Journey for Sustainable Development and Peace Journal ISSN: 2976-1328 (Online)
(A Peer-Reviewed, Open Access Journal) 2976-1360 (Print)
Vol 2 Issue 1 February 2024 www.jsdp.org.np

Hydropower Development and Economic Growth in Nepal: Challenges and Prospects

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DOI: https://doi.org/10.3126/jsdpj.v2i1.63236

Abstract
Nepal is rich in water resources, and hydropower development has been a key issue for the country's socio-economic development. But, it needs to produce huge amounts of electricity to support economic activities and growth, though it faces challenges. The paper attempts to fill this gap by studying hydropower development in support of economic growth and overall development, and further discussing its challenges through a literature review analysis and Key Informant Interviews. Economically, Nepal has more than 42000 MW of hydropower generation capacity, but the present generation capacity is 2945 MW, though only below more than 50 percent of the total generation capacity works out in the dry season due to low water discharge and faces a deficiency of electricity. Nepal also imports electricity from India to fulfill domestic demands in the season. There is a gap in the demand and supply lines. Hydropower has become a de-facto reality in light of economic development and the production of hydropower is crucial as Nepal exported electricity of Rs.15.4 billion worth last year. However, this study shows that the prospect of hydropower development is optimistic, though, there are several challenges in terms of priorities of needy projects, investment, environment-forest-land policies, and governance aspects. If pragmatic policy, effective governance, and leadership interventions are adopted on time, challenges can be overcome.

Keywords: *Economic development, hydropower production, investment, policy interventions, governance*

Introduction
Nepal possesses many perennial rivers and an abundant source of hydropower. The altitude variation of Nepal is unique as it ranges from 80 m to 8848 m a.m.s.l. which greatly contributes to the favorable environment for hydropower generation. There are three major river basins

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in Nepal- Koshi, Gandaki, and Karnali river basins. Literature suggests that technically, more than 80,000 MW (Mega Watt) is feasible; though economically around 42,000 MW of electric energy can be generated. Hydropower is considered as a clean and renewable energy that is free from any kind of pollution, which is linked with positiveness in climate change. However, environmental impacts are studied and impacts are mitigated as far as possible under the Environmental Protection Act/Regulation of Nepal as well as internationally accepted norms.

Nepal has a long history of hydropower development as it generated 500 kilowatts in 1911 at the Pharping of Kathmandu Valley. However, Table 1 shows that over the period of 110 years, 2945 MW of energy from hydropower has been generated. Nevertheless, Nepal still imports electricity from India in the dry season. Nepal consumed only 68% of the total produced electricity in 2021 domestically, though 32% of the remaining was imported from India (Basnet, 2022). In terms of utilization basis, about 44% of electricity has been consumed by the residential sector, followed by industries (37%), commercial establishments (7%), and the agricultural sectors. Domestically, the electricity demand is high to fulfill economic growth of 7.5% (on average and above). At the same, there is a potential for experts in hydropower energy in India and Bangladesh; though only 0.7% of electricity was exported to India (MOF, 2021). There is a gap between energy demand (around 34656 MWh) in relation to supply (30363MWh, including imported energy) in the present context. Conceptually, the demand for electric energy is high but production and reliability of distribution need to be improved, and the work in this regard is being done. However, there are various challenges behind it.

The paper aims to explore the scenario of hydropower development and discuss the challenges. This study adopts secondary data to review and analyze the hydropower scenario in relation to economic development and assess challenges. Besides, two Key Informants (one from a top government officer and one from a developer from the IPP sector) are interviewed in an in-depth way.

Hydropower Development Scenario

According to the NEA (2024) Annual report, Nepal's electricity generation capacity is 2945 MW(www.nea.org.np). Amongst, 94.5% of energy comes from hydropower, followed by thermal (1.99%), solar (3.24%), and others (biomasses). However, thermal power is currently not in use, and solar is used in the daytime only. The below-mentioned full capacity(Table 1) is produced in the wet season mostly, and it depends upon water discharge. In the dry season, this capacity falls below 30-50% of the total capacity in the dry season. Both NEA and IPPs have been involved in developing hydropower projects. However, 55.02% of the total energy in Nepal has been produced by IPP (Independent Power Producers). It implies that the private sector is also able to produce hydropower. NEA is the sole body for distributing and transmitting electricity, and energy business center

Table 1: Hydropower production in Nepal

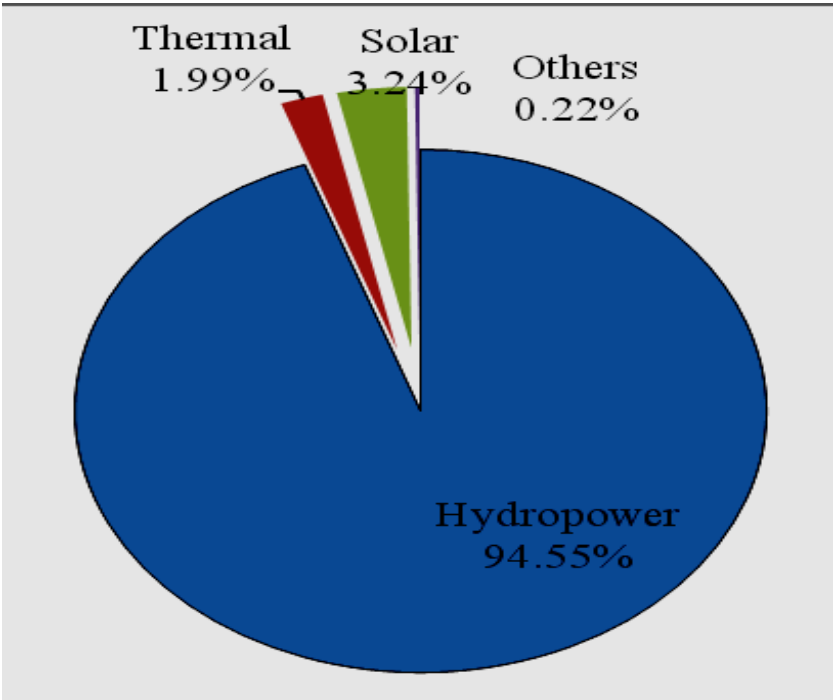
Energy Sources	Capacity(MW)	Developers
Hydropower	1061.26	NEA
Hydropower	1477.01	IPP
A. Total	2538.27	
Thermal	53.41	NEA
Biogases	6.00	IPP
Solar	61.94	IPP
Solar	25.00	NEA
B. Total	146.35	
Total (A+B)	**2684.62 (up to 2023)**	
Grand Total	**2945.00 (updated with 2024)**	

Source: NEA, 2023, and www.nea.org.np.(Retrieved on 1 February) but it has reached 2945 MW by January 2024

Note. *NEA stands for Nepal Electricity Authority (Nepal Government)/IPP stands for Independent Power Producers.*

Presently, various hydropower projects are planned for construction purposes. According to the Department of Electricity Development (DoED) website, the survey licenses for 15,885 MW of 302 projects have been issued; 172 projects have got generation licenses and construction is ongoing for 4,642 MW capacity (Gunatilake, et al., 2000).

Figure 1: Source of Electricity in Nepal



Similarly, Power purchase agreements have been signed with a total capacity of 4,138 MW among 244 projects. NEA has the sole authority for PPA in Nepal. Around 5000 MW of hydropower projects have been planned for generation by NEA and the Government of Nepal in the coming days; some of them are Upper Arun(1061 MW), Dudhkoshi

Storage(636 MW), Arun-4(490 MW), Sunkoshi, Chainpur Seti(215 MW), Budi Gandaki storage(1220 MW), Nalsyang Gad, Tamor storage projects and Sunkoshi hydropower projects. Recently, the Government of Nepal decided to launch Karnali Chisapani (more than 10800 MW) and its license has been provided to NEA. However, this project is in the beginning phase and it takes more time to operate. Likewise, IPPs have also been involved in generating small-medium ranges of hydropower projects. It is expected to come out around 2000 MW within two years and it could harness domestic demands to some extent. But, for export purposes, more surplus energy should be needed.

Table 2: Hydropower development between 1911 and 2022

Years	Powers (MW)
1911	0.5
1934	0.6
1980	27.5
1990	180.3
2000	195.3
2010	700.00
2022	2538.27
2024	2945.00

Source: NEA, 2024 and MoEWRI, 2023

Table 2 shows the trend of hydropower generation over more than 100 years is not satisfactory. It produced only 27.5 MW of hydropower till 1980. Over 30 years (1990-2010), progress in hydropower generation was struck. Nepal faced the acute situation of load shedding in this period, and the overall economy of the country suffered losses. However, over ten years, the pace of hydropower development is a little bit satisfactory and it provides a glimpse of hope for the future.

Economic Growth, Development and Hydropower

Economic development and growth are major agendas for all political parties in Nepal, and it is also the country's need. Energy is the backbone of any country's development, and Nepal's major source of energy is electricity. The electricity demand has increased due to the expansion of industrialization and urbanization over 3 decades in Nepal. Industry, manufacturing, transportation, households, and services are major sectors that consume more electricity (WECS, 2017). In recent days, the service sector is dominated in contributing to national GDP and its contribution to employment is significant. The service sectors accounted for 51.6% of GDP, followed by agriculture (26.2%) and industry (13.4%) in 2017. The agriculture sector is also demanding more electricity, but its mechanism subsidiary issues are complicated.

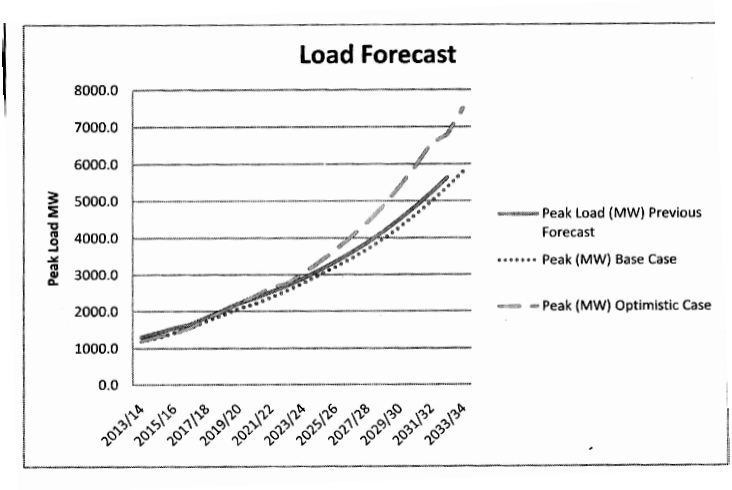
According to the Water and Energy Commission Secretariat, WECS (2017), the requirement for electricity by 2025 is 5787 MW and 6617 MW to meet the demands of 4.5% and 7.2% of economic growth (expected) respectively. By 2030, it will require more than 10000 MW, which can be said as an above-moderate demand situation for an average growth rate (around 6 -7.5%), but additional power will be needed for export purposes and to balance peak demand. Literature suggests that increasing hydropower generation in the country by 20% of the economic potential would outcome in an 87% increase in real GDP by 2030 above the baseline growth (Adhikari, 2006).

Table 3: Requirement of electricity as per estimated economic growth by WECS

Years	Total Installed Capacity Requirement (MW) Estimated Growth Rates(%)		
	4.5%	**7.2%**	**9.2%**
2020	3384	3611	3794
2025	5787	6617	7366
2030	8937	11111	13296
2035	13242	18124	23588
2040	19151	29427	42228

Source: WECS, 2017

Figure 2: Load Forecast by NEA



Source: NEA, 2015

However, NEA (2015) projected the peak load demand in 2014 for 2033/34 based on estimated economic growth and population; per capita GDP was projected to grow 1.98% in 204/15(growth rate was low due to earthquake); 5.08% in 2018/19-2022/23 and 6.07% in 2028/29-2033/34 per annum over the base case of the forecasting period. This load forecast projection was 5800 MW for 2033/34, though the peak optimistic case was projected at 7500 MW(Figure 2). This study was done when the country's political situation was in transition and the new constitution was not promulgated. The county was facing huge load shedding and there was a frustrating political-social situation. However, the situation is better now and IPP sectors are excited and the government's willingness is more confident. Since 2014, the development of hydropower has significantly increased, NEA changed the old mindset of load-shedding working with effective management and leadership, and this made a more optimistic view toward the prospect of hydropower along with economic development.

It has been proved that the role of electricity in economic growth and development is vital. For exemplify, electricity has appeared as one of the largest export items in Nepal exporting Rs15.4 billion worth in 2023(TheKathmanduPost, 2024 Feb 04). The increasing role of the service sector in the national GDP also demands more electricity supply. At the same, the industrial sector is also expanding, and this is expected to continue. To fill the gap between installed power and the peak demand scenario, hydropower development is important. Literature suggests that there is a positive relationship between hydropower and economic development. The comfortable and reliable situation in hydropower enhances and promotes the consumption of electricity and ultimately, economic activities in the country. Hydropower as the prime source of electricity is not only playing a pivotal role in enhancing industry and service sectors, but it also directly contributes to generating foreign currency (especially Indian rupees) and exporting to India and Bangladesh. Presently, a small amount of electric energy has been exported to India. It can be said that the trade deficit with India may be reduced through the electricity export.

Discussion and Challenges

The impact of electricity on economic growth can apparently be seen as Nepal's economic growth was less than 4% per annum during the 2000s and the reason was the shortages in the supply of electricity (Herath et al., 2020). The economic growth from 2013 has recorded 6%-7.3 % between 2016 and 2018. However, it significantly slowed down during the COVID period, but an improving situation can now be seen. According to the Ministry of Energy, Water Resources and Irrigation (MoEWRI), energy demands have increased by 7–10 % annually. Based on these demands, an annual electricity demand growth will be around 12.19 % by 2025 and 15 % by 2030(someone says it is an ambitious demand). The unimpeded demand for electricity is expected to increase from an estimated 10,138 gigawatt-hours (GWh) in 2019–2020 to 31,196 GWh in 2029–2030 (Nepal 2019). Within 2026, if all planned projects come into operation, Nepal will

be self-reliant on power energy adding around 2000 MW of hydropower generation.

In SAARC countries, Nepal and Bhutan are completely dependent upon hydropower for energy. The oil is more expensive, and hydropower is essential for it. India and Bangladesh have largely been dependent upon coal(60%) and gas (76%) respectively. Both are non-renewable energy and these are depleting day by day and pollution issues are associated herewith. Bangladesh has heavily been dependent upon domestic natural gas reserves, but depleting domestic natural gas reserves is putting pressure on the economy (Khan et al. 2023). It clearly indicates that Bangladesh needs more energy and Nepal can fulfill its increasing capacity of electricity through cross-border trade.

Table 3: Sources of Power Sector in SAARC Countries in %

Countries/ Resources	Hydropower	Gas	Oil	Coal	Nuclear	Renewable
Bangladesh	2	76	19	3		
Bhutan	99		1			
India	16	9		60	2	13
Nepal	93		7			
Sri Lanka	33	14	13	21		19

Source: Acharya, 2023

The Government of Nepal set a target to provide easy access to electricity to all population in the next two years; 93 % of the population has now direct access to electricity. The number of consumers has been increasing gradually over the years and, in the Fiscal Year of 2022/23, it reached 5.13 million, an increase of 7.76 % against 4.77 million in the previous year. The use of technologies in daily life at household levels has significantly increased.

According to WB (2023), the export of hydropower energy is essential to overcome in trade deficit. For trade, the development of high-voltage

transmission lines can not be forgotten. For example, Bhutan exported 2260 MW which is the maximum capacity, and similarly, India exported 1160 MW to Bangladesh. Nepal imported about 500-1000 MW of electric power from India to fulfill the power supply gaps. Nepal spent Rs. 19.44 billion on buying electricity from India, whereas export was Rs. 10.10 billion in 2022-23 (TheKathmanduPost, 2024 Jan 18). More surplus products of electricity is the demand of time-being to fulfill the unbalanced trade of electricity. At the same, the development of high-voltage transmission lines is also essential for cross-border business; it requires a huge investment and governance intervention. Nepal can be one of the major green power exporters in the region (Firoz Alam, et, al. 2017).

Recently, Nepal and India made a mutual understanding that India will take 10000 MW of electricity from Nepal in ten years and create a conducive environment in supplying power to Bangladesh in the coming days. This is good news for investors in the hydro sectors. However, its legal aspect is complex as this mutual understanding issue is in court. Nepal has declared the Energy and Water Resources Decade (2018-28) to implement the Roadmap for Energy Development, but lots of challenges. The energy sector not only generates revenue but also contributes to a huge employment situation. There is a tendency to go for foreign employment; number of Nepali workers (institutional and individual-new) taking approval for foreign employment increased 64.6 percent to 275,643 in the review period (Nepal Rastra Bank, 2023). To reduce the dependency upon a remittance-oriented economy, the development of hydropower is essential. The changing socio-economic scenarios of Nepal demand more electricity, not only for consumption purposes but also for business and income-generation purposes.

The government's willingness is found to a positive but needs to be more assertive in hydropower development. The power purchase agreement (PPA) is more supportive for investors as it is based on ‘take and pay’ to a large extent. It ensures the market for hydropower developers. Nevertheless, production has faced a lot of challenges, and delays in the

construction of the projects are common. It is contributing to the project cost high though it is against the principle of the competitive market.

Challenges:

Hydropower is a major resource for the economic development of the country. Realizing this truth, the Government of Nepal announced the target for generating an electric capacity of 28000 MW by 2035. To generate a huge production of hydropower and high voltage transmission lines, Nepal needs to do a lot of work ranging from investment environment to policy intervention to administrative effective mobilization. The technical aspects such as geology and hydrology part are very important, but it has been investigated during the project study. After technical and financial feasibility, projects have been proceeding with construction. While talking favorable environment for hydropower development, the following issues have frequently been heard in every forum:

Attention for dry season demands and priority of selection projects: Nepal has been faced with a poor supply of electricity in the dry season. The hydro energy capacity drops down up to 40 % below in the season. There is a need to store energy that can be used whenever needed. However, Nepal possesses only one storage hydropower plant namely Kulekhani-I with a capacity of 60 MW. It is fulfilling the peak demand of Kathmandu Valley particularly. From this point of view, Nepal needs some storage hydropower projects. Unfortunately, none of such projects are in the construction phase. The study of the Budhi Gandaki storage project has been completed, and waiting for construction. Therefore, the Government of Nepal should give serious attention to the development of storage projects immediately.

Similarly, the government entity has been involved in small-medium (below 100 MW) range projects. Involving in small projects means engaging in resources in dispersed ways, as there are constraints on resources in Nepal. This situation may hinder the mobilization of large-

scale resources. Economically, some less feasible projects have been launched under the influence of the elite-power groups. We should not forget that IPPs are now able to construct such small-medium projects. Therefore, the selection of projects is important in this regard.

Investment Issue- One major barrier to hydropower development is poor investment. The investment situation of Nepal is not satisfactory. In Nepal, energy industries had received 60 % of the investment pledges as of the fiscal year of 2020/21, but actual investment was introduced to only 35%. It clearly indicates the gap in favorable environments for investment. Presently, the Nepal government cut around 25% of the total developmental budget and facing delays in payment for the contractors or suppliers. In the same way, the cost of a hydropower project is high. If we assume around 20 Crore per (NRs.) MW cost(without transmission line), more finance investment for larger projects is required. According to engineer and developer Mr. Ananad Chaudhary(50 years of age):

> 'The present market allows approximately 10 billion USD investment, but it will be more than around 46 billion USD for around 25000 MW production, a huge amount of investment is needed. The present scenario of investment policy could not support massive investment and FDI. Presently, the private sector can produce around 100 MW with its own resources, and for more than 100 MW, we should invite donors or big investors. To promote hydropower generation, forest law must be amended, and power-trade should also be given to private sectors.'

(In-depth interview was taken on 5 February 2024, 8.10 – 8.43 PM by phone as a Key Informant Interview)

However, project cost also depends upon the accessibility of roads, locations, and size of dams, tunnels, powerhouses, etc. Generally, storage projects need more financial investment. Only domestic finance resources could not afford larger hydropower projects as they need huge investments. Foreign Direct Investment (FDI) and huge loans from outside of the

country are crucial, but the country should be aware of its risk factors. The ultra-nationalist views towards FDI are also harmful to the country's development. Many East Asian countries are promoting FDI for development. One thing is that investment refers not only to finance but also to technology and skill transfer. However, this can be done by developing different types of models i.e. direct government investment through loans or grants or government-private model, or the Bhutan model. However, the infrastructures (transmission lines and substations) should be constructed by the government.

Improvement in Consumption situation: The consumption pattern can not be forgotten when talking about hydropower development. Presently, Nepal is facing a challenge to fulfill the present demands and some amount of power is imported in the dry season. However, within 2-5 years, Nepal will be able to fulfill domestic demand based on the present scenario of production. People are not ready to abandon completely LP gas for household purposes and oil for transportation. The reliability of the supply of electricity can only make it sustainable. According to the Water and Energy Commission Secretariat Report (2017), Nepal's government's target is to produce 18124 MW to support a 7.2 % growth rate by 2035 for domestic consumption, but there are challenges to consuming all amounts of electricity. The promotion of using electricity at every pace of life is essential. If the electricity is not consumed, we may face a financial burden. The seasonal tariff may be a more appropriate option to apply in the wet season.

Environmental, Forest, and Land Issues: Most of the developers have raised the issue of environmental, forest, and land policies as hurdles in hydropower development. It is heard that the environmental study is lengthy, as it passes through two ministries: the concerned Ministry and finally to the Environment Ministry. It takes more time for the process, generally 2 years. In terms of social issues, developers have to convince locals, and sometimes local demands have obstructed project progress; and

political self-interest makes it more complex. Most of the physical issues have been assessed in the feasibility study phase. The biological issue faces hurdles, especially in forest cases. Nepal is small in size and increasing trends in conservation areas are making it more complex as it is also hurting local and indigenous people's right to use local natural resources freely. It inputs financial burdens in terms of administrative and security aspects. However, the forest area is increasing as it covers more than 35 % of the total land in Nepal. At the same, energy security focuses on environmental security but food security is forgotten. The cultivated land in the hills is converted into bush and forest areas due to migration and forest mitigation policy for the environmental study. The Environmental Protection Act (2019) and Regulations (2020) as legal documents that direct about the environmental study and its procedures. It includes ToR, Scoping, and EIA preparation. The preparation of ToR/Scoping takes more months, but it can be managed by the Concerned authority, it is a like guideline, but it has become part of the study. It may be rational whether the ToR or Scoping should be kept in a report or not. The public hearing has also been an issue, it can be linked with local governments.

Similarly, the permission for tree-cutting takes more time and it goes to the Cabinet for final approval. Likewise, the mitigation procedure for tree-cutting has also been raised as a question by the developers. As per legal obligation, the planting of 25 trees and 10 trees should be done against one cut-down tree, and land arrangement for it near the project should also be done by the developers. These issues have severely been criticized from a practical point of view. In the context of storage projects, it may not be practical. It will be needed more land for plantation in light of the mitigation of the tree-cutting policy. The tree clearance issue has become complex in the case of fast-track roads. Tarai/Madhesh fast track has faced challenges as it took 9 months to cut down 4 trees; old rules and acts need to be updated to support the development (My Republica, 2023 December 21). From the standpoint of the developing country, the environment and development should go in a win-win situation.

Land acquisition has also been taboo in many projects. For instance, NEA could not acquire land for the Lapsifedi substation at Bhaktapur, though the compensation for the land has already been provided. In the transmission line, land under transmission line wire is not given full compensation, only land coverage by towers is given compensation. Numerous problems such as obstruction due to compensation-related issues and delays in environmental clearances have emerged as other problems(Ghising, 2023).

Governance and leadership: The governance system is related to the institutional environment where citizens and stakeholders interact positively. Good governance includes the rule of law, which is compulsory for a favorable environment of investment. It also links with the security aspect as many hydropower projects have been targeted in the name of local rights. At the same, bureaucratic delays during the process are also under the governance system. In Nepal, Private developers complain of administrative delays in tax refunds and issuance of permits as well as approvals(Pandey, 2022). The coordination between different ministries and departments has been an issue and it has been contributing to the project lingering to some extent. There is a relationship between governance and the investment environment. The governance system in terms of security and rule of law in East Asia is found good and that's why the investment environment is considered favorable (Chaudhary, 2078 BS). Nepal must learn about the governance policy towards investment in hydropower development from East Asia. Last but not least, the role of leadership can not be forgotten in creating a favorable environment for hydropower and economic development in terms of policies and positive interventions.

According to Madhu Bhetuwal,

> *'...I am optimistic about hydropower development in Nepal. Presently, private sectors are overwhelmingly excited in their sectors and Nepal Banking sectors are also willing to invest in it. Nepal's government is promoting an investment environment as hydropower is clean energy and cheap. However, I am worried*

about the delays in construction work, which is contributing to the project cost increase. Some challenges such as an investment-friendly environment and forest and land acquisition problems need to be addressed on time to meet the target.'

(Bhtuwal is a Joint Secretary of the Government of Nepal and he was interviewed on 28 January 2024, 7.30 pm by phone as a Key Informant Interview)

Conclusion

Nepal has huge potential for hydropower generation, which is crucial for the country's overall development and economic growth. With the development seen in the hydropower sector over a decade, it is not impossible to grasp a big leap. There is a huge market both domestic and international; India and Bangladesh are big international markets. Presently, the private sector is also excited in light of investment in hydropower development, but good governance and leadership issues are crucial. Despite the positive willingness of the government and affirmative PPA policy, many things need to be improved to realize the dream of hydropower development for economic growth. The augmentation of private sectors with foreign partners in this journey can play a vital role and governmental coordination and enhancement roles are essential. In essence, without policy interventions ranging from the environment to forest clearance to land acquisition, good governance, and effective leadership, it will be very difficult to meet the target of generating more electricity by 2035.

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