 will connect to the Indian grid.

Electricity generated at Sunkoshi-3 will be transmitted to Dhalkebar substation in Nepal by domestic power system. Then, it will be transmitted to Muzaffarpur via 400kV interconnection line with India. Although India and Bangladesh are also interconnected by a 400kV HVDC line, the available capacity of this transmission line is almost fully utilized. It is necessary to develop a new transmission line between India and Bangladesh. The cost burden of this transmission line needs to be monitored through the pilot project.

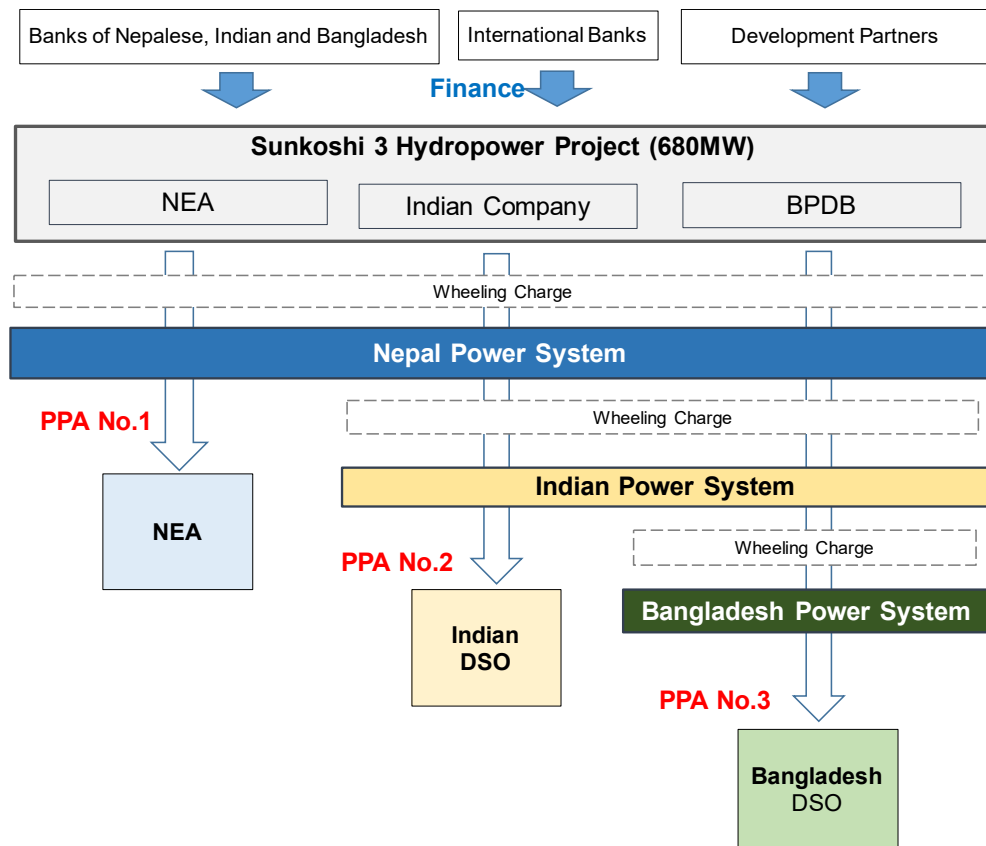
**(2) Effectiveness of Promotion of Sunkoshi-3 HPP**

The commercial flow and finance scheme for Sunkoshi-3 HPP are described in Figure 15.5-2 and Figure 15.5-3. Through the pilot project of Sunkoshi-3, it is expected to establish good practices in the following areas necessary for power trade to India and Bangladesh:

- Application of necessary legal frameworks for project implementation
- Application for interconnection among the three countries
- Consideration of wheeling charges for transmission and interconnections in each country
- Establishment of SPC and shareholder agreements by developers in each country
- Conclusion of PPAs with off-takers in each country
- Utilization of Indian and Bangladeshi funds in project finance

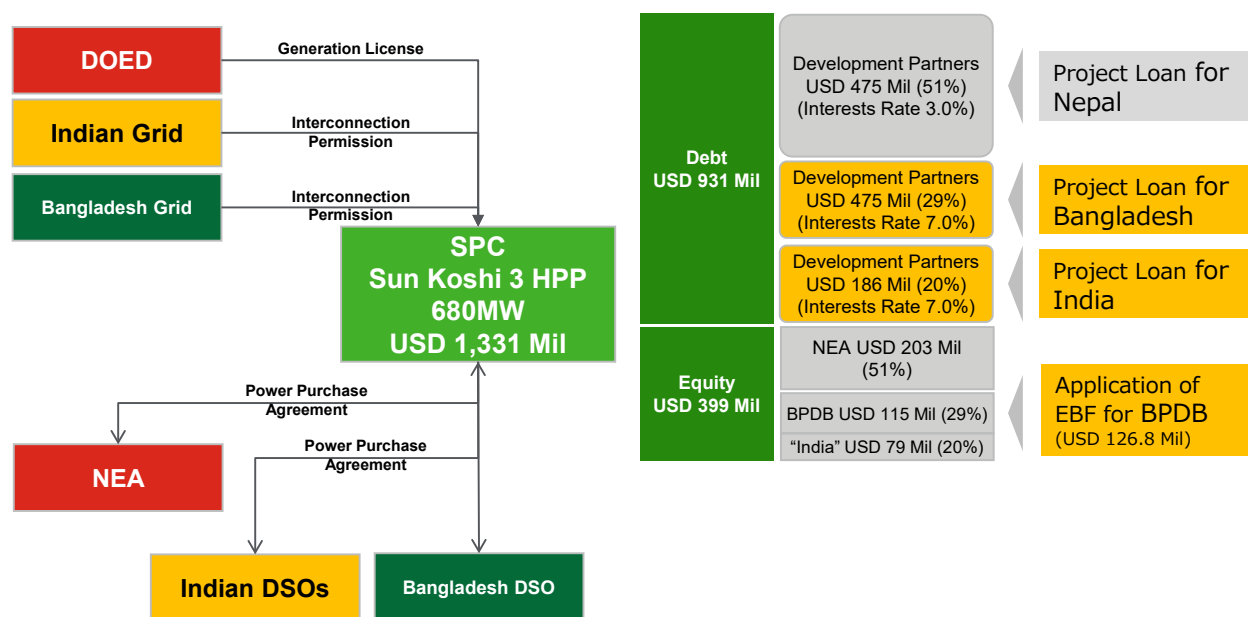
To facilitate the application of PPAs, interconnection applications to power system and the setting of wheeling charges for transmission lines in three countries, the participation of experienced power companies from each country is desirable. Therefore, participation from India is also assumed to involve experienced power utility companies.

As described in Chapter 12, it is necessary to maximize the use of financing not only from Nepal but also from India and Bangladesh to efficiently develop hydropower potential in Nepal. As Sunkoshi-3 is not a profitable project, it is favorable to utilize advantageous financing from development partners such as sovereign loan or PPP loan. It shall be noted that the allocation of equity and debt for each country's developers is just an assumption and required to be revised in accordance with mutual discussion among related stakeholders.



Source: Prepared by JICA Study Team

**Figure 15.5-2 Commercial Flow of Sunkoshi-3 HPP**



Source: Prepared by JICA Study Team

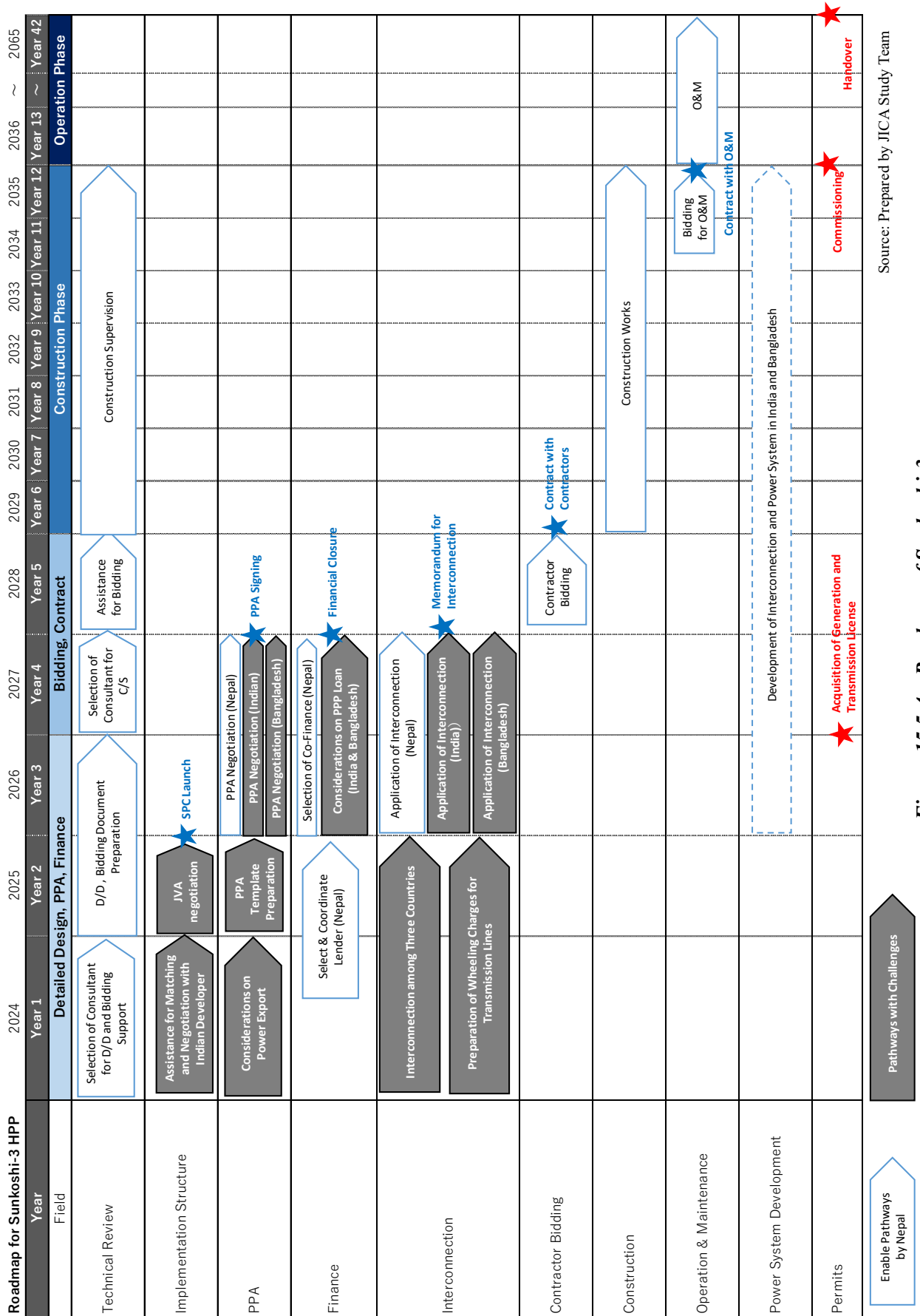
Figure 15.5-3 Financing Scheme of Sunkoshi-3

### (3) Action Plan for the Development of Sunkoshi-3 HPP

Based on the understanding presented in this section, the schedule and roadmap for issues for the development of Sunkoshi-3 HPP are illustrated in Figure 15.5-4 and Table 15.5-2.

The proposed schedule for Sunkoshi-3 HPP includes establishing an SPC in 2025, signing the PPA in 2027, achieving financial close, signing a memorandum of understanding for interconnection, starting construction in 2029, and commencing operations in 2035. Immediate actions required include selecting a development partner on the Indian side, which is a critical path in the project formulation stage and must be promptly initiated. Concurrently, it is desirable to promptly start examining the supply allocation to Nepal, India, and Bangladesh necessary for PPA considerations, and the system plan necessary for transmission charge considerations. These examinations require coordination among the three countries, and a framework where all stakeholders can collaborate for the project's success needs to be established. In addition to technical aspects such as international interconnection and SPC establishment, PPA, and system interconnection agreements across three countries, ongoing support from development aid agencies in coordinating stakeholders is also considered crucial.

The development of Sunkoshi-3 for Clean Export expansion encompasses many of the critical tasks needed for India's and Bangladesh's participation in PPA, finance, and interconnection. Immediate actions include attracting Indian developers, supporting the formation of SPCs, optimizing the generation plan considering power exports, and securing interconnection among the three countries. Subsequently, SPC establishment, PPA conclusion, and interconnection applications in each country need to be carried out. These are common issues for other projects, and realizing this project as a good practice would enable horizontal expansion, making it a priority project to promote.



Source: Prepared by JICA Study Team

Figure 15.5-4 Roadmap of Sunkoshi-3

Table 15.5-2 Action Plan for Sunkoshi-3 HPP

Item	Issue	Solution	Policy Action	Outcome Indicator	Implementing Agency	Support Needs	MoE/WRI Work Plan Consistency
Implementation Structure	Indian partner is not decided	Select hydropower developers with hydropower development and grid interconnection experience in India such as SJVN, NHPC	Year 1: Support formatching and discussions with Indian companies	Joint venture partner for Sunkoshi-3 is selected	NEA	Support for discussions with Indian side	
	JVA for SPC jointly funded by three countries is not prepared	Prepare JVA template	Year 1: Prepare JVA template	JVA template is prepared	NEA, ERC	Continuous technical cooperation	No.50
PPA	NEA doesn't have experience in establishing SPC jointly funded by three countries	Support negotiations for establishing SPC	Year 2: Support for establishing SPC	SPC is established	NEA	Continuous technical cooperation	
	Optimization for power generation planning involving power export and project benefit are not studied	Optimize power generation plans and project benefits	Year 1: Review optimization of power generation plans formulated by NHPC	Power generation plans are optimized	NEA	Support for technical review	
	Allocation of domestic supply and power export are not reviewed	Determine allocation ratio of domestic and export supply based on power generation plans		Allocation of domestic and export supply are determined	NEA		
	There is no examples of wholesale prices for three-country sales	Set wholesale prices	Year 2: Prepare PPA template and support for negotiations	PPA template is prepared	ERC, NEA	Continuous technical cooperation	No.18
	No PPA template for selling power to three countries	Prepare PPA template					
Finance	NEA doesn't have experiences of PPA negotiations with Indian DSO	Assign roles for PPA negotiations with Indian developers	Year 3: Support for PPA negotiations	PPA with Indian DSO is signed	NEA	Support for discussions with Indian developers	No.18
	NEA doesn't have experiences of PPA negotiations with Bangladesh DSO	Assign roles for PPA negotiations with BPDB	Year 3: Support for PPA negotiations	PPA with Bangladeshi DSO is signed	NEA	Support for discussions with BPDB	No.18
	No experience in foreign investment applications for Indian and Bangladeshi developers hydropower projects in Nepal	Support Indian developers and BPDB to process foreign investment applications	Year 3: Support for foreign investment applications	Indian developers and BPDB achieve financial close for foreign investments	Indian developers, BPDB	Support for discussions with Indian developers and BPDB	No.27
Interconnection	Power system planning including interconnection for three countries is not considered	Conduct Evacuation Route Study	Year 2: Support for D/D	Evacuation Route Study is prepared	NEA	Review D/D components	No.18
	Capacity of international interconnection lines between India and Bangladesh is insufficient	Develop 765kV international interconnection line from Kathal (India) to Parboitpur (Bangladesh)	Year 3 onward: Monitor the progress	Interconnection line between India and Bangladesh is developed	India, Bangladesh	Monitor progress of interconnection line development	
	Wheeling charges for transmission lines are not prepared for Nepal, India, and Bangladesh power systems	Prepare wheeling charges for transmission lines	Year 2: Prepare wheeling charges	Wheeling charges for transmission lines in three-countries are set	NEA	Continuous technical cooperation	No.18, No.25
	There is no experiences in application of interconnection with Indian TSO	Assign roles for interconnection applications to Indian developers	Year 3: Support for interconnection applications	Interconnection with Indian TSO is approved	NEA	Support for discussions with Indian developers	No.18
Grid Development	There is no experiences in application of interconnection with Bangladesh TSO	Assign roles for interconnection applications to Indian developers	Year 3: Support for interconnection applications	Interconnection with Bangladeshi TSO is approved	NEA	Support for discussions with BPDB	No.18
	400kV transmission lines and substation needs to be developed	Sunkoshi-Dhalkebar 400kV transmission line		Transmission system will be developed by commissioning	NEA	Various supports	No.54, No.62, No.80, No.81

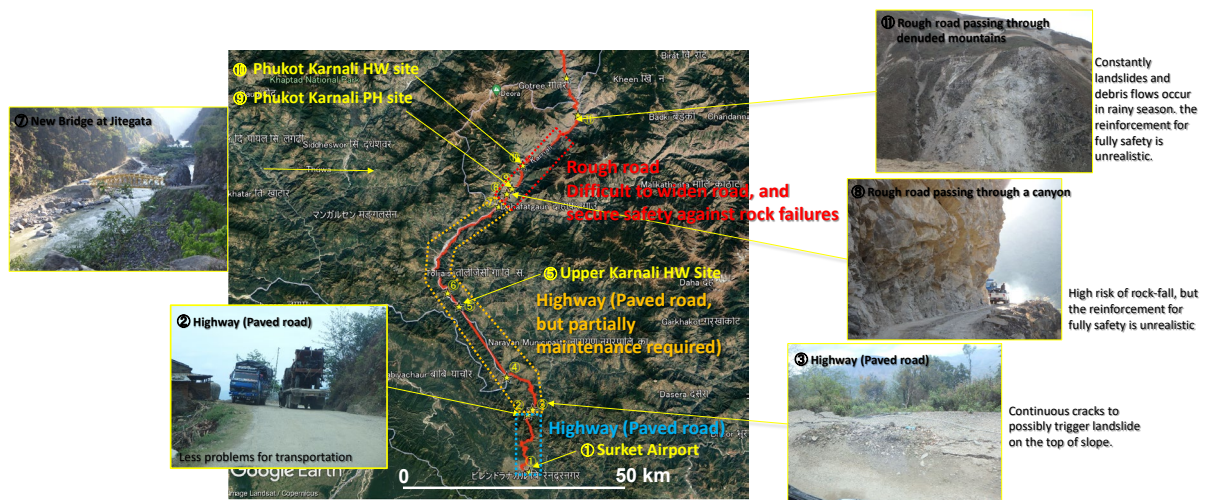
Source: Prepared by JICA Study Team

## 15.5.2 Phukot Karnali HPP

As a case example of pioneer of Karnali River Basin, this section focuses on the Phukot Karnali HPP in Karnali River. Phukot Karnali is a PROR type hydropower plant with an output of 480MW owned by VUCL, currently applying for a Construction License. It is located at midstream of Karnali River which has abundant hydropower potential but have been not developed and planned to be co-developed with India's state-owned hydropower developer NHPC (National Hydroelectric Power Corporation).

### (1) Effectiveness of Promotion of Phukot Karnali HPP

Karnali River has large-scale planned sites like Upper Karnali and Betan Karnali and Mugu Karnali Storage but progress has not been seen in construction stage. Various equipment and materials are expected to be procured from India. Paved road is available from India to Birendranagar, the provincial capital of Surkhet. The mountain road from Birendranagar to the confluence of the Karnali River is asphalted but necessitating major repairs to ensure the slope stability and to expand the width of road for heavy machineries access. Currently, 132kV transmission line is connected at Koharpur, but a 400kV western transmission line (New Butwal to Lumki) and a 400kV transmission line along the Karnali River (Lumki to Phukot) need to be developed for power system.



Source: Prepared by JICA Study Team

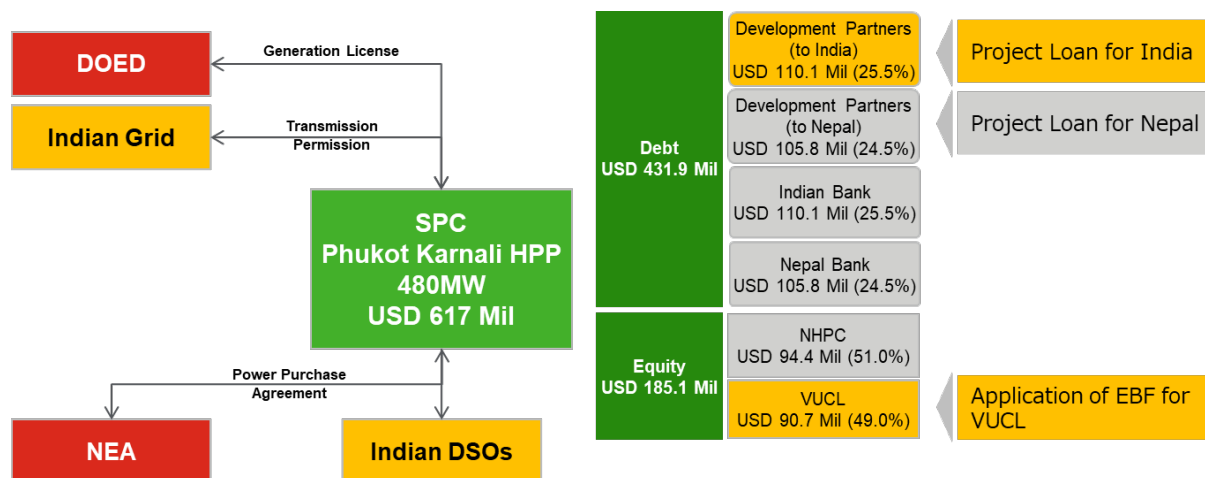
**Figure 15.5-5 Access to Phukot Karnali HPP**

The development of Phukot Karnali HPP is expected to bring the following benefits to the river basins:

- Promotion of regional development through improved logistics in the upstream area of Karnali river
- Access to Betan Karnali, Upper Karnali, Mugu Karnali Storage, Tila-1 and Tila-2
- Development of Phukot Karnali 400kV substation as a key substation
- Power export to India via Lumki interconnection line
- Implementation of the project as a JV between NHPC and VUCL

Although installed capacity of Phukot Karnali is 480MW, the total potential in Karnali and Tila rivers is 5,538MW, suggesting significant benefits beyond the development of the individual site. The development of Karnali river basins is significantly essential for achieving MoEWRI's target in 2035. Phukot Karnali has completed DPR (Detailed Project Report) and is progressing towards

obtaining Construction License, considering a highly important and effective for accelerating the development of Karnali basin.



Source: Prepared by JICA Study Team

Figure 15.5-6 Assumption of Finance Scheme for Phukot Karnali HPP

## (2) Roadmap and Action Plan for the Development of Phukot Karnali HPP

Based on the understanding presented in this section, the roadmap and action plan for addressing issues for the development of Phukot Karnali HPP are illustrated in Figure 15.5-7 and Table 15.5-3.

As of June 2024, the implementation structure for Phukot Karnali is not yet determined but the investment ratio is assumed to be 51% for NHPC and 49% for VUCL based on current discussions. The roadmap is prepared on the premise that NHPC will take the lead, and the action plan considers necessary measures from VUCL's standpoint.

The schedule for the Phukot Karnali HPP assumes the establishment of the SPC in 2024, the signing of the PPA, financial closure, and the signing of the memorandum of understanding for system interconnection in 2026, the start of construction in 2027, and the commencement of operations in 2032.

As previously mentioned, NHPC is assumed to hold the majority stake in this project and it is expected to take the lead in organization of SPC, negotiation of PPA and applying for grid interconnection. NHPC has extensive experience in hydropower projects both within India and in Bhutan and is considered to have the necessary experience and capabilities as an implementing agency. On the other hand, VUCL is a relatively newly established organization with no projects currently in the construction phase. It is assumed that VUCL will need support in negotiations with NHPC and in considering funding through PPP and other means. Additionally, since the PPA involves ERC and NEA and the grid interconnection also involves NEA. These aspects are assumed to be considered as well.

Regarding the operation commencement schedule, VUCL has already applied for a Construction License. Based on progress and timing, construction commencement in 2027 does not appear to be an unrealistic schedule. However, as indicated in the previous section, the Karnali river basin may face bottlenecks due to the renovation of existing roads. It is necessary to consider the period required for the basic design, budget securing and implementation of these construction works. Although which agencies are responsible for implementation these works are not decided, the

coordination is supposed to be required for Nepalese side. Early commencement of this examination is necessary.

Additionally, regarding the related power system development, NEA or RPGCL are assumed to be the implementing agencies and some of the 400kV backbone systems are expected to be implemented by IPPs. Considering the support from development partners, starting from the F/S stage will not allow for a relaxed schedule. It is also necessary to monitor this consideration.

The pilot project of the Phukot Karnali HPP is expected to promote the development of hydropower in Karnali river, which has the largest capacity among the undeveloped river basins. Similarly, selecting and prioritizing the first pioneer development projects for rivers like the West Seti, Bheri, Dudhokoshi, and Tamor is considered as effective solutions to accelerate the development.

Furthermore, the Phukot Karnali HPP is expected to serve as a model case for project implementation with a majority stake held by an Indian public company. In this regard, the project is also considered one that anticipates support from development partners.



Table 15.5-3 Action Plan for Phukot Karnali HPP

Item	Issue	Solution	Policy Action	Outcome Indicator	Implementing Agency	Support Needs	MoE/WRI Work Plan Item
Technical Review	Implementing agency for existing road renovations is not decided	Decide the implementing agencies	Year 1: Coordination with relevant agencies	The implementing agency for existing road renovations is decided	GoN	Coordination with relevant agencies	No.31
	Basic design and bidding documents for road renovations are needed	Carry out F/S and prepare bidding documents	Year 1: Hire a consultant	F/S and bidding documents are prepared	GoN	Support for basic road design in mountainous areas	No.31
Implementation Structures	VUCL lacks knowledge on forming SPC with foreign companies	Enhance capabilities related to JVA negotiations	Year 1: Support for JVA negotiations	SPC is formed	VUCL and ERC	Capacity building for VUCL	
	Optimization for power generation planning involving power export and project benefit are not studied	Optimize power generation plans and project benefits	Year 1: Review optimization of power generation plans formulated by NHPC	Power generation plans are optimized			
PPA	Allocation of domestic supply and power export are not reviewed	Determine allocation ratio of domestic and export supply based on power generation plans		Allocation of domestic and export supply are determined	VUCL	Capacity building for VUCL	
	No examples of setting wholesale prices assuming export to Indian DSO	Set wholesale prices	Year 1: Create PPA template and support negotiations with Indian DSO	PPA template is prepared	ERC, NEA, VUCL	Support for negotiations with NHPC	No.18
	No PPA template for selling power to Indian DSO	Prepare PPA template					
	VUCL has less experiences in PPA negotiations with NEA and ERC	Enhance VUCL's negotiation capabilities	Year 2: Support for PPA negotiations	PPA with NEA is signed	VUCL	Capacity building for VUCL	
Finance	VUCL lacks experience to obtain foreign finance	Enhance VUCL's capabilities for application of PPP loan	Year 2-3: Support for applications of PPP loan	VUCL achieves financial close	VUCL	Capacity building for VUCL	No.27
Interconnection	Wheeling charges for transmission lines are not prepared between Nepal-Indian power system	Prepare wheeling charges for transmission lines and negotiate with NEA and Indian TSO	Year 2: Set and negotiate wheeling charges for transmission lines	Wheeling charges for transmission lines are set between Nepal and Indian power systems	NEA, VUCL	Support for negotiations with NHPC	No.18, No.25
	Bidding for road renovation are not planned	Implement bidding for existing road renovations	Year 2	Road renovation contractors are selected	GoN	Support for bidding	No.31
Contractor Bidding	Budget for road renovations is not secured	Allocate budget for road renovation works	Year 3	Road renovations are budgeted	GoN	Project financing	No.31
	400kV transmission lines and substation needs to be developed	Phukot - Betan 400kV transmission line - Dodothara - Bareli 400kV international interconnection line - Dodothara - Kohalpur - Lamahi - New Butwal 400kV transmission line <sup>6</sup>	-	Transmission system will be developed by commissioning	NEA, RPGCL	Various supports	No.54, No.62, No.80

Source: Prepared by JICA Study Team

### 15.5.3 Transaction Advisory Service

When the GoN develops new projects (mainly power generation projects) using PPPs or ODA (Official Development Assistance), they have to select operators through public procurement. However, at present, it cannot be said that MoEWRI and other government agencies already have sufficient experience or know-how. TAS (Transaction Advisory Service) are a support menu provided by development partners to complement such aspects.

TAS is one kind of technical assistance in which development partners support a series of procedures (transactions) for a fee or free of charge when a government agency conducts public procurement for a specific project. In the power sector, IFC (International Finance Corporation) and ADB have provided TAS to many other countries. JICA has also provided TAS for a waste-to-energy project in Indonesia in cooperation with IFC.

The support items included in TAS are selected on a tailor-made basis for each individual project, but the scope of coverage includes the following:

- ✓ Support for preparation of feasibility studies (including demand forecasts and financial analysis)
- ✓ Support for implementation of market soundings (prior dialogue with private companies)
- ✓ Support for preparation of RFPs and PPAs
- ✓ Evaluation of proposals submitted by private companies and selection of preferred negotiators
- ✓ Support for contract negotiations

For GoN, receiving TAS has the advantages in terms of increasing the likelihood of successful procurement of a specific project, or strengthening institutional and human capacity through OJT, which can be utilized for future procurement of similar projects.

As mentioned above, TAS is provided for procurement of individual projects, but the following projects are considered to be included to the candidates for target projects.

- ✓ Sunkoshi-3 HPP (Utilization of ODA funds)
- ✓ Phukot Karnali HPP (Utilization of PPP)

### 15.5.4 Strengthening the Financing Capacity of HIDCL and Domestic Financial Institutions

The application of sovereign loans for the Sunkoshi-3 HPP is proposed in Section 15.5.1 and PPP finance scheme for Phukot Karnali HPP through private investment is proposed in Section 15.5.2. It presents a project finance model for large-scale hydropower aiming at Clean Export. This Section proposes strengthening the financing capacity of domestic financial institutions to support small and medium-sized hydropower development which constitutes the majority of the sites in terms of number.

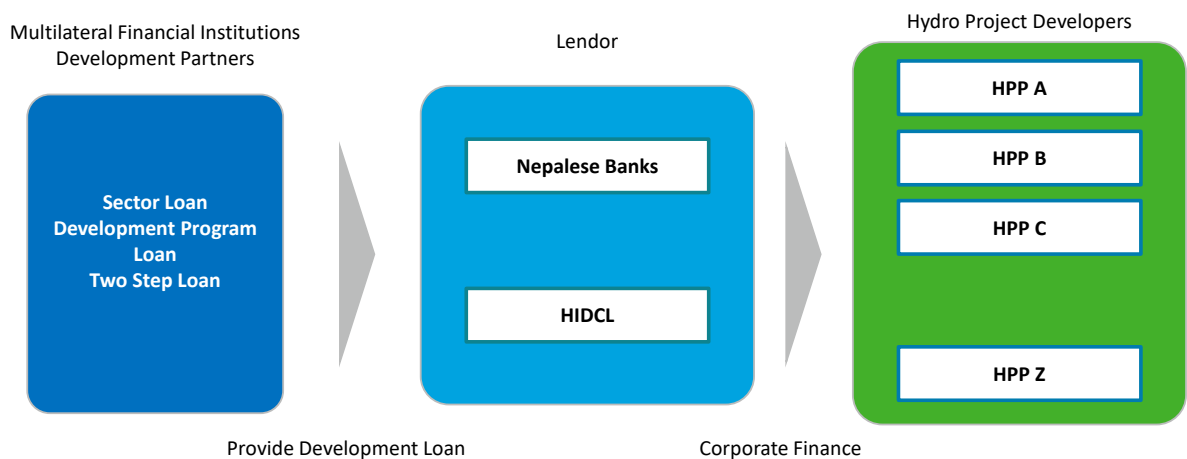
#### (1) Strengthening of financing functions and capabilities, and strengthening of project development capabilities

In order to promote hydroelectric development in Nepal, it is hoped that the challenges facing the financial sector in terms of lending capacity and appraisal capacity will be resolved.

Nepal's private financial institutions are relatively small in scale, have a high loan-to-deposit ratio, and may not have the capacity to lend long-term funds such as project loans. Loans to small-scale

hydropower projects and IPPs are made against the personal guarantees of project owners, and local financial institutions have not developed the capacity to provide project finance that evaluates the feasibility of hydropower projects, or to assess the credit of companies developing such hydropower projects.

One possibility is for international development financial institutions to provide loans in the form of TSL to local financial institutions interested in hydropower project development, which in turn provide loans to individual development companies or projects. HIDCL (Hydroelectricity Investment and Development Company Ltd.), which is involved in hydropower projects of over 25MW, has traditionally provided loans and advisory services to projects, and strengthening its lending capacity is believed to contribute to promoting the development of hydropower projects.



Source: Prepared by JICA Study Team

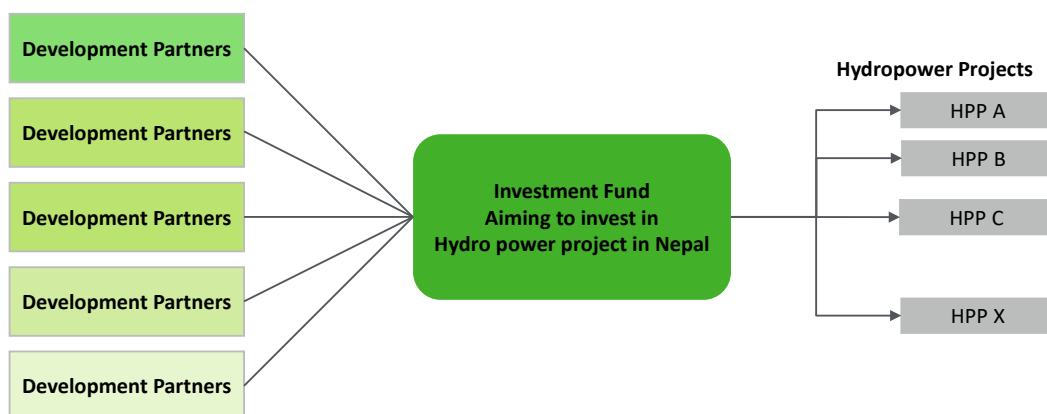
**Figure 15.5-8 Efforts to strengthen the capacity of local financial institutions**

This initiative requires that financial institutions be provided with loans to increase their lending capacity, as well as technical support for capacity building and advisory service support. The development financial institutions providing the loans will need to reduce the initial burden on local financial institutions by, for example, taking on the responsibility of evaluating and screening business risks. The GoN has set a goal of increasing the ratio of lending to the energy sector by local financial institutions, and this will also contribute to achieving this goal.

**(2) Establishment of a fund for hydroelectric power generation projects**

There are numerous hydroelectric power projects in Nepal, and in order to overcome the current situation where each project is individually trying to raise funds, we propose forming a fund for the purpose of investing in hydroelectric power in Nepal, and soliciting investments from IFC, development aid agencies, commercial financial institutions, and general investors.

The challenge with fund-based fundraising is that if the fundraising period does not match the fundraising activities of individual projects, businesses cannot join the fund as target projects. In addition, by incorporating the individual circumstances surrounding hydroelectric power generation projects into a fund, the fund is expected to have a risk hedging function, but as economically superior projects can raise funds without joining the fund, the projects that join the fund bear high risks and there is a possibility that the fund will be biased towards less economical projects. If the profitability of the fund declines, it will become difficult to attract investors, so it will be necessary to devise ways to achieve economic viability by incorporating economically superior projects to a certain extent into the fund.



Source: Prepared by JICA Study Team

**Figure 15.5-9 Concept diagram of Hydropower Development Fund**

### 15.5.5 Implementation of Pilot Projects for Energy Transition

Nepal, with its abundant hydropower potential, generates surplus electricity mainly during the rainy season, which is used for Clean Export to neighboring countries. Currently, surplus electricity is limited to the rainy season and Nepal imports electricity from India during the dry season. However, power generation is expected to exceed demand even during the dry season from 2029 onwards allowing for year-round utilization of surplus electricity.

In addition to power exports, further electrification and the introduction of CN fuels such as green hydrogen or ammonia are expected to be additional solutions for utilizing surplus electricity. IPSDP proposes the following two key measures for utilizing surplus electricity as part of the energy transition:

1. Promoting electrification in the buildings sector
2. Promoting research and pilot projects for green ammonia

#### (1) Promoting Electrification in the Buildings Sector

The "Net Zero by 2050 Roadmap for the Global Energy Sector" formulated by IEA (International Energy Agency) in 2021 outlines recommendations and priority measures to achieve carbon neutral by 2050, keeping the temperature rise due to climate change within 1.5°C. The roadmap for the buildings sector is shown in Table 15.5-4.

In Nepal, various measures focusing on E-cooking, conversion from biomass to electricity are already being promoted and implemented. IPSDP proposes the introduction of energy-efficient electric products such as heat pumps, ZEBs (Net Zero Energy Buildings), inverter air conditioners and refrigerators. In particular, heat pumps are considered to be promoted drastically in building sector. It is highly efficient and multi-purpose equipment for heating, cooling, and drying across a wide temperature range (-100°C to 100°C) and their widespread introduction is highly desirable.

**Table 15.5-4 Roadmap for Net Zero Emissions in the Buildings Sector by 2050**

Category			
<b>New buildings</b>	• From 2030: all new buildings are zero-carbon-ready.		
<b>Existing buildings</b>	• From 2030: 2.5% of buildings are retrofitted to be zero-carbon-ready each year.		
Category	2020	2030	2050
<b>Buildings</b>			
Share of existing buildings retrofitted to the zero-carbon-ready level	<1%	20%	>85%
Share of zero-carbon-ready new buildings construction	5%	100%	100%
<b>Heating and cooling</b>			
Stock of heat pumps (million units)	180	600	1 800
Million dwellings using solar thermal	250	400	1 200
Avoided residential energy demand from behaviour	n.a.	12%	14%
<b>Appliances and lighting</b>			
Appliances: unit energy consumption (index 2020=100)	100	75	60
Lighting: share of LED in sales	50%	100%	100%
<b>Energy access</b>			
Population with access to electricity (billion people)	7.0	8.5	9.7
Population with access to clean cooking (billion people)	5.1	8.5	9.7
<b>Energy infrastructure in buildings</b>			
Distributed solar PV generation (TWh)	320	2 200	7 500
EV private chargers (million units)	270	1 400	3 500

Source: IEA: Net Zero by 2050 Roadmap for the Global Energy Sector

**(2) Promoting Research and Pilot Projects for Green Ammonia**

Regarding the use of CN fuels, green ammonia is assumed to be a focal point in Nepal. MoEWRI and Kathmandu University are advancing various policy considerations and research studies. The "Green Hydrogen for Development in Nepal" by Kathmandu University's Green Hydrogen Lab proposes pilot projects for green ammonia production and commercial-scale fertilizer manufacturing using green ammonia.

Future utilization of green ammonia in Nepal envisions two directions: i) short- to mid-term fertilizer manufacturing and ii) mid- to long-term export of green ammonia. The former can mitigate the dependence of food security to India because almost full of fertilizer is imported from India and green ammonia may be one solution to reduce this dependency. On the other hand, there are several challenges to move on commercial scale which will require project finance, technical and legal framework improvements and subsidy considerations. The latter anticipates supplying green ammonia for coal co-firing and marine fuel applications as CN fuels in India or other countries. Global researches are ongoing in this field and the economic viability of green ammonia production be proven in future. At that time, green ammonia could become a new form of Clean Export following power exports.



# **ANNEX 16**

## **CAPACITY DEVELOPMENT REPORT**



**Japan International Cooperation Agency**

**PROJECT  
ON  
INTEGRATED POWER SYSTEM DEVELOPMENT PLAN  
IN NEPAL**

**CAPACITY DEVELOPMENT REPORT**

**November 2024**

**NEWJEC Inc.  
Deloitte Tohmatsu Financial Advisory LLC  
Kansai Transmission and Distribution, Inc.**



## Project on Integrated Power System Development Plan in Nepal

# Capacity Development Report

### *Table of Contents*

<b>1. Outline of the Project .....</b>	<b>16-1</b>
1.1 Summary of the Project .....	16-1
<b>2. The Capacity Assessment .....</b>	<b>16-3</b>
2.1 Purpose of the Capacity Assessment .....	16-3
2.2 Implementation Structure of the Project .....	16-3
2.3 Methodologies on Capacity Assessment .....	16-5
2.3.1 Organizational Structure .....	16-5
2.3.2 Capacity on the Formulation and Implementation of IPSDP .....	16-5
2.4 The Organizational Structures of Relevant Agencies .....	16-7
2.4.1 The Overall Organization Structure of the Power Sector .....	16-7
2.4.2 The Organizational Structures of Relevant Agencies .....	16-8
2.5 Considerations on Capacity on the Formulation and Implementation of IPSDP .....	16-14
2.5.1 Existing Policy, Development Plan and Projects in the Power Sector .....	16-14
2.5.2 Evaluation of each WG .....	16-16
2.5.3 Summary of Capacity Assessment of each WGs .....	16-18
<b>3. THE Capacity Development.....</b>	<b>16-22</b>
3.1 Overall Activity.....	16-22
3.1.1 Holding of Overall WG Meetings.....	16-22
3.1.2 Japan Visit .....	16-24
3.1.3 Japan Training .....	16-25
3.2 Records of Technology Transfer Activities in Each WG .....	16-26
3.2.1 Power Demand Forecast / Power Trade / Power System Planning.....	16-26
3.2.2 Hydropower Development / Power Generation Development Planning (Power Generation WG).....	16-28
3.2.3 Financial, Economic and PPP Analysis.....	16-29
3.2.4 Environmental and Social Considerations.....	16-31
3.2.5 Power Sector Governance .....	16-32



## **1. OUTLINE OF THE PROJECT**

### **1.1 SUMMARY OF THE PROJECT**

This Study aims at enhancing the plan formulation capacity for MoEWRI, promoting the coordination among relevant agencies and contributing development and maintenance of systematic electric power generation and power system by formulation of the Integrated Power System Development Plan and capacity building related to its method in Nepal.

#### **(1) Impact**

Systematic hydropower development and power system are developed and maintained.

#### **(2) Outcome**

Capacity of formulating plan for staff of relevant agencies such as MoEWRI and organizational institutional framework in order to implement power development smoothly are enhanced.

#### **(3) Output**

Capacity development related to the formulation of the Integrated Power System Development Plan upto 2040 and its planning method, in addition enhancement of coordination among government agencies are achieved.

#### **(4) Activities**

In this Project it is aimed that the Integrated Power System Development Plan is endorsed as National plan and power development is promoted based on this Plan. The following activities are carried out.

- I. Review the current situation and prospects of power sector in Nepal and surrounding countries.
- II. Domestic load forecast (power and energy) at different economic growth rate and probable demand at the neighboring market.
- III. Formulation of the vision, guiding principle and scenarios for power development based on review of existing plans.
- IV. Improvement of the power system planning consistent with the power development plan based on review of existing plans.
- V. Study on the Interconnection with neighboring countries.
- VI. Financial schemes and economic and financial analysis for project implementation.
- VII. Formulation of the governance mechanism for power sector development such as organizational institution, coordination function among relevant agencies, concretization of endorsement process, Electric Utility management etc.
- VIII. The environmental and social considerations (comparative study of alternatives including environmental and social impacts based on SEA concept)

- IX. The formulation of the Integrated Power System Development Plan of Nepal (including road map for promoting implementation)
- X. Capacity Development for formulation of the Integrated Power System Development Plan of Nepal (including On-the-Job Training)

**(5) Objective Area**

Overall Nepal

**(6) Relevant Government Ministries and Agencies, Institutes**

Implementing agency : Ministry of Energy, Water Resources and Irrigation (MoEWRI)

Relevant agencies : Department of Electricity Development (DoED)  
Water and Energy Commission Secretariat (WECS)  
Rastriya Prasaran Grid Company Limited (RPGCL)  
Nepal Electricity Authority (NEA)  
Vidhyut Utpadan Company Limited (VUCL)  
Electricity Regulatory Commission (ERC)

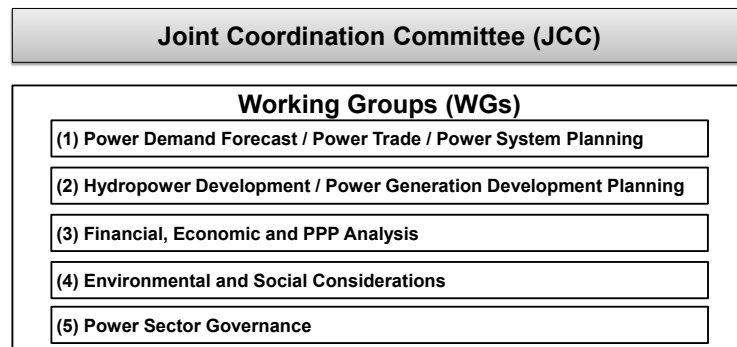
## 2. THE CAPACITY ASSESSMENT

### 2.1 PURPOSE OF THE CAPACITY ASSESSMENT

Capacity development on the formulation and implementation of IPSDP is required as one of the outcome for the Project. Therefore, capacity assessment of Counter Parts (C/Ps), implementation agency and relevant agencies will be carried out in order to obtain the baseline of their capacity at the beginning of the Project and to monitor the outcomes including the improvement of technical capacity and progress in meeting targets.

### 2.2 IMPLEMENTATION STRUCTURE OF THE PROJECT

Implementation structure of the Project was discussed at the kick-off meeting in May 2021, 1st JCC (Joint Coordination Committee) in September 2021 and 2nd JCC meeting in April 2022. As a result, it was confirmed that the project would be implemented under the structure of the JCC and WG (Working Groups) in each field, as shown in Figure 2-1.



Source: Prepared by JICA Study Team

**Figure 2-1 Implementation Structure of the Project**

#### (1) JCC

JCC is composed of the Secretary (Project Chairperson), Joint Secretary (Project Director), Senior Divisional Engineer (Project Manager) and senior officials of relevant agencies. JCC is responsible for sharing information, monitoring of the progress, coordinating matters and making decisions on the Project.

#### (2) WGs

WGs are responsible for practical activities on formulation and implementation of IPSDP and are composed of following five (5) groups;

- (1) Power Demand Forecast / Power Trade / Power System Planning
- (2) Hydropower Development / Power Generation Development Planning
- (3) Financial, Economic and PPP Analysis
- (4) Environmental and Social Considerations
- (5) Power Sector Governance

Roles of each WG and assigned agencies are shown in Figure 2-1. Based on the discussion with MoEWRI, MoF (Ministry of Finance) and IPPAN (Independent Power Producers' Association,

Nepal) are additionally invited to (3) Financial, Economic and PPP Analysis.

**Table 2-1 Roles of each WG and Assigned Agencies**

WG	Main Activities	Members	
		Nepalese	JICA Expert Team
Power Demand Forecast / Power Trade / Power System Planning	<ul style="list-style-type: none"> <li>Data collection and management for power trade including BBIN</li> <li>Understanding of methodologies on power demand forecast and execution of analysis</li> <li>Forecast of maximum power (transmission end) and annual power generation</li> <li>Data collection of existing/planning facilities of transmission and substation</li> <li>Considerations on the power trade with BBIN</li> <li>Execution of power system analysis consistent with power generation development planning</li> <li>Formulation of the power system planning</li> </ul>	MoEWRI, WECS, NEA, RPGCL	Power Trade / Power System Planning, Power Demand Forecast, Power System Analysis and Power System Analysis 2 / Coordinator
Hydropower Development / Power Generation Development Planning	<ul style="list-style-type: none"> <li>Data collection and management of hydropower development</li> <li>Data collection of existing / new hydropower projects</li> <li>Preparation of the generation mix concept for the Development Scenario</li> <li>Formulation of the Power Generation Development Planning</li> </ul>	MoEWRI, DoED, NEA, VUCL	Deputy Team Leader / Integrated Power System Development Planning / Power Generation Development Planning, Hydropower Planning, Natural Condition / Geologist
Financial, Economic and PPP Analysis	<ul style="list-style-type: none"> <li>Considerations on issues for implementation of PPP/IPP projects</li> <li>Economic and financial analysis for power generation and power system planning.</li> <li>Formulation of long term investment plan for the power generation and power system</li> </ul>	MoEWRI, MoF, IBN, ERC, DoED, NEA, IPPAN	Financial, Economic and PPP Analysis
Environmental and Social Considerations	<ul style="list-style-type: none"> <li>Comparison of development scenarios of SEA for the power generation and power system planning</li> </ul>	MoEWRI, DoED, NEA	Environmental and Social Considerations
Power Sector Governance	<ul style="list-style-type: none"> <li>Confirmation of mandate, relation and operational status of focal stakeholders</li> <li>Confirmation and analysis of process and procedures including authorization for the implementation of projects in the power sector.</li> <li>Recommendations on the improvement of the power sector governance and coordination and discussion with related stakeholders</li> <li>Capacity development on the power sector governance through OJT</li> <li>Association and coordination with JICA long term expert or development partners</li> </ul>	MoEWRI, DoED, NEA,	Power Sector Governance, Stakeholder Analysis

Source: Prepared by JICA Study Team

## 2.3 METHODOLOGIES ON CAPACITY ASSESSMENT

Understandings of the current situation on the capacity for IPSDP formulation and implementation of Nepalese side which has been obtained through the discussion on the establishment of the implementation structure of the Project is shown below.

- Policy, legislation and development plan in the power sector is under jurisdiction of MoEWRI and WECS, which has the capacity to formulate policies covering various and comprehensive sectors such as “White Paper” published in 2019 which includes power demand forecast, power generation development plan and power system planning. However, it does not have experience in developing plans that integrate each sector in a series of study flows, such as IPSDP.
- MoEWRI and the relevant agencies have experience in formulating development plans in each sector such as power demand forecasts, hydropower potential studies and transmission master plans. They also have enough capacity to formulate development plans in some fields. Although opinion exchanges and coordination are conducted in formulation of development plans among related organizations, there are many areas where cross-sectoral cooperation has not yet been achieved.
- There are less experiences on SEA (Strategic Environmental Assessment) and economic and financial analysis in comprehensive development plans which cover the evaluation and analysis of wider range of fields such as demand, generation and transmission.
- This project is the first attempt to formulate an integrated development plan by organizing WGs composed of relevant agencies.

As one of outcome of the Project is to improve the capacity for formulation and implementation of IPSDP and to strengthen cooperation among relevant agencies, it is recognized that it is important to understand the current situation of capacity, structure, performance and inter-organizational cooperation in MoEWRI and other relevant agencies as a baseline at the beginning of the Project. Therefore the capacity assessment will consider an analysis and evaluation of the relevant agencies that make up each WG, focusing on their organization structure and capacity to formulate and implement IPSDP in each expertise field.

Note that the scope of (5) Power Sector Governance is not limited to IPSDP, but also covers regulatory frameworks and approval processes in hydropower development. The capacity assessment of this WG is not dealt with in this Capacity Assessment Report because it corresponds to considerations in the establishment of governance mechanisms in the power sector.

### 2.3.1 Organizational Structure

In the capacity assessment, the key organizations and their roles in the power sector will be identified and the jurisdiction and organizational structure of relevant agencies of the Project, MoEWRI, DoED, ERC, WECS, IBN, NEA, VUCL and RPGCL are summarized. Based on this understanding of the current situation, the expected roles in the formulation and implementation of IPSDP in the future will be considered.

### 2.3.2 Capacity on the Formulation and Implementation of IPSDP

With regard to capacity on the formulation and implementation of IPSDP, the first step is to clarify the existing studies and plans and to organize track records by implementing agencies. Then, the formulation and implementation capacity of the relevant agencies is assessed from two perspectives: technical knowledge (Basic Knowledge) and practical experience (Experience) with

regard to the content of IPSDP studies in each WG. In addition to their achievements in the preparation of each development plan, interviews are conducted with WG members and persons in charge of each relevant organization based on the checklist shown in Table 2-2. The results are evaluated on a three-level scale (Good, Fair and Less Knowledge/Experience).

**Table 2-2 Criteria of Capacity on the Formulation of IPSDP**

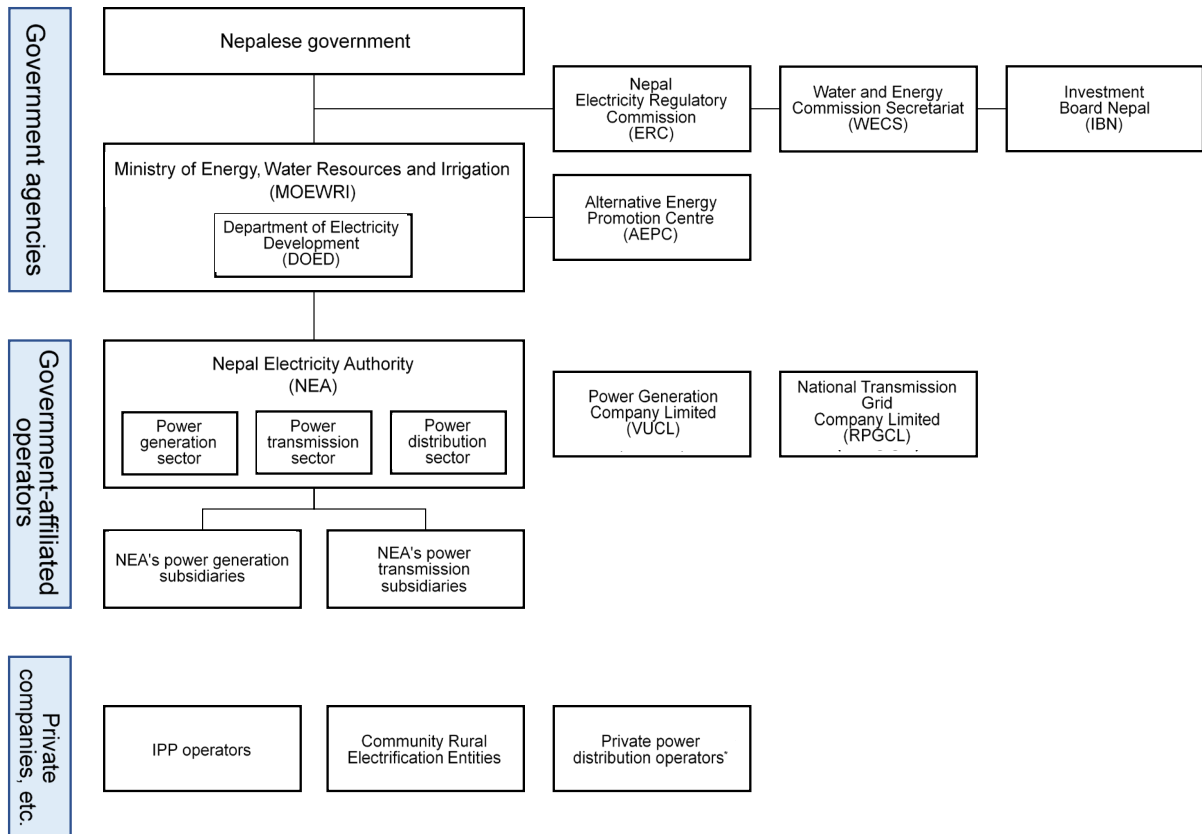
Item		Check Points
<b>(1) Power Demand Forecast / Power Trade / Power System Planning</b>		
Power Demand Forecast	Basic Knowledge	Difference between power consumption (kWh) and demand (kW), Peak demand time, Macro and Micro approaches, Elasticity factor, Load factor (yearly, daily), Transmission loss (technical, non technical), Types of users by sector
	Experience	Short term forecast, long term forecast, by sector, by regions, by voltage, daily load duration curve, EV, E-cooking, SDGs, NDC smart lighting, SEZ, DSM, energy efficiency
Power Trade	Basic Knowledge	Policy, legal frameworks, procedures, mechanisms, market survey
	Experience	Daily operation, trade amount, short term forecast, long term forecast
Power System Planning	Basic Knowledge	Thermal capacity, T/L availability, Transformer availability, N-1 criteria, System switching for power flow adjustment, Loop system / Radial system, Voltage basis level, Frequency basis level, Power system stability, Power flow calculation, Short circuit current calculation, Dynamic stability calculation
	Experience	Short term, long term. by region, allocation of power demand
<b>(2) Hydropower Development / Power Generation Development Planning</b>		
Primary Energy	Basic Knowledge	Hydropower, oil, coal, gas, solar, wind, biomass
	Experience	Reserve estimation of primary energy, energy demand forecast, assessment of primary energy availability, cost setting of fuel
Analysis of Least Cost Operation	Basic Knowledge	LCOE, least cost operation, LOLP, reserve margins, thermal efficiency, O&M conditions, emission factors, OPEX, CAPEX
	Experience	Tools such as WASP or Optgen, short or long term expansion planning, scenario studies
Power Generation Development Planning	Basic Knowledge	Screening, generation mix, river basin planning, cascade operation
	Experience	Preparation of project list, estimation of annual power generation, installed capacity and emissions and generation cost
<b>(3) Financial, Economic and PPP Analysis</b>		
Financial Statement Analysis	Basic Knowledge	cost/expense, gross profit, operating income, non-operating income, ordinary income, income before tax, current asset and noncurrent asset, Liability, Equity, B/S, P/L, cash flow
	Experience	Preparation of B/S, P/L and cash flow, budget allocation, financial soundness of electric utilities analysis of electricity-tariff levels
Economic and Financial Analysis for Long Term Plan	Basic Knowledge	Discount rate, cost recovery factor, NPV EIRR, FIRR, ROE, LPMC
	Experience	Evaluation of specific generation/transmission projects, analysis of electricity tariff levels, estimation of investment and O&M cost
Project Finance	Basic Knowledge	Equity, loan, interest rates, grace period, maturity period, hedge of foreign currency, PPA, SPC
	Experience	Generation projects by government or IPP, transmission and substation projects
<b>(4) Environmental and Social Considerations</b>		
EIA/IEE Studies	Basic Knowledge	Laws and regulation, procedures, scoping, mitigation, MNP, resettlement plan, stakeholder meetings
	Experience	Generation projects such as hydropower, renewable and, thermal, transmission and substation projects
SEA studies	Basic Knowledge	Laws and regulation, procedures, scoping, mitigation
	Experience	SEA for generation, transmission development plan

Source: Prepared by JICA Study Team

## 2.4 THE ORGANIZATIONAL STRUCTURES OF RELEVANT AGENCIES

### 2.4.1 The Overall Organization Structure of the Power Sector

Figure 2-2 shows the organizational structure of the power sector in Nepal. MoEWRI is in charge of policies and legislation in the power sector. DoED, a subordinate organization of the Ministry, creates master plans for each region and issues and manages licenses for electric power projects. Similarly, AEPC, which is also under the control of the Ministry, promotes popularization of alternative energy sources and electrification of rural areas.



\* At the time of writing this report, Butwal Power Company was the only private company that had obtained a power distribution license in Nepal, and according to the company's FY2020 business report, the number of households using their power distribution service was 58,091 as of the end of the fiscal year.

Source: Prepared by JICA Study Team

**Figure 2-2 The Organizational Structure of the Power Sector in Nepal**

Other government agencies related to the power sector include ERC, WECS, and IBN. ERC is responsible for determining electricity tariffs and establishing standards for the construction of electricity facilities. WECS is in charge of formulating policies for water resources/electric power sectors, making recommendations to MoEWRI, etc., for project formation, and promoting environmental protection.<sup>1</sup> IBN is responsible for promoting and managing investments from inside and outside the country as well as negotiating for PDAs, concerning hydropower projects of 200 MW or more, and granting the right to consider business development relating to them.

Regarding the electric power business, NEA, under the umbrella of MoEWRI, covers power generation, transmission and distribution with a vertically integrated structure. However, in the

<sup>1</sup> Japan Electric Power Information Center (2020) "Electricity Business in Overseas Countries Vol. 2"

power generation sector, IPPs (Independent Power Producers)<sup>2</sup> as well entered the market and operate business, based on the Electricity Act enacted in 1992. Major IPPs include Himtal Power Limited, Bhoite Koshi Power Company Pvt Ltd, and Sinohydro-Sagarmatha Power Company Pvt Ltd.<sup>3</sup> In 2006, VUCL (Vidhyut Utpadan Company Limited) was established to carry out power generation business as per PPP. In addition, since the government is aiming to separate generation, transmission and distribution in the future, RPGCL was established in 2015. Furthermore, in the power distribution sector, Community Rural Electrification Entities were established in various places to promote local electrification, and they are supplying electricity to local households by receiving wholesale supply from NEA.<sup>4</sup>

## 2.4.2 The Organizational Structures of Relevant Agencies

### (1) Ministry of Energy, Water Resources and Irrigation (MoEWRI)

Through the reorganization of ministries and agencies in March 2018, the MOWR (Ministry of Water Resources) and the Ministry of Irrigation were abolished, and the water resources and irrigation departments were integrated to the MOE (Ministry of Energy) at that time. This way, MoEWRI was born<sup>5</sup>. It consists of three departments: DoED, Department of Water Resources and Irrigation, and Department of Hydrology and Meteorology. It also has AEPC as its subordinate agency.

MoEWRI is responsible for formulating policies, laws, regulations and standards related to energy, water resources and irrigation, and promoting research, surveys and technological development related to these.

The objectives and goals of MoEWRI for the power sector are as follows:<sup>6</sup>

- Increase the volume of power generated by hydropower and secure clean energy.
- Expand access to high-quality and reliable electricity services, including energy efficiency, and increase electricity consumption for all households and production sectors.
- Expand access to environmentally friendly, sustainable, reliable, inexpensive, and high-quality power technologies, even in areas beyond the reach of power transmission systems.
- Improve energy consumption efficiency and productivity through efficient use of energy.
- Contribute to improving Nepal's balance of payments by expanding regional energy export trade and gradually substituting petroleum product imports.

In addition, as a long-term thinking on the development of the electric power sector, following goals are presented by MoEWRI: contribute to the prosperity of the country through sustainable and reliable development of hydroelectric power generation; and promote sustainable development of power source technologies through promotion, expanded use and efficiency improvement for alternative and renewable energy sources.<sup>7</sup>

Specifically, MoEWRI aims to attract domestic and foreign investments toward the development of hydroelectric power generation. In addition to hydroelectric power generation, it presents the strategy to ensure energy security by expanding the introduction of alternative and renewable

<sup>2</sup> In Nepal, NEA's power generation subsidiaries are also classified as PPPs.

<sup>3</sup> Japan Electric Power Information Center (2020) "Electricity Business in Overseas Countries Vol. 2"

<sup>4</sup> Ibid.

<sup>5</sup> myRepublica "Government restructuring its ministries" (March 2, 2018) <https://myrepublica.nagariknetwork.com/news/37259/>

<sup>6</sup> MoEWRI website <https://moewri.gov.np/pages/about-the-ministry>

<sup>7</sup> MoEWRI website <https://moewri.gov.np/pages/about-the-ministry>

energy sources and energy trade within the region. Also, it intends to expand the access to and demand for electricity through improving the efficiency and reliability of the grid system by strengthening and expanding domestic and international power transmission. In areas where the power system is not well developed, priority will be given to the introduction of alternative energy sources in cooperation with local governments. In the process of development, emphasis will be placed on utilizing the latest sustainable and energy-efficient technologies. Furthermore, it aims to strengthen the involvement of the banking and financial sectors in the field of alternative energy, develop alternative energy technology as a decarbonization initiative, and establish an international and domestic carbon market mechanism.<sup>8</sup>

## **(2) Department of Electricity Development (DoED)**

In July 1993, Electricity Development Center was established under the then Ministry of Water Resources (MOWR) with the aim of developing and promoting the electric power sector and improving financial efficiency through attracting private investments. After that, it was renamed to DoED in February 2000 and became a department of the current MoEWRI in the reorganization of ministries and agencies in March 2018.

DoED is responsible for the management and auditing of the power sector. Specifically, it implements the following: create a master plan for each region; conduct surveys and make plans for hydroelectric power generation; consider alternative energy sources; examine applications for electric power development; and issue and manage licenses for electric power projects. For various applications and examinations, it introduced the one-window service to realize a system that makes it easy for private companies to enter the electric power sector.<sup>9</sup>

## **(3) Electricity Regulatory Commission (ERC)**

ERC was established in 2018 under the Electricity Regulation Commission Act, replacing the former Electricity Tariff Fixation Commission.<sup>10</sup> The Commission determines the electricity tariffs, formulates the standards for constructing power generation facilities, and oversees the electric power sector. Its mission statement includes the following objectives: make the power generation, transmission, distribution, and electricity transactions systematic and transparent; maintain a good supply-demand balance of electricity; strive to protect consumers under a controlled electricity tariff system; ensure the operation of competitive power market; and ensure the access to reliable power systems.

Regarding the regulation of power generation, transmission and distribution, ERC establishes and implements levels and procedures for operation and maintenance of power systems as well as the standards for quality and safety level, and supervises power system operators. It is also responsible for formulating, implementing and monitoring grid codes and for creating and executing action plans for supply and demand of electricity services. In times of power outage, it plays a role in identifying the situation and cause and setting the priorities for recovery.<sup>11</sup>

The electricity tariffs are determined by ERC. In addition, the Commission regulates electricity trading and sets the charges and procedures for buying and selling electricity between power distribution operators and power generation operators. It is also responsible for determining the transmission and distribution charges (consignment charges) and temporary surcharges.<sup>12</sup>

---

<sup>8</sup> Ibid.

<sup>9</sup> Japan Electric Power Information Center (2020) “Electricity Business in Overseas Countries Vol. 2”

<sup>10</sup> Ibid.; JICA “Final Report: Information Gathering and Confirmation Survey on the Development of the Urban Transmission and Distribution Networks in Nepal” (July 2019)

<sup>11</sup> ERC website <https://erc.gov.np/pages/functions>

<sup>12</sup> Ibid.

Creating and maintaining a healthy competitive environment in the electricity market is also an important role of ERC to protect the interests of consumers. That is, it prevents monopolistic electricity charges, establishes and operates a wholesale electricity market, determines transaction processes, and ensures open access (fair access to the power grid). In addition, it formulates the criteria and provides authorization for each case concerning the following: merger between licensed electric power companies; sale of 50% or more of the shares of such companies and their subsidiaries; and sale or relocation of power plants.<sup>13</sup>

Furthermore, in order to maintain and strengthen the governance of electric power companies, it sets the levels and standards for business performance of these companies, formulates and has them follow the Code of Conduct, and issues instructions and standards necessary for maintaining governance. Also, ERC establishes unified standards for internal control, accounting systems, and audit methods.<sup>14</sup>

#### **(4) Water and Energy Commission Secretariat (WECS)**

WECS was established in 1981 as the permanent secretariat of the Water and Energy Commission for the integrated and accelerated development of water and energy resources. It consists of Water Resources Division, Energy Division, Social, Economic and Environment Division, and Legal and Institutional Development Division.

The objectives and goals of WECS are as follows:<sup>15</sup>

- Formulate policies and strategies for the water resources and energy sectors.
- Provide support to relevant ministries and agencies to formulate policies and objectives to be included in plans for the water resources and energy sectors.
- Provide proposals, recommendations, and guidance regarding irrigation, hydropower generation, drinking water, industrial use of water and flood control as well as regarding the development of large-scale and medium-scale multi-purpose projects; also, promote project development and environmental protection.
- Provide opinions, advice and recommendations on bilateral and multilateral issues related to the water resources and energy sectors.

Therefore, WECS enacts laws and regulations, conducts surveys and research projects, formulates policies and strategies in line with government priorities, goals and policies, concerning the development of water resources and energy, and also reviews large- and medium-scale projects and presents proposals for them. In formulating policies, WECS analyzes bilateral and multilateral water resource and energy development projects.<sup>16</sup>

#### **(5) Alternative Energy Promotion Centre (AEPC)**

AEPC was established in 1996 with the aim of promoting the development and utilization of renewable energy. Since then, it has promoted the development of alternative energy and renewable energy with the support of development aid agencies.

The objectives and goals of AEPC are as follows:<sup>17</sup>

---

<sup>13</sup> Ibid.

<sup>14</sup> Ibid.

<sup>15</sup> WECS website <https://www.weecs.gov.np/pages/objectives-and-mandate>

<sup>16</sup> Ibid.

<sup>17</sup> AEPC website <https://www.aepc.gov.np/mission-vision-and-strategy>

- Promote the spread and utilization of alternative and renewable energy technologies.
- Improve the standard of living of rural people.
- Protect the environment.
- Develop a commercially viable alternative energy industry in the country.

AEPC implemented the NRREP (National Rural and Renewable Energy Programme) from 2012 to 2017. In the program, Central Renewable Energy Fund was established for the purpose of providing subsidies and credit guarantees to the renewable energy sector, and also, technical support and business development were promoted towards effective use of renewable energy services in rural areas.<sup>18</sup>

In addition, the Centre oversees the alternative/renewable energy projects implemented by each development aid agency.

#### **(6) Investment Board Nepal (IBN)**

IBN is an organization established for the purpose of promoting and managing domestic and foreign investments. Headed by Prime Minister, it approves foreign investment projects or project costs of 6 billion rupees or more<sup>19</sup>. In the power sector, it is in charge of negotiating a PDA for hydropower projects of 200 MW or more and granting the right to consider business development for the said projects. IBN is also responsible for PPP and IPP projects.

#### **(7) Nepal Electricity Authority (NEA)**

NEA has centralized jurisdiction over the entire power sector, including generation, transmission and distribution. Based on the Nepal Electricity Authority Act enacted in August 1984, it was established through the merger of the Ministry of Electricity, Nepal Electricity Corporation, and related Development Boards. It comprises five business divisions (Generation Directorate, Transmission Directorate, Distribution and Consumer Services Directorate, Planning, Monitoring and Information Technology Directorate, and Engineering Services Directorate) and some administration divisions. NEA has over 10,000 employees<sup>20</sup>. It has also established a number of subsidiaries for hydropower development and the construction of international grid line<sup>21</sup>.

The Board of Directors, the highest decision-making body of NEA, is chaired by Secretary of MoEWRI and comprises a total of seven members: the Chair, NEA Managing Director, Secretary of the Ministry of Finance, one representative from the Federation of Nepalese Chambers of Commerce and Industry, one consumer representative, and two electric power experts. The Board deliberates and decides on important matters such as the reorganization of the electric power business and the PPAs.<sup>22</sup>

#### **(8) Vidhyut Utpadan Company Limited (VUCL)**

VUCL was established in 2006 as the main actor for the development, construction, holding and operation of large-scale hydropower projects using the PPP method. MoEWRI, the company's largest shareholder, has a 20% stake, followed by the general public (17%) and NEA (10%).

<sup>18</sup> AEPC "Annual Progress Report FY2014-15 – NRREP" (2018.06) <https://www.aepc.gov.np/documents/annual-progress-report-nrrep>

<sup>19</sup> One Asia Lawyers "Investment Environment and Investment Regulations in Nepal" (October 14, 2020) [https://oneasia.legal/wp-content/themes/standard\\_black\\_cmspro/img/1b82e3e068abef1b4e0735ac91276913.pdf](https://oneasia.legal/wp-content/themes/standard_black_cmspro/img/1b82e3e068abef1b4e0735ac91276913.pdf)

<sup>20</sup> Dun & Bradstreet website [https://www.dnb.com/business-directory/company-profiles/nepal\\_electricity\\_authority.18ed9709586abc4ca9c7c0fcc1d79983.html](https://www.dnb.com/business-directory/company-profiles/nepal_electricity_authority.18ed9709586abc4ca9c7c0fcc1d79983.html)

<sup>21</sup> Japan Electric Power Information Center (2020) "Electricity Business in Overseas Countries Vol. 2"

<sup>22</sup> Ibid.

**Table 2-3 VUCL Shareholder Composition**

No.	Shareholder	Investment amount (Million rupees)	Equity stake
1	MoEWRI	4,000	20%
2	General Public	3,400	17%
3	NEA	2,000	10%
4	Employees Provident Fund	2,000	10%
5	Nepal Doorsanchar Company Limited <sup>23</sup>	2,000	10%
6	Project-affected local people (PAPs) <i>* Open to the general public in the main company, structure applicable only for subsidiary projects</i>	2,000	10%
7	Ministry of Finance	1,000	5%
8	Ministry of Law, Justice and Parliamentary Affairs	1,000	5%
9	Citizen Investment Trust <sup>24</sup>	1,000	5%
10	Hydroelectricity Investment and Development Company Limited <sup>25</sup>	800	4%
11	Rastriya Beema Sansthan <sup>26</sup>	400	2%
12	Under-privileged people	400	2%
<b>Total</b>		<b>20,000</b>	<b>100%</b>

Source: Prepared by JICA Study Team based on public information on VUCL website (<https://vucl.org/pages/capital-structure>)

The government envisions a power sector reform that will divide NEA into power generation companies, transmission companies, and distribution companies in the future. At that time, VUCL will take over the power generation division of NEA and become the executing agency for hydropower development. However, the division has not progressed at the current moment, and the power generation divisions of VUCL and NEA continue to develop hydropower projects in parallel. In addition, there are no laws nor policies that clearly prescribe the division of roles between the power generation divisions of VUCL and NEA<sup>27</sup>.

At the time of writing this report, VUCL did not have a power plant in operation. On the other hand, SPCs (Special Purpose Companies) had been established for three projects, and construction of Base Camps and access roads had begun<sup>28</sup>. For two of the three, VUCL was the only corporate shareholder though they were partially held by the general public, PAPs, etc.,<sup>29</sup> so it can be said that they were projects unique to the company. The other one had been developed by the Employees Provident Fund and NEA and VUCL joined the consortium<sup>30</sup>. Table 2-4 shows SPCs of VUCL.

<sup>23</sup> Nepal Telecom

<sup>24</sup> Public civil trust investment institution established by the Nepalese government

<sup>25</sup> A government-affiliated hydropower investment and development company held by the Nepalese government (50%), three state-owned enterprises (30%), and the general public (20%)

<sup>26</sup> Government-affiliated insurance company

<sup>27</sup> According to a survey by the local consultant.

<sup>28</sup> VUCL website <https://vucl.org/>

<sup>29</sup> Refer to "2.4.4 Project finance" for investments in hydropower projects by the general public and local communities.

<sup>30</sup> Betan Karnali Sanchaya Karta Hydropower Company Limited website (<https://bkshcl.com.np/>)

**Table 2-4 List of VUCL SPCs**

No.	SPC	Established	Capacity	Shareholder
1	Jagdulla Hydropower Company Limited (JHCL)	2017	106MW	VUCL..... 75% General Public..... 13% PAPs ..... 10% Under-Privileged Citizens of Nepal..... 2%
2	Nalgad Hydropower Company Limited (NHCL)	Unknown	410MW	VUCL..... 75% General Public..... 13% PAPs ..... 10% Under-Privileged Citizens of Nepal..... 2%
3	Betan Karnali Sanchaya Karta Hydropower Company Limited (BKSHCL)	May 2017	440MW	Karmachari Sanchaya Kosh ..... 15% NEA ..... 10% VUCL..... 10% Karmachari Sanchaya Kosh representing its Contributors..... 40% General Public..... 13% PAPs ..... 10% Families with very low-income..... 2%

Source: Prepared by JICA Study Team based on the information posted on the websites of JHCL, NHCL, and BKSHCL

### (9) Rupantarita Prakritik Gas Company Limited (RPGCL)

As mentioned above, the government is aiming to separate generation, transmission and distribution, and as part of the step-by-step pursuit, RPGCL, which oversees the transmission sector, was established in 2015<sup>31</sup>. Table 2-5 shows RPGCL shareholder composition.

**Table 2-5 RPGCL Shareholder Composition**

No.	Shareholder	Investment amount (Million rupees)	Equity stake
1	Ministry of Finance		
2	MoEWRI		
3	Ministry of Defence		
4	Ministry of Home Affairs		
5	Ministry of Forests and Environment		
6	Ministry of Education, Science and Technology; Ministry of Land Management, Cooperatives and Poverty Alleviation		
7	Ministry of Communication and Information Technology		
8	NEA		
<b>Total</b>		<b>10,000</b>	<b>100%</b>

Source: Prepared by JICA Study Team based on public information on RPGCL website (<https://www.rpgcl.com/pages/capital-structure>)

As of July 2019, RPGCL did not own any assets. Looking forward, a business model is being considered in which consignment charges will be used as the source of income by constructing power transmission facilities for IPPs and connecting them to the NEA grid for operation. The grid systems (distribution systems) of 132 kV or less are under the jurisdiction of NEA, so they are outside the jurisdiction of RPGCL.<sup>32</sup>

At the time of writing, RPGCL was planning or constructing multiple transmission line projects, but it was confirmed that no project started the operation yet.

<sup>31</sup> JICA “Final Report: Information Gathering and Confirmation Survey on the Development of the Urban Transmission and Distribution Networks in Nepal” (July 2019)

<sup>32</sup> Ibid.

The articles of incorporation of RPGCL show its objectives and goals as follows<sup>33</sup>:

- Conduct a research for and formulate a transmission line master plan considering long-term power supply and demand.
- Ensure management of transmission grids for reliable power supply and develop transmission infrastructure to promote the electricity market.
- Collect consignment charges from power grid users.
- Collect other royalties set by regulatory authorities.
- Construct, expand and modernize transmission lines, substations and load dispatch centers.
- Develop power grid systems in areas with hydroelectric potential, and construct east-west and north-south power transmission lines based on river mapping.
- Ensure evaluation, monitoring and control of the grid systems.
- Adopt trunk communication systems for power grid systems.
- Ensure in-house human resource development and provision of consultant services.
- Ensure access to the grid for consumers.
- Ensure supervision of power transmission and fulfill the responsibility of real-time operation.

## **2.5 CONSIDERATIONS ON CAPACITY ON THE FORMULATION AND IMPLEMENTATION OF IPSDP**

### **2.5.1 Existing Policy, Development Plan and Projects in the Power Sector**

Existing policies, development plans and project in the power sector past 20 years are summarized in project period, implementing agencies, development partners and study fields as shown in Table 2-6.

As mentioned in the previous Chapter, MoEWRI, including its predecessor MoE, is responsible for formulating major policies such as the Hydropower Development Policy (2001), White Paper (2019). WECS is responsible for the Water Resources Strategy (2002) and National Water Plan (2006), as well as development plans such as the Electricity Demand Forecast Report (2015), Energy Consumption and Supply Situation in the Federal System of Nepal (on-going). In addition, development plans such as Preparation of River Basin Plans and Hydropower Development Master Plans and Strategic Environmental and Social Assessment (WB, on-going) are also prepared. AEPC is also responsible for off-grid planning using renewable energy.

Loan projects in the power sector are mainly handled by NEA with support from JICA, ADB, WB and others. In addition to them, the Preparation of River Basin Plans and Hydropower Development Master Plans and Strategic Environmental and Social Assessment (JICA, 2014), the Transmission Master Plan (ADB, 2015), and various other development plans are also prepared.

In recent years, there has been an increasing trend on projects assisted by development partners to support multiple agencies, such as the Urja Nepal Project (USAID, on-going).

---

<sup>33</sup> RPGCL website <https://www.rpgcl.com/pages/about-us>

**Table 2-6 Existing Policy, Development Plan and Projects in the Power Sector**

Title	Project Period	Implementation Agency	Development Partners	Power Demand Forecast	Primary Energy	Power Trade	Power System Planning	Power Generation Development Planning	Financial and Economic Analysis	Environmental and Financial Considerations
Hydropower Development Policy, 2001	10/2001	Former MOWR			✓		✓	✓		
Water Resources Strategy	1/2002	WECS			✓	✓				✓
National Water Plan	2005	WECS			✓	✓		✓		✓
Rural Energy Policy of Nepal	11/2006	APEC			✓		✓			
National Electricity Crisis Resolution Action Plan (2008)	2008	Former MOE			✓	✓				
Nepal's Energy Sector Vision 2050 A.D.	2013	WECS		✓	✓					
Nationwide Master Plan Study on Storage-type Hydroelectric Power Development	2014	NEA	JICA	✓	✓		✓	✓	✓	✓
Transmission Master Plan	2015	NEA	ADB	✓		✓	✓	✓		
Electricity Demand Forecast Report (2014-2040)	2015	WECS		✓						
Action Plan on National Energy Crisis Mitigation and Electricity Development Decade (2016)	2/2016	Former MOE			✓	✓	✓	✓	✓	
Renewable Energy Subsidy Policy, 2013 (2016)	5/2016	AEPC			✓					
Detailed Feasibility Studies for Transmission Projects in Nepal	2016.9-2017.3	NEA	MCC				✓		✓	✓
Biomass Energy Strategy	1/2017	AEPC			✓					
National Renewable Energy Framework	11/2017	AEPC			✓					
Transmission System Development Plan of Nepal	7/2018	RPGL		✓		✓	✓	✓		
Energy, water resources and irrigation sector's current status and roadmap for future (White paper)	5/2019	MOEWRI			✓	✓	✓	✓	✓	
Hydropower Potential of Nepal 2019	2019	WECS			✓					
Nepal Hydropower Development Project	2015.7-2020.7	IBN /NEA /DOED	USAID		✓				✓	
Power Transmission and Distribution Efficiency Enhancement Project	2021	NEA	ADB				✓		✓	✓
Nepal: Grid Solar and Energy Efficiency	2022	NEA	WB		✓					
Energy Consumption and Supply Situation in Federal System of Nepal	on-going	WECS		✓						
Preparation of River Basin Plans and Hydropower Development Master Plans and Strategic Environmental and Social Assessment	on-going	NEA/WECS	WB		✓			✓	✓	✓
Urja Nepal Program	on-going	MoEWRI/NEA /ERC /MoF	USAID	✓		✓	✓	✓	✓	
Construction of Transmission Lines and substation in Nepal	on-going	NEA	MCC				✓		✓	✓
Data Collection Survey for Regional Grid Integration in BBIN (Bangladesh, Bhutan, India and Nepal)	on-going	MoEWRI/NEA	JICA			✓				
South Asia Subregional Economic Cooperation Power Transmission and Distribution System Strengthening	on-going	NEA	ADB			✓	✓		✓	✓
Electricity Grid Modernization Project	on-going	NEA	ADB				✓		✓	✓
Project on Integrated Power System Development Plan in Nepal	on-going	MoEWRI	JICA	✓	✓	✓	✓	✓	✓	✓

Source: Prepared by JICA Study Team

## 2.5.2 Evaluation of each WG

### (1) Power Demand Forecast / Power Trade / Power System Planning

With regard to power demand forecast, WECS and NEA have developed and updated their own medium- and long-term forecasts and have extensive knowledge and experience. In the interviews related to technical issues, the introduction of new policies that have been promoted in recent years (Policy Intervention) such as EVs, electrification by E-Cooking and Energy Efficiency. On the other hand, there are some opinions obtained the hearings from various stakeholders which result of power demand forecast prepared by WECS or NEA are correct. In addition to this, consistency with national medium and long-term development plans, such as NDC prepared under the initiative of MoFE and SDGs prepared by NPC was also mentioned as an issue. These gaps of the inconsistency among studies of power demand forecast are assumed to be institutional issues such as the definition of purpose, coverage and roles of each study, not technical ones.

In terms of power trade, NEA is the practical agency for India's imports/exports. They participates in technical studies such as JSC/JTT and continue consultations on regional power trade such as SASEC. MoEWRI also leads India's policy discussions, including on individual projects such as Upper Karnali and Sunkoshi hydropower. While there are short- and medium-term plans for power trade such as 400 kV interconnection lines still under considerations, there is an absence of long-term planning that takes into account the demand in each country and the development capacity of the power supply.

NEA has developed various types of power system plans and has sufficient technical knowledge including studies of individual projects using power system analysis tools such as PSSE. Medium- and long-term plans for the 400 kV transmission network which will be the future backbone of bulk power system by RPGCL. On the other hand, the accuracy of the studies on power demand forecast and power generation development plans which are the basis of the development plans is different in projects to projects, although the appropriate plans are considered at that moment. In the hearings, several comments are noted that these studies usually need to be carried out in series and it is necessary to be consistent with power demand and power generation.

**Table 2-7 Evaluation of Power Demand Forecast / Power Trade / Power System Planning**

Item		MoEWRI	WECS	NEA	RPGCL	Check Point
Power Demand Forecast	Basic Knowledge	Fair	Good	Good	Fair	Difference between power consumption (kWh) and demand (kW), Peak demand time, Macro and Micro approaches, Elasticity factor, Load factor (yearly, daily), Transmission loss (technical, non technical), Types of users by sector
	Experience	Less	Good	Good	Less	Short term forecast, long term forecast, by sector, by regions, by voltage, daily load duration curve, EV, E-cooking, SDGs, NDC smart lighting, SEZ, DSM, energy efficiency
Power Trade	Basic Knowledge	Fair	Less	Good	Fair	Policy, legal frameworks, procedures, mechanisms, market survey
	Experience	Fair	Less	Good	Less	Daily operation, trade amount, short term forecast, long term forecast
Power System Planning	Basic Knowledge	Fair	Less	Good	Fair	Thermal capacity, T/L availability, Transformer availability, N-1 criteria, System switching for power flow adjustment, Loop system / Radial system, Voltage basis level, Frequency basis level, Power system stability, Power flow calculation, Short circuit current calculation, Dynamic stability calculation
	Experience	Less	Less	Fair	Fair	Short term, long term. by region, allocation of power demand

Source: Prepared by JICA Study Team

## (2) Hydropower Development / Power Generation Development Planning

A lot of technical studies on hydropower have been carried out in the past such as Hydropower Potential Study in Nepal supported by JICA. Major organizations concerned with power generation has enough knowledge and experience in studies of F/S or DPR for individual hydropower projects. MoEWRI and DoED has them as regulators and NEA and VUCL are as developers. On the other hand, VUCL has less experience in handling studies on renewable energy and thermal power.

Regarding least cost power generation planning, some staff at MoEWRI, DoED and NEA have knowledgeable in this area through various technology transfers. Only NEA has personnel who can handle the tool such as WASP at a practical level. Furthermore, it was commented that such personnel are also limited even in NEA and do not have extensive experience in practice. Least cost power generation planning is very important for optimization of the capacity and timing of hydropower development and assumption of the amount of power trade. It is considered that there is a need to focus on capacity strengthening.

With regard to Power Generation Development Planning, the project list itself is important for various types of planning and MoEWRI, DoED and NEA have produced many lists. However, project lists in medium- and long-term development plans should be based on the results of the above-mentioned least cost operation. There are comments that there is little practical experience of these. At the same time, there are awareness concerning lack of consistency between generation projects and transmission and substation facilities.

**Table 2-8 Evaluation of Hydropower Development / Power Generation Development Planning**

Item		MoEWRI	DoED	NEA	VUCL	Check Point
Primary Energy	Basic Knowledge	Good	Good	Good	Fair	Hydropower, oil, coal, gas, solar, wind, biomass
	Experience	Good	Good	Good	Fair	Reserve estimation of primary energy, energy demand forecast, assessment of primary energy availability, cost setting of fuel
Analysis of Least Cost Operation	Basic Knowledge	Fair	Fair	Fair	Less	LCOE, least cost operation, LOLP, reserve margins, thermal efficiency, O&M conditions, emission factors, OPEX, CAPEX
	Experience	Less	Less	Fair	Less	Tools such as WASP or Optgen, short or long term expansion planning, scenario studies
Power Generation Development Planning	Basic Knowledge	Good	Good	Good	Less	Screening, generation mix, river basin planning, cascade operation
	Experience	Fair	Fair	Fair	Less	Preparation of project list, estimation of annual power generation, installed capacity and emissions and generation cost

Source: Prepared by JICA Study Team

## (3) Financial, Economic and PPP Analysis

MoEWRI, DoED, ERC, NEA and IBN have finance departments in their respective organizations and have basic knowledge and experience in preparing and reporting financial statements such as B/S, P/L and cash flows in their annual reports.

With regard to economic and financial analysis, they have enough knowledge and experience in general analysis methods such as NPV, IRR and ROE but has limited experience in comprehensive cost evaluation across sectors, such as generation, transmission and distribution costs in medium- and long-term plans such as LRMC.

In terms of project finance, MoEWRI, DoED and IBN have knowledge as supervising ministries and NEA as implementing agencies. In particular, NEA has various experiences in ODA projects supported by various development partners and in structuring finance through holding companies.

However, it was commented that while Nepal has extensive experience in small-scale projects, there are few cases of medium to large-scale projects or foreign investment projects that have progressed to finance.

**Table 2-9 Evaluation of Financial, Economic and PPP Analysis**

Item		MoEWRI	DoED	ERC	NEA	IBN	Check Points
Financial Statement Analysis	Basic Knowledge	Good	Good	Good	Good	Good	cost/expense, gross profit, operating income, non-operating income, ordinary income, income before tax, current asset and noncurrent asset, Liability, Equity, B/S, P/L, cash flow
	Experience	Good	Good	Good	Good	Good	Preparation of B/S, P/L and cash flow, budget allocation, financial soundness of electric utilities analysis of electricity-tariff levels
Economic and Financial Analysis for Long Term Plan	Basic Knowledge	Fair	Fair	Fair	Fair	Fair	Discount rate, cost recovery factor, NPV EIRR, FIRR, ROE, LRMC
	Experience	Less	Less	Less	Less	Less	Evaluation of specific generation / transmission projects, analysis of electricity tariff levels, estimation of investment and O&M cost
Project Finance	Basic Knowledge	Good	Good	Good	Good	Good	Equity, loan, interest rates, grace period, maturity period, hedge of foreign currency, PPA, SPC
	Experience	Fair	Fair	Fair	Good	Fair	Generation projects by government or IPP, transmission and substation projects

Source: Prepared by JICA Study Team

#### (4) Environmental and Social Considerations

MoEWRI and DoED have rich experience and knowledge of EIA/IEE as supervising ministries and NEA as implementing agency. Concerns were raised about less experience of EIAs in relation to large storage hydropower projects. However these projects are being addressed by employing international consultants.

With regard to SEA, it was commented that they have general knowledge but there have been few cases in power sector so far and the Project is the first case that covers an integrated and comprehensive area in development plans.

**Table 2-10 Evaluation of Environmental and Social Considerations**

Item		MoEWRI	DoED	NEA	Check Point
EIA/IEE Studies	Basic Knowledge	Good	Good	Good	Laws and regulation, procedures, scoping, mitigation, MNP, resettlement plan, stakeholder meetings
	Experience	Good	Good	Good	Generation projects such as hydropower, renewable and, thermal, transmission and substation projects
SEA studies	Basic Knowledge	Fair	Fair	Fair	Laws and regulation, procedures, scoping, mitigation
	Experience	Less	Less	Less	SEA for generation, transmission development plan

Source: Prepared by JICA Study Team

### 2.5.3 Summary of Capacity Assessment of each WGs

Summary of capacity assessment of each WGs is shown in Table 2-11.

**Table 2-11 Summary of Capacity Assessment of each WGs**

	Item		MoEWRI	DoED	ERC	WECS	NEA	VUCL	RPGL	IBN
PSP	Power Demand Forecast	Basic Knowledge	Fair	-	-	Good	Good	-	Fair	-
		Experience	Less	-	-	Good	Good	-	Less	-
	Power Trade	Basic Knowledge	Fair	-	-	Less	Good	-	Fair	-
		Experience	Fair	-	-	Less	Good	-	Less	-
	Power System Planning	Basic Knowledge	Fair	-	-	Less	Good	-	Fair	-
		Experience	Less	-	-	Less	Fair	-	Fair	-
PGDP	Primary Energy	Basic Knowledge	Good	Good	-	-	Good	Fair	-	-
		Experience	Good	Good	-	-	Good	Fair	-	-
	Analysis of Least Cost Operation	Basic Knowledge	Less	Less	-	-	Fair	Less	-	-
		Experience	Less	Less	-	-	Fair	Less	-	-
	Power Generation Development Planning	Basic Knowledge	Good	Good	-	-	Good	Less	-	-
		Experience	Fair	Fair	-	-	Fair	Less	-	-
Finance	Financial Statement Analysis	Basic Knowledge	Good	Good	Good	-	Good	-	-	Good
		Experience	Good	Good	Good	-	Good	-	-	Good
	Economic and Financial Analysis	Basic Knowledge	Fair	Fair	Fair	-	Fair	Fair	-	Fair
		Experience	Less	Less	Less	-	Less	Less	-	Less
	Project Finance	Basic Knowledge	Good	Good	Good	-	Good	Good	-	Good
		Experience	Fair	Fair	Fair	-	Good	Fair	-	Fair
SEA	EIA/IEE Studies	Basic Knowledge	Good	Good	-	-	Good	-	-	-
		Experience	Good	Good	-	-	Good	-	-	-
	SEA studies	Basic Knowledge	Fair	Fair	-	-	Fair	-	-	-
		Experience	Less	Less	-	-	Less	-	-	-

Source: Prepared by JICA Study Team

Capacity in each WGs is considered from three viewpoints; Individual (Technical skills and experience), Organization and Institution.

### (1) Individual (Technical skills and experience)

The capacity of each relevant agency to formulate and implement IPSDP was assessed mainly by the WG members. The results indicated that each of the agencies has a high level of expertise and a wealth of knowledge and experience in their respective fields. For example, they has extensive knowledge and experience in technical studies such as power demand forecast, power system planning, hydropower development, financial analysis of each organization and EIA/IEE of individual projects, even though the implementing or supervising authorities may differ in terms of their positions.

Following areas are abstracted as focal points on capacity development of the formulation and implementation of IPSDP.

In the hearings, there were high expectations for capacity development for items above. Thus, it is important to focus on them in the technology transfer in the Project.

It was also commented that the need for collaboration not only within WGs but also between WGs is required in many cases such as power demand forecast into power generation and system plans, and the assurance of consistency between generation, transmission and substation facilities. Most of the development plans in Nepal have been carried out within their expertise respectively by each agency. However, cross sectional cooperation for preparation of integrated development plans have

been considered in several projects such as this IPSDP, Urja Project and River basin master plan. In the formulation of IPSDP, in addition to cooperation within each WG, it is also important to strengthen coordination between WGs.

**Table 2-12 Priority Areas of Capacity Development in Technical Skills**

Fewer cases in Nepal	<ul style="list-style-type: none"> <li>✓ Estimation of generation or transmission cost such as LRMC</li> <li>✓ SEA</li> </ul>
Less experience in practical works	<ul style="list-style-type: none"> <li>✓ Medium and long term power system planning</li> <li>✓ Medium and long term power trade planning</li> <li>✓ Power generation development planning by least cost operation</li> <li>✓ Project finance of large scale development</li> </ul>
Technologies recently introduced	<ul style="list-style-type: none"> <li>✓ Involvement of new technologies to power demand forecast such as EV and E-cooking</li> <li>✓ Water resource management by cascade operation of river system</li> <li>✓ Promotion of countermeasures on the climate change</li> </ul>
Strengthen of cooperation between WGs	<ul style="list-style-type: none"> <li>✓ Series studies of demand, generation and power system</li> <li>✓ SEA and economic and financial analysis for overall power sector</li> </ul>

Source: Prepared by JICA Study Team

## (2) Organization

In terms of organizational capacity to formulate and implement IPSDP, the power sector can be broadly divided into two categories: the relevant bodies of MoEWRI (the Ministry, DoED, ERC, WECS, VUCL and RPGCL) and NEA. They have engineers with a high level of expertise in their respective fields. On the other hand, it was also observed that there is currently no department that covers all fields related to IPSDP and is capable of carrying out practical works independently. MoEWRI has Planning Division, further departments in charge of planning such as WECS and supervising agencies of DoED. However, these engineers in each expertise are allocated among the agencies. It was also commented that NEA also has engineers in its internal divisions, but there is no division responsible for the integrated planning of these divisions.

By the specific field, knowledge and experience in power system planning, transmission and substation facilities and system operation is unevenly distributed among NEA. Knowledge in these areas is developed through actual experience in the operation and planning of facilities such as central power system control center in which areas it takes time to develop human resources. In case of other countries, it is generally considered that it is important to utilize human resources and organizational structure of the power utility companies responsible for system operations and planning in the formulation and execution of plans in these areas.

As already mentioned, with regard to the human resources of engineers in each related agencies, they are highly specialized in their respective fields. In the Project, experienced members have been selected for the WGs from each agencies. In the interviews, it was commented that the shortage of technical personnel and technology transfer are challenges for them. As technical studies in IPSDP differs from their regular works and there are few opportunities to learn them, the core technologies tends to be depended on individual skills and not sustainable. This is particularly the cases for analyses using tools such as power demand forecast, least-cost operation planning (WASP) and power system analysis (PSSE). It is important to establish sustainable training courses, and to secure personnel who can handle these technologies.

Based on the recognition so far, it is assumed that the formulation and implementation of IPSDP will be difficult to be carried out by one agency alone considering the current power sector structure and human resources. Therefore, for the time being, it is preferable to conduct activities in the form

of WGs consisting of experts from each relevant agencies such as in the Project. In capacity development, it is important that each WG functions as a template for cross-organizational initiatives in the Project and the operation of the WG itself should be recognized as part of technology transfer.

### **(3) Institution**

Regarding institutional systems related to IPSDP, Asian countries have similar institutions for the formulation of medium- and long-term power development planning, such as National Electricity Plan (NEP) in India, Power Development Plan (PDP) in Thailand and RUKN in Indonesia. They have also established the implementation structure to enable sustainable update of the plan. In Nepal, an institutional framework for comprehensive development planning in the power sector such as IPSDP was absent as of July 2022.

In the interviews related to the situation surrounding preparation of development plans in Nepal, the consistency between the power demand forecast by WECS and NEA and the power system plan by RPGCL and NEA was often mentioned. Although persons in charge of practical works are aware of these issues, it was recognized that it have not been resolved because definition of roles on each study and the relationship between the implementing agencies is not clear and there is no opportunity for stakeholders concerned to come together and discuss the issues. It is assumed that these matters are issues in institutional design, not technology. It is important for the Project to clarify the role of each technical study and implementing agencies in the future.

Policy, legislation, regulations and standards in the power sector are under the jurisdiction of MoEWRI. Strategy and development plans are responsible for WECS. To ensure the quality and sustainability of IPSDP in the future, it is important to establish a new framework that institutionalizes the positioning of the plan, implementation arrangements, frequency of updates and approval processes.

As described in the previous section, the activities of WGs in the Project can be as a template for future IPSDP updates. It is important to develop recommendations for the institutional design of IPSDP updates through these activities.

### 3. THE CAPACITY DEVELOPMENT

#### 3.1 OVERALL ACTIVITY

The technology transfer in this project involved general activities such as conducting overall WG meetings inviting WG members and relevant stakeholders within Nepal, and organizing Japan visit and training programs for JCC and WG members. The overall WG meetings aimed to share major study outcomes from each WG widely with Nepalese stakeholders, including discussions on power demand forecasts, development scenario evaluations, and the IPSDP direction, facilitating opinion exchanges. The training programs in Japan invited JCC and WG members to interact with Japanese stakeholders, introduce Japanese technologies, and visit power facilities.

##### 3.1.1 Holding of Overall WG Meetings

Overall WG meetings were held to share the project activities, progress, and main achievements with WG members and stakeholders. The first meeting focused on the kickoff of the project and development scenario directions, while the second meeting reported and discussed the results of the IPSDP as project outcomes.

###### (1) 1st WG (June 21, 2022)

The first overall WG meeting was held as a kickoff meeting for each WG establishment. The project activities were explained and discussed, sharing the project progress. The meeting was attended by 29 participants, including WG members from MoEWRI, DoED, WECS, ERC, RPGCCL, VUCL, NEA, IPPAN, IBN and the JICA study team. The agenda for the first overall WG meeting is as follows:

- Opening Remarks
- Introduction of Participants
- Outline of IPSDP Formulation
- Power Demand Forecast / Power Trade / Power System Planning
- Power Generation Development Planning
- Financial, Economic and PPP Analysis
- Environmental and Social Considerations
- Power Sector Governance
- Closing Remarks





## (2) 2nd WG (August 7, 2024)

To report the results of the IPSDP studies and project progress, the second overall WG meeting was held, inviting WG members and stakeholders. Attendees included 45 participants comprising WG members, Nepalese stakeholders, and development partners such as USAID Urja, GIZ, ADB, KfW and the JICA study team. The agenda for the second WG meeting is as follows:

- Opening Remarks
- Introduction of the IPSDP
- Studies on Development Scenarios and Optimum Scenario
- Strategic Environmental Assessment
- Coffee Break
- Economic and Financial Analysis
- Power Sector Governance
- Integrated Power System Development Plan
- Closing Remarks



### 3.1.2 Japan Visit

In November 2023, six WG members were invited to Japan to conduct site visits related to hydropower development and hold discussions that included policy aspects relevant to IPSDP. The objectives, content and schedule of the invitation are outlined below.

- To facilitate in-depth discussions on development planning by gathering relevant policy-making institutions and aiming for the finalization and compilation of the plan as a policy document.
- To provide opportunities for gaining knowledge and insights through visits to technologies already implemented in Japan, relevant to advancing hydropower development in Nepal.

**Table 3-1 Overview of Activities During the Invitation to Japan**

Item	Content
Discussions on Integrated Power System Development Plan	<ul style="list-style-type: none"> <li>• Screening of hydropower projects</li> <li>• International interconnection with India</li> <li>• Methods of economic and financial analysis</li> <li>• Exchange of opinions on overall governance</li> <li>• Challenges in the power sector</li> <li>• Details of the roadmap and action plan</li> </ul>
Visit to Kansai Electric Power Facilities	<ul style="list-style-type: none"> <li>• Central Load Dispatch Center</li> <li>• Okutadashirogi Pumped Storage Power Plant</li> </ul>
Others	<ul style="list-style-type: none"> <li>• Exchange of opinions with Japanese hydropower operators</li> <li>• Discussions on future Japanese support in Nepal</li> </ul>

**Table 3-2 Schedule of Activities During the Invitation to Japan**

Date	Time	Venue	Stay
11/5 (Sun)	All day	Departure	-
11/6 (Mon)	-	Arrival at Narita, transfer to Kansai, hotel check-in	Osaka
11/7 (Tue)	AM	Briefing & Discussions on power sources and systems @ Newjec Osaka HQ	Osaka
	PM	Courtesy visit to the Central Load Dispatch Center and Kansai Electric Power International Business Headquarters	Osaka
11/8 (Wed)	AM	Okutadashirogi Pumped Storage Power Plant	Osaka-
	PM	-	
11/9 (Thu)	AM	Transfer to Tokyo	Tokyo
	PM	Discussions on sector governance @ Newjec Tokyo HQ	
11/10 (Fri)	AM	Project-wide discussions @ JICA HQ	Tokyo
	PM	-	
11/11 (Sat)	All day	Return	-

The invitation included participants from MoEWRI, DoED, ERC, NEA, and other power sector organizations. The discussions on IPSDP were comprehensive, particularly with regard to governance structures, unbundling, power trade, and power policies. Notably, a more open environment allowed the collection of practical opinions that were hard to express freely within Nepal. At the Central Load Dispatch Center, interest was shown in system interconnections and transmission concepts related to hydropower plants, which bear similarities to Nepal. Questions about the design and operational planning of pumped storage facilities were actively discussed, providing valuable insights into adjusting solar output and balancing loads.

### 3.1.3 Japan Training

In April 2024, 10 WG members were invited to Japan for site visits and cross-sectional studies related to IPSDP. The objectives, content, and schedule of the training are as follows.

- To conduct lectures on the formulation of the IPSDP, allowing participants to gain comprehensive knowledge and expertise through cross-sectional study.
- To enhance understanding of technologies already implemented in Japan for advancing hydropower development in Nepal.
- To create an action plan based on training content to contribute to future power sector development.

**Table 3-3 Overview of Activities During Japan Training**

Item	Content
Lectures on Integrated Power System Development Plan	<ul style="list-style-type: none"> <li>• Power demand forecasting</li> <li>• International interconnection with India (power trade)</li> <li>• Economic and financial analysis</li> <li>• Project finance for hydropower projects</li> <li>• Improving power sector governance</li> <li>• Strategic Environmental Assessment</li> <li>• Challenges in the power sector</li> <li>• Integrated Power System Development Plan</li> </ul>
Visit to Kansai Electric Power Facilities	<ul style="list-style-type: none"> <li>• Central Load Dispatch Center for Kansai Electric Power transmission and distribution</li> <li>• Kisenyama Power Plant</li> </ul>
Visit to Japanese Companies	<ul style="list-style-type: none"> <li>• Visit to power generator manufacturer's factory</li> <li>• Japanese technology in variable-speed pumped storage</li> </ul>
Lectures and Visits on Hydropower and Dam Development	<ul style="list-style-type: none"> <li>• Comprehensive basin development</li> <li>• Reservoir sedimentation countermeasures in dams</li> <li>• Japanese technologies in dam rehabilitation</li> <li>• Visit to hydraulic model experiment facility</li> </ul>
Others	<ul style="list-style-type: none"> <li>• Discussions on future Japanese support in Nepal</li> <li>• Lecture on the overview of Japan's power sector</li> </ul>

**Table 3-4 Schedule of Activities During the Training in Japan**

Date	Time	Venue	Stay
4/17 (Wed)	All day	Arrival in Japan	Kobe
4/18 (Thu)	AM	Briefing	Kobe
	PM	Overview of IPSDP and lecture on hydropower and power development	
4/19 (Fri)	AM	Lecture on comprehensive basin development and dam sedimentation countermeasures	Kobe
	PM	Visit to Central Load Dispatch Center	
4/20 (Sat)	All day	Historical Route Program	Kobe
4/21 (Sun)	All day	Sightseeing in Osaka	Kobe
4/22 (Mon)	AM	Visit to Kisenyama Power Plant	Kobe
	PM	-	
4/23 (Tue)	AM	Visit to hydraulic model experiment facility	Kobe
	PM	Lecture on dam rehabilitation	
4/24 (Wed)	AM	Lecture on power demand forecasting and strategic environmental assessment	Kobe
	PM	Economic and financial analysis, project finance for hydropower projects, and governance lectures	
4/25 (Thu)	AM	Visit to Hitachi Mitsubishi Hydropower	Kobe
	PM	Lecture on power trade and action plan preparation	
4/26 (Fri)	AM	Action plan preparation	Kobe
	PM	Training report, evaluation, and closing ceremony	
4/27 (Sat)	All day	Return	-

The training involved participants from MoEWRI, DoED, ERC, NEA, and various power sector organizations. The lectures and discussions on the IPSDP content were found to be extensive. Topics such as "difficulties in power trade with India," "domestic demand stimulation," and "the need for capacity building for government officials" were prominent in the discussions and incorporated into the action plan. The session on "difficulties in power trade with India" provided critical feedback for the core IPSDP discussions. The lectures and site visits regarding Japanese technology were beneficial for knowledge acquisition. Visits to Kisenyama Pumped Storage Plant and Hitachi Mitsubishi Hydropower allowed participants to learn about equipment and technology related to variable-speed pumped storage, under consideration for Nepal. The visit to Kansai Electric's Central Load Dispatch Center emphasized the importance of balancing supply and demand, raising awareness among participants of challenges such as Nepal's limited adjustment capacity. However, the specialized nature of the hydraulic model experiments appeared to attract less interest from some attendees.

### 3.2 RECORDS OF TECHNOLOGY TRANSFER ACTIVITIES IN EACH WG

#### 3.2.1 Power Demand Forecast / Power Trade / Power System Planning

The records of technology transfer activities in the Power Demand Forecast / Power Trade / Power System Planning WG are shown in Table 3-5.

**Table 3-5 Records of Technology Transfer Activities in Power Demand Forecast / Power Trade / Power System Planning WG**

Date	Activity Item	Content
2nd Field Study (Nov-Dec 2021)	Discussions on Demand Forecasting	Confirmed the methods of demand forecasting by WECS and NEA.
	Discussions on System Planning	Reviewed current system analysis practices of NEA and identified challenges in system planning formulation.
	Discussions on Power Trade	Verified the current system necessary for examining future power trade mechanisms.
3rd Field Study (April 2022)	Discussions on Demand Forecasting	Explained the demand forecast results conducted by the study team and discussed reasons for discrepancies with results from Nepal.
	Discussions on System Planning	Provided explanations of parameters related to system analysis from the study team.
	Discussions on Power Trade	Summarized and explained the structure of current power trade with India, and reviewed the status of power trade with China and Bangladesh.
4th Field Study (June 2022)	Discussions on Demand Forecasting	Held discussions based on revised demand forecast results, reflecting feedback from the previous visit, and finalized parameters for demand forecasting.
	Discussions on System Planning	Conducted discussions on the planning direction for a 400kV system.
	Discussions on Power Trade	Explained the organized results of the current power trade system and discussed power trade among Nepal, India, and Bangladesh.
5th Field Study (Aug-Sep 2022)	Discussions on Demand Forecasting	Explained demand forecast results and finalized values for adoption in the project.
	Discussions on System Planning	Presented the results of system analysis for 2040 based on the power development plan and discussed the future approach.
	Discussions on Power Trade	Held discussions on trading at IEX.
7th Field Study (May 2023)	Discussions on System Planning	Explained analysis results of 400kV transmission lines for 2025, 2030, and 2035 and discussed direct exports. Additionally, discussed findings and countermeasures for 220kV and 132kV lower systems.
System Analysis Training (Sep 2023)	PSS/E Software Training	Conducted a 5-day training program at Siemens India to learn basic operations (steady-state and transient state analysis).

Date	Activity Item	Content
8th Field Study (Dec 2023)	Discussions on System Planning	Discussed analysis results for increased interconnection lines with India and cases of increased transmission capacity per route, finalizing the system planning content at the WG level.
	Discussions on Power Trade	Explained findings from surveys conducted in India and proposed mechanisms for future power trade.



**Figure 3-1 Photo of System WG**

Insights on technology transfer is summarized as shown below.

**(1) Power Demand Forecast**

Given that WECS and NEA have traditionally been responsible for demand forecasting, they were able to understand and engage in discussions on annual electricity consumption and peak demand assumptions for low, middle, and high cases. Although aware of policy-driven high demand projections, there was an understanding of the need for realistic demand assumptions for efficient infrastructure development. Additionally, the impact of policies promoting EVs and e-cooking on demand increases was recognized as new knowledge gained.

**(2) Power System Planning**

In the foundational system planning up to 2040, system analysis was considered challenging for entities other than NEA, which handles system planning in practice. However, NEA benefited from technical discussions and, through the provision of PSS/E software and training opportunities during the project, improved its system planning skills.

### (3) Power Trade

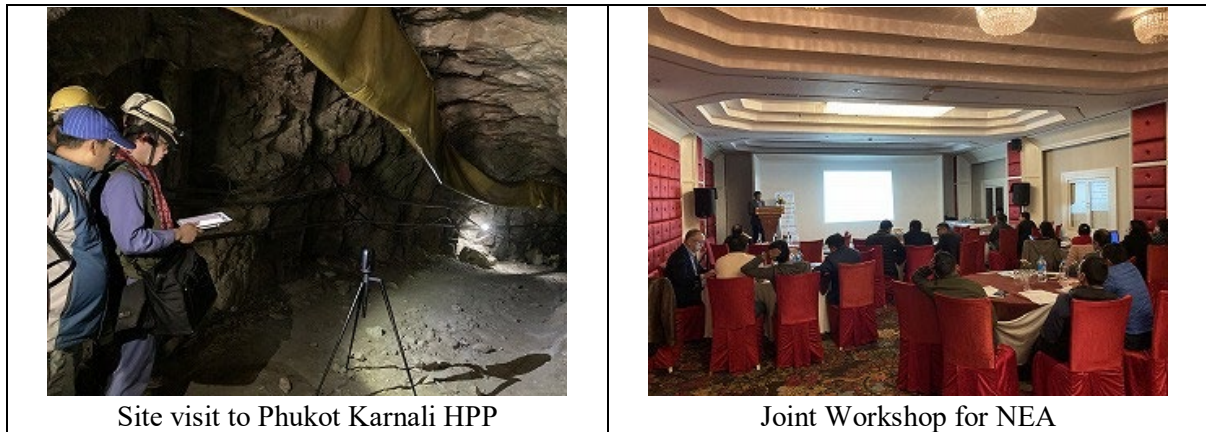
Since there were no members specifically responsible for power trade within the WG, experts led the collection of information from the NEA Power Trade Division and shared it with the WG. For the Nepal-India international interconnection, technical discussions led by India posed difficulties for NEA members due to information asymmetry. Nevertheless, the project facilitated discussions on technical challenges for stable large-scale power transmission, enhancing understanding among participants.

#### 3.2.2 Hydropower Development / Power Generation Development Planning (Power Generation WG)

The records of technology transfer activities in the Hydropower Development / Power Generation Development Planning WG (Power Generation WG) are shown in Table 3-6.

**Table 3-6 Records of Technology Transfer Activities in Hydropower Development / Power Generation Development Planning WG**

Date	Activity Item	Content
4th Field Study (June 2022)	WG Kickoff	Conducted a hearing on Power Generation WG activities and discussed the formulation policy for power generation development planning.
	Hydropower DB Construction	Discussed data collection items for the hydropower database, including the format for deliverables (longitudinal diagrams, plan views, and reports).
5th Field Study (September 2022)	Review of Hydropower DB and Outcomes	Reviewed the completed hydropower DB and discussed key items such as generation output differences between wet and dry seasons and generation cost.
	Considerations on Power Generation Development Direction	Discussed primary energy availability in Nepal, potential utilization of solar and wind power, power trade, and thermal power development, considering power generation inputs.
	Review of Development Scenario Proposals	Held discussions on four development scenario proposals based on hydropower DB and previous discussions.
6th Field Study (January 2023)	Comparative Review of Development Scenarios	Discussed the comparative review results and confirmed the selection of Scenario 3: Mid-Level Hydropower as the optimum scenario.
	Updates to the Optimum Scenario	Discussed necessary updates and additional items for the formulation of the optimum scenario.
7th Field Study (May 2023)	Hydropower Screening	Discussed and confirmed the evaluation criteria and weighting for hydropower screening.
	On-site Surveys of Promising Hydropower Sites	Conducted joint on-site surveys for hydropower projects at Lower Seti (NEA), Phukot Karnali, and Mugu Karnali (VUCL).
8th Field Study (December 2023)	Confirmation of Hydropower Screening Results	Reviewed and confirmed the results of hydropower screening.
	Discussions on Priority Hydropower Project Selection	Discussed and confirmed the criteria for selecting priority hydropower projects and identified priority sites.
9th Field Study (March 2024)	Workshop on Power Generation Development Plan	Conducted a workshop on power generation development planning, targeting the NEA Engineering Department, with collaboration from expert Kikukawa.
10th Field Study (August 2024)	Confirmation of Optimum Scenario	Discussed the findings related to the final review of the optimum scenario.



**Figure 3-2 Photos from Power Generation WG**

Insights on technology transfer in Power Generation Development Planning are shown below.

WG members had experience in policy formulation for hydropower development and in the study and design of individual projects but had not used analytical tools like WASP, which did not align with their responsibilities. Many members, being department heads, expressed difficulties in allocating time for analytical tasks. Consequently, during the initial hearing, the focus was shifted from learning analytical tools to discussing and examining the direction of power generation development planning.

The discussions within the WG, facilitated by the construction of the hydropower database, led to vibrant discussions about Nepal's overall hydropower potential. This revealed that the development direction of the power sector heavily relies on hydropower capacity, providing significant insights into the overall consideration of IPSDP. Joint on-site surveys with NEA and VUCL yielded suggestions related to comprehensive river basin development and proposals for pioneering hydropower projects.

### **3.2.3 Financial, Economic and PPP Analysis**

The activities of the Financial, Economic and PPP Analysis WG were mainly conducted through interviews conducted during overseas trips and communication through various information gathering opportunities, and through reaching out to WG members and counterpart organizations. In the capacity assessment at the start of the project, it was recognized that the target organizations had a certain level of knowledge but little practical experience, especially for the medium to large-scale projects to be developed by IPSDP. Based on this understanding, JICA study team analyzed the economic and financial impact of IPSDP implementation, and organized information on fundraising methods for individual projects, focusing on projects that need development promotion, identified through the compilation of IPSDP and explained them to WG. Through these opportunities, the study team provided analytical methods and suggestions on fundraising for individual projects to be developed.

#### **(1) Economic and Financial Analysis on IPSDP implementation**

Activities were carried out to deepen the knowledge of relevant organizations regarding methods for analyzing the economic and financial impacts of IPSDP implementation. Specifically, analysis of IPSDP using Internal Rate of Return (IRR), financial modeling using financial statements, and macroeconomic analysis using macroeconomic indicators were presented to encourage WG members and counterpart organizations to understand actual application of these methods. The study team also sought to deepen the content of the analysis by receiving appropriate feedback

from WG members and counterpart organizations. Through these activities, the relevant organizations have deepened their understanding of the effects of IPSDP and how to grasp its impact by applying the analytical methods. With these ways to measure the economic and financial impacts of IPSDP in numerical form, the relevant organizations have gained a means to continue to grasp the impacts of IPSDP implementation even after the completion of this study.

## (2) PPP Analysis

JICA study team presented the impact of IPSDP on the Nepalese economy, and demonstrated the necessity of long-term hydropower development based on quantitative economic analysis. While encouraging understanding of the purpose of such analysis, we pointed out that it would be difficult for the Nepalese government alone to raise funds, and that the involvement of development aid agencies and international development financial institutions is essential. By sharing this awareness, the cooperation between the Nepalese government and development aid agencies was emphasized. Particularly, as future development projects will be export-oriented, cooperation involving the destination countries, such as India and Bangladesh, is crucially important.

Even during the period in which this survey was being conducted, discussions toward the development of individual projects were ongoing between individual businesses and funding organizations. Although the progress was not necessarily rapid, efforts to diversify funding sources could be seen even outside WG member organizations.

## (3) Evaluation of Capacity Building Activities

The comments from WG and the individual discussions are summarized below.

- Understanding of the effects of power source development based on IPSDP has progressed, and when the results of the estimates by JICA study team and those by WG members for the comprehensive cost assessment of the mid-to-long-term plan were compared, major differences of opinion did not arise.
- In addition, there was a shared understanding that it is necessary to find more diversified funding sources for IPSDP projects, including not only development aid agencies but also the governments of electricity exporting countries. At the same time, the need to strengthen the capacity of Nepalese domestic financial institutions was pointed out, and this can be seen as a key area for future efforts.

**Table 3-7 Records of Technology Transfer Activities in Financial, Economic and PPP Analysis WG**

Date	Activity Item	Content
4th Field Survey (June, 2022)	Exchanged opinions with local businesses	Through meetings with HIDCL and IPPAN, opinions were collected regarding the difficulties of obtaining funds for hydroelectric power generation projects in Nepal, and suggestions were obtained for considering solutions
6th Field Survey (February, 2023)	Held WG	While the estimated investment amount required for the implementation of the IPSDP was presented, the ideas on priority projects were shared and the agreement was reached on the direction of future consideration
7th Field Survey (July, 2023)	Exchanged opinions with Indian stakeholders	Observing the investment promotion activities of Nepalese hydroelectric power generation companies in India gave JICA study team a real sense of how Indian companies view their projects in Nepal
Training in Japan (April, 2024)	Presented economic and financial analysis on IPSDP implementation	The impact of IPSDP on the Nepalese economy and national balance, as well as job creation effects were shared with the training participants, and a common understanding was sought
10th Field Survey (August, 2024)	Discussed the financial analysis on individual projects	Discussions were held with project operators and donors to confirm the rationality and appropriateness of the figures applied in the economic analysis of individual projects

### 3.2.4 Environmental and Social Considerations

The activity records of technology transfer regarding Environmental and Social Considerations (Environmental WG) are shown in Table 3-8.

The members of the Environment WG were environmental and social officers from MoEWRI, DoED, and NEA. They had a certain level of experience and knowledge of environmental and social considerations in general, including impact assessments and points to be considered regarding environmental and social aspects of hydropower project development. However, there were few projects in Nepal that had implemented SEA, and they lacked both knowledge and experience regarding SEA. Therefore, through the Environment WG, the discussions were first held to deepen understanding of the purpose and significance of SEA. In particular, the discussion about the difference between SEA and EIA was held, which was easily confused. In each Environment WG meeting, constructive opinions were exchanged regarding the SEA evaluation of development scenarios and optimum scenario. By holding several discussions in the Environment WG, the Environmental WG members learned the SEA evaluation process as an example. In addition, activities were conducted to deepen the understanding of SEA by having the WG members experience the process of reflecting the stakeholders' opinions through the preparation and implementation of stakeholder consultations.

**Table 3-8 Records of Technology Transfer Activities in Environmental and Social Considerations WG**

Date	Activity Item	Content
6th Field Survey (February, 2023)	SEA (Strategic Environmental Assessment): Approach and methodologies	The purpose of SEA in general and the difference with EIA (Environmental Impact Assessment) were explained in order to deepen their understanding of SEA itself. The approach and methodologies of SEA in this IPSDP were also discussed.
	SEA: Scoping	The anticipated environmental and social impacts of hydroelectric power generation and renewable energy (solar, wind, biomass) were discussed, and the opinions on the results of the SEA scoping were exchanged.
7th Field Survey (May 2023)	SEA: Evaluation of development scenarios	The results of the comparative analysis of the four development scenarios in the IPSDP were explained and opinions were exchanged.
	Preparation of 1st stakeholder consultation	Prior to the 1st stakeholder consultation, discussions and preparations were done regarding the agenda, presentations, participant list, etc.
	Implementation of 1st stakeholder consultation	The 1st stakeholder consultation on SEA (scoping stage) was held (with 50 participants). WG members participated as facilitators in group discussion.
8th Field Survey (December, 2023)	SEA: Evaluation of optimum scenario, examination of mitigation measures	Taking into account the change in the Environmental WG members from MoEWRI, the objectives of SEA in IPSDP were explained again, and opinions were exchanged on the results of the evaluation of the optimum scenario and the study of mitigation measures, which were reflected in the SEA results.
10th Field Survey (August, 2024)	SEA: Evaluation of optimum scenario (updated results), recommendations	The opinions on the updated results of the optimum scenario evaluation as well as recommendations were exchanged.
	Preparation of 2nd stakeholder consultation	Prior to the 2nd stakeholder consultation, discussions and preparations were done regarding the agenda, presentations, participant list, etc.
	Implementation of 2nd stakeholder consultation	The 2nd stakeholder consultation on SEA (draft report stage) was held (with 33 participants). The WG members also participated, and had a Q&A session and discussion.



**Figure 3-3 Pictures of Environmental WG**

### 3.2.5 Power Sector Governance

In the governance sector, technology transfer was made through the following activities:

The members of the Governance WG were mainly executives from departments related to the planning section of MoEWRI, DoED, and NEA. Regarding capacity development on governance, discussions on governance were held through multiple workshops and discussions at the time of the invitation to Japan. In addition to the group meeting format, related discussions were also held at individual meetings.

Specific agendas include the following:

- Activation of inter-agency communication to attract private investment
- Increasing opportunities for dialogue and exchange of views with the private sector
- Future unbundling of the NEA and coexistence with other public authorities (VUCL and RGCL)
- Relationship between governance and finance
- Strategies for international power interchange (including case studies in other countries, such as Lao PDR)

**Table 3-9 Record of Technology Transfer Activities on Power Sector Governance**

Date	Activity Item	Content
5th Field Study (September 2022)	WG	A working group comprised of government officials was held. Explanations and discussions were held on the WG's considerations and how to proceed.
6th Field Study (January 2023)	WG	The WG was held to exchange information and discuss the licensing process, the unbundling of the NEA, the activities of the Development Partners involved, and the importance of dialogue between the government and the private sector.
7th Field Study (June 2023)	WG	A working group was held to summarize and present the current issues (five main points) in the Nepalese power sector. After that, the participants discussed and confirmed the situation. At that time, it was also pointed out that there is a need for capacity development in the future.
8th Field Study (December 2023)	Discussion with MoEWRI Members	After gathering information and exchanging opinions with major Development Partners such as ADB and USAID, we held individual discussions with MoEWRI stakeholders on how to effectively collaborate and collaborate with Development Partners.
9th Field Study (March 2024)	WG Meeting: Discussion on Current Issues in Governance and Future Improvement Measures (Summary)	The working group consisting mainly of members of the DoED and the NEA held a discussion. They also confirmed the importance of not only exporting electricity but also stimulating domestic demand for electricity.
Invitation to Japan (April 2024)	Discussion on current problems related to governance and future improvement measures (summary)	The issues identified by the mission were intensively discussed with the Nepalese government officials who participated in the invitation, and it was confirmed that the two sides were generally on the same page. In particular, he introduced the case of Laos and emphasized the importance of governance and strategy.
10th Field Study (August 2024)	Workshop: Discussion on current governance issues and future improvement measures (summary)	Based on the discussions at the 9th Field Survey and the Invitation to Japan, a workshop was held and presentations were held inviting Nepalese government officials, Development Partners, and private businesses, and the results of the discussions to date and future issues were shared with the relevant parties. At that time, they received both oral and written feedback.