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Environmental and Social Impact Assessment: A Study of Hydroelectric Power Projects in Satluj Basin in District Kinnaur, Himachal Pradesh, India

LATA R[1]*, RISHI M S[2], HEROJEET R[2] AND DOLMA K[2]

[1*]*G.B. Pant national Institute of Himalayan Environment and Sustainable Development, Himachal Unit, Mohal-Kullu, Himachal Pradesh, India*

[2]*Department of Environment Studies, Panjab University, Chandigarh, India*

***Email:** renu15_negi@yahoo.co.in**

Abstract: *Construction and operation of HEPs have always been associated with changes in the social, physical and biological environment. Building dams on rivers have severe impacts on livelihood of the indigenous people, altering the river ecosystems and wildlife habitats. The present study, therefore, focuses mainly on the HEPs in river Satluj and its tributaries in Kinnaur district of Himachal Pradesh. On the perception survey frequent natural hazards and their resultant tangible and non tangible loss on local communities due to construction of hydropower projects and its surrounding has been analyzed. Further, preventive measures to mitigate the adverse impacts have been suggested to strengthen these projects in eco-friendly manner in the highly fragile mountain ecosystem. The impacts due to hydropower development, especially reservoir and dams are always space extensive which covers catchment area of upstream, downstream and on site surrounding area of plants. Generally, HEPs in Kinnaur district have been given all attention regarding its technical design, economical issues and very least or almost negligible attention on social and environmental factors. The present study is the need of hour to protect rich tribal culture and very high earthquake sensitive zone (IV& V) of Kinnaur district.*

Key Words: *Adverse Impacts, Hydroelectric Power Projects, Local Community, Natural Hazards, Preventive Measures, Social and Environmental Impacts and Sensitive Zone.*

1. Introduction

Hydropower in the Himalayan region is recognised as an important resource for meeting the region's energy demand and in promoting its economic development. India, like many countries around the world, has a significant need for energy, and has identified hydropower generation as a key component in meeting that need (Sharp, 2000; Alternative Hydro Energy Centre, 2011). While hydropower development produces economic and social benefits, large-scale dams in India cause many of the same social and environmental concerns documented worldwide (Khagram, 2004). One significant criticism of the dam development process in India is a lack of meaningful public participation, which is an especially critical issue for local people directly affected by the projects (Sinclair and Diduck, 2000; Paliwal, 2006; Rajaram and Das, 2006; Diduck et al., 2007).

The mountain ecosystem is a separate and distinct ecosystem, which is globally very crucial since it has the only freshwater tower on the earth's surface, rich repository of biological diversity and potential tourist destination for recreation (Singh and Roy, 2003). Snow melt runoff is very important in the Himalayan rivers in India where the plannings for hydropower generation and water management during the monsoon seasons are important issues (Prasad and Roy, 2005). The steep elevations and numerous fast flowing perennial rivers of the Himalayan region of India provide the area with a high potential for hydroelectricity (Government of India, 2008). This potential, combined with India's substantial need for energy, makes the Himalayan region a crucial source of hydroelectric generation (Rangachari et al., 2000). In recent years, number of hydro projects in the Himalayan region has increased significantly. Recently India's central government announced a 50,000 MW initiative intended to increase the contribution of hydropower from 25% to 40% of the total energy generation in the country (Agrawal et al., 2010; Central Electricity Authority, 2015).

Recently Himachal Pradesh, has been marked as the 'Power state' with a good potential to produce electric energy. The pressure is not just to make electric power, but to make clean power with good technology use which is less damaging and more environmental friendly. The protests in a number of localities of study area have indicated that these projects are damaging livelihood and environment in different ways. While the large and medium hydroelectric projects have been in the line of fire for their harmful environmental impacts, small hydroelectric projects of less than 5 MW capacities seem to have escaped the lens. However these small hydropower plants also

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influence the microclimate as well as spatial distribution of macro invertebrate of the project site and surrounding area of hydro power projects (Xiaocheng et al., 2008; Diduck and Sinclair, 2016). Each dam site may have its own unique set of geologic and geotechnical challenges since the design requirement are different for dams of different size, purpose and hazard potential classification (Tabwassah and Obiefuna, 2012). More than 400 projects have been allotted and 43 are already commissioned in the Himachal Pradesh (Sharma and Rana, 2014). Further the government of Himachal Pradesh to achieve optimal harnessing of the available potential and to identify new hydro power potential in the State. The total power potential of various river basins in the state is estimated as 27,436 MW, which is available in five river basins with some micro projects. The basin wise potential are Satluj (13,332 MW), Beas (5,995MW), Chenab (4,032MW), Ravi (3,237MW) and Yamuna (840MW).

The Himachal government has taken several initiatives to encourage private sector participation in small hydroelectric power plants development. Attractive incentives for independent power producers, in the form of easy land acquisition procedures and speedy clearances have been ensured but still poor affected families are awaiting various legal clearances and compensations (Agarwal, 2000). What has been overlooked is that a large number of projects are sanctioned but what affects local livelihood of remotely located poor and tribal communities and fragile biodiversity ecosystems in numerous ways is overlooked by government. In several palaces, these rivers and streams support the traditional irrigation channels and watermills. In many villages of the study area the streams even supply drinking water to the inhabitants (Williams and Porter, 2006). In case of small hydroelectric projects even no environmental clearance from the Ministry of Environment, Forest and Climate Change (MoEFCC) required. The critical clearances that are required at the state level include the techno-economic clearance and those from the Irrigation and Public Health Department, Fisheries Department and Public Works Department. But there are no procedures and regulations in place at the state level to ensure a cost benefit analysis with an environment and social impact assessment of HEPs (Sharma and Rana, 2014). No doubt electricity generation is the need of the hour for development, but large projects do involve the submersion of forests and displacement of people. To maximize the positive impacts and mitigate the negative environmental, social and economic impacts sustainability of water resources projects are required (Lata et al., 2013).

1.2 Geological Settings of Satluj River

Geology of Satluj river has been studied in detail by a number of researchers (Bassi and Chopra, 1983; Bhargava and Bassi, 1998; Sharma, 1976; Srikantia and Bhargava, 1998; Tiwari et al., 1978). The basin comprises of thick succession of medium to high grade metamorphic rocks and their sedimentary cover. The succession is emplaced by granite intrusions of varying ages. The rocks in the study area has been reported to be subdivided into several contrasting units, which are bounded by major north-dipping tectonic fault systems that run parallel along-strike the mountain belt (Burchfiel et al., 1992; Fuchs, 1975; Gansser, 1964; Heim and Gansser, 1939; Hodges, 2000). From southwest to northeast, these units comprise:

- The Lesser Himalaya Sequence (LHS), which mainly consists of massive quartzarenites intruded by basalts (Miller et al., 2000).
- Medium to high grade metamorphic sequence of the Lesser Himalayan Crystalline Sequence (LHCS), which consists of mylonitic micaschists, granitic gneisses with minor metabasites and quartzites (Vannay and Grasemann, 1998).
- The Higher Himalaya Crystalline Sequence (HHCS), which is composed of amphibolites facies to migmatitic paragneisses with minor metabasites, calcsilicate gneisses, and granitic gneisses often intruded by granitic plutons (Thiede et al., 2004, 2006; Vannay and Grasemann, 1998).
- The weakly metamorphosed sediments of the Tethyan Himalayan Sequence (THS), which consist of metapelites and metapsammites that comprise the cover sediments of the former Indian continental margin (Vannay et al., 2004).

The geological map for the study area based on Thakur (1992) is presented in Figure 1.

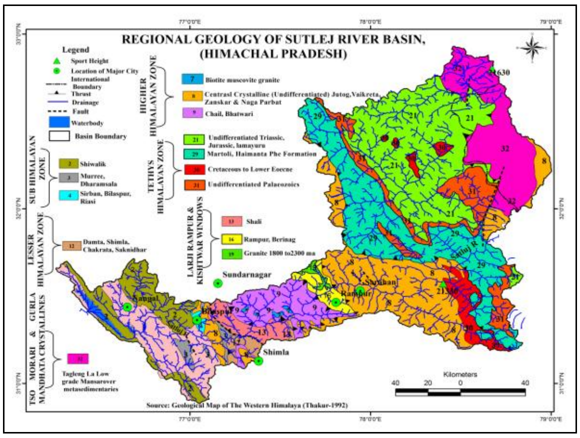

Fig. 1.Geological Settings in the Satluj Basin, Himachal Pradesh

1.3 Drainage

River Satluj originates at Rakshas Tal Lake near Mansarover Lake, and is called as 'Longcchen Khabab' in Tibet. It flows generally towards west and southwest till it enters India at Shipkilla at an altitude of 6608 metres. The river cuts through the great Himalayan and the Zanskar range. River Satluj has been reported as 4th order stream in accordance with the glacier-inventory norms (Muller, 1978) and as 5th order from Nathapa and downstream up to Bilaspur town (Vaidya et al., 2013).

The highest point in the basin is about 4400 m. The streams on the eastern block flow in escarpments along most of their course. Drainage represents lower order streams joining the trunk stream at 90°. The streams on the eastern blocks are longer and more in number compared to those on the western blocks. The main river Satluj flows through a crystalline basement belonging to Vaikrita Group near Khab where the area lies in the Kaurik-Chango fault zone. Quaternary reactivation of these faults has lead to bedrock incision by Satluj which flows in a gorge for most of its course. Its major right bank tributaries are Spiti, Chaso, Ropa, Kerang, Kashang, Sorang, Kurpan, Ganvi, Behna and Karsog, whereas its major left bank tributaries are Titang, Nesang, Tidong, Baspa, Duling, Soldang, Nogli and Sainj (Fig. 2).

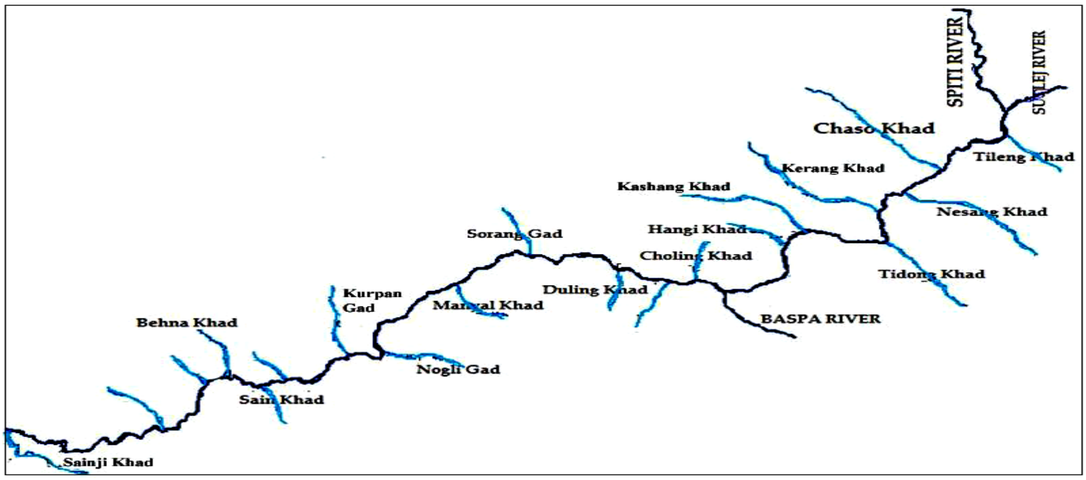

Fig. 2. *Major River and Tributaries of Satluj Basin, Himachal Pradesh*

1.4 Natural Disasters occurred in the Satluj Basin

Geologically the Himalaya is considered to be youngest mountain chain in the world and is still in the building phase. Himalaya was formed about 45 million years ago, when the Indian plate collided with Eurasian plate at the rate of 15 cm per year. The Indian Plate is still moving northwards into the Eurasian Plate at the rate of about 35mm per year (Larson et al., 1999; Wang et al., 2001). As a result, Himalayas are rising at the rate of about 5 mm per year. The major natural disasters or hazards experienced by the region over the years include earthquakes, landslides, flash floods, cloud burst, avalanches, hailstorms and droughts. Thus the basin under study is vulnerable to different kinds of disasters including natural and manmade.

1.4.1 Earthquake

The state lies in the very seismically sensitive zones (zone IV and V) as per the Seismic Zoning Map of India (Ref: IS: 1893-1984 Fourth Revision). During the past five decades, 20 earthquakes with magnitude > 5 have been recorded from the Satluj valley (Wulf et al., 2012). Major earthquakes that occurred in the study area are presented in Figure 3 (a).

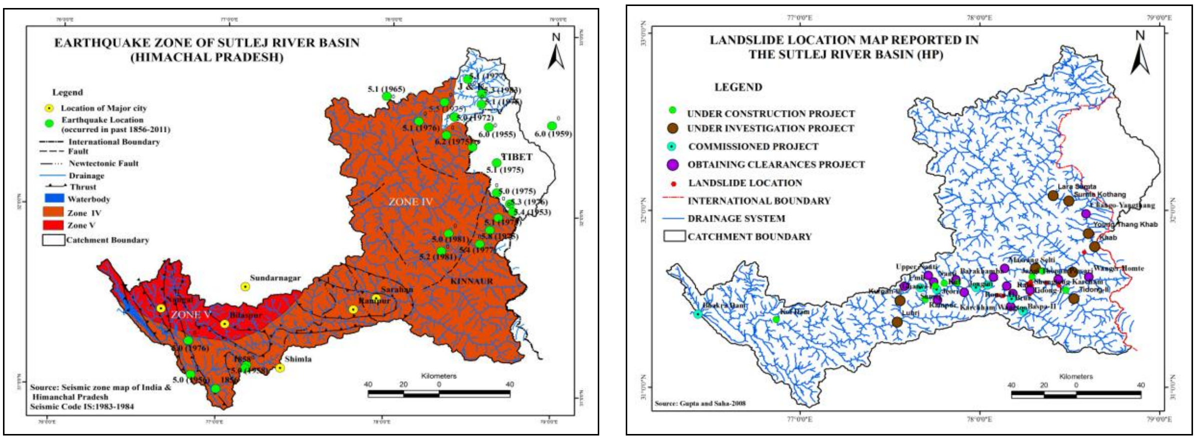

Fig.3. *(a) Earthquake Zones in Satluj Basin (b) Land Slide areas observed in Satluj Basin*

1.4.2 Land Slides

Generally, local geology and the long-term climatic conditions interact significantly with varying degree on land susceptibility and condition. The vulnerability of the geologically young and not so stable steep slopes has been reported to be increasing in recent decade due to inappropriate human activity like deforestation, road cutting, terracing and changes in agriculture crops cultivation that require more intense watering (State Council for Science, Technology and Environment and Disaster Management, Himachal Pradesh, 2012). Earthquakes and heavy rainfall acts as triggering mechanisms to initiate a landslide (Kessarkar et al., 2011). Such natural disasters observed to occur commonly in all parts of Himachal Pradesh. Numerous land slide deposits were observed along the Satluj river and its tributaries. The land slide has been reported to contribute to large quantities of sediment (Bookhagen et al., 2005).

Land slide in the study area is mapped in figure 3. (b) shows the Land slides in the region. The climatic transition i.e. orthographic rainfall threshold contributes to pronounced geomorphic changes, such as a decrease in river sinuosity, steepening channel gradients and hill slopes. Such gradients and hill slopes are reported to cause frequent landslides in Satluj river basin due to high slope instability, weak geology and seismic activity. During field survey such areas were observed at several locations. It was also observed that irrigated orchards on terraced uplands having rocky sub-stratum generally have saturated soil profile. The sub-surface rain flow moves down the slope and saturated soil mass located on steep slopes slips down due to wetting and increased weight of the soil mass. Slope failure induced by significant monsoonal rainstorms is a common phenomenon in the orogenic interior, as documented by Bookhagen (Bookhagen et al., 2005).

1.4.3 Snow Avalanches

The snowfall during the month of February and March causes avalanches on the mountains slopes and the valleys. The snows avalanches unlike glaciers are smaller in mass and faster in movement. The flash points of avalanches have been reported in: Bhagat Nalla, Tinku Nalla, Pyala Nalla (Jangi) and Ralli on the National Highway-22 (NH). Besides, avalanche is reported in the valleys and slopes along the villages particularly in Lippa, Jangi, Rispa, Thangi, Kunnu-Charang, Pangi, Barang, Kalpa, Mebar, Roghi, Sangla, Rakchham, Chhitkul, Batsehri, Shong, Sapni and Yula valley. Where there is heavy snowfall in the month of February and March. The incidents of avalanche reported in the districts that fall within the study area are presented in Table 1.

Table 1: *Avalanche Accidents Reported in the Satluj Basin, Himachal Pradesh*

S. No.	District	No. of Accidents
1.	Kinnaur	32
2.	Kullu	6
3.	Lahaul and Spiti	21
4.	Shimla	2

(Source: District Disaster Management Report, 2012)

1.4.4 Flash Floods

The occurrence of water related natural disasters especially floods and flash floods are common in most of the hilly states including Himachal Pradesh. The riverine flooding is mostly associated with the rivers having snow fed origin because in summer the snowmelt coupled with heavy rain often triggers flood and the river Satluj has been reported to be flooded almost every year. Another form of flooding is flash flooding which is principally associated with hydrologically small regions and the duration of this phenomenon is short but cause extensive damage. Flash flood in Satluj valley has caused damage of about Rs 1466.26 crore and 895.8 crore during 2000 and 2005 respectively (State Council for Science, Technology and Environment and Disaster Management, Himachal Pradesh, 2012).

1.5 Hydropower Development in Satluj Basin

The Government of India and State GoHP have identified the Satluj river basin as one of the main sources of hydropower potential. The total power potential of five river basins in the state is estimated to be about 23,000 MW. Out of the total potential 9396.75 MW are identified in the Satluj river basin. There are various hydropower developers such as Nathpa Jhakri HP 1500 MW a major joint venture hydropower project of Central Government and SJVNL; Baspa-II 300 MW and Karcham Wangtoo 1000 MW of M/ s JSW Group; SVP-Bhaba 120 MW by the GoHP and few small and mini HEPs are under operation in the Satluj Basin. Rampur (412 MW) and Kol Dam HP (800 MW) on Satluj river are under execution by SJVNL and NTPC respectively. Shongtong Karcham (450 MW); Integrated Kashang (243 MW) are state sector scheme. Khab (636 MW) and Luhri (775 MW) are the central/ joint sector hydropower projects; Jangi Thopan Powari (960 MW); Yangthang Khab (261 MW) by the private sector are under various stages of development. Further, few projects identified are either allotted or under investigation.

1.6 Genaral Discription of the Study Area

Kinnaur, located on the Indo-Tibetan border, is very scenic but less known district of Himachal Predesh. It is surrounded by the Tibet on the east, Garhwal Himalaya on south, Spiti valley on north and Kullu on west. Kinnaur is about 235 kms from Shimla. The much religious Shivlinga lies at the peak of Kinner Kailash Mountain [Fig. 4(a)]. The old Hindustan-Tibet road passes through Kinnaur valley along the bank of river Satluj and finally enters Tibet at Shipki La Pass and lies between North latitude 31o-35’-40” to 31o-34’-42” and longitude 77o-52’-38” to 78o-51-’28” east covered in the Survey India Toposheet No. 53E/14/3, 53E/14/6. There are three, almost parallel Mountain ranges: the Zanskar Mountains, the Great Himalaya and the Dhaula Dhar with their peaks varying between 5,180 m to 6,770 m and covered with snow throughout the year.

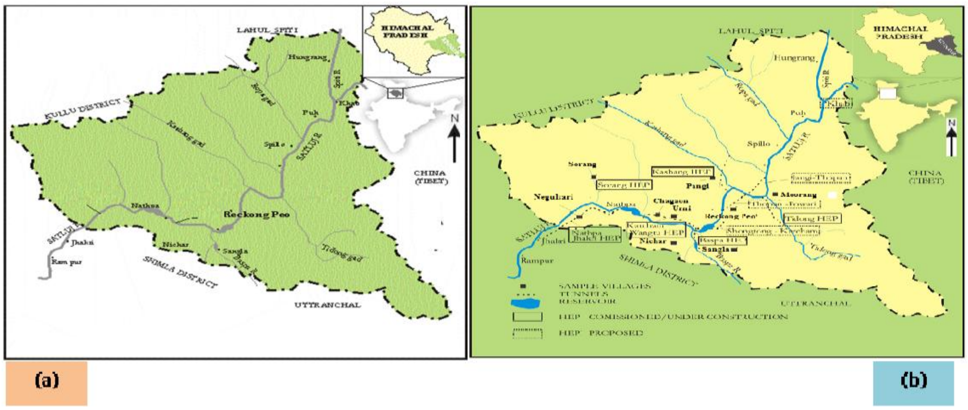

***Fig.4 (a)**. Location of the Study Area **(b)** Major Hydroelectric Power Projects in District Kinnau (Source: Himachal Pradesh Gazetteer, 2001)*

1.7 Materials and Methods

A sample questionnaire was used to examine the perceptions of the local population about the major Hydroelectric Power Projects like Nathpa-Jhakri (1500 MW), Karcham - Wangtoo (1000 MW), Kashang project (243 MW), Tidond (100 MW), Baspa (300 MW) and Sorang (100 MW) and their impact in the surrounding area [Fig. 4 (b)]. The questions were simple and specific, avoiding vague, ambiguous, hypothetical, leading and personalized questions. The questions asked in the interview schedule were both open ended and closed types.

1.8 Tools and Techniques of Data Collection

The tool of the present study was the "schedule" and the "technique" was the interview. Questions were framed in regard to the objectives of the present study. The questions were simple and specific, avoiding vague, ambiguous, hypothetical, leading and personalized. Questions asked in the interview schedule were both open ended and closed types. Data collection is done by two main ways – primary sources and secondary sources.

1.9 Results and Discussion

The data was collected on various aspects of socio-economic profile of the villages located around these hydropower projects. The population distribution is correlated with the physiographic divisions. The study area is scarcely populated, because of snow-capped peaks, forested steep slopes, unavailability of proper roads and other amenities of life. On an average each village has about 200 – 650 residents. Male population is more i.e. about 65% in the age group of 25–50 years. The numbers of single and married persons are 47% and 48% respectively (Lata, et. al., 2015).

1.9.1 Population and Respondents

The universe of the study was 300 households covering the major villages around HEPs. Though a standard sample size comprises 15% of the total population, to get more accuracy in the result the researcher has taken 20% of the total population, that is, 60.

1.9.2 Criteria for Selecting Respondents

It is very important to involve marginalized groups who may not necessarily come forward voluntarily and the 'silent majority', whose perspective is sometimes overlooked due to vocal community groups or individuals instead of only engaging with groups and individuals who are positive or have high influence. Women may bring different perspectives and views on issues than their male counterparts as they are also important stakeholders within communities. Therefore:

Accidental selections of respondents were done to eliminate the element of bias. Different age groups and different socio-economic status involving both males and females were interviewed in order to assure a clear picture. Sometimes groups of two to three people were interviewed to get collective information related to hydropower development and related activities in the area.

1.10 Impact on Socio-economic Environment

The Hydropower projects are likely to entail both positive as well as negative impacts on the socio-economics of the area.

1.10.1 Positive Impacts Perceived by the Respondents

One of the positive aspects of HEPs lies in the fact that it promotes social development as a result of employment generation and peripheral development. This form of energy, unlike the energy from other conventional sources, entails comparatively less discharges of wastes or emission of toxic gases. It is virtually free from pollution and thus can be looked as "technology of the future" for the rural and remote areas.

A number of marginal activities and jobs would be available to the local people.

- The availability of electricity to the rural areas will reduce the dependence on alternative energy sources namely fuel wood to the people.
- With increased availability of electricity, small-scale industries will also come up and will serve as an important component for employment generation.

With Construction of HEPs, project sites will be well connected by the roads and will create opportunities for tourism development and improve the socio-economic status. Figure. 5 depict the advantages of hydropower development in the study area.

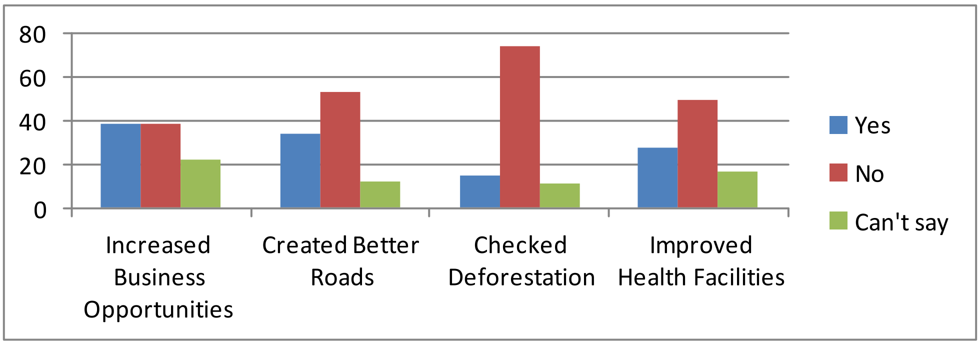

Fig.5. *Positive Impacts Perceived by the Respondents*

Views of the respondents reflected in Fig.6 revealed that there are some advantages of hydropower development in the area. About 38% of the respondents agreed that there is an increase in small scale business opportunities after the hydropower development in the area and 35% respondents feel that the condition of roads has improved after the construction of these hydropower projects. Apart from this during the field visit other related positive impacts of HEPs were observed in the study area. There was a growing market of vegetables, small scale cottage industries and improvement in transport facilities. Perhaps this may be the reason why some of the people are ready to live with negative implications of the projects. They believe that the development may further increase after the operationalization of the project.

1.10.2 Negative Impacts Perceived by the Respondents

Development of roads, dams and other constriction activities has followed a technocratic model that has failed the environment and the people. Local people are environmentally aware and more concerned about what is happening to their virgin environment (Lata et al., 2015). According to PRA and individual case studies the following negative impacts were noticed in the area.

1.10.2.1 Decline in Joint Family System

According to 46 % of the respondent, after coming up of the hydropower industry in the region, concept of nuclear families has increased from that of joint family (Fig.7). They stated that the old joint family system could benefit everyone. Not only do the children have to live and grow with their grandparents and cousins, they also learn the value of relationship. The joint family system inadvertently contributes to one's security, health and prosperity. During field visit one of the respondents stated that due to the land acquisition for the purpose of hydropower construction, the money they got as a compensation was distributed among his two sons. One of them utilized that money properly and other wasted it which created financial difference and was reflected in their relationships/behavior and shifted the joint family to nuclear family system. The feeling of insecurity that was not present earlier in a joint family system, where the unemployed, sick, aged and handicapped were well taken care of, arose rapidly.

1.10.2.2 Landlessness and Homelessness

63% of the respondents stated that the displacement due to HEP construction threatened people's livelihood and has resulted in conflicts between the locals and project operating agencies (Fig.7). According to them they were dependent on the land as a source of their livelihood. Initially in greed of money they sold out their land to project developers but later realized that money never lasts for long. Now, they were against these projects, have initiated many protests and filed cases in the police station and the courts.

1.10.2.3 Damage to Property

59% of the respondents were complaining about the cracks in their houses and adjoining fields. "Debris fall" was the common problem identified in the surveyed villages (Fig.7). They further stated that the construction of HEPs had damaged the village paths, local temples, rain shelters, cremation places and private *kuhls* (Water Channels), *pakdandies* (kuccha paths) restricting thereby the movement of pedestrians from one place to another and hence, separation of the communities. The muck deposition in the nearby ponds and *nallas* (Tributries) is another hazard that restricts the use of water for cattle and irrigation.

1.10.2.4 Socio-economic Inequalities and Social Disintegration

People who did not get the demanded compensation were not happy with the hydropower authorities and raised protests and movements whereas others who were in favor got gifts and employment either in the same project or at some different units of the company. Additionally, some were reluctant to share the negative effects of hydropower construction. Whether justified or not, 67% of the respondents believed that:

The hydropower projects are here to stay anyway, if they will complain about the project then Project operating agencies will stop funding for the community projects and then they will have only negative impacts but no benefits. The power operators had given compensation only to a few people. According to them they did not understand this discrimination as they all are directly or indirectly equal sufferers (Fig.7). According to them all the money for developmental activities goes into the pockets of middlemen. Mostly the villagers in the area are illiterate or less educated and hence they gets trapped by the lucrative offers made to them without giving a second thought about their future. No doubt the authorities are putting their efforts for their well being but no facilities were bestowed to them locally". The social disintegration has been induced due to the difference in the thought process and financial status of persons in the study area.

1.10.2.5 Problems Arising out of Cash Compensation

According to 52% of the respondents from the study area, at first they welcomed these projects as these projects were supposed to bring development in the area but so far they had seen only the negative impacts (Fig.7). Majority of respondents stated that they refused to accept the compensation as the assessment value for their land and property was much below the market rate. They said that they should also be assured of continuing their revenue and forest rights which they were enjoying being the owners of land. Though a few villagers had conditionally accepted the compensation, they said that they would not vacate their land and houses till they were given more money and alternative employment.

1.10.2.6 Deprivation of the Right on Natural Resources

39% of the respondents stated that earlier the local people used to go to the forest areas to collect herbs, timber, fodder (grass) and graze their sheep and cattle. The herbs worked as medicines for them and helped them fight many diseases. High altitude grasses are rich in proteins and minerals so they helped in more wool and milk production in livestock. Now the restricted entry to core and buffer zone of the area deprived them of their rights. Livestock had decreased due to these activities so has the wool and milk. Now they have started buying medicines and clothes from the market. Allopathic medicines did not suit many of them and therefore the mortality rate had gone up. The main culprits of these problems were hydropower construction and associated activities.

1.10.2.7 Cracks in Buildings

61% of the respondents believed that blasting and construction activities in the area accelerated the cracks in buildings and houses (Fig.7). Major hydropower activities prevalent in the surroundings of the projects caused environmental degradations mainly due to either infrastructural development or construction of project activities. The blasting is a frequent activity around hydropower project sites. As a result, it has considerable adverse impacts, such as noise pollution, slope destabilization, cracks in houses, muck generation and its unscientific dumping and dust generation. A larger number of the respondents stated that they had recently constructed their houses and shops, and they were not willing to re-habilitate themselves in other places. One of the women respondent responded with tears in her eyes that her family had spent more than thirty hundred thousand rupees (65.93 Indian rupees =1 US$) to construct the three-storey building. But the project authorities started to vacate her family. Villagers even do not know where to re-build their new houses to live in. Villagers did not know exactly the time to vacate the place. But when the time comes, they could do nothing and only refused to move out from the village.

According to 72% of the respondents, muck dumping without caring much was also one of the serious problems that became a cause of unrest among the local people. The siltation in river beds and downstream reservoirs was a common adverse feature of muck dumping. The muck or waste material from boring that dumped at the hill side could destroy the village in down slope regions due to sliding especially during rainy season. Villagers allegedly responded that the muck that was being extracted from the tunnels was dumped at the sites prone to various environmental degradations and also was not approved by the State Pollution Control Boards (SPCBs).Villagers alleged that the muck was dumped here and there without any approval of the concerned authorities (Fig. 6). This indiscriminate dumping of muck, according to the local villagers, had destroyed the patches of land which would make the land dried and water sources closed. As a result, growth and yield of crops in the terraced hill farming have started to decrease.

1.10.2.8 Law and Order

More than 30% of the respondents commented that the law and order had deteriorated as the police favours the project operating companies rather than the local communities (Fig.7) whereas 20.37% respondents were of the view that it was the same as before. They stated that they are living there since decades with their relatives and acquaintances but with project operating companies, people from more than 15 states have migrated to the study area which has increased the thefts and eve teasing in the area. Some employees were caught red handed carrying guns without license that has created a fear amongst us. Those who voluntarily sold their land for the projects haven't got the demanded compensation as yet.

Fig.6. *Disposal of Excavation/Construction material along Satluj River in the Study Area*

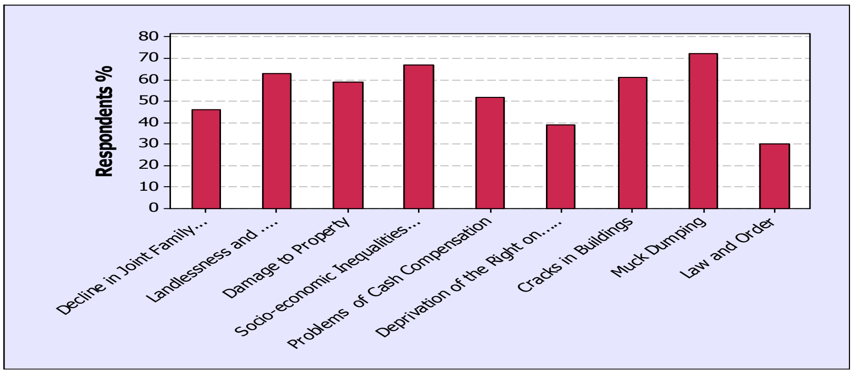

Fig.7. *Adverse Impacts Perceived by the Respondents*

Apart from this, majority of respondents stated that environmental conditions had deteriorated after initiation of hydropower projects in the area. It is noted that 68.51% respondent felt that environmental conditions of the area became worse after initiation of HEPs construction and only 11.11% respondents felt that it became better whereas 20.37% respondents said that there was no change in the environmental conditions. This may be attributed to lack of awareness among these respondents. Majority of respondents stated that the hydropower operation agencies in the area are not serious about degradation of environment and they are only completing the formalities by preparing and submitting the EIA reports for approval of projects from the government. Even after approval their work is not in accordance with the EIA reports for managing the environment. Only during inspection day's water sprinkling is done to suppress the dust due to construction activities (Fig.8). Attainment of sustainable development and conservation goals needs proper strategies for managing the whole landscape including both man and nature.

Fig.8. *Air Pollution due to Traffic, Road building and Tunneling Activities in the Study Area*

1.11Rating of Environmental Problems as Perceived by the Respondents

Environmental impacts observed in the study area varied from village to village. However, 97% of the respondents indicated landslides as one of the primary environmental problem (Fig.7.). In study area landslides occur generally in weak rocks or zones formed due to blasting for mining and road construction. The landslides seem to be governed by topography / slope / land use / geological structure / lithology or combination of these. These landslides have caused lot of destruction of life, property, road wreckages and blockage, drying up of springs and other natural water resources and other inconveniences to people. 92 % of the respondents rated erosion as second major environmental problem in the area under investigation. The factors contributing in the acceleration of the rate of erosion could be the removal of vegetation as part of increased construction activities and faulty farming practices. More than 88% of the respondents identified flooding as third common problem in the surveyed villages. The explanation given for the flooding could be geographical in character specially when the area is located in the downstream of the dams or reservoirs and when the spillway of the dam opens and closes some parts of nearby area becomes inundated and water logged for few hours to several days (Fig. 9).

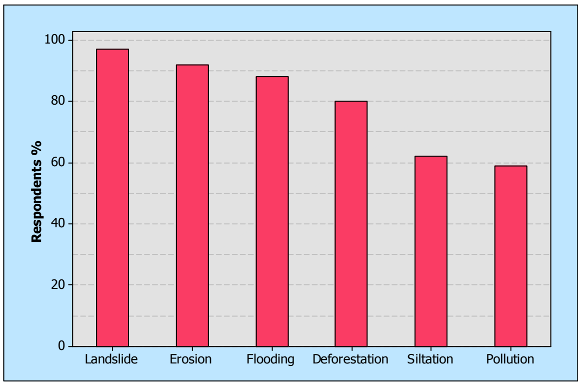

Fig. 9. *Major Environmental Problems Perceived by Respondents*

Fourthly, deforestation and siltation or the clearance of vegetation in general has been identified as one of the major environmental problems in the study area as per 80% and 62 % of the respondents respectively. The causes of deforestation are common across the globe. However, it is the extent that may vary from region to region. The most important factor worldwide as well as in the study area is the permanent conversions of forest to agricultural land, particularly slash and burn agriculture. Other causes of deforestation are increased population pressure, combined with poverty and landlessness with uncontrolled human settlement, lack of awareness of forest fires and demand for fuel wood. The consequences of deforestation are the acceleration of soil erosion, watershed and downstream problems of siltation. Lastly, more than 59% of the respondents identified the degradation of environment in terms of air pollution, noise pollution, dust generations, water contamination and land degradation as one of the major problem in the study area. According to the respondents, source of pollution is derived from the construction activities, domestic and agricultural wastes.

1.12 Conclusions

The implementation of hydropower projects has both positive and negative impacts. A sound environment may exist only within a sound mind and attitude of human beings. The results of the present study confirmed a lack of meaningful opportunities for public participation in the planning and assessment of the HEPs. Right from the inception of project, from planning phase to execution and afterward, natives were set-aside by executing agencies and the state/central government. The major criteria of ecologically grading projects need the level of sustainability with the association of local communities. It is not the only case where such types of deprivations are being faced by the inhabitants, similar situation in all development projects in India.
The policies should be framed to protect and conserve inhabitants and potential utilization of water resources. Before sanctioning any power project, World Commission on Dams recommendations must be taken into consideration, focused on four fundamental values viz., *equity*, *efficiency, participatory decision-making, sustainability and accountability*. The sustainable approach for hydropower project development lies in the good coordination among project proponents, political leaders, local population, non-government organization and researchers and developmental institutions. It is recommended that a state level interdisciplinary committee on hydropower should be constituted with eminent professional like basin planner, botanist, hydrologist, environmentalist, ecologist and socio-economic experts.

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