"The Project Work On The Hydroelectricity In Nepal"

A PROJECT WORK SUBMITTED FOR THE PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE GRADE-XII SCIENCE IN PHYSICS

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ABSTRACT

Nepal has endowed high potential of water resources, covering 395,000 ha (48%) area within 45,000 km in length of 6000 rivers with 170 billion m^3 annual runoff and 45,610 MW feasible hydroelectricity generation. Since 1911, 500 kW power generation at Pharping, now reached 782.45 MW production in 2016. Nepal government has planned to increase its current 67.3% access in electricity to 1426 MW (87%), by 2022. Globally, 16.6% generation of hydroelectricity, 1,079 GW production, in 2015 will be increased to 1,473 GW by 2040 as projected. Although, hydropower is considered as a renewable clean energy, dam closure, influence within the downstream river and connected ecosystems have consequent impacts on hydropower production. Nepal's topography offered more RoR types of hydropower and has more risk of landslide, flooding, GLOFs, LDOFs, and flash floods. Despite, Nepal contributes 0.027% of total global Green House Gas (GHG) emissions; Nepal has focused on renewable energy, hydropower production, targeting 12000 MW by 2030 to fulfill its growing demand of 11,500 MW. Consequent development of clean energy, GHG reduction, single Bhotekoshi hydropower can reduce 160092 tons CO_2/year. The energy-related CO_2 emissions increased 43.2 billion metric tons by 2040 globally, which can be reduced through promotion of clean energy.

ACKNOWLEDGEMENTS

We would like to express our special thanks of gratitude to our Lecturer of Physics ***Mr. Bimal Adhikari,*** who gave us the golden opportunity to do this wonderful project on the topic **"THE PROJECT WORK ON THE HYDROELECTRICITY IN NEPAL",** which also helped us in doing a lot of research in hydroelectricity in Nepal and we came to know about so the hydroelectricity in Nepal. We are really thankful to them. Secondly, We would also like to thank our friends, who helped us a lot in finalizing this project within the limited time frame.

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CERTIFICATE OF APPROVAL

The project work on **"THE PROJECT WORK ON THE HYDROELECTRICITY IN NEPAL"** by us under the supervision Lecturer of Physics ***Mr. Bimal Adhikari***, National Academy of Science and Technology College, Nepal, is hereby submitted for the partial fulfillment of requirement of Physics in Grade XII. This project work in our knowledge has not been submitted in any other schools or institutions.

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This is to certify that the project work entitled "**THE PROJECT WORK ON THE HYDROELECTRICITY IN NEPAL**" has been carried out by us as a partial fulfilment of grade XII in Physics under my supervision. To the best of knowledge, this work has not been submitted to any other purpose in this institute. I, therefore recommend the project work report for appraisal.

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DECLARATION

We are hereby declare that the project work entitled "**THE PROJECT WORK ON THE HYDROELECTRICITY IN NEPAL**" under the supervision Lecturer of Physics ***Mr. Bimal Adhikari***, National Academy of Science and Technology college, Nepal, presented here as genuine work done originally by me and has not been published or submitted elsewhere. Any literature, data or works done by others and cited in this project work has been given due acknowledgement and listed in the reference section.

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“The Project Work On The Hydroelectricity In Nepal”

INTRODUCTION

Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity. Hydroelectricity, or hydroelectric power, is electricity produced from hydropower. Nepal has endowed high potential of renewable water resources, possessing about 2.27% of the world’s fresh water resources. Most of the rivers flowing from Nepal Himalayas covers 818,500 ha land area equivalent to 5%, out of the total surface area of the country. In total, Nepal possesses 6000 rivers including rivulets and tributaries in totaling of about 45,000 km in length and covering an area of 395,000 ha (48%) and offering dimensional uses including hydropower development. There are 33 rivers having their drainage areas exceeding 1000 km^2 and all the rivers in Nepal comprise the total drainage area of about 194,471 km^2 and the rest in China and India. The annual average discharge of the Nepalese rivers is about 7124 m^3/s including the total basin area and about 5479 m^3/s excluding the area outside of Nepal.

The source of energy shares from a conventional source in Nepal is 87% as a significant share of electricity and renewable energy with 56.1% households have access of electricity. Hydropower is the main source of energy in Nepal, nearly 90% installed capacity and 90% generation of electricity. The country status report showed that Nepal’s energy sources supplied mostly from traditional resources such as firewood (75%), petroleum products (9.24%), animal waste (5.74%), agricultural residue (3.53%), electricity (1.47%), and other renewable resources (0.48%). Nepal Electricity Authority (NEA) has a total installed capacity of about 746 MW and 26 MW operating from mini and microhydropower plants in the hills and mountains of Nepal. There is a significant energy deficit due to the poor economic and instable government to continue the electricity supply. However, the country has three strategic considerations for exploring large-scale hydropower like storage types of projects, to fulfill country's required demands through installation of medium-sized projects and finally small hydropower projects targeting to fulfill demand of the local communities.

Hydropower is an environment friendly source of energy with no pollution emitting in air or in land, and it also the most efficient method to all. Thus, traditionally hydropower has been considered environment friendly that it represents a clean and renewable energy source.

The multipurpose use of water as fresh water, agricultural, industrial, household, recreational, and environmental and power generation, Nepal's water demand is increasing day by day. Nepal has built several dams for hydroelectricity and irrigation purposes. The human influence with population growth, affluence increase, business activity expansion, and rapid urbanization persuade climate change issue seriously resulting depletion of aquifers and health effects with increasing water pollution. The country's fragile environment consisting rugged topography, monsoon climate, juvenile geology results high rates of runoff, erosion, landslide, sedimentation, and flooding. The climate change problems and issues are related to the resource impacts concerning the geographical and ecological characteristic of the country. The water resource impact evaluation is challenging toward water availability, quality and stream flow, and sensitive to changes in temperature and precipitation. According to Ref. , "inflow of precipitation in the basin depends on the upstream rainfall and snowfall" and affects river regimes in different environmental factors at various timescales like seasonal, monthly, daily, and hourly. Similarly, large-scale hydropower projects may have greater economic and environmental implications. However, the impacts on specific ecosystem of each hydropower depend on the size and flow rate of the river or tributary, climatic, and habitat conditions, type, size, design, and operation of the project, and nature of cumulative impacts that occur upstream or downstream of the river.

MATERIALS AND METHODS

LOCATION

Nepal is a land locked and least developed country, occupying 147,181 sq. km total land area, lies between 26°22" and 30°27" N latitudes and 80°04" and 88° 12" E longitudes with north to south of 193 km width and 885 km average stretch from east to west [16]. The country's varying topographic and climatic conditions from south tropical to alpine in north with 80% of the annual rainfall in summer season, distributing both from north-south and east-west directions. Three major river systems originate from across the Himalayan range divided in Nepal from east to west the Koshi, Gandaki, and Karnali River, major tributaries of the Ganges rivers in northern India.

TOTAL REVERS IN NEPAL

Nepal's river has a storage capacity of 202,000 million m3, which includes about 74% amount from three major rivers, Koshi, Gandaki, and Karnali. Geographically, perennial nature of rivers estimated an annual runoff accounting up to 170 billion m3 that flows from steep gradient and rugged topography and estimated 45,610 MW, feasible for hydropower generation which is equivalent to 50% of the total theoretical potential of 83, 290 MW. The hydropower system is dominated by run-of-river schemes in Nepal while storage schemes have been benefited to control flood, provide irrigation facility, drinking water supply, navigation, recreation, tourism, aquaculture, and generate revenue. From the beginning, hydropower is used as the natural water-cycle-based renewable energy, which is reliable, most mature, and cost-effective technology of power generation. The discharge and river flow depends on the catchment area, rainfall pattern, and the volume of the water estimates the mechanical energy produced by the falling or flowing water called hydropower.

DATA

All data used in this chapter were obtained from baseline studies, research, plan and policies, sectoral guidelines and strategies, case studies, and reports. The collected data were compiled, crosschecked, and analyzed from history of hydropower development to current scenario consisting impacts and implications as well as their planning, statistical analysis/downscaling, computational simulations and development of indicators, modeling and projections.

Policies And Legal Instruments

The policy and legal instruments relevant to hydropower development were reviewed and presented considering the energy issue and analyzed policy level impacts and implications of Nepal's HEPs.

Technical Review, Analysis, Projection And Modeling

The relevant data were collected from various sources such as Government of Nepal/Water Energy Commission Secretariat (GoN/WECS), Department of Electricity Development (DoED), Nepal Electricity Authority (NEA), Department of Hydrology and Meteorology (DoHM), and other hydropower developing agencies. To analyze the baseline scenario of the hydropower project at the national and global level, collected data were computed, projected, and assessed including web-based information. For hydropower generation, analytical methods and procedures engineering toolbox were used to determine and crosschecked the potential capacity of water resources, available power, efficiency, river flow, power generation capacity, hydroelectric power, and hydroelectric energy. The measurement of water discharge has quantifed with comparison of hydrological data and modeling, impacts and implications on hydrology, and flow regime including climate change impact modeling and projections as per the Intergovernmental Panel on Climate Change (IPCC) guidelines. For case comparison, existing overview of the hydropower development, climate change issues, impacts and implications including future scenario with GHG emission and reduction has synthesized from different hydropower's in Nepal, emphasizing details of upper Bhote Koshi hydropower project.

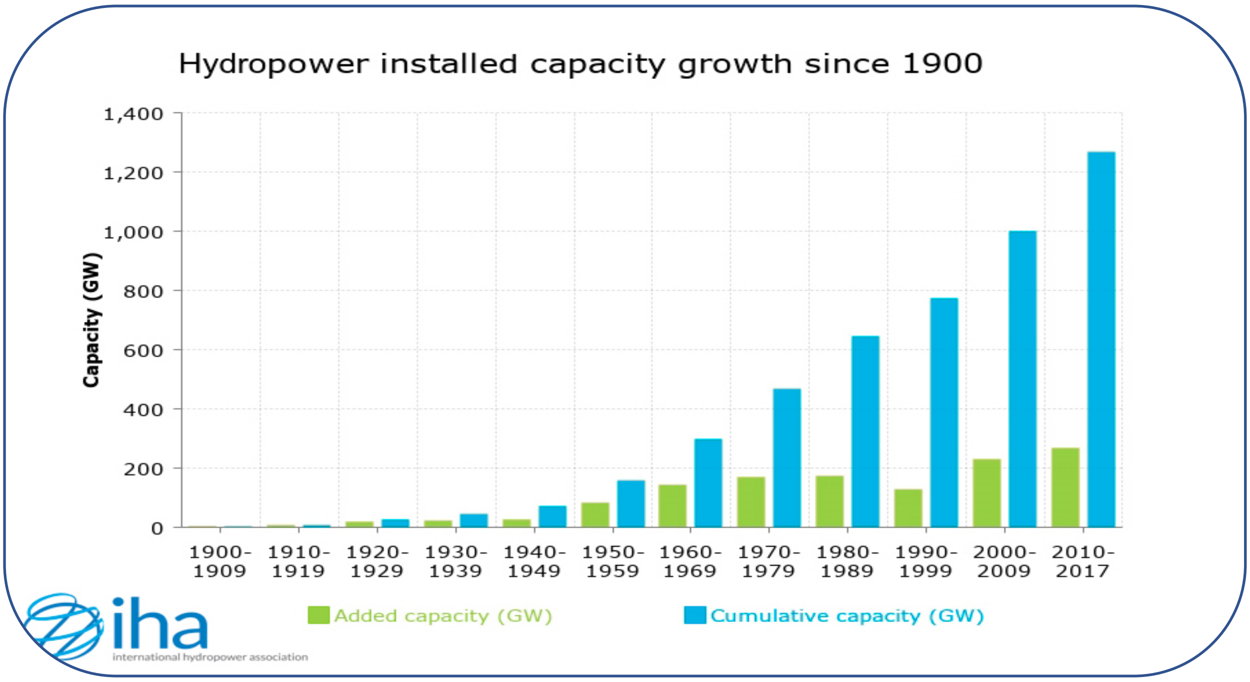
HYDROELECTRICITY BASELINE AND ELECTRICITY GENERATION

The electricity generated by hydropower was 16.6% of the total world's electricity, which is 70% of all renewable electricity and about 3.1% projected to be increased yearly for the next 25 years. The increasing rate of global population by around 1.5 billion projected to be 8.8 billion by 2035 needs 34% increase in energy consumption between 2014 and 2035. The total 549 quadrillion British thermal units (Btu) of world's energy consumption in 2012, would increase up to 815 quadrillion British thermal units (Btu) in 2040 with an increasing ratio of 48%. The average generation capacity of hydro, geothermal, and biomass electricity has fluctuated around 42–43% and the average capacity utilization rate will be 43% for the period of 2016–2040. The generating capacity of renewable sources of energy like hydropower, geothermal, and biomass 1079, 14, and 52 GW in 2015 will considerably increase globally to 1473, 132, and 275 GW, respectively, as projected for 2040. Among the renewable source of energy in Asia, hydropower has significant potential with installed capacity of 542 and 2204 GW potential.

WORLD HISTORY OF HYDROELECTRICITY

Some of the key developments in hydropower technology happened in the first half of the nineteenth century. In 1827, French engineer Benoit Fourneyron developed a turbine capable of producing around 6 horsepower – the earliest version of the Fourneyron reaction turbine.

In 1849, British–American engineer James Francis developed the first modern water turbine – the Francis turbine – which remains the most widely-used water turbine in the world today. In the 1870s, American inventor Lester Allan Pelton developed the Pelton wheel, an impulse water turbine, which he patented in 1880. Into the 20th century, Austrian professor Viktor Kaplan developed the Kaplan turbine in 1913 – a propeller-type turbine with adjustable blades.



THE FIRST HYDROPOWER PROJECTS

The world's first hydroelectric project was used to power a single lamp in the Cragside country house in Northumberland, England, in 1878. Four years later, the first plant to serve a system of private and commercial customers was opened in Wisconsin, USA, and within a decade, hundreds of hydropower plants were in operation.

In North America, hydropower plants were installed at Grand Rapids, Michigan (1880), Ottawa, Ontario (1881), Dolgeville, New York (1881), and Niagara Falls, New York (1881). They were used to supply mills and light some local buildings.

By the turn of the century the technology was spreading round the globe, with Germany producing the first three-phase hydro-electric system in 1891, and Australia launching the first publicly owned plant in the Southern Hemisphere in 1895. In 1895, the world's largest hydroelectric development of the time, the Edward Dean Adams Power Plant, was created at Niagara Falls.

By 1900 hundreds of small hydropower plants were in operation as the emerging technology spread across the world. In China, in 1905, a hydroelectric station was built on the Xindian creek near Taipei, with an installed capacity of 500 kW.

THE HISTORY OF HYDROELECTRICITY IN NEPAL

The history of hydropower development in Nepal began on May 22, 1911 (9 Jestha 1968 BS) by installing 500 kW electricity at Pharping named as Chandra Jyoti. After 25 years, long duration, Prime Minister Dev Shamsher initiated 640 kW, Sundarijal Hydropower plant with a capacity of 900 kW in 1936. Sundarijal, hydroelectricity development in Nepal was once again stalled for decades. Some years later, Morang Hydropower Company established in 1939 and completed construction of third Letang hydropower plant with an installed capacity of 1800 kW in AD 1943 under public-private partnership. The plant supplied electricity to Biratnagar Jute Mill and later destroyed by landslide [21, 22]. Historically, however, Nepal's first bilateral agreements with India were Koshi and Gandak Projects in 1954 and 1959, respectively, exclusively designed to cater for irrigation and flood control in India with small irrigation and hydropower component for Nepal.

During the late 1960s, a hydropower plant was constructed with foreign assistance such as exUSSR (Panauti-2.4 MW), India (Trisuli-18 MW, Devighat-14.1 MW, Gandak-15 MW, SurajpuraKosi-20 MW), and China (Sunkoshi 10 MW, built in 1972 as a gift to Nepal from China). The 92 MW Kulekhani Hydropower Plant (I and II) was commissioned in 1982, which is the only project offering seasonal water storage in Nepal. The 144 MW Kali Gandaki A hydropower project, commissioned in 2003 is the biggest hydropower project in Nepal so far. In 2005, a plan to develop Kaligandaki-Nawalpur diversion (multipurpose) project (with about 20 km tunnel) to generate 22 MW of electricity was formulated but it could not be materialized. The growing demand of electricity was estimated to be 557 MW in 2005 to 1200 MW in 2013. In 2013, there was 733 MW hydropower out of 782 MW installed capacity including NEA that owned 478 MW capacity of hydropower and 255 MW operated from the private sector. Similarly, electricity demand estimated 105 GWh in 2006/2007 and increasing to 678 GWh in 2009/2010, with the temporary peak in 2008/2009 with 745 GWh. Thus, the problem was mainly due to all hydropower plants which are RoR types except the capacity of 92 MW of storage. The estimated electricity demand growth rate will be 8.34%

increasing from current growth demand 4430 GWh annually to the system peak load of 17,400 GWh with the annual growth projection of 3679 MW by 2027.

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DEMAND OF ELECTRICITY IN NEPAL

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Nepal has an estimated 42,000 MW hydropower potential, 100 MW of microhydropower, 2100 MW of solar power for the grid, and 3000 MW of wind power renewable energy commercially exploitable. Nepal's ninth plan addressed to generate 22,000 MW electricity by

2017 and other studies estimated 10,000 MW within 10 years and 17,000 MW by 2030. The policy of government for small hydropower generation from 1 to25 MW has focused on providing incentives to local institutions/organizations and promoting the development of medium hydropower from >25 to 100 MW for national private sectors and seek support for large hydropower projects. The electricity generation in FY 2013/2014 was 746 MW, which increased by 4.98% (782.45 MW) in 8 months of the year and 1987.36 km transmission line has been extended. The electricity consumers have been increased 2,789,678 in the number and 116,090-km-extended line of electricity distribution. The total demand of the electricity 1291.1 MW has limited to just 782.45 MW by the end of the year.

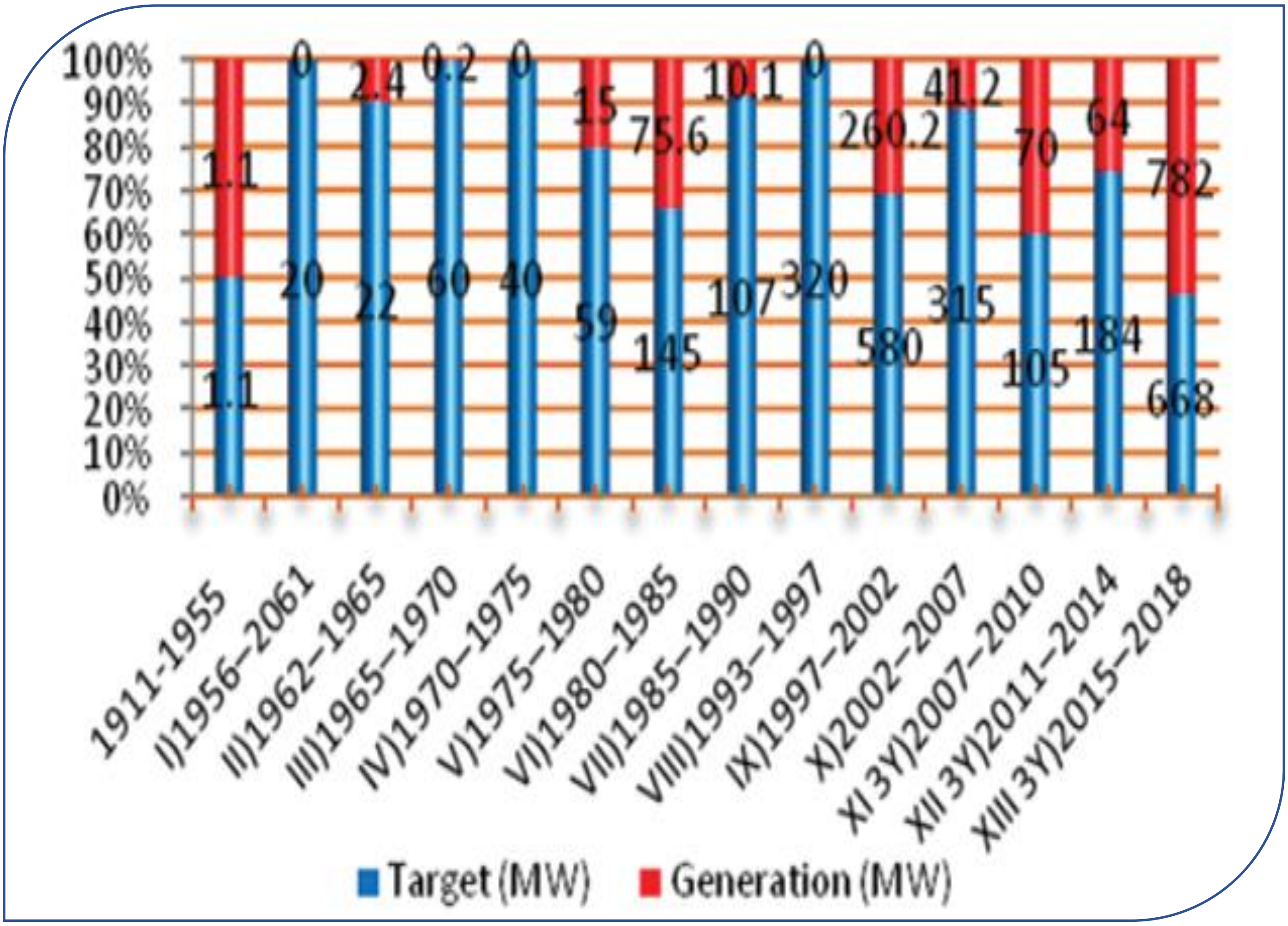
Electricity demand, consumption, production, and physical structures.

Particulars	Fiscal year				
	2010/2011	2011/2012	2012/2013	2013/2014	2014/2015*
Production (MW)	697.85	705.57	746	746	782.45
Transmission line (km)	1917.62	1987.36	1987.36	1987.36	1987.36
Customer number	1,854,275	2,053,259	2,599,152	2,713,804	2,789,678
Distribution line (km)	89,108.86	95,815.98	11,4160.40	116,066.64	116,090.64
Available energy (GWH)	3389.27	3858.37	4260.45	3092.47	3228.9
High demand (MW)	946.1	1026.00	1094	1200.98	1291.1
Demand supply gap (MW)	248	320.43	348	454.98	508.65

Source: Ministry of Energy, 2016

PERIODIC DEVELOPMENT OF HYDROPOWER IN NEPAL (1911–2016)

The hydropower development started from 1911 generating 1.1 MW electricity, before first five year plan and consequent development in the thirteenth plan which targeted to 668 MW hydropower generation in 2018. The growing energy demand has estimated at 11,500 MW by 2030 for moderate GDP growth (5.6%) and higher demand for GDP growth of >8%. Thus, the existing policy and legal arrangement need to be put in a place, considering the present situation for the sustainable development of hydropower for the overall development of the country. As per the WECS energy strategy 2012, clean energy technology (CET) scenario, in which the fossil fuels should be decreased by 20% by 2020 and 30% by 2030. The produced and targeted electricity generation is shown in figure below.



Source: Ministry of Energy, 2016

CONTRIBUTION OF HYDROPOWER TO REDUCE GHG EMISSIONS

The electricity generation and supply become even more important in combination with increasing shares of renewable energies with the low-carbon future envisioned in the Paris agreement. The climate meeting held in Paris in December 2015 (COP21) has superseded global efforts toward embarking upon climate change as the largest source of greenhouse-gas (GHG) emission from energy sector and CC conference (7-18 Nov. 2016, Marrakech, Morocco) Conference of the Parties (COP_{22}), agenda for sustainable development goals to reduce greenhouse gas emissions and foster adaptation efforts. The climate leaders of 150 countries representing 90% of global economic activity and 90% of energy-related GHG emissions have submitted a commitment to reduce emissions. The measures submitted by 40% were related to targeting increased renewable energy and one-third submitted suggested improvised energy efficiency. The G7 countries committed in their Declaration on Climate Change to strive “for a transformation of the energy sectors by 2050” and to “accelerate access to renewable energy in Africa and developing countries in other regions.

Nepal is a country with least 0.027% of the total global GHG emissions. The total GHG emission recorded in 2008 was 30,011 CO_2-eq Gt, which was found to be increased from l24,541 CO_2-eq Gt GHG emissions in 2000. Considering the country as a party of United Nations Framework Convention on Climate Change (UNFCCC), Nepal limits temperature below 2°C leading to 1.5°C above preindustrial levels. According to the Economic Assessment study of climate change in 2013, the direct cost of current climate variability and extreme events in key sectors agriculture, hydropower, and water-induced disasters has estimated which is equivalent to 1.5–2% of current GDP/year (approximately USD 270–360 million/year in 2013 prices). The model projected for hydropower in lower dry season flows leads lower energy availability, while 2800 MW energy production by 2050 estimated cost will increase by USD 2.6 billion (present value). The economic costs of climate change in hydropower, agriculture, and water-induced disasters could be 2–3% of current GDP/year by midcentury. Thus, the generation of renewable energy like hydropower may reduce the emission trend of the GHG. As suggested in Ref. some areas of Nepal are highly vulnerable in terms of landslide, GLOF and flooding events which can be predict and mitigated through climate resilience strategies and adaptation.

A NEW ERA FOR HYDROPOWER

Not long after the turn of the twenty-first century, hydropower development gained a renewed momentum, particularly across Asia and South America.

Between 2000 and 2017, nearly 500 GW in hydropower installed capacity was added worldwide, representing an increase of 65 per cent, with growth since 2010 already outstripping that recorded in the first decade of the century. The significant rise in installed capacity and generation from hydropower has been driven by a variety of often interrelated factors, notably.

DEMAND FOR ENERGY IN EMERGING ECONOMIES

Developing countries, including Brazil and China, needed an affordable, reliable and a sustainable source of electricity to support rapid economic growth.Since 2000, China has more than quadrupled its installed capacity to 341 GW (2017), accounting for over half of the world's hydropower capacity growth.

THE FUTURE OF HYDROELECTRICITY

Due to its multiple services and benefits, hydropower is expeted to remain the world's largest source of renewable electricity for years to come and with significant untapped hydropower potential; much of the sector's future growth is expected to come from Africa and Asia. In 2018, IHA, in its annual Hydropower Status Report, reported worldwide hydropower installed capacity to have risen to 1,267 GW, with a record 4,185 TWh estimated to have been generated in 2017.

According to the International Energy Agency, in order to meet the main energy-related components of the Sustainable Development Goals, including the below two degrees Celsius commitment of the Paris Agreement, an estimated 800 GW of additional hydropower will need to be brought online over the next two decades.

BENIFITES OF HYDROELECTRICITY IN NEPAL

The benefits of hydropower have been recognized and harnessed for thousands of years. In addition to being a clean and cost-effective form of energy, hydropower plants can provide power to the grid immediately, serving as a flexible and reliable form of backup power during major electricity outages or disruptions. Hydropower also produces a number of benefits outside of electricity generation, such as flood control, irrigation support, and water supply.

Nepal has planned to produce 12,000 MW clean energy by 2030 including 4000 MW hydroelectricity by 2020, 2100 MW solar energy, 220 MW bioenergy by 2030, and 50 MW of electricity from small and micro-hydropower plants. Nepal government has a strategy to maintain 40% of the total forest area of the country promoting conservation of biodiversity, resilience infrastructure, a forestation in public, and private lands. The ecosystem of ecoregions of the country supports to be managed endorsing sustainable management of forests, enhance capacity of local communities’ adaptation and resilience, widen carbon storage through sustainable forest management, and reduce carbon emissions.

The conventional or ongoing approach to determine the dam and reservoirs capacity during planning and design phases on the basis of limited data and estimation of sediment discharge could be improved by considering seismic design through ICOLD Bulletin 148 (2010), guidelines for the study of hydropower projects. Likewise, GLOF risks are difficult to predict but proper assessment of glacial hazards in upstream catchments, reviewed, and monitored regularly, preferably every 5 years may help for preparedness and appropriate strategies for mitigation of the probable risk. For such events, Nepal has adopted national policies, strategies, and program such as Sustainable Agenda for Nepal (2003), Water Resources Strategy (2002), National Water Plan (2005), and Disaster Risk Reduction Strategy (2009) which can be the best mitigation measures for HEP development.

To evaluate possible risks or failure and downstream hazards all actions such as early warning system, emergency action planning, dam-break hazard analyses, inundation mapping, dam-break flood analyses, and dam-break mechanism practices for emergency action planning are necessary to be taken or embarked. The key contribution of afforestation activities in tropical zones avoiding deforestation, or REDD (Reducing Emissions from Deforestation and Forest Degradation), Kyoto Protocol, Clean Development Mechanism (CDM) negotiations are underway for the future international climate agreement. Similarly, internally emerged effective and environmentally, economically and socially adaptive ecosystem-based approach can be resilient the hydropower infrastructure and reservoirs to cope with the impact of climate change. The storage hydropower brings climate adaptation services like flood protection, source of water supply for agricultural, industrial, urban, and/or environmental purposes. Nepal’s sustainable goal 2016–2030 emphasized major objectives to access quantity and quality-based electricity supply with efficiency, safety and convenience of household energy, and promotion of hydropower potential as clean energy in the South Asian region. Thus, there is a great need to protect the ecosystem together with the hydropower development by improving resilient hydropower infrastructure through good planning, design and sitting; construction; operation and maintenance, contingency planning, and restoring ecofriendly environment.

The benefit of hydropower can be analyzed, the example of a case study that the Upper Bhote Koshi plant (45 MW) annual electricity output with 70% Plant Capacity Factor would be 275,940 MWh/year. To determine expected project emissions of hydropower annual CO2 emissions (tons CO_2) = zero project emissions. The annual baseline emissions reduction for UBHEP only will be 160,092 tons CO_2/year. Since 2001–2016, Bhote Koshi HEP alone has reduced approx. 2,49,1380 tonsCO_2.

CONCLUSION

The global energy agenda for the seventh successive year in 2016 renewable energies is the high impact issue for the feature, with a strong perception to reduced uncertainty, as a top action for priority agenda in the energy sector, to build on the importance of developments around both climatic framework and innovation. The countries determinant commitment in COP21, toward an increase in the anticipation for further scaling up of renewable energies, reinforcing the reduced level of uncertainty as large hydro is understandably an issue closely aligned to localized resource availability and sustainable development 2030s goals for benefiting and adapting climate change of COP 22s efforts. Hydropower development is the top priority action of global energy leaders such as Latin America, followed in priority for those in Asia and Africa who perceive the issue with similar low uncertainty but a relatively low degree of impact. All countries have energy efficiency priority in policy objectives bearing in mind its multiples benefits including prominent role on climate change issues/GHG reductions. In this context, Asia has estimated the largest remaining unutilized potential of hydropower at 7195 TWh/year, making it the likely leading market for future development and support to reduce global GHG emission in the near future.

The hydropower potential in Nepal depends on the 6000 or more rivers flowing from mountains to hills and plains, although Nepal is divided into five geographic regions namely Terai plain, Siwalik Hills, Middle Mountains, High Mountains, and the High Himalayas. The world’s water coverage of 97% seawater and 3% fresh water, Nepal constitutes nearly 5000 lakes; 1380 reservoirs; and 5183 village ponds including 3808 glaciers with a total area of 4212 km2, and 1466 glacial lakes with an area of 64.75 km2. Among these glacial lakes, 20 lakes were identified as a potential risk of glacial lake outburst floods . Despite the natural beauty of Nepal with its unique topography, ecological regions, geography, and enormous source of water potential, Nepal is the poorest countries in the world wherever electricity infrastructure is heavily reliant for hydroelectricity power generation.

Despite the high potential of hydropower potential, Nepal's low economy and slow GDP growth rate in combination with environmental and socioeconomic constraints, effective implementation of existing policy and political stability may support to reach the sustainable development goals of the county. Nepal however ratified the UNFCCC, the Convention to Combat Desertification (UNCCD), and the Convention on Biodiversity (UNCBD), the most critical impacts of climate change consisting water resources and hydropower generation, stemming from glacier retreat, expansion of glacial lakes, and changes in seasonality and intensity of precipitation through the grid and off grid system. The projected climate change scenarios for Nepal average mean temperature will increase by 1.2 and 3°C as projected by 2050 and 2100. This trend is significantly dangerous for glacier retreat and glacial lakes expansion, making them more prone to GLOF. The GLOFs significant impacts on hydropower, rural livelihoods, and agriculture and storages dams anticipated a climate change impacts which poses environmental conflicts for sustainable hydropower development.

The national and international norms, policies, laws, and regulations for maintenance of ecological integrity are generally not fulfilled as per the case study of UBHP. Maintenance of 40% forest area, downstream release of 10% water, and compensation even for singletree are the significant constraints short out in implementing-related policies. The benefits of hydropower development should be considered with analysis of cost benefit, technical accuracy, and scientific structural design, implementation of relevant policy and legal instruments, strong implementation of EIA mitigation measures might make hydropower sustainable clean energy reducing global warming, and dependency on fossil fuel. The impacts on physical receptors especially downstream flow and change in river morphology have generated major concern as they remain as cumulative impacts. The fluctuation of minimum downstream release was found as the major cause for declining fish diversity. More anthropogenic disturbances and project structures were found creating impact on extinction of wildlife and protected species like birds and mammals. Furthermore, hydropower development has negative environmental and social consequences, although it does not emit air pollution or greenhouse gas emissions. Since 1970, global hydroelectric capacity doubled and dam blocking of rivers degrading water quality, disturbance of aquatic and riparian habitat, migratory fish route blockage, economic impacts on fishery, and displacement of local communities.

REFERENCES

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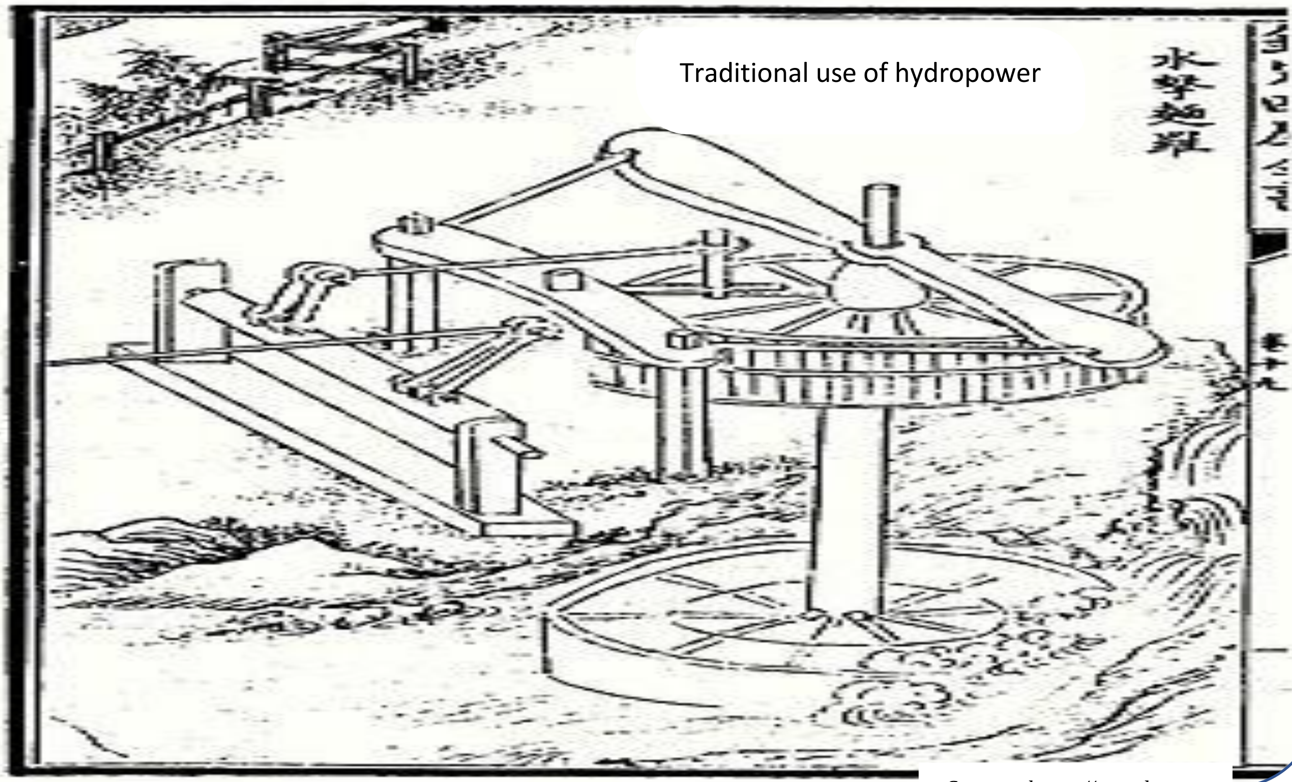
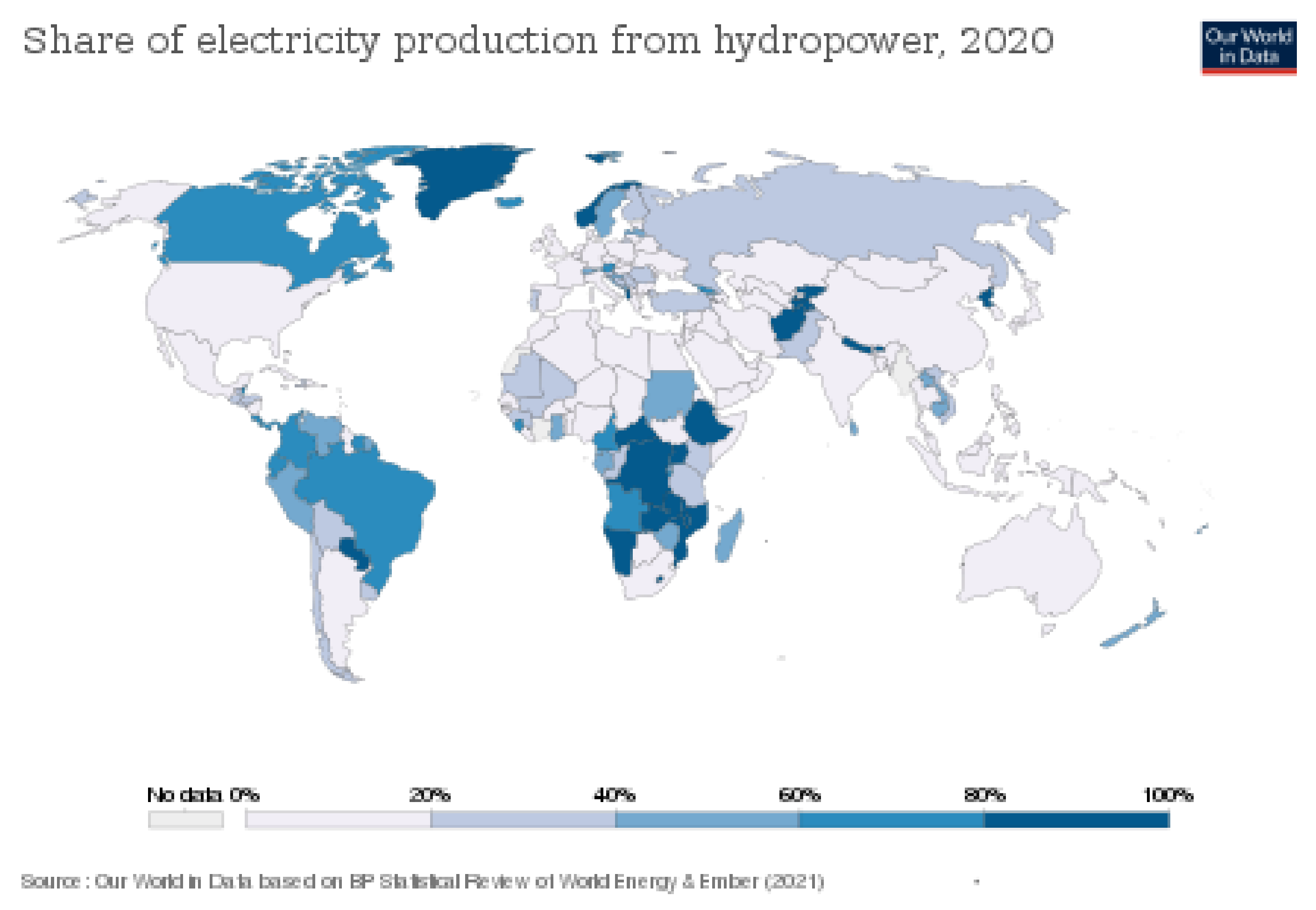
- Ministry of Energy of Nepal

APPENDICES (Images)



Traditional use of hydropower

Source: https://google.com



Damp of hydropower

Effects of hydropower

Source: https://google.com