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Case Study

Consequences of infrastructural development: a study on the environmental impact of a hydropower project on the Teesta River in North Sikkim, India

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Abstract

Dams have long been heralded by many as a harbinger of development. However, since the late 1980s, owing to its socio-cultural and environmental cost, the construction of dams has drawn criticism from diverse sections of people from different parts of the world. Construction of large dams or diversions of rivers destroys not only aquatic habitat but also contribute significantly to the destruction and extinction of fishes and other aquatic species, and the overall loss of the ecosystem services on which millions of humans seek their livelihood. Sikkim, a tiny Himalayan state, where several such dams are being proposed and constructed is an ecologically sensitive region. These projects encompass widespread tunnelling in a landscape which is geologically very fragile, the environmental and social impacts of which are often neglected. The construction of such projects causes serious problems like drying up of natural water sources, landslides, pollution, land degradation and cracks in houses and other structures are very common. The current study seeks to study the environmental impact of the Teesta Stage III hydropower project of Sikkim, keeping some of these issues in mind.

Keywords: Blasting, environment, hydropower, Teesta, tunnelling, Sikkim.

Introduction

Large dams have played an important role in economic growth, serving a variety of purposes, like controlling floods, electricity generation/hydroelectric power, water supply, river navigation and irrigation among other things. As such dams have often described asepitome of modernisation and state-driven intervention in the development decades[1], accounting for a large share of public investment in many countries. Hydropower has emerged as a viable complement to hydrocarbons, coal, as a clean energy source[2].

Hydropower came into the energy matrix as a consequence of a sequence of technological innovations in the late 19th century. Hydropower projects by their continually growing size reflect the changing and ever-rising electricity needs of the constantly increasing population. It is often categories as a green, renewable, economic and environmentally benign source of energy. In 2000 hydroelectricity contributed 22.4% of world's electricity and in 2016 with an installed capacity of 1,064 GW, it generated 16.4% of the world's electricity by the prevalent energy sources[3,4]. Rapidly escalating electricity demand turned hydropower into an '*energy bridge'* in numerous countries.

Thus, India's Northeastern region, which has the country's largest perennial water system with potential for vast hydrological resource — has been identified as India's 'future powerhouse'; and '168 large Hydroelectric Projects' with a cumulative installed capacity of 63,257 MW have been proposed in the region[5-8].

However, in recent decades the ecological impacts of large dams have been strongly contested. Repeatedly, they have threatened the environmental sustainability of project sites and have thus attracted several environment critics. Diversion of river, submergence of lands, clearing forest, degraded catchment areas, mining, quarrying, reservoir-induced seismicity and so on are just some of the common ecological threats that come with large hydropower projects.

Similarly, they also raise specific '*socio-economic issues'* related to the transformation of local and regional living conditions. The rise of public awareness of environmental issues of the early 1970s put hydropower into a co-existence mode. This narrowed public acceptance of hydropower as an energy source and reduced its role in the energy matrix in numerous states significantly. In academic literature, it was downgraded as a major energy source, and the sector attended the technical aspects professionally, but the decision makers treated the dam-site and reservoir area population with woeful neglect.

Sikkim, a tiny State with enormous hydropower potential located in the lap of pristine Himalayas is an integral part of the *'India's future powerhouse'* scheme of thing. As part of India's grand 50,000 MW programme and taking the opportunity of a number of recent energy sector deregulation, the State Government signed MoU (Memorandum of Understanding) for more than thirty different large hydropower projects with more than twenty different public and private firms in the year between 2003 and 2011.

Table-1: Region-wise distribution of hydropower potential[15].

Region	Potential Identified		Installed Capacity		Capacity under construction		Capacity yet to be taken up for Construction	
	Total MW	Above 25 MW	MW	%	MW	%	MW	%
Northern	53395	52263	18639.3	35.66	4786.5	9.16	28837.3	55.18
Southern	16458	15890	9722.1	61.8	1090.0	6.86	5077.9	31.96
Eastern*	10949	10680	4911.5	45.99	1253.0	11.73	4515.6	42.28
Western	8928	8131	5552.5	68.28	400.0	4.92	2179.0	26.80
Northeastern**	58971	58356	1342.0	2.30	2854.0	4.89	54160.0	92.81
India Total	148701	145320	40166.8	27.64	10383.5	7.15	94769.7	65.21

Note: *Including Sikkim. **The total potential of Northeastern Region including Sikkim is 63,257 which is much more than India's current installed capacity.

Often portrayed as 'green' energy and but extensive studies from different parts of the world shows that hydropower hasserious negative environmental as well as social cost. Though the projects in Sikkim are 'run-of-river' projects, they all very large and involve extensive tunnelling, sometimes as long as 20 km long which have lasting, if not permanent impact on the ecology and the environment of the area[9,10].

Sikkim being a mountainous area, where the majority of the population lives in villages, whose dependence on natural resources for livelihood is very high. The environmental impact of such hydropower project which has a direct bearing on the sustenance of the people could be engulfing and havoc in the long run.

Taking the example of Sikkim, this paper discusses the environmental impact of the Teesta stage III Hydropower Project in the project affected area. The paper delves deep into the impact of the hydropower project on the environment, agricultural land and other human-made structures and scrutinises the different aspects of impact and relates how these impacts eventually bring about a change in the affected area.

Methodology

This study is a part of my academic research. The data used in the study is based on primary collected from the study area. The study uses an exploratory research design. The qualitative paradigm of research has been employed in the study. The research design and methodology is based on the case study of Teesta Stage III HEP, Sikkim, where tools of data collection used were in-depth unstructured interviews, focus group discussion and observation. The multi-stakeholders approach has been adopted to capture the perceptions of different stakeholders[11].

The Teesta Stage III Hydroelectric Project

The Teesta Stage III Hydroelectric Project is a 'Run-of-River' hydropower project scheme on the river Teesta. This project is one among the cascades of six power projects that were recommended by the experts of former Central Water & Power Commission in 1974 after they carried out the preliminary reconnaissance survey in 1974. The project once completed will have an installed capacity of 1200 MW. The concrete gravity dam Project is located in the Chungthang sub-division of North District of Sikkim, whereas, the powerhouse of the project is located in Singhik of the same district. According to the Carrying Capacity study of Teesta Basin[12], the project is situated in one of the most ecologically sensitive and fragile areas of Sikkim.

Hydropower Development in Sikkim

The power situation of Sikkim before its merger with India in 1975 was in its infancy because of low demand. With the commissioning of the first hydro project at Lower Sichey Busty on the bank of Ranikhola River near Gangtok the first hydropower project was installed in the State as early as in 27th May 1927. It had an installed capacity of 50 KW.

Though the first generating unit in the State was installed on 27th May 1927, it was only in 1962 that the electricity was made available to thepublic in Gangtok. Before 1975, the power requirements of Gangtok and a few townships along the National Highway were met from the Jali Power House set up in 1964. Till 1975, only eight towns in Sikkim had access to electricity. By the end of 1978, the state had a generation capacity of 3 MW from three of its small hydel stations, i.e., Jali Power House, Rimbi Micro hydel, and Rothak Micro Hydel. During 1979-82, with the commissioning of 12 MW LLHP, the state electrified more villages leading to growth in demand.

Table-2: Details description of the Teesta Stage III HEP[13].

Name of the Project	Teesta Stage III (1200) HEP, North Sikkim
Type of the Project	River Valley Project (Run-of- River)
River	Teesta
Vicinity	400 m downstream of the confluence of the Lachen Chu and Lachung Chu near village Chungthang
Location	Dam site- Chungthang Power House- Sighik (Mangan)
State	Sikkim
District	North District
Dam site	Latitude: 27°35'50" N Longitude: $88^0$32'39" E
Dam Height	60 m
Dam length:	273 m
FRL	1585 m
MDDL	1565m
Tail Race Tunnel:	
Type	free flow tunnel
Length	980 m
Dimension	8m x 8m

Table-3: Power House specification of Teesta Stage III[13].

Type	Underground
Size of machine	220.5 m ×21.5m×46m
Central line of Turbines	780 m
Gross head	785m to 805m
Rated net Head	778 m
Type of turbine	Pelton wheel type coupled with vertical shaft
Type of generator	Vertical Shaft 200MW, 0.9 power factor 3 phase, 11kV at 50 Hz
Installed Capacity	1200 MW (6 200MW)

As per studies conducted by the CWC, total estimated Hydro Power Potential of the State is 8,000MW, out of which, around 2,300MW are below 25MW. The total installed capacity as on 31st March 2009 was only 610.70MW. Till 2008-09 a total of 24 hydropower projects at a total estimated installed capacity of around 4,694MW had been awarded to various developers, out of which; 2,081MW was expected to be commissioned within the Eleventh Plan and remaining within the Twelfth Plan period. Out of total capacity of 610. 70MW hydropower station installed in Sikkim as on 31st March 2009, 570MW is under NHPC and 40.70MW under State Government (E&P = 35.7 MW and SPDCL=5MW). Therefore, a large potential remains to be tapped. When the "50,000 MW initiative" was announced in 2003, of the 162 dams proposed a substantial number of these projects are from Sikkim[14]. As per reassessment Study from Major/Medium Schemes (Schemes having a capacityabove 25 MW), a total of 4248 MW capacity from 24 hydropower projects has been identified. As of 31stDecember 2017, the installed capacity in the state is 2169 MW which is 51.06% of the reassessment capacity[15].

Results and discussion

Taking account of the perception(s) of the local people, panchayat bodies, representatives of NGOs and government official this researcher tried to analyze the environmental impact of Teesta Stage III HEP in the context of environmental changes or it's implication to the environment and to the local society that might have occurred (or still occurring) during the implementation process. Therefore, the perception considered in the study is the opinion of the locals, the government and the activists regarding the impact that the environment and society are experiencing due to the project. Criteria used to understand the impact was direct interaction with the affected people and personal observation and validating them with the secondary published data.

From the data and field experience, it was found that there are mainly two groups of opinion about the environmental impact of the project. One group comprising of very few numbers of respondents said there is no or minimal negative environmental impact of the hydropower project, while the other group, the majority one deeply regrets and are concerned about the severe negative environmental impacts due to the project. According to them, the environmental stability is very disturbed, and the main cause is the enormity of the project, which requires tunnelling, blasting, movements of giant machines and vehicles and other constructed related activities.

The data shows there is great variation among the views of the respondents. It is found that very few of the respondents think that there is no negative impact on the environment. According to them, there is no negative impact on the environment from the project. All these respondents are from the Singhik, a project affected village. They mentioned nothing has changed; the environment is as good as it used to be. They are all male respondents from different age group. According to Mr Sonam Wangchuk, a 45-year-old male respondent, who is a government employee stated that,

"...there is no negative impact on the environment. It is as good as it used to be earlier because along with hydropower projects the Chief Minister has also launched the Green Mission which takes care of the environment".

However, though they mentioned that there is no impact on the environment but at the same time, few of them pointed that a large numbers trees were chopped down at project sites and also water sources are drying up in the entire area.

Nonetheless, the study shows that there are substantial changes in the natural as well as in the human environmental after the project has already been. The findings of the research strengthen the general claim of the negative environmental impact of hydropower projects to a great extent. These impacts can be categorised into different categories.

Physical Impact

"Many aspects of dam building, like the submergence of forests, large-scale river diversions, disruption of aquatic ecosystems – both upstream and downstream, blasting, digging, excavation, debris dumping and other construction-related activities, are likely to wreak havoc on the ecology of the Himalayan region." --Dharmadhikary, *Mountains of Concrete,* 2008.

The physical impacts of the hydropower project are many and are very much associatedwith the environmental impact of the hydropower project. Nevertheless, they include the destruction of both physical environment and human-made structure. To understand the physical impact of the power project the researcher took consideration of the activities that are associated with the construction of the project, which in turn are directly connected with the impacts. Some of the activities that havebeen scrutinised are the impact of tunnelling, blasting, movement of heavy vehicles, big machinery etc. on the physical environment and society.

Impact due to tunnelling: The physical impact of the hydropower project in the Teesta Stage III is mainly attributed to extensive tunnelling and large-scale blasting. The project entails widespread tunnelling in a geologically fragile and sensitive landscape, the ecological or the environmental impacts of which are grossly underestimated. The structure of the project is such that it requires tunnels to divert water from the dam to the turbine, i.e., to the powerhouse. For this, 'Head Race Tunnels' are required. Tunnels have adversely affected the environment in the entire area. These impacts are:

Drying up of water sources: One of the major environmental impacts of the Teesta Stage III project is the drying up and degradation of water sources. The researcher found from his field experience and observation as well as from his respondents that intensive blasting and tunnelling is being done at the construction site(s). As such that almost all the project-affected villages are facing water-related problem. Most of the respondents revealed that the locals do not have enough water anymore; many of the water sources that were perennial in nature has turned seasonal now and dry up during the winter months. The villagers link the problem directly to the tunnelling activity that is going on below their land. This is not the case only with the Teesta Stage III, even at Teesta stage V HEP that was commissioned in 2008 too faced the same water-related problem. In fact, the problem has augmented over the time, and it is more serious now.

Impact on agriculture: Water is one of the essential requirements for agriculture among other basic uses. However, there is an acute shortage of water in the project-affected villages, which further becomes more severe during the winter months, this is mainly due to seepage because most of the groundwater, near the project sites as well as along the tunnels, percolates into the tunnels and the water table becomes dry. As a result of this agriculture is being affected. Even the people do not have sufficient water for household use. To quote Mr Tsethen Lepcha, a 48-year-old activist from Chungthang.

"There is huge impact due to tunnelling; most of the houses are showing signs of cracks and are damaged due to vibration from the constant powerful blasting. Most of the water sources are drying up; this is affecting agriculture adversely. Even drinking water is scarce now. This was never the case before this project was initiated. This problem is more serious in Teesta Stage V HEP".

Apart from water scarcity, agriculture is also affected due to allied activities related to tunnel construction, like the use of explosives for the blasting, which emits various harmful gases and also smokes from vehicles and machines too have affected agriculture.

A large section of the respondents mentioned that in Dikchu area agriculture have suffered tremendously. To cross-check the validity of their claim the researcher visited Dikchu and found the claim of the respondents to be true. Most of the land near the dam site at Dikchu has become unproductive and barren. The locals of the area mentioned that it all happened after the project started. Now they suffer from acute water as well as food shortages. To fetch water for household purposes, they have to travel long distance now. The whole gamut of symptoms is very much visible in Teesta Stage III HEP. The people of the area fear the same fate will befall them soon.

Impact due to blasting: As mentioned, tunnels are one of the main components of the Teesta Stage III. Constant blasting is carried out for the construction of tunnels. Along with blasting, drilling and other heavy machineryare also employed. However, blasting is the main technique, for which explosives are used during the construction of the tunnels, which are generally very strong in nature. It was observed that tunnelling had very serious consequences on both physical as well as the human environment. The impact of blasting could be seen all over the project area. These impacts are grouped into different categories.

Damages on houses/building/gumpas: The most prominent and serious impacts of blasting are damage to physical structures like houses, buildings, gumpas and even on the land surface in the form of cracks. The extent of damage from blasting ranges from mild to severe. Majority of respondent mentioned that almost all the houses near the project vicinity are damaged to some extent if not severely. Most of the houses of the affected village of Saffoo, Choten, Theng, Pedong, Pakel, Singhik and Chungthang which are close to the dam site has developed cracks in them. The intensity impacts were more severe in the villages of Singhik, Saffoo, Choten Basti (Chungthang), and Pegong. Impact in Theng village is also very high as the Tunnel passes right under the village and even the adit II is located inside the village.

Most of the respondent mentioned that blastings are so powerful that it shakes the whole area almost like a small tremor. During the time of blasting, everything starts shaking from the vibration that it creates. Few respondents mentioned that a house in Singhik, a village in the affected area fully collapsed. The reason behind it as mentioned by the respondents was strong vibration from a powerful blast. Most of the respondents are of the opinion that blastings are so powerful; many times they misunderstood them for small earthquakes.

Landslides: The carrying capacity study of the Teesta Basin conducted by CISME[16] states that Chungthang and its surroundings are very fragile and prone to frequent landslides and earthquake, so any developmental activity or any heavy structure like dam would trigger environmental disturbance.

Majority of the respondents mentioned that there are more incidences of landslides in the area after the project started. The main causes of landslides are powerful blasting, drilling and heavy vehicles plying there. The respondents revealed that, though landslides used to occur before but the frequency and magnitude has increased after the project started. The hill slopes are very fragile and consist of loose material so they cannot resist against powerful blasting. Hence, landslides have become a very common phenomenon now. Another factor, which is also responsible for landslides, is deforestation. Most of the project sites have experienced huge chopping down of trees. Trees are believed to bind the soils and keep them intact; hence, the lack of trees exposes the area to vulnerabilities, and in the event of moderate disturbance landslides occur. Thus, during powerful blasting, drilling and movement of heavy vehicles often lead to landslides. Most of the respondents mentioned that incidence of the landslidehad increased tremendously after the project started. A big landslide occurred at the main dam site during one of the blastings.

Pollution: Environmental pollution is one of the major concerns among all the respondents. Most of the respondents think that apart from water-related problem, pollution is the second major threat posed by the project. There are different sources of pollution from the project; these sources are from crushers, blasting, vehicles, machinery, and explosives used. Accordingly, there are different types of pollution too. These are air pollution mainly in the form of dust, and noise/sound pollution.

Dust Pollution: It was found that majority of the respondents believe that there has been a significant change in the physical environment, which they blame on to the power project. The area was pristine and peaceful, but the project has spoiled that. The dust pollution is very severe in the area. For example, Chungthang is adversely affected by pollution from the crusher located at the dam site only 500m away. Hence, the main dam site remains heavily clouded with dust, as there is very little scope for the dust to escape from the valley because the area is locked from all sides by mountains. In the same way, Theng village too is severely affected by dust pollution because of tunnel construction and location of Adit II right in the middle of the village. Moreover, big exhaust fans are used to pump out air and gases from inside the tunnel, which also brings alot of dust. Further continuous noise from exhaust causes disturbance which is very irritating.

This problem becomes more severe in the months of winter. As per norms, the project authorities are supposed to sprinkle water on roadsides, but many respondents said it is being neglected. Hence, in the winter months, when the climate is dry, the whole area becomes full dust. The movements of vehicles aggravate this problem. As mentioned above, most of the respondents feel that their agriculture too is badly affected due to pollution.

Noise Pollution: Apart from dust pollution, noise pollution too is a serious problem in the area. The main sources of noise are also same as that of the dust pollution. Hence, crushers, blasting, vehicular movement, and drillers are the main sources of noise pollution. However, powerful sirens too are cause for noise pollution. Most of the respondents mentioned that the continuous noise disturbs them mentally. It has become a psychological problem for many, and mainly for the children. Like dust pollution, noise pollution too is severe in the villages of Theng, Choten Basti, Chungthang, and Saffoo village because of the proximity and construction activity right inside the villages.

Deforestation

Deforestation is another critical issue with most of the developmental projects. This is also true with the Teesta stage III power project. Except few, almost all the respondents highlighted it, which is very prominent in all the project sites. Large-scale chopping down of trees were seen in the main dam site area, four Adits sites area and the powerhouse area. There is almost absence of trees in all the construction sites. The extent of deforestation could be visualised when one tries to compare the undisturbed area around the project where there is no project related activity. The surroundings areas are dense forest cover, whereas the project site is almost devoid of trees.

Though the authorities have tried replanting saplings but with utter negligence. It was the observation of the researcher that most of the sapling planted by the authorities have whether withered away or does not exist where they were planted. Very few of the sampling planted survived. In some cases, only the iron cage with the writing "save a tree", could be seen without any sign of trees inside them. Some respondents' think that deforestation to a great extenthas aggravated the pollution level in their area.

Land degradation

The total land requirement for the project is 196.96 ha, which is acquired mostly from the agricultural land. However, the agricultural land in the whole catchment area is only 362.948ha or just 1.24 percentage of the total land in the whole catchment area of the project. The project construction entails significant vehicular movement for transportation of large construction material. The researcher observed that there is significant callousness in the way the tunnels are constructed and muck is disposedof. Due to tunnelling most of the local water sources are drying up and or perennial water sources becoming seasonal, which make the land uncultivable or unproductive.

Apart from tunnelling, muck is handled very carelessly. Careless disposal of muck around and the vicinity of the project site without proper planning have caused a lot of damage to the land. Moreover, it was observed by the researcher that very often excavated material or muck have been disposed of into the Teesta river, which has serious implication on the aquatic life, mainly the fish species.

Impact on wildlife

The Teesta stage III project is adjacent to the Kanchenjunga National Park; so many wild animals used to reside near the project site, but most of the respondents said that wild animals are no more seen around the village anymore, which use to be very normal before the project came. According to them, most of the wild animals moved away due to threat and excessive disturbance in the form of blasting and interference in their habitat. The forest in the area is under tremendous pressure due to the sudden inflow of excess human population and with their activities.

Few respondents mentioned that an animal called sorrow was killed at the dam site last year. In fact, it was due to blasting the animal probably was scared, jumped off the mountain, and died. Most of the respondents said that hardly any wild animals couldbe seen within the 20km radius of the project as most of them might have moved deeper into the forest due to habitat loss, constant noise and too many human activities.

Apart from blasting movement of heavy vehicles and rollers is another major cause of damage. Almost all the respondents are of the opinion that along with blasting, heavy vehicles and big machines have caused tremendous damage to the society and environment.

Impact on fish species

Apart from mentioned by few respondents, it was observed that there is impact due to the diversion of the Teesta River through an HRT have an adverse impact on the fish species and aquatic life. The impact will be aggravated after the project is completed. The obstruction created by the dam hinders the migration of certain migratory species especially Schizothorax or Snowtrouts (from the upper reach to the lower reaches). This fish species undertakes annual migration for feeding and breeding. Now with the dam, they find their path obstructed. This can adversely affect the species in the long run. Moreover, the long stretch of more than 13km where the river is diverted through the HRT will almost run dry; hence, flora and fauna of the area will be highly affected.

Impact on Microclimate

The construction activity is so dynamic and vast that it is having a significant impact on the microclimate. According to the respondents, pollution is the main reason behind it. Many respondents are of the view that since the project started, there are certain changes in the local climate.

These changes are untimely rainfall, winters are less cold, and summers are hotter. The respondents think that pollution is so high that it is changing the entire micro-region. To quote a respondent one of the respondents:

"…there are certain changes we can see in the environment. Earlier summer never used to be as hot as it now. This year winter was not very cool. And sometimes we get unexpected rainfall. This is happening after the project started."

Thus, it is not only that there is severe pollution in the project area, but also pollution has gone far beyond the literal term and altogether taken a new form here. This microclimatic change is affecting almost everything, right from agriculture to social life.

Earthquakes

The Teesta Stage III hydropower project is located in the high-risk Zone IV of the seismic zoning map, which is one of the high seismic zone of the country. Like the rest of the state, the area is prone to high risk of earthquakes and will be highly affected by the development of any megastructure like dam or power project. Further, Prof. M.K Pandit, the director of the Centre for Interdisciplinary Studies of Mountain and Hill Environment (CISMHE) supports this (Arora 2008:28).

Furthermore, it has been proved now by many scientific studies that reservoir induces earthquakes, and as the project is already in the high earthquake risk zone, there is great possibility that it

will give rise to reservoir induce earthquake. As such, the Sikkim Earthquake of 2011 caused maximum destruction around the Teesta Stage III project areas.

Conclusion

It can be summarised that the project has to a large extent affected the ecology of the area that was otherwise pristine and healthy. It has not only affected the environmental balance but also had an impact on the rich biodiversity of the area. Moreover, it has affected the people that depend on the environment for natural resources for survival. Furthermore, as the project is located in an environmentally sensitive area, it is presumed that the impact could be more severe in the days to come.

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