Term Paper: Power Plant Engineering (ME416)

Hydroelectric Power Generation: Indian Perspective

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Abstract: India is the 2nd most populous country in the world and it can be the most populous country in the time ahead. With Elevated growth in the economy, energy requirement is going to increase significantly and that means higher amount of electricity demand in India. Industrial activities, mining, construction, agriculture, are constantly increasing in India and to meet the requirement of such a sector, huge amounts of electricity is required. Fossil fuels meet all the demand for the electricity in most of the countries. India, as the World's 3rd most electricity generating country, has a capacity of 395 GW in the recent survey on 31st January 2022. Consumption of energy doubled from 2000 because of the rapid growth of population in India. 0.9 billion citizens of India have achieved a connection of electricity since 2000. For the Indian consumer, reliability and affordability are the main factors for energy supply. Further, in this paper, it is highlighted that only 25% of the hydropower potential is being harnessed in India. While performing the life cycle assessment, we observe that as the power capacity of the power plant rises, the energy pay-back time and the greenhouse gas emissions reduce. By analyzing some projects, we observe that even though hydropower projects have potential and advantages, local aspects must be taken into consideration. The locals whose land was used for these projects were compensated but they couldn't utilize those resources for long term sustenance. There was temporary job creation while the construction was going on. There is also a need for policy reforms by the government.

1. Introduction

Urbanization and industrialisation are constantly increasing in India that becomes the key to the rise of the economy, electricity is the prominent requirement for ongoing urbanization and industrialisation. Production and configuration of electricity are important factors for nations which are in the developing phase. Number of people in India is near 1.35 billion and GDP of India is 2.62 trillion USD, the increase of the electricity sector will be a significant factor for sustainable growth of the economy. In India, 60% of energy generation is through non-renewable sources and 40% through renewable. Coal, Diesel, Gas are the various fossil fuels which contribute to the production of electricity in India. The distributions of various fossil fuels are such that coal accounts for 204GW (~52%) , Gas 25GW(~6%) and diesel produces 510 MW (0.1%). The low production of electricity from diesel is because accessibility of diesel in India is low and it needs to be imported from different countries. Non fossil fuels include renewable energy and nuclear energy. Allocation of non fossil fuels are such that hydro produces 47GW (~12%) , Wind 40GW(10%) , Solar 50GW (~13%) , BM Power 10GW(~2.5%) , energy from waste 0.4GW(~0.1%), Small hydropower plant 5GW(~1%) and nuclear account for 7GW (~1.5%). The gross electricity generated in India was ~1400 terawatt-hour but the total electricity generated was ~1600 terawatt-hour in FY2019. In India, the per capita energy consumption is low as related to the world's average energy consumption. According to the report in 2015, the per capita energy consumption of India was ~1200 kWh but in most of the developed countries the per capita energy consumption is ~7000 kWh which is relatively high in comparison with India . As from the central electricity authority, the total installed capacity in various sectors are central 98 GW(~25%), state sector 105GW(~27%) and private sector 191GW (~ 48%). In India , different ministries are working for power generation and using the resources in a sustainable way. So for the policy settings, the ministry responsible for the policy settings is the Ministry of Power. Law enrolled for the electricity sector which is electricity act 2003. The aim of this act is to protect consumer's interests, competition, and provide power for all. Distribution and transmission of electricity is substandard but the capacity for the power generation is outstanding. Most energy production in India is carried out by conventional sources so the government is planning to expand renewable power generation. Government also states that it doesn't require more conventional power plants until 2027, as it focuses more on renewable energy production. Government goals for the electricity generation is 45% from the renewable power plants of the total electricity capacity of the country until 2030. The first electric light was shown in 1879 in Calcutta and it was set up for power supply in 1897 . After the successful supply of electricity in Calcutta, the new place decided was Bombay. The first installation of hydroelectric power was at Darjeeling for tea estate in 1897. Increasing the demand of electricity for the people of India is not only the problem but also the supply of electricity is also a key concern for the government. Key focus of India is to minimize the electricity production from coal and enhance the renewable energy production. In India the production of electricity mainly deals with coal as it contributes 70% of final electricity generation and in coal reserves India stands 5th largest in the world . With the current usage of coal, even with the increment in coal production it is clearly understood that coal will last only 40-50 years. Oil will last the next 23 years keeping in mind the current production of coal. While India doesn't depend more on oil ,production of electricity by natural gas is constantly increasing by the discovery of coal bed methane and the government is focusing on production and exploration of coal bed methane. Cost of production and extractions of uranium ores is 2-3 times more than world trade as the quality of uranium ore is very low. Focus of the Indian government is mostly on renewable energy generation, hydroelectric power plants and solar energy power plants. India is expectating the production of 100GW solar energy by 2026. The production of electricity by wind, biomass, small hydropower plants ,waste to energy is kept on increasing as these are renewable sources of energy. The gross domestic production by utilities is 1379 TeraWatt-hour and the total domestic production including both utilities and non utilities is 1589 TeraWatt-hour. The most consumption of electricity is by the industrial sector which is 43.7 and it's the key feature for the economy of the nations . Various industries in the industrial sector are steel, aluminum, cement, petroleum,fertilizer, pulp and paper industry. These industries require a huge amount of electricity which needs to be fulfilled as it boosts the economy. Residential sector consumes 24% of electricity of the total power generation. As urbanization is significantly increasing with increment in population, the demand of electricity needs to be propelled potentially.

Hydropower is a cleaner and sustainable source of energy generation. However, it cannot be compared to the significance thermal power plants have in terms of energy generation. This can be seen further in this paper when comparisons are made between the potential and installed capacity of hydropower generation in India. There are a number of challenges that this sector faces.

This paper focuses on analyzing the hydropower potential in India- collectively and region-wise, advantages and challenges of hydropower plants, detailed analysis (life cycle assessment) of a few hydropower schemes in India, discussion on the consequences of the hydropower development of the following two projects: Sorang power project in Kinnaur District, Himachal pradesh and another project in Sikkim. This study can be used to make a predictive analysis of the future of hydropower generation in India by drawing conclusions from the present state of production, the geographical parameters and their benefit, and the projects at present in India and the consequences they have. In this paper, we perform the life cycle assessment of a few small hydropower schemes and estimate two sustainability indicators.

2. Hydro Potential in India

Global stand of India is 5th for installed hydro potential in the world. India's power potential in hydroelectric is assured at 148GW at 60% load factor. New 56 pumped hydroelectric storage projects have been launched which accounts for 94GW installed capacity. Surplus 6GW of hydroelectricity is produced from small, micro and mini schemes all over from 1512 sites.Therefore the total potential of hydroelectric power plant is 250GW which is not achieved because of certain constraints. Contribution of hydro power was 37% in 1947 which further increased to 51% in 1963 but due certain constraints its keep on declining and now its contribution is only 13%. Basin wise Hydro power potential of india is following:

BASIN/RIVERS	INSTALLED CAPACITY(GW)	PERCENTAGE
INDUS BASIN	34	22.90 %
GANGA BASIN	21	14.10%
CENTRAL INDIAN RIVER SYSTEM	4	2.50%
WESTERN PART OF SOUTHERN RIVER SYSTEM	9	6%
EAST PART OF SOUTHERN RIVER SYSTEM	14	9.30%
BRAHMAPUTRA BASIN	66	45.20%
TOTAL	148	100%

Table 1 : basin wise hydro power potential . [4]

Himachal Pradesh uses 45% of its installed capacity and yet to utilize 38% of installed capacity. Private companies are also anticipated to explore with the hydro energy in the northeast and in himalayan mountains. Anticipation from the international hydropower association for India is 660 TeraWatt-hour per year but 540 TeraWatt hour per year (79%) is behindhand.

2.1. Understanding the development and distribution of hydropower plants' Installed Capacity and production

The first hydro power plant in India was installed in Darjeeling for tea estate in 1897 and from there the production kept on increasing and developing till 1963 and then it declined in generation of electricity from hydropower plants. At present 13% is the contribution of hydro power in the total energy generation. In 1998, preferences were made for involvement of the private sector for the generation of electricity from hydro energy to boost investment and flourishment of hydroelectricity. The capacity of the hydro power plant kept on increasing from the first installment but the contribution of the hydro power plant kept on decreasing since 1963 to the total installed capacity as depicted by the figure 1. [8][4]

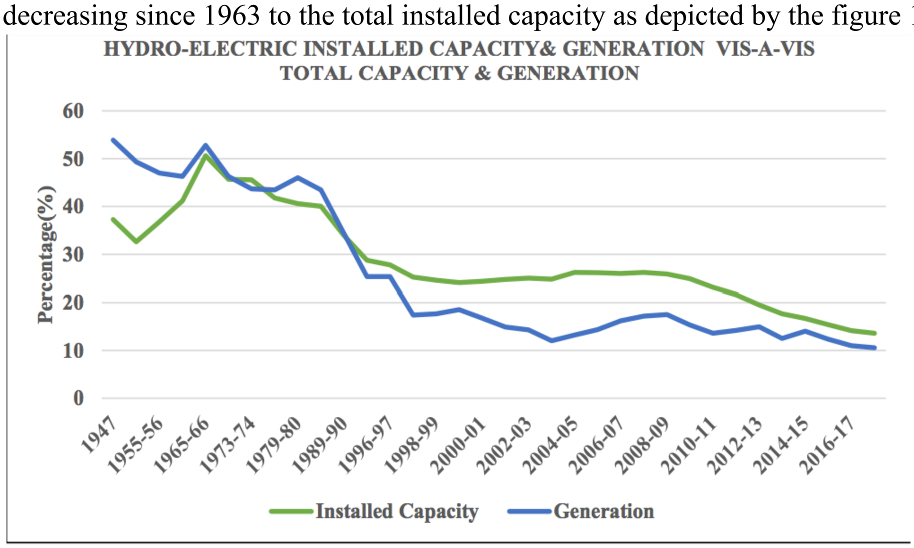
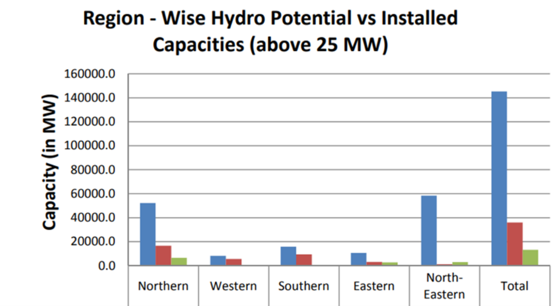


Figure 1: Hydropower installed capacity & generations. [8]

The following bar graph shows the region-wise hydro potential vs what is being harnessed and is installed right now:



	Northern	Western	Southern	Eastern	North-Eastern	Total
Identified Capacity	52263.0	8131.0	15890.0	10680.0	58356.0	145320.0
Developed Capacity	16653.60	5552.00	9426.90	3138.70	1242.00	36013.20
Under Construction	6560.7	400	510	2782	2954	13206.7

Figure 2: Region-wise potential vs installed capacity (above 25 MW) [1]

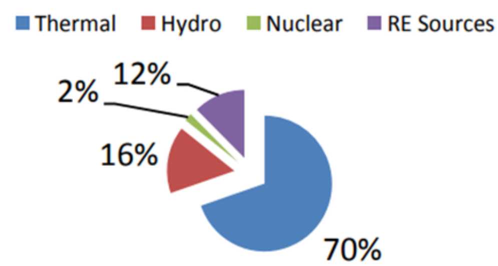


Figure 3: Installed power capacity %[1]

This shows that the north-east has great potential but only about 2% is being harnessed at the moment. Even in the northern states like Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Punjab, etc there is great potential which is not being used. Also, we can observe that very little will be contributed by the current constructions.

The following pie-chart shows the present scenario of installed capacity distributed in various other non-renewable sources of energy (as on 30-11-2014) (Figure 3)

This shows that still, about 70% of power generation is expected from the thermal power plants. [1]

2.2. Policy initiatives to promote Hydropower in India:

Recent policies include the Gujarat Small Hydel Policy (2016), Policy for Development of Small Hydro Energy for Power Generation (Upto 10 MW) Government of Jammu & Kashmir (2017), Kerala Small Hydro Power Policy (2012), Manipur Hydro Power Policy (2012), etc. in different states of India, with main objectives of:

- Laying projects on canal, run-of-rivers, etc to use the energy source.
- Promote reduced use of fossil fuels for energy generation and using a more sustainable and yet efficient mode of energy generation.
- Reducing the greenhouse gas emissions and to harness the clean natural resource.
- To create employment opportunities for people in the locality.
- Effective way to solve the power problems in remote, hilly and less approachable regions.

3. Subject matter in Hydropower generation:

3.1. Mechanism of Hydro power generation:

Dams are constructed near the availability of natural waterway and its aim is to hold the water and accumulate pressure energy, so the water stored has additive energy. The supply flows through a channel known as penstocks which will turn the turbine with the pressure energy stored in the reservoir. The water which has enough pressure energy when comes down through the penstock will have ensured kinetic energy to run the turbines. By such energy conversion of water leads to starting the turbine to rotate and then kinetic energy of water converts into mechanical energy by rotation of the turbine. The turbine attached to the generator generates power and work is produced by the kinetic and potential energy of the water. [4]

3.2. Benefits/Advantages of hydropower:

- Environment friendly: being a sustainable form of energy generation, it helps lower down and contain the use of coal for meeting the electricity requirements of the country and it opposes any changes to the climate and brings down the carbon footprint and emissions. It does not discharge any waste to the environment. The run-of-river projects are quite popular and have very little negative impact on the environment. It gives lesser Greenhouse gas emissions as compared to the other modes of energy generation as we will see further.
- Lower maintenance costs: once the power plant is up and running, it requires lesser operating and maintenance costs compared to the thermal power plants. And the recovery of the installation costs is also quicker compared to the other methods of energy generation, so the subsequent energy generation becomes cheaper. Also, only a few operators are required since most of the operations are automatic.
- Renewable: the fuel is renewable and depends on the rain cycle.
- Multipurpose: water from the dams can be used for irrigation, provides drinking water management, flood control and the reservoirs can be used for recreational activities, prevents soil erosion, etc.[4][7]

3.3. Challenges/Disadvantages of hydropower:

- Changes in the natural flow will affect the wildlife by changes in temperature etc of the flow. Also, economic clearance is required by the central electricity authority, which will depend on how it will impact the wildlife and flow of the region.
- Breeding ground for insects which will result in water borne diseases.
- Accidents may take place due to defective construction and target for terrorist activities.
- Lack of communication and transportation due to geographic barrier: difficult to transport the equipment and machines via routes susceptible to landslides or bandhs by neighboring localities.
- Financial aspects: Government needs to allocate some budget for the construction of roads and bridges for better communication with the sites where hydropower plants are located. The debt is expected to be recovered in the first 12 years. Such conditions make it difficult to set up a hydropower plant. Tweaks were made in this plan to support the hydropower plants. Postponed and suspended payments make it difficult to carry on with the project. [4]

4. Life cycle energy and greenhouse gas emission analysis:

The central electricity authority in India classifies the small hydropower schemes as the ones having station capacity upto 25,000 kW. Some small hydropower schemes include Canal-based small hydropower scheme and dam-toe small hydropower scheme.[1]

4.1. Canal-based small hydropower scheme

The canal based small hydropower scheme makes use of the fall and flow in the canal to generate power. As in figure 4, we see that flow can be in the bypass canal or the main canal. These are low head such as 3-20 m head with high discharge. The energy generated by the water flowing through the canal is the source of energy generation. The low-head plants are close to the users so that high transmission costs are not incurred and there are less distribution losses. Components include the civil works such as the powerhouse, spillway and diversion channel and the electromechanical equipment such as turbines, transformers, generators, etc. It has certain advantages such as low gestation period, easy structure, no problems of it submerging the land, no recovery process and no environmental concerns.[1]

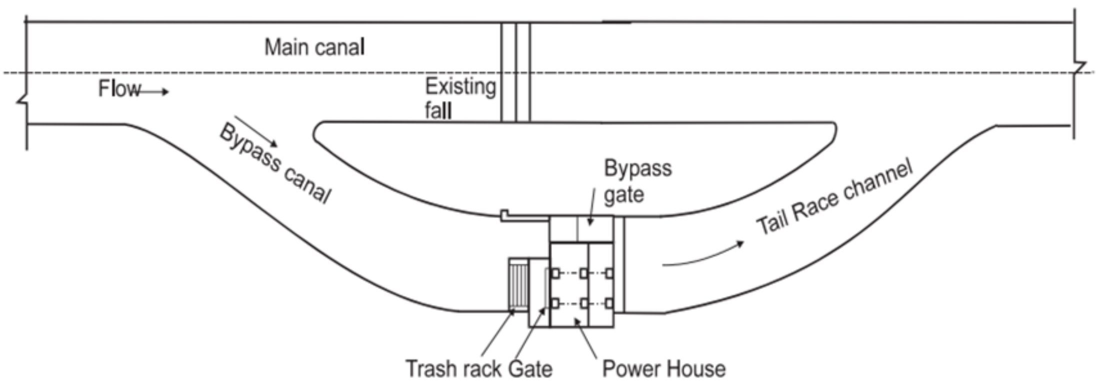


Figure 4: canal based small hydropower scheme, [1]

4.2. Dam-toe based hydropower scheme

The dam-toe based hydropower plants contain a dam with water stored in it and energy is generated by regulated discharge from this stored water. Powerhouse is at the toe and the main dam is filled with the stored water. The penstock drains water into the powerhouse at the toe. By this, the potential energy of water is converted to kinetic energy.[1]

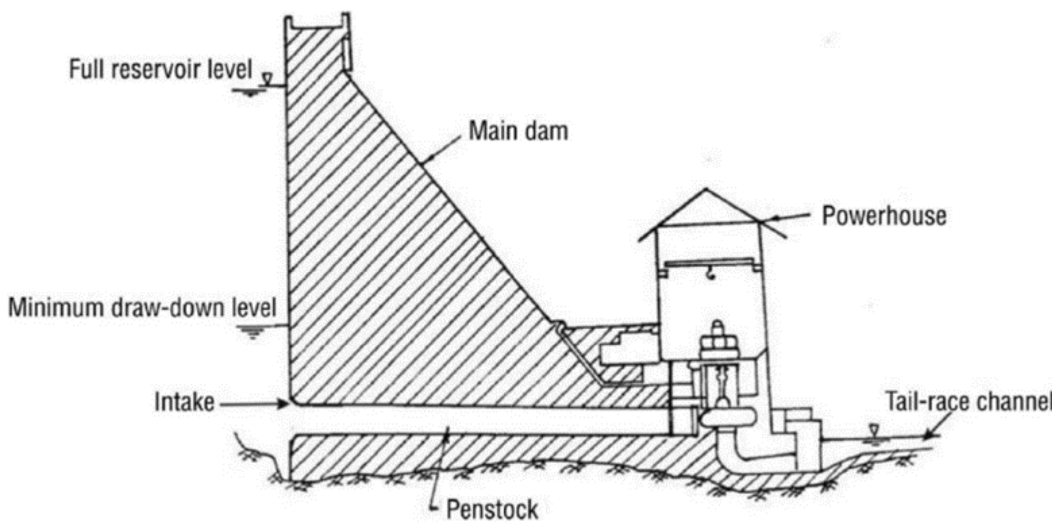


Figure 5: dam-toe based scheme, [1]

Here, this is used to assess the environmental impact of small hydropower schemes' construction and working, their greenhouse gas emissions and the energy input output characteristics. For this report, we use 1 kWh as the unit for net electricity produced and normalized greenhouse gas emissions to an equivalent of CO_2 emissions in grams per kWh of net electricity produced. These are taken as per the guidelines of the International Panel on Climate Change.[1]

4.3. Projects taken for study:

For the canal based small hydropower scheme, three projects of varying capacity and heads were used. The projects studied were Bahadrabad mini hydropower project, augmentation canal mini hydel project and Badarpur return channel mini project having capacities 250, 1000, 400 kW respectively and for the dam-toe based, two small hydropower projects and one large hydropower project were used. The two small hydropower projects were Devarabelakere mini hydel scheme and Sadani mini hydroelectric project having capacities 2000 and 1000 kW respectively and for the small hydropower project, Dhukwan hydropower project on river Betwa having capacity of 30,000 kW. The detailed description for these projects is shown in table 2. [1]

Year	Name	Type	Net head (m)	Capacity (kW)
1993	Devarabelakere	Dam-toe	11.00	2*1000
1993	Sadani	Dam-toe	101.00	2*500
1994	Augmentation canal	Canal	2.15	2*500
2004	Bahadrabad	Canal	4.90	2*125
2005	Badarpur return channel	Canal	2.31	2*500
2005	Dhukwan	Dam-toe	20.00	2*15000

Table 2: Detailed description of hydropower projects [1]

4.4. Phases in life cycle analysis:

1. Civil works: This includes the construction of channel, spillway, diversion, penstock, erection, etc.
2. Electro-mechanical equipment: This includes the turbine, generator, transformer, switch yard and station auxiliaries such as the valves, cables, lighting, battery, etc.
3. Operation and maintenance: It is generally estimated that the energy use and green house gas emission for operation and management is taken to be 3% of the total civil works and 3% of electromechanical costs. The power usage of the plant annually is estimated to be 5% of the total electricity generated annually. The carbon content differs from 0.3 kg of CO2(eq)/m2 for desert shrub to 0.3 kg of CO2(eq)/m2 for tropical forest. For each unit of reservoir air, the biomass differs from 100 Mg/hectare for boreal climate to 500 Mg/hectare for tropical forest.
4. Decommissioning: There is no need to account for the demotion of a hydropower because when the life of a hydropower, which is usually 20-35 years, the power house is either abandoned or undergoes renovation, upgrading, etc.

4.5. Indicators of sustainability:

We will now understand some indicators of sustainability :

1. Energy pay-back time: It is the ratio of the energy requirement of the system throughout its life cycle to the annual primary energy generated by the system. It basically calculates the number of years it takes for the plant to recover back the energy that has been spent in the installation of the plant. The annual power generated is converted to the primary energy generation by using the average efficiency, in India, the average efficiency is taken to be 0.35.

2. Greenhouse gas emissions: It is the ratio of the total CO2 emissions throughout its life cycle (CO2(eq)) to the total power generation in its lifetime. The total power generation is calculated by multiplying the annual power generation (kWh/year) to the lifetime of the project(year). The lifetime of these projects is estimated to be 30 years.[1]

4.6. Inferences:

The energy usage and greenhouse gas emissions corresponding to each of the life cycle stages are obtained using the Energy Input Output- Life Cycle Assessment software.

4.7. Energy usage:

1. Canal based projects

Project name	Contribution in energy usage by Civil works (%)	Contribution in energy usage by electromechanical equipment (%)	Contribution in energy usage by operation and management (%)	Total energy usage (lakh units)	Energy pay-back time
Bahadrabad	27.46	23.21	49.33	16.644	1.31
Augmentation canal	22.05	29.76	48.13	66.576	1.18
Badarpur	29.39	21.96	48.65	26.63	1.26

Table 3: Energy usage by Canal-based Projects, [1]

2. Dam-toe based projects

Project name	Contribution in energy usage by Civil works (%)	Contribution in energy usage by electromechanical equipment (%)	Contribution in energy usage by operation and management (%)	Total energy usage (lakh units)	Energy pay-back time
Dhukwan	40.14	11.33	48.53	1997.28	0.44
Devarabelakere	23.23	25.96	19.54	133.152	0.68
Sadani	27.45	19.54	53.01	66.57	1.12

Table 4: Energy usage by Dam-toe based Projects,[1]

We observe differences in the energy usage by the projects because of different materials being utilised in these projects and these materials will have differing energy levels. The operations and management stage contributes to nearly half of the energy usage in most cases. Hence, there is a need to make improvements in the civil work and electromechanical equipment so that there is less need of operations and management.[1]

4.8. Greenhouse gas emissions:

1. Canal based projects

Project name	Contribution in greenhouse gas emissions by Civil works (%)	Contribution in greenhouse gas emissions by electromechanical equipment (%)	Contribution in greenhouse gas emissions by operation and management (%)	Total greenhouse gas emission (gCO2(eq)/kWh)
Bahadrabad	26.54	24.08	49.38	35.35
Augmentation canal	21.16	30.65	48.19	32.23
Badarpur	28.53	22.79	48.68	33.87

Table 5: Greenhouse gas emissions by canal based Projects, [1]

2. Dam-toe based projects

Project name	Contribution in greenhouse gas emissions by Civil works (%)	Contribution in greenhouse gas emissions by electromechanical equipment (%)	Contribution in greenhouse gas emissions by operation and management (%)	Total greenhouse gas emission (gCO2(eq)/kWh)
Dhukwan	39.66	11.78	48.56	11.91
Devarabelakere	23.53	25.74	50.73	19.37
Sadani	27.38	19.65	52.97	31.20

Table 6: Greenhouse gas emissions by Dam-toe based Projects, [1]

We observe that for both the canal based and dam-toe based projects, operation and management contribute to about half of the total greenhouse gas emission. So, there is a need to minimize the operation and management works in order to reduce the greenhouse gas emissions from the hydropower plants which will result in a reduction of the environmental load. We also observe that as the power capacity of the power plant rises, the energy pay-back time and the greenhouse gas emissions reduce. [1]

5. Discussion on the consequences of Hydropower projects:

5.1. Sorang power project in Kinnaur District, HP, India

With economic growth, demand for energy is growing exponentially due to faster industrial growth, better quality of life and increased infrastructure network. Since standard energy sources are finite, there is an urgent need to take a look at new and different power sources. Himachal Pradesh can generate hydroelectric power on its five rivers, the Ravi, Sutlej, Chenab, Yamuna and Beas.[3]

5.1.1. General Features:

The Sorang Power Generation Project is a tributary of the Sorang Khad River, tributary of the Satluj River, in the state of Kinnaur. It will use the Sorang Khad original flow to produce power. The water will be diverted through a subcutaneous connecting channel to a desert area before being transferred to the head race tunnel, penstock tunnel and surge shaft. The water that will pass through the penstock tunnel and then the underground power plant will take two Pelton 50MW wheel engines installed vertically and connected to the corresponding generators. The power house will be fitted with an air intake duct. Water will be pumped back to the Satluj River using a tail race tunnel. [3]

5.1.2. State of Education in the Region:

Education is a two-dimensional force, which can eradicate attempts at social and economic inequality, but in itself can introduce a new kind of inequality between the haves and the have-nots. It is the greatest measure of regional development socially and economically and a basic need as well. The regional literacy rate increased from 58.36% in 1991 to 75.2% in 2001. (Figure 6) [3]

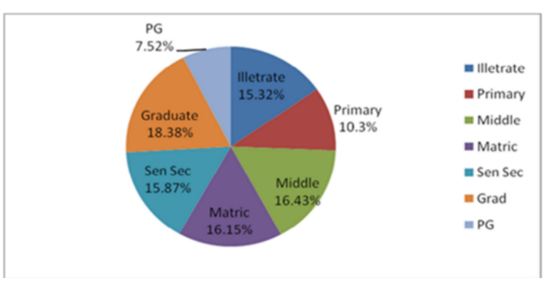


Figure 6 [3]

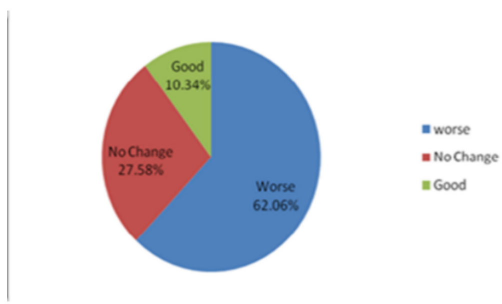


Figure 7: status of environment after HEP[3]

5.1.3. Local Status After HEP:

Dams that generate electricity can cause a few environmental problems, though they do not burn fuel. Rivers with dams may change river flow structures and wildlife. The fish, for the first time, may not be able to swim upward. Energy efficiency might increment soil fertility, change water temperature, and reduce dissolved oxygen levels.(Figure 7 and figure 8) [3]

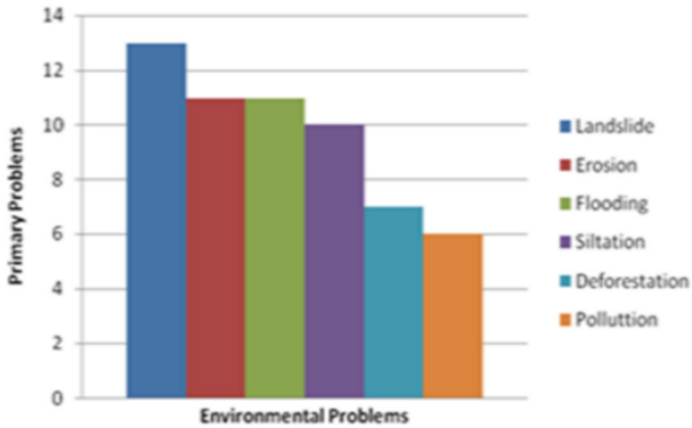


Figure 8 : Primary Problems related to the environment in the research area. [3]

5.1.4. Exploring the Water Strength of North East India:

The north eastern states of India have the greatest potential for hydropower. The development of the Northeast receives significant attention from the Government of India, both in the welfare of the people of the region and the potential contribution to the Indian economy, as well as in the promotion of links and economic relations with neighboring countries.[6]

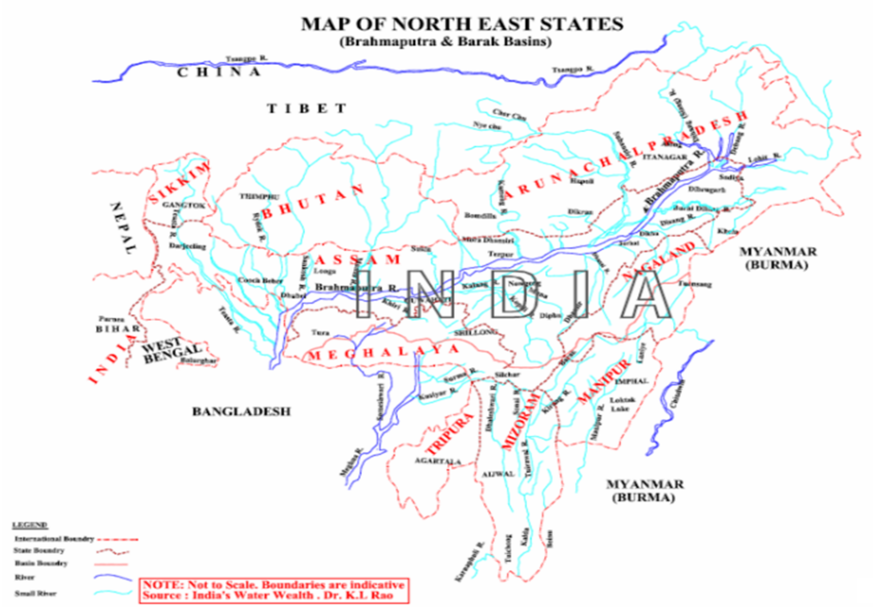


Figure 9 : north eastern states showing the river basins [6]

5.1.5. Geographical Problems:

The probability of experiencing an earthquake is very high in the northeast and between the years 1953 and 1992, northeast has had about 21 earthquakes which have been greater than 6.5 on the richter scale. So, construction in these areas is also a concern.

5.1.6. Land Acquisition Issues:

A framework for regional governments to facilitate land acquisition, resettlement and rehabilitation processes. Automatic migration and insufficient displacement of people are some of the major reasons for the anti-dams movement in India, which hinders the massive procurement process.[6]

5.1.7. Risk of North East hydropower projects

The construction of dams in India has become a legacy of colonialism, with flood control, irrigation and power generation technologies beginning in Europe, and then in North America. Such dams have played an important role in making India independent in food requirements.[6]

5.1.8. Intervention in Green Growth:

A major advantage to hydropower is the lack of greenhouse gas in its generation compared to fossil fuels. But hydro power projects are having a significant impact on aquatic and coastal ecosystems through degradation of sand dunes. They change the bio-physical standards of the ecosystem leading to the loss of biodiversity, as well as other environmental functions, affecting the health of people who depend on the ecosystem. [6]

5.1.9. Acne Treatment and Soil Removal:

The aim of the Catchment Area Treatment (CAT) program is to reduce the amount of mud in the pond, to conserve soil and to reduce runoff. Dams are subject to soil immersion which includes a series of erosion, erosion, evacuation, placement and compaction. Soil inclination not only reduces the strength and life of the lake but also contributes to water availability. Different methods of soil decomposition are used. Prior to this are river rehabilitation, sediment clearing, soil removal and soil disposal. Rehabilitation of wetlands that focus on land conservation strategies including buildings such as desert farms, floodplains and diversion services, bank protection services, waterproof protection. [6]

5.1.10. Muck Management System:

Construction of various components of hydroelectric power projects including both excavation and groundwater and tunnel resulting in bulk load and disposal of Rock Muck should be scientifically planned in designated areas so as not to disturb the environment or the environment, and not affect river flow or water quality. Most hydro developers use part of the mud during the construction work itself.[6]

5.1.11. Fisheries Management:

The construction of India's largest hydroelectric dams has had an impact on marine life, particularly the movement of river fish. The rivers of India hold about 700 species of fish and the highest number of fish in Asia.[6]

5.2. Understanding the consequences of Hydropower Development in Sikkim :

5.2.1. Research Area:

Sikkim- region of the Eastern Himalayas. It covers 46% of its land area. The region has steep slopes and rocky outcrops scattered by the erosion of rivers and streams. [5]

5.2.2. Reduction in agricultural production:

Traditional farming in the Himalayas depends on factors such as livestock use in the production of manure and fertilizer, conservation of sufficient forest access to irrigation water, and the existence of an informal labor exchange system. , which has led to a decline in agricultural production. Farmers report reduced demand of livestock and also report crop failure due to dust pollution.[5]

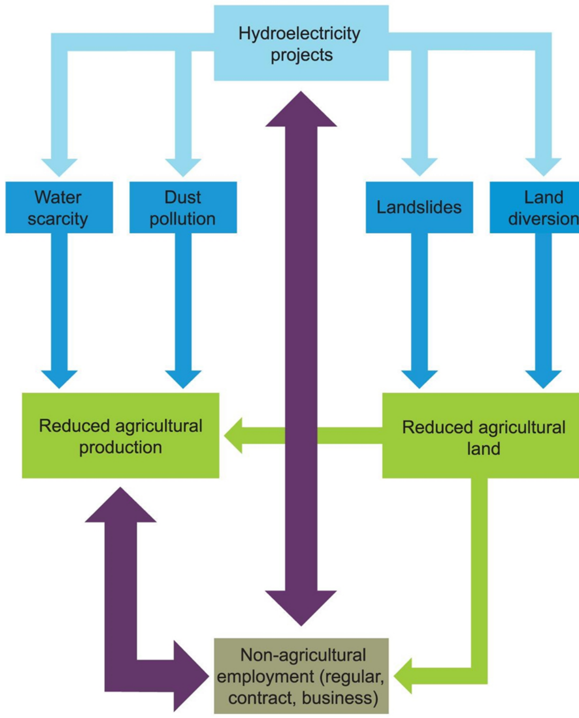


Figure 10：Relationship between development projects and the transformation of the Sikkim settlements. (Thomas Chandy's drawings) [5]

5.2.3. Social and economic impacts:

The migration of young people from the cities to the cities where the power generation project was built caused the community to disintegrate, leaving the villages full. The employment provided by local hydropower companies helped to alleviate the unemployment problems facing poor farmers due to poor agricultural production. Most of the beneficiaries of employment in the companies include farmers and illiterate youth who are given underemployed work, especially as non-permanent workers or non-permanent security guards on construction sites. [5]

6. Conclusions

India is globally ranked 5th for the usable hydropower potential. In 1970, around 40% of the percentage of power generation in India was through the hydro power plants; this was reduced to 18% in 2014. This had peaked in 1962-63 and since then, it has been reducing continuously. [2]

In the past years, many policies have been developed by the government which will help increase the energy production by hydropower plants and reduce dependence on fossil fuels. Even though there are a lot of advantages of hydroelectric power generation, there are various challenges it has to overcome, such as the disadvantage provided by the location, security concerns, frequent bandhs by the locals, and geological degradation it can cause, etc. [4]

Job creation in the area was of social and economic benefit, but a great amount of jobs that were given to local people were based on the construction work in these schemes and thus became non-permanent. These activities will end when the project construction phase is completed. The green economy treats natural resources with respect and provides employment security and small industries for rural people. They have solved the problems of temporary unemployment but do not provide long-lived insurance. There is a need for policies and investment strategies that empower rural people to participate in a variety of livelihood activities, both on farms and on non-farms. Hydroelectric projects have made significant contributions to human development as well the benefits outweigh the costs, but with this the development has also diverted the flow of natural rivers, affecting existing rights and the access of local people to water and resulted in a major impact on health and the environment.[3][5][6]

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