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Socio-economic Vulnerability and Environmental Implications of Major Hydropower Projects in District Kinnaur, Himachal Pradesh, India

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Abstract*:* *The Indian Himalayan Region (IHR) with its major river systems has vast potential for hydropower development. Recognizing this potential, the Government of India in its recent initiative for 50,000 MW power generation proposes to develop several hydropower projects formulated by Central Electricity Authority (CEA) for preparation of preliminary feasibility reports of 162 new hydroelectric schemes (47,930 MW) and out of these 162 schemes, 133 are in IHR because of the available water resources and favourable topography. No doubt hydropower projects have made an important contribution to local communities but such developments had significant impacts on local livelihood and the environment. Due to the fragile nature of topography and delicacy of ecology of the Himalaya, it results in a lot of disturbances because of high degree of human interferences like construction of major hydropower projects. The increased extent of geological hazards, such as landslides, rock fall and soil erosion, have mainly due to developmental interventions in the natural ecosystem. So understanding and analyzing such impacts of the hydropower projects have mainly been on the environment in various forms but natural hazards have been frequent ones. Present study, therefore, focuses mainly on the major hydropower projects in Kinnaur district of Himachal Pradesh. Based on the quessennaire survey of the local communities frequent natural hazards and resultant loss to the local communities due to upcoming construction of hydropower projects have been analyzed. There is an unfavourable perception and a negative attitude towards hydropower projects among the people of the study area. This is mainly because the local residents do not perceive any direct benefit in terms of employment opportunities or improvement in infrastructure rather they believe that these projects are damaging their social setup.*

Keywords: *Mountain Ecosystem, Hydropower, Natural Hazards, Environment, Landslides, Soil Erosion and Infrastructure.*

1. Introduction

India being a developing country has witnessed a rapidly growing energy needs owing to fast industrialization. Primary energy demands are met largely from conventional energy sources; coal, oil, natural gas and hydropower resources. Hydroelectricity represents a large-scale alternative to fossil fuel generation, contributing only very small amount to green house gas emissions and other atmospheric pollution. Hydropower is a renewable and sustainable energy source to meet global challenges (Frey and Linke, 2002) but developing the remaining hydroelectric potential in a sustainable way offers many challenges (Balsar, 2002). Information in detailed project reports based up on survey and investigations works for a potential site are not adequate and reliable at the time of actual implementation (Yogendra, 2000).

India is blessed with immense amount of hydroelectric potential. The demand for power is growing exponentially in accordance with the high level of developments on both infrastructure and social fronts. India, home of more than 1.2 billion (Census, 2011) accounting over 17% of the world's human population is moving towards unquenchable thirst for energy. India today is the fifth largest consumer of energy in the world, accounting for 3.7 % of the world consumption. Its total primary energy demand is expected to be almost double by 2030 (Kumar and Mohan, 2012). In the infrastructure sector the focus is on the progress in tele-communication, roads, airports and ports. On the social front the aim of providing reliable power has emerged as the main reason for increased focus on the power sector. Most of the hydropower potential of India lies in the Himalayan states which is supposed to be harnessed in favour of human development. These states have low industrial development and see their rivers and the hydropower potential "as the proverbial goose that lays the golden egg" (Mountains of Concrete: Dam building in Himalayas, 2008).

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Recently Himachal Pradesh, has been marked as the 'Power state' with a great 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 ≤ 5 MW capacities seem to have escaped the lens. However these small hydropower plants also influence the microclimate as well as spatial distribution of macro invertebrate of the project site and surrounding area of hydropower projects (Xiaocheng et al., 2008). Each dam site may have its own unique set of geologic and geotechnical challenges since the design requirements 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. Further the government of Himachal Pradesh to achieve optimal harnessing of the available potential and to identify new hydropower 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). Himachal government has taken several initiatives to encourage private sector participation in small hydroelectric 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 is 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 hydro projects (Sharma, et al. 2014). Living with the risk of natural hazards is part of everyday life in the Himalaya. Yet, when a disaster or a catastrophe does occur, it is often held up to scrutiny as if it were something unusual or unexpected. The Indian subcontinent has been prone to disasters of great scope for generations, and recent events such as the 1999 Orissa cyclone and the 2001 Gujarat earthquake, coupled with the ongoing floods, droughts and other hazards that are in fact common place, fuel a "disaster mentality" in the media and public conscience that extends to policy, bureaucratic, and scientific contexts (Parasuraman and Unnikrishnan, 2000). In the Himalaya and adjacent regions, evaluations of floods and other disasters often assert an increasing frequency of whatever process is involved and imply that this is related to the degradation, primarily deforestation, of the Himalayan environment.

2. District Wise Disaster Vulnerability of the State

Considering the proneness of the state towards different kinds of natural hazards, a broad district wise vulnerable status was devised for the state depending upon the vulnerability towards different hazards. Vulnerability matrix was developed based on the qualitative weightage which was given in the scale of 0-5 for different hazards such as earthquakes, landslides, avalanches, industrial hazards, construction type and density of population. District wise matrix was prepared by evaluating the risk severity (Fig.1). The evaluation also gives weightage to the density of population likely to be affected. The matrix also includes the evaluation of hazards likely to be induced on account of development of projects such as hydel projects, roads industries etc.

In case of earthquake vulnerability, the district Kangra, Hamirpur and Mandi falls in very high vulnerable category on the basis of the matrix devised. The districts which falls in high earthquake vulnerability are Chamba, Kullu, Kinnaur and part of Kangra and Shimla districts, where as the moderate and low vulnerable districts are Una, Bilaspur ,Sirmour and Solan,Shimla and Lahaul & Spiti districts respectively (Fig.1).

The landslide vulnerability in case of Chamba, Kullu, Kinnaur and part of Kangra and Shimla districts is high followed by Kangra, Mandi, Bilaspur, Shimla, Sirmour and Lahaul & Spiti districts falling in moderate vulnerable category. The areas falling in low vulnerable category are in the districts of Una, Hamirpur and Solan.

The avalanche hazard vulnerability map suggest that the districts of Lahaul & Spiti and Kinnaur are very high vulnerable followed by Chamba, Kullu and part of Kangra and Shimla as moderate vulnerable areas where as the remaining districts fall in the category where avalanche hazards are nil.

The flood hazard vulnerability map indicates that the areas falling in the districts of Chamba, Kullu ,Una and Kinnaur falls in high vulnerable districts where as the Lahaul & Spiti, Mandi, Shimla, Kangra, Hamirpur, Bilaspur, Solan and Sirmour falls in moderate and low vulnerability areas.

The overall vulnerability of the state on the basis of the matrix clearly suggests that the district Chamba, Kinnaur, Kullu and part of Kangra and Shimla falls in very high vulnerable risk. Similarly district Kangra, Mandi, Una ,Shimla and Lahaul & Spiti falls in high vulnerable risk status. District Hamirpur, Bilaspur, Solan and Sirmour falls in moderate vulnerable risk status (Fig.2). The disaster management strategies and infrastructure required to be evolved by taking the above factors into consideration.

District	Earthquake	Landslide	Floods	Avalanche	Forest Fire	Drought	Cloud Burst
Kangra	VH	L	M	M	H	H	M
Chamba	VH	VH	H	M	H	M	H
Hamirpur	H	L	L	-	VH	M	L
Mandi	VH	H	H	-	VH	M	H
Kullu	VH	VH	H	H	H	M	VH
Bilaspur	H	M	L	-	VH	M	L
Una	H	L	H	-	M	H	L
Sirmour	H	L	L	-	VH	M	M
Solan	H	M	L	-	M	M	L
Kinnaur	H	H	H	VH	M	M	VH
Lahaul & Spiti	M	M	M	VH	M	M	H
Shimla	VH	H	H	M	H	M	H

(Symbol: L= Low, M= Medium, H= High, VH= Very High)

***Fig.1** District wise Hazard threat in Himachal Pradesh (Source: after NIDM, 2013)*

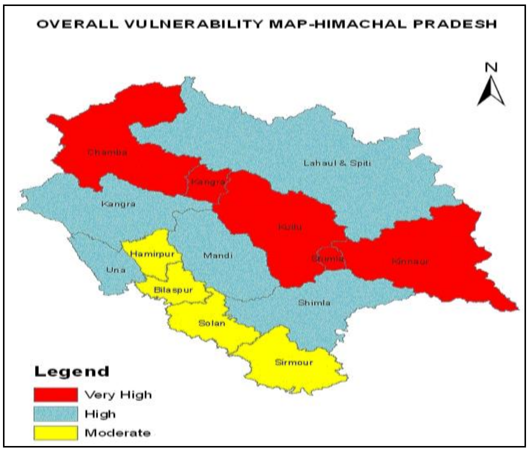

***Fig. 2** Overall Vulnerability Map of Himachal Pradesh (Source: http://www.hpsdma.nic.in/ProfileofState/CurrentStatus.html)*

3. General Description of the Study Area

Kinnaur district, entirely rural and located on the Indo-Tibetan border, is very scenic but less known district of Himachal Pradesh. 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.3). 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. The district is endowed with enchanting natural beauty in its picturesque snow-clad peaks, thick natural forests, meandering river courses through deep gorges, streams cascading down the hills with great fury, hanging ropeways across the rivers, alpine meadows, rare wild fauna, clear blue skies, high altitude lakes and rich cultural heritage of people, that give thrilling and memorable experience to trekkers and tourists from within and outside the country.

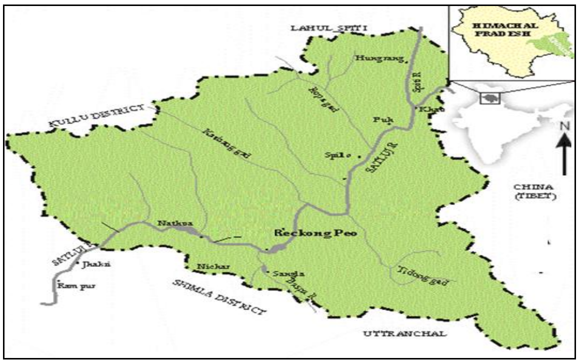

***Fig.3** Location of the Study Area District Kinnaur (Source: Himachal Pradesh Gazetteer, 2001)*

4. Geomorphological and geological set up

Geomorphologically, entire area depicts a highly rugged and unstable topography due to its high relief and active erosion processes. The relief along the valley slope varies between 1000 m and 4000 m. Two major peaks, the Leo Pargil (6790 m) in the northeast and the Kinner Kailsh (6050 m) in the south surrounds the area. Amongst the geomorphic processes, glacial and fluvial processes have played a dominant role in the terrain evolution in the past. Most of the processes currently operating in the area are denudational, but depositional processes also occur. Slopes in the area are generally steep, with angles greater than 40°. These mainly consist of barren rocks covered with scattered trees and bushes, however, at places, 5 ~ 10 m thick glacial and periglacial deposits are observed. In the lower reaches, the valley is 'V' shaped and terminates into a narrow gorge along the Satluj River. The gorge section is nearly vertical to subvertical and is about 200 ~ 300 m deep. Fluvial terraces, debris fans and talus cones are other geomorphic features present along the valley slopes. In the upper reaches, glaciers and snow-capped peaks are the prominent features.

Geologically, study area cuts across the entire Higher Himalayan sequence, and is made up of a thick succession of medium to high-grade metasediments belonging to the Wangtu Gneissic Complex, the Vaikrita Group and the Haimanta Group, and their sedimentary cover of Tethyan sequence. Near Akpa and Leo Pargil, these have been intruded by early Paleozoic and Tertiary leuco-granites, respectively. The geological setting of this part of the valley has been studied in detail by Sharma (1976), Sharma (1977), Tewari et al. (1978), Bassi and Chopra (1983), Kakkar (1988) and Gupta (1998). Apart from having a wide variation in lithology, the river valley has an extensive cover of glacial, glacio-fluvial, fluvial and paleo-slided material of Quaternary origin. These have been mapped earlier by Gupta et al. (1993).

5. Climate

The climate of Kinnaur is as varied as is the face of district. For reasons of peculiar geography and topography, a person may experience every change, from the heat of Torrid Zone almost too frozen temperature of Lapland winter‟. The climate of the valley is temperate with an extremely cold winter forcing the people of upper villagers to grow one crop in a year. Valley is fairly well wooded with deodars, blue pines, firs and silver birch in the higher zones. As a valley gets a fair amount of monsoon rains, it is very lush with grass and alpine pastures.

6. Methodology

A sample questionnaire was used to examine the perceptions of the local population about the major Hydropower Projects in the study area. Primary data were collected from 200 sampled households of the project affected areas on different aspects. 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.

7. Results and Discussion

The data was collected on various aspects of socio-economic profile of the villages located around 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., 2013). The universe of the study was 200 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, 40.

Base on questionnaire survey a checklist of impacts due to major HEP’s in the area was prepared (Table 1). A perception of respondents about the hydropower development in the area is given in Fig.4.

Table 1. *Checklist of the Impacts of Hydropower Projects in Kinnaur, Himachal Pradesh*

Sl. No.	Environmental Impacts	Impacts		No Change	Short Term	Long Term
		Positive	Negative			
A.	**Impacts due to Project Location**					
1	Displacement of People		✓			✓
2	Loss of Land/ Change in Landuse		✓			✓
3	Encroachment into forest land/ Loss of forest produce		✓			✓
4	Encroachment into Natural Reserves / Wildlife		✓			
5	Loss of Historical/Cultural Monuments			✓		
6	Loss of Infrastructure		✓			✓
7	Erosion and Silt Risk		✓		✓	
8	Disruption of Hydrological Balance		✓			✓
B.	**Impacts due to Project Construction**					
9	Soil Erosion at Construction Site		✓		✓	
10	Generation of Solid waste material		✓			✓
11	Transportation of Solid waste material and construction material		✓			✓
12	Deforestation		✓			✓
13	Human Health		✓			✓
14	Water Quality		✓		✓	
15	Air and Noise pollution		✓		✓	
C.	**Impacts due to Project Operation**					
16	Reservoir Evaporation Loss			✓		
17	Human Health		✓		✓	
18	Change in Water Quality		✓		✓	
19	Increase Incidences of Water Borne Diseases		✓			✓
20	Impact of Fish and Aquatic Life		✓		✓	
21	Effect on Wildlife		✓			✓
22	Drainage		✓			✓

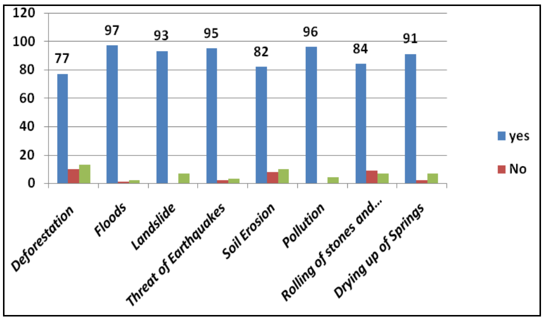

***Fig.4** Major Hazards Perceived by the Respondents in the Study Area*

Majority of the respondents from the study area observed natural hazards are increasing remarkably and environmental conditions had deteriorated after initiation of hydropower projects. There is an unfavourable perception and a negative attitude towards HEPs among the people of study area. All the respondents observed the severe environmental problems in almost all the villages, such as landslides, soil erosion, floods, threat of earthquakes, Deforestation, drying up of springs and cracks in the houses due to blasting in the region.

It is evident from the figure 4 that the majority of the local people perceived only negative impacts of the Hydropower development. In response to a query made on the occurrences of natural hazards observed in their surrounding area, the observation on the first ranking basis included more than 97% of the respondents rated flood as one of the major problems. Whereas, 96% of the respondents expressed acceleration in different types of pollution and 95% respondents felt increased threat of earthquakes after Hydropower development in the study area. While, 93% perceived increased risk of landslides, 91% drying up of springs, 82% soil erosion, 77% deforestation and 84% rolling stones and boulders are deteriorating environment and damaging their buildings & houses (Picture 1) due to road construction and blasting activities. It was a common belief of the people that as the works had kept up a pace, the degree of pollution would certainly increase in a larger extent which would be more dangerous to the natives as well as to the surrounding environment. According to these respondents, with the construction of large-scale Hydropower Projects in the fragile area, the flora and fauna and other negative impacts like displacement of people, acceleration of landslides, soil erosion and deforestation has increased. The sustainable development of the area is not possible, without maintaining a balance between development and conservation of natural resources.

***Picture 1.** Cracks and Crevices due to the Blasting and Construction of HEPs in the Region*

8. Solid Waste (Muck) Disposal

Construction of hydropower projects involves excavation for dam, roads, barrages, coffer dams, power houses and other auxiliary infrastructure generating large quantities of muck. While part of the muck is generally used by the project, excess muck is disposed off at designated sites. However muck disposed in an unscientific manner pose serious threat to biodiversity and local population.

The unscientific disposal of muck generated during the construction of hydropower projects causes social and environmental hazards in the area where it is dumped. For instance, loose muck increases the level of suspended particulate matter in the atmosphere causing serious health hazards and photo-retardation among the local population. Similarly, muck which leaches into the aquatic ecosystems increases the turbidity of water that has serious impact on the aquatic life due to change in water quality and reduction in the availability of light.

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. 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 (Picture 2). 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, the growth and yield of crops in the terraced hill farming would have started to decrease.

***Picture 2.** Disposal of Excavation/Construction material along Satluj River in the Study Area*

9. Conclusions

Natural and anthropogenic changes in the study area frequently cause redistribution in the catchments, which strongly, suddenly and dangerously affects processes of water circulation at the local or regional scale. Generally these changes are unforeseeable, unexpected and with hazardous consequences. Occurrence of landslides, floods, regional water redistribution and drying up of springs can be caused. Some of them are caused by natural processes, while others by humans. In the future it is realistic to expect new and greater human interventions in the study areas. All existing structures on the area were built with the same objective, i.e. to improve the water regime and the living conditions in the region. Past experience has shown that many of these works have been suboptimal. The benefit resulting in one area was frequently smaller than damage caused in another area. There is an unfavourable perception and a negative attitude towards HEPs among the people of the study area. This is mainly because the local residents do not perceive any direct benefit in terms of employment opportunities or improvement in infrastructure rather they believe that the projects may damage their social setup. On an average, the number of respondents who expressed favourable opinion about HEPs was only about 5%, whereas 85% opined in negation and 10% were neutral. A sound environment may exist only within a sound mind and attitude of human beings. A basic study of a project in an area needs to be carried out in an effective way only after being confirmed by public participations. The interest of the public also needs to be kept in mind as much as possible by the project authorities as well as Government. The sustainable approach on a way of hydropower project development lies in the fact that there should be a good coordination among project proponents, political leaders, communities, researchers and developmental institutions.

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