Socioeconomic & Environmental Risk Impact of Hydro Power Projects in Uttarakhand

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This paper examines impact of socioeconomic and environmental risk factor that has developed from construction of large dams for mega hydroelectric power generation project through a case study of Tons river catchment in Uttarakhand. The impact assessment is determined through a household survey in three villages. The analysis reveals mixed impact. Although there is a socioeconomic and environmental cost involved in constructing large dams like, income, deforestation, noise effluence and depletion in soil fertility, but people are also aided with employment and infrastructure development through road construction and better drinking water facility. This paper also proposes relevant mitigation measures.

Keywords: Socioeconomic Risk, Environmental Risk, Hydroelectric Power Project, Employment, Infrastructure Development

1. Introduction

Hydropower plays an important role in the development of the country as it provides power at cheaper rate being perpetual and renewable sources of energy. In hydroelectric power plant, the energy of water is utilized for generating electricity which is pollution free and also inflation free energy due to absence of fuel costs. Apart from the clean and cost economic nature of power, the other key advantage includes an inherent ability for instantaneous starting, stopping and load variations which helps in improving reliability of power system. In other words, hydroelectric power defines the usage of water resources towards inflation free green energy in the absence of fuel cost with mature technology characterized by highest prime moving efficiency and spectacular operational flexibility.

Although planned development of hydropower projects in India started only in the post independent era, but the development of Micro, Mini, and Small Hydro Power Projects started in the year 1897. One of the first hydropower stations in India was commissioned at Galogi in 1907. More power stations were subsequently developed over a period of time. At present, hydropower generation has been an important component within the overall electricity portfolio of the country. India is endowed with significant hydroelectric potential and ranks fifth in the world in terms of usable potential. As per the latest available data, India has around 36 Giga Watt (GW) of installed hydropower capacity whereas an additional 13 GW is under construction. This puts the total capacity which is yet to be tapped at around 67 per cent of the potential.

The government of India has, over the years, taken a number of initiatives to prioritize hydropower development and to attract investments in the sector. In Five Year Plan the hydroelectricity is always considered to be prime motive of government to generate power. The government has targeted to harness till 150,000 Mega Watts (MW) by the end of 14th Five Year Plan around 2026-27 (Figure 1).

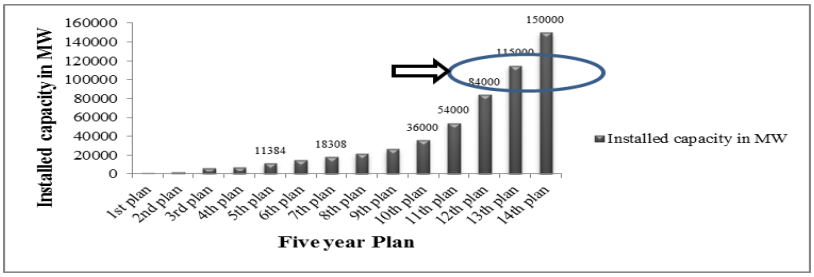

Figure 1 *Hydroelectric Power Status with Five Year Plans*

To achieve the desired target, the government has taken few key measures including the preparation of a shelf of well investigated projects, which could substantially reduce risk perceptions, streamlining clearance procedures, the provisions of open access and trading as per the Electricity Act 2003, among others.

Figure 2 presents the investment projection trend in hydroelectric projects in India from 11th Five Year Plan. For 11th plan the fund requirement was approximately Rs. 90,000 crore and it is projected to increase to around Rs. 175,000 crore during the 14th Five Year Plan. To accelerate growth in the hydropower sector and to bridge the gap between the actual and planned capacity addition, the private sector is being seen as an important stakeholder.

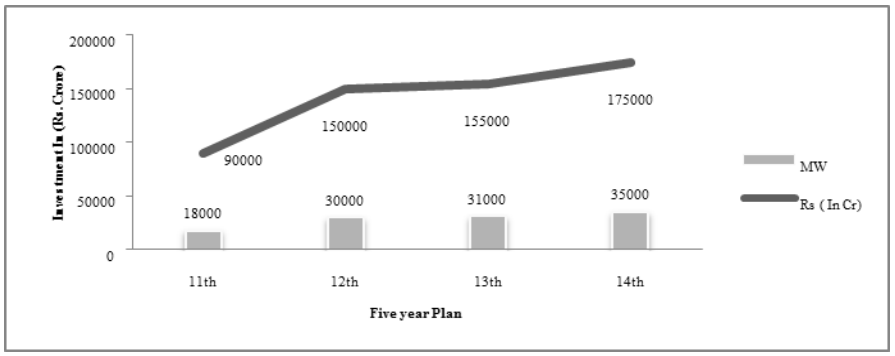

Figure 2 *Investment Projection Trend in Hydroelectric Projects in India*

The hydropower sector was opened up for private sector participation in 1991. Subsequently over the years, to facilitate projects through Public Private Partnership (PPP) and Joint Ventures (JV) mode, some states have nominated a state nodal agency with an option of equity investment by the state government. However, from 1991 to 2012, the private sector has contributed to about 11.5 per cent of the hydropower capacity addition. So far only about 2700 MW has been commissioned through the private route, which constitutes less than 7 per cent of the total installed hydropower capacity.

The major public sector companies which are engaged in development of hydropower in India are National Hydroelectric Power Corporation (NHPC), Northeast Electric Power Company (NEEPCO), NTPC-Hydro, Sutlej Jal Vidyut Nigam Limited (SJVNL) and Tehri Hydro Development Corporation. The major hydroelectric power plants are located in Bihar, Punjab, Uttarakhand, Karnataka, Uttar Pradesh, Sikkim, Jammu & Kashmir, Gujarat and Andhra Pradesh (Table 1).

Table 1 *Major Hydroelectric Power Generating Units in India*

S.No	Year of completion	Name of Dam	State	Capacity (MW)	Type	Length of Dam(m)
1.	1963	Bhakra Dam	Punjab	1100	PG	518
2.	2005	Tehri Dam	Uttrakhand	1000	TE/ER	592.7
3.	1977/83	Dehar	Himachal Pradesh	990	TE/ER	255
4.	1960	Nagarjuna Sagar	Andhra Pradesh	960	TE/PG	4865
5.	1964	Koyna	Maharashtra	920	PG	805

(National register of large dams-2009)
Abbrevation: - Earth: TE, Rock fill: ER, Gravity/Masonry: PG

The State of Uttarakhand has electrification rate of nearly 97 per cent which is significantly higher compared to the Indian average of 82 per cent. Approximately 500 villages are still not electrified due to reasons like, unfavorable geographic locations (example, remote and forest areas), improper roads or somewhere no roads available, long distance from the grid, among others which leads to high connection cost. The industrial development and increasing economic performance of Uttarakhand also leads to a higher electricity demand.

Uttarakhand has a large network of rivers and canals which provides an immense scope for hydropower energy. In Uttarakhand, the estimated capacity of Small hydropower projects is about 1500 MW out of total estimated capacity of 20,363 MW. Out of the 13 districts of Uttarakhand, geographically eight districts are completely in the hilly region of the Himalayan Region with the remaining four districts are partly hilly and partly plain areas with Tarai and Bhabar characteristics while one district Haridwar is completely in the plain area. This state is also having the origin of some of the ice-fed rivers like the Ganges, Yamuna, Bhagirathi, Alaknanda, Sarju, Tons, Kali and Gori. In the foothills, the medium and large dams for collecting the water of rain fed rivers for irrigation and flood protection purposes have been built. Thus the availability of ice fed and rain fed rivers along with the natural incline make this province a State having a good hydropower potential and a future Energy State.

Dams are a primary example of a large infrastructure project that presents opportunity for economic development, while also engendering environmental changes that consequentially feedback to social and economic values of communities downstream. Dams have the potential to produce a variety of positive and negative impacts on the surrounding people and environment. In order to maximize the benefits of a dam, the valuable relationship between communities and their river networks must be accounted for. In other words, dams are large socioeconomic investments built to fulfill such purposes as domestic and industrial water supply, energy production, irrigation and flood control. Fischer et al. (2005) expressed that water resource projects such as dams represents large scale engineering works or activities that can cause significant impacts on socio economic components of the environment. The positive and negative impacts of dam construction are very selective both spatially and socially.

Given this background, the central argument in this article revolves around assessing the socioeconomic and environmental risk factors of the construction of Chibro Power House in Tons river catchment. Specifically, this study focuses on two objectives: first, to identify the socioeconomic and environmental risk factors; and to assess the impact of the proposed risk factors in the project area.

The organization of the paper is as follows. A brief review of socioeconomic and environmental risk identification in hydropower projects is done from a global perspective. Next, an overview of the study area is presented in Section 3. The methodology of this research study is provided in Section 4. Section 5 provides the analysis and discussion of results followed by the concluding observations and recommendations in Section 6.

2. Socioeconomic and Environmental Risk Identification in Hydropower Projects

The socioeconomic and environmental risk in hydropower generation is mainly based its impact on ecology of the surroundings in terms of nature and people. Although there are considerable macro level global and Indian studies showing socioeconomic and environment related risks in stages of hydropower project construction, however, it is limited in terms of micro level scenario in the Indian context and especially for the State of Uttarakhand. In this aspect, this study is expected to have a significant contribution in assessing the potential risk and impact of hydropower generation in India.

Although considered a renewable energy resource, hydroelectric generation often engenders significant social and environmental impact. Dams impact existing habitat, stream hydrology, stream chemistry, sediment transport, and migratory patterns (Yuksel, 2009). Essentially, dams fragment river ecosystems, degrading the ecosystem upstream and downstream from the dam. Fragmented river ecosystems change the climate of the river making upstream and downstream into essentially different ecosystems (Bird, 2012). This results in habitat change leading to extinction of aquatic species. Changes in flood plain and the natural flood pattern have contributed to a disappearance of many bird species (Barcott, 2008). Lack of wetlands removes many environmental services such as flood control, habitat, and natural water filtration. These impacts are magnified as the dam holds back sediment and deprives the downstream waters of nutrients. When a river is deprived of nutrients and sediment it adjusts course to gain sediment by eroding downstream riverbanks. This leads to the deterioration of natural flood plains, which would otherwise be regularly replenished by the natural flood cycle of the river.

Several empirical studies based on the hydroelectric power projects in Norway identified various crucial unsystematic climatic risks and its impact on the electrical system as well as investment performance of hydroelectric plant (Heggedal, et al., 2011; Harrison et al., 2012). Kucukali (2011) also found various external factors such as site geology, grid connection, and environmental issues in the construction of river type hydropower plants. A study at the environmental impacts of dams on an ecologically diverse and partially protected river in China found that small dams can pose a greater threat to ecosystems and natural landscapes 39 times more than large dams (Zelenakova, et. al, 2013). Maingi and Marsh (2002) in their paper addresses risk factors of river flow and river precipitation which impact the environment as well as machinery of hydroelectric project.

Forest clearance sometimes becomes essential in the case of construction of dam. This activity definitely misbalances the ecology of the system (Grimay, 2006). Wittwer (2009) identified socioeconomic and environmental risks are one of the most influential factors before construction of small hydro power projects. Since a dam is required hence there is an issue of relocation and rehabilitation of the villagers in the project area. This cost has a substantial impact on investor's profit (Bhanu, 2011). Hossain (2009) showed how the Tipaimukh dam had affected the inhabitants of Kachar district of Assam. Kucukali (2011) identified few socioeconomic and environmental risk factors like water quality, soil erosion, employment, flora and fauna, noise pollution and tourist attraction which impact small hydroelectric power projects.

Shang and Hossen (2013) in their study described rehabilitation and resettlement cost associated with Tipaimukh dam in Bangladesh which increased the investment cost of the project. In Uttarakhand it is observed that the investors are dominated by farmers and other local landowners near to hydropower dam in Ganga and Yamuna Basin (Kesharwani, 2006).

3. Study Area

Chibro power plant is located in the Tons river catchment area in Dehradun district. However, three districts viz. Dehradun, Chakrata and Kalsi get the benefit of hydropower generated in Chibro power plant. The dam is located at an elevation of 635 meter above the sea level and lies between latitude 29°55'N and 30°30'N and longitudes 77°35'E and 78°24' E. It is bounded in the North and North West by the Uttarkashi district.

The Chibro power station is near to Ichari dam which is concentrate gravity dam on Tons river 13 Km North of Daakpathar. The flood intensity in Tons river, a tributary of Yamuna, is relatively less than the major of the state but due to often cloud burst in this region the probability of flood every year is high. The Chibro power station is located nearly 35 km upstream of the barrage.

The distance between the barrage and Chibro power house is 16 km and nearly 5 km downstream of the dam the housing colony for the dam and the power house employees are situated. It is known as Koti colony since it is located close to Koti village up on the hills on the left bank of Tons river. Some of the villages in the area are Atliyo, Asnog, Danda, Dimau, Samog, Lakhwar and Rupou among others.

4. Research Methodology

Initially this study identifies the socioeconomic and environmental risk factors through literature review and for confirmation of those risk factors and impact assessment a well-structured questionnaire was surveyed with households in the villages of the Tons river catchment. A sample survey was carried out in Koti, Dimoh and Lakhwar villages November and December of 2014. A sample survey generally selects a small number of units from a population to enable researchers to make reliable inferences about the nature of that population. The affected household of the project area was used as sampling units.

For the purpose of the study, the determination of the appropriate size of sample households to be surveyed is very important. Three criteria are used for this purpose. They are: level of precision, level of confidence and degree of variability in the attributes being measured. Although the study area consists of a total population of 937 households who are aware with Chibro hydropower plant, by considering the statistical formula, the sample size of households is calculated as 184. It is often observed that a self-administered questionnaire enabled the researcher to allay respondents fear, distress and anxiety over issues raised in the questionnaire. Hence, the questionnaire was personally administered to the respondents of the field.

A small pilot survey of 15 households was first organized and conducted in order to test the questionnaire and to get familiarize with the procedure of asking question. Furthermore, all the collected data and information were compiled, analyzed and interpreted using different statistical techniques both in qualitative and quantitative modes.

5. Analysis and Discussion of Result

The responses analyzed using moving average approach and impact of total risk all risk factors are mentioned in Figure 3. The data clearly indicates that around 22 per cent are of the affected households are influenced by socioeconomic factor like searching for better employment or income opportunities followed by an environment issue of loss of soil fertility due to improper disposal of hazardous waste. Interesting, land acquisition, irrigation and drinking water have not shown any significant risk impact for the inhabitants of the study area

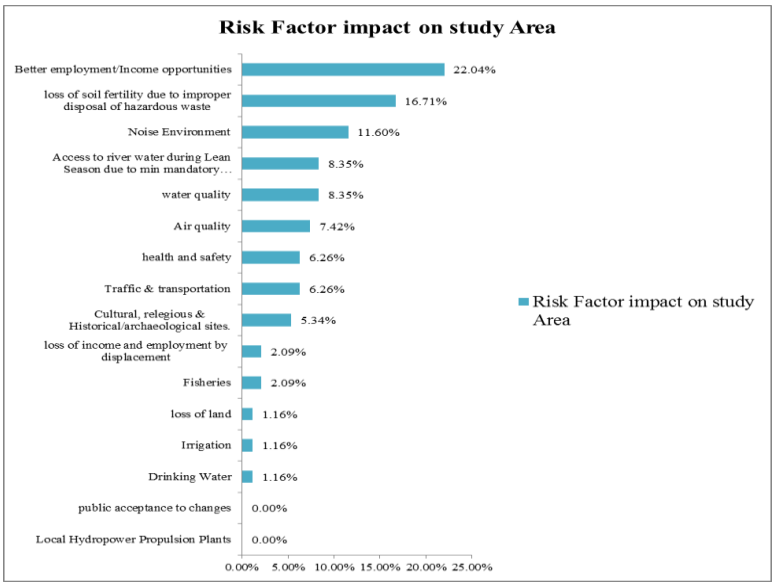

Figure 3 *Risk Factor Impact on the Study Area*

The risk factors are also individually analyzed for the three villages of study area viz. Koti, Lakwar and Dimoh and presented in Figure 4(a), (b) and (c). The results are almost in line with the overall result. The most dominant risk factor analyzed is income opportunities followed by soil fertility, noise environment and water quality. The least impacting risk factors are drinking water, irrigation and loss of land.

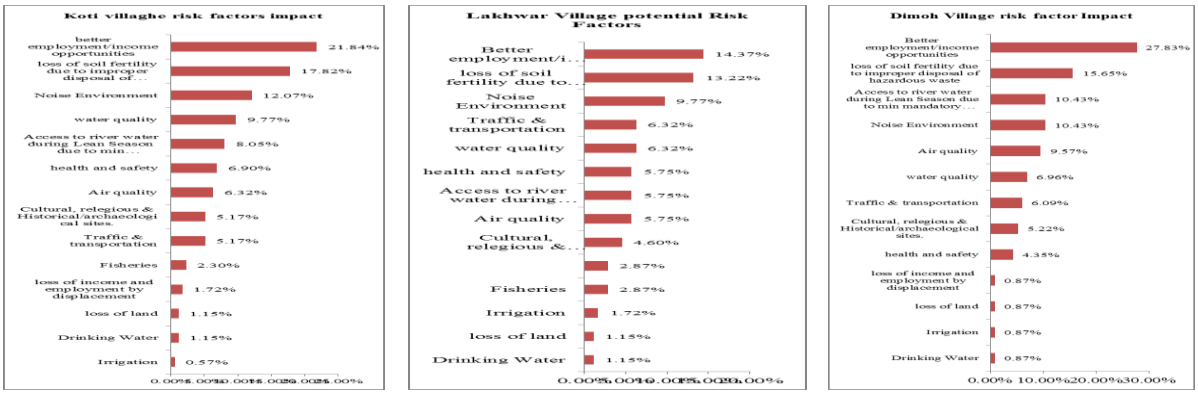

Figure 4 (a), (b) and (c) *Risk factor Impacts in Villages*

In order to validate the socioeconomic and environmental factors discussed above an extensive discussion with the respondents were done. It also helped to assess the impact of the proposed risk factors in the project area. A detailed analysis of it is presented here.

5.1 Social Infrastructure of Villages

The information collected from the survey covers an appreciable extent of a comprehensive cross section of the inhabitants in the selected villages in terms of education and gender. Overall 30 per cent people of the sample population had either no primary school level or formal education (Figure 5). Only five per cent of the sample has an exposure to higher education. It is also observed that the Dimoh village has higher proportion literacy Koti and Lakhwar.

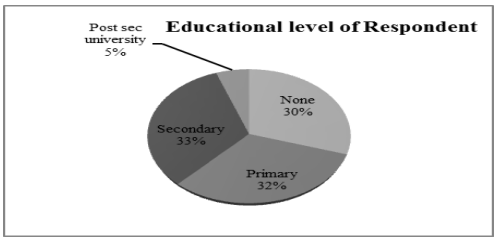

Figure *5 Education Level of Respondents*

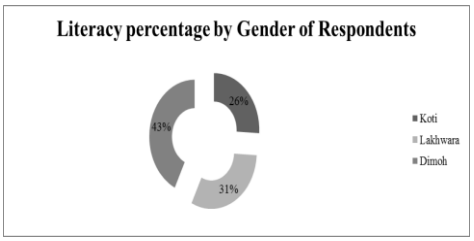

Figure 5 *Gender Percentages of Respondents*

It is already observed that better employment or income opportunities is highest among the risk factors and this can easily be justified with low education level.

5.1.1 Cultural Religious & Historical/Archeological

Dehradun district has a predominant Hindu population followed by Muslims and Sikhs. There are no sites or archaeological importance in the project area. The dam does not have any adverse impact on the sites of the religious or cultural importance in the area. As per study, this risk factor importance shows only 5.6 per cent which is very insignificant.

The temples located along the corridor may be partly disturbed only if the road connecting the dam and the power house is proposed to be widened for purposes of the carriage of heavy machinery and equipment. However, that effect is for short run and the mitigation is done in prior consultation with the temple authorities and local representatives so as to avoid any possible conflicts with the local population.

5.1.2 Public Acceptance to Change

The Chibro hydroelectric project has been operational since 2005. Although the entrance to the power house is adjacent to road, but the functioning units of the plant is located underground and it is away from the main road. Hence, there is no intrusion into the lives of the nearby villagers because of the activities in the power house.

The survey shows that the villagers in the area are accustomed to a normal life although the dam and the power house are close to vicinity. The Koti colony, built for the dam and plant officials has a lot of amenities such as post office, schools, intermediate college, bank and one medical dispensary which make life much easier for the local villagers.

The two communities' viz. the dam/plant officials and the local village residents seem to coexist quiet amicably. There is no apparent conflict between the two groups. The firsthand information about local population does not indicate any possible obstruction to plant activities and public acceptance to changes caused by the proposed project should not be a problem. During the course of the present study, no reservation or apprehension was expressed by them with regard to the issue of modernization and upgrading of the power plant of the dam. Hence, the analysis shows that there is no impact to public acceptance to change.

5.1.3 Road Infrastructure and Accessibility

The congestion of roads due to heavy movement of project vehicle sometimes creates traffic in roads and transportation problem. According to the survey results, traffic and transportation problem is 6.26 per cent only. This is hypothesized to be a short term problem and can be easily removed with the proper use of traffic signs and maintenance of access roads.

5.1.4 Access to Water Resources

During the survey, it was observed that as per records of the panchayat samiti and zilla parishad, all the villages in the project area have access to safe drinking water through their taps, hand pumps and other sources of delivery. The study of Chibro area has not found any impact on the safe drinking water resources available to the villagers because the supply of drinking water is taken care separately by the concerned government department and is independent of the water requirement for the existing power project. The construction staff and labourers are located in the area owned and managed by Uttarakhand Jal Vidyut Nigam Limited (UJVNL). Therefore, the additional population in the area during the construction period does not act as a burden on the village resources.

Fishing is not a significant economic activity in the project area as not many fish are reported to be present in this stretch of Tons river. No data could be provided by the Directorate of Fishery, Uttarakhand on the status of fish and fisheries in the project area. Rivers in Uttarakhand come under the jurisdiction of the forest department and the directorate/ department of fisheries which do not provide any fishing rights in the rivers flowing through the stream. So this problem shows impact of only two per cent which is significantly removed.

Running of local hydropower propulsion plants is another use of river water in Uttarakhand region. Some of these water mills were observed in the villages in the project area too. The project is unlikely to have any adverse impacts on these water mills. With the provision of the minimum mandatory downstream discharge under the project, the water availability for these mills will only likely to improve.

The villagers have free access to river water for their various others need which includes their needs for agriculture and irrigation. The water of Tons river is available to them throughout the year except during the lean period when the stretch downstream of the Ichari dam is nearly dry. At that time almost the entire discharge of water is utilized for energy generation by the power plant. This situation is likely to improve with the project as a mandatory downstream discharge of 10 per cent of the minimum flow per year has been proposed for ecological and social revisions.

One of the major objectives of the Ichari dam is to control water levels due to frequent floods causing a historical problem around the Vikas Nagar in Tons river. The project can efficiently control the water from upper stream and reduce the flood and sand pouring into tons river during the rainy season. Thus, the sediment accumulation rate of Tons river can be controlled and the threat of flood can be addressed.

5.1.5 Tourism

The dam attracts a significant volume of tourists. The Government of Uttarakhand needs to highlight it as a major spot of attraction for the visitors. It is also important to improve the infrastructure in the nearby areas in terms of development guest houses and hotels. The government can also build a picnic spot near the dam as it can attract many visitors from the nearby places like Kalsi, Vikas Nagar, Chakrata and Dehradun. These initiatives of the government can generate additional revenue not only for the government but also for the local people as well.

5.2 Economic Infrastructure of Villages

5.2.1 Income and Employment

The field survey has witnessed that a large number of the respondents are engaged in the agricultural sector. The result from the study confirms that 47 per cent are cultivators, three per cent are agricultural labourers, and around 2 per cent are engaged in household industries. It is observed that 31 per cent are involved in some nonfarm activities mainly that are related with hydropower area (Figure 6).

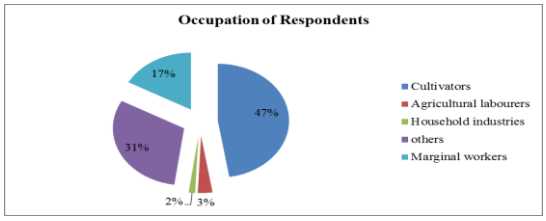

Figure 6 *Occupation Percentage of Respondents*

The increase in traffic along the project stretch has added to several income generation opportunities. The growth of tiny and small shops at Dimoh, Koti and Lakhwar area is supposed to be a direct outcome of this. Better connectivity with adjoining urban areas also means access to better educational facilities and access to better health care facilities for the villagers which directly or indirectly translate into economic benefits in the long run. The study revealed that the people working in the farm sector also started some nonfarm activities like small shops, vendor, among others to generate an additional income. This ultimately enhances their opportunity to earn from multiple sources and increase their livelihood opportunities. It implies that the hydropower plant has created an opportunity for the villagers in generating occupations and additional revenue for running their families in a better mode.

The survey in Dimoh village, which is very near to the hydropower project area, revealed that the people in this area have comparatively more education than the other two villages and they are more inclined towards joining in project related jobs than involving themselves in farm activities.

5.3 Environmental Infrastructure

5.3.1 Health and Safety

Injuries and sickness of the staffs and workers and also of local residents due to accidents and fires is not a regular phenomenon. But natural hazards such as land slide or cloud burst often seen in these villages. But the impact is for short term and it can be easily mitigated through the medical facilities available near the plant.

5.3.2 Air Quality

The air quality is affected on a scale of significance which is 7 per cent but the impact is for short term only. When the heavy vehicular movement is there on the roads, the fumes and dust start spoil the air quality which is a controllable factor. It is observed during the survey that as the villages are surrounded mostly by hills and forests, hence the air quality is relatively good in the project area.

5.3.3 Water Quality

Contamination of water sources is possible if the physical or chemical waste produced during the construction work is drained or dumped directly into the river stream. This includes the waste generated on account of civil works, equipment disposal, disposal of transformer oil, tunnel excavation and dredging of reservoirs. As per study, this risk factor importance shows around eight per cent which is not very significant. Adverse impact of the project is possible in terms of quality and quantity.

5.3.4 Noise Environment

The project work entails activities that are likely to cause temporary environmental disturbance in the area. This will largely be in the form of additional dust, fumes and noise on account of increased movement of heavy vehicles carrying construction material and equipment to the project site. This noise problem creates a negative impact but that is for short term only. The proportionate of impact of noise problem is 11 per cent approximately.

6. Conclusion and Recommendation

The purpose of the socioeconomic and environment risk assessment is to gauge the nature and magnitude of impacts of the project well in advance so that adverse impacts can be minimized by adopting suitable mitigation measures. This helps not only in containing the potential dangers to the environment and lives of the people in the project area but also in reducing chances of obstruction from the local people.

Although disturbance to the local communities in the project area is expected to be minimal, it is advisable that an effective grievance redressal mechanism is developed so that community concerns and grievances, if any, can be addressed in an appropriate and timely manner. A grievance redressal cell can be formed by UJVNL with representation of key stakeholders including the community members. Efforts should be made to ensure that the local population is aware about the grievance redressal mechanism.

Information about activities likely to cause inconvenience to the local population should be disseminated prior to the commencement of the project work. Information dissemination and regular consultation with community can be effective in curbing unrealistic aspiration of the community with respect to the benefits arising out of the project.

The hydroelectric project under consideration has in operation for a long time now. Most of the work will be confined within the premises of the power plant. The staff and workers involved in the power plant activities mainly stay in the housing colonies of the UJVNL and Irrigation department at Daak Patthar and Koti. Therefore there will be no additional demand of resources of the local people owing to influx of workers during the project. No outbreak of new diseases is anticipated either.

Land required for dumping of muck and silt comprises primarily government land. No additional land needs to be acquired for expansion of existing structures. There will be no loss of income or employment to the local pollution because of the project. There is no element of discord between the plant and dam officials and the local residents. The infrastructural amenities created as a result of the hydroelectric projects are easily accessible to the villagers. The access roads have to lead to better trading, employment and income opportunities for the villagers as also to better access to education and health care facilities.

In view of the above, no significant adverse impacts can be anticipated on account of the project activities. Some of the adverse impacts of the plant activities will include the traffic congestion and the air and noise pollution, because of increased vehicular movement in the project area. These issues need to be suitably addressed so as to minimize the impacts and cause least inconvenience to the people in the area.

For disposal of muck and silt generated because of tunnel excavation and reservoir dredging, suitable land has already been identified. Other kinds of waste produced during the plant exercises will have to be handled carefully so as not to cause adverse impacts on the lives of the local people. The dismantled equipment, transformer oil and other waste material should be stored and disposed strictly according to standard norms and practices. Treatment of waste and their alternative use should be considered wherever necessary. In case the existing roads or other land areas are disturbed because of earth work required for the project. It should be ensured that the same area restored to the pre project level.

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