HYDRO POWER PROJECTS IN HIMACHAL PRADESH-
Review and Analysis of Impacts and Risks

A Thesis

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF TECHNOLOGY

IN

CIVIL ENGINEERING

With specialization in

ENVIRONMENTAL ENGINEERING

Under the supervision of

Dr. Veeresh S. Gali

(Professor)

By

Anamika Gandhi
(142757)

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT, SOLAN – 173234

HIMACHAL PRADESH, INDIA

June, 2016

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT

CERTIFICATE

This is to certify that the work which is being presented in the thesis title **"HYDRO POWER PROJECTS IN HIMACHAL PRADESH- Review and Analysis of Impacts and Risks"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "**Environmental Engineering**" and submitted to the Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat is an authentic record of work carried out by **Anamika Gandhi (142757)** during a period from July 2015 to June 2016 under the supervision of **Dr. Veeresh S. Gali** Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat. The matter enclosed here is not been submitted elsewhere for award of any degree or diploma.

The above statement made is correct to the best of my knowledge.

Date: - ………………………

…………………..	……………………	…………………..
Dr. Veeresh S. Gali	Dr. Ashok Kumar Gupta	External Examiner
Professor	Professor & Head of Department	
Department of Civil Engineering	Department of Civil Engineering	
JUIT Waknaghat	JUIT Waknaghat	

ACKNOWLEDGEMENT

I earnestly wish to express my heartfelt thanks and a sense of gratitude to my guide **'Dr. Veeresh S. Gali'** Professor, Civil Engineering Department, for his valuable guidance and constant inspiration in preparing this report. My frequent interactions with him in all aspects of the report writing have been a great learning experience for me.

I am thankful to **'Dr. Ashok Kumar Gupta'** Professor and Head of Department, Civil Engineering Department, Jaypee University of Information Technology, Waknaghat. I also express my sincere thanks to '**Dr. Rajiv Ganguly**' Associate Professor in Civil Engineering Department; for their inspiration and suggestions during the course of my study.

I am also thankful to the **'Directorate of Energy (DoE), Shimla'** Nodal Agency of Himachal Pradesh Government & **'Mr. Deepak Jasrotia'**, Sr. Ex. Engineer in DoE Shimla who provided me with the necessary information like DPR, EIA reports, data for Hydro Power Projects and gave their expert opinion on various infrastructures.

I am thankful to the project's staff that provided me with the necessary information and allows me to visit the projects. I also take this opportunity to thank the loving people who shared their views and helped in better understanding of the issues related to Hydro Projects.

My friends were always very helpful to me. They were always there for me whenever I needed their support. This study could not be completed without the blessings and support of my grandparents & parents who are always there for me.

Last but not the least, I heartily appreciate all those people who have helped me directly or indirectly in making these task a success. In this context, I would like to thank all the other staff members, both teaching and non-teaching.

ANAMIKA GANDHI

EE (142757)

ABSTRACT

The demand for electricity has increased in both developed and developing countries due to rapid growth in population and industrialization. To meet the increasing demand, conventional and renewable energy resources such as thermal energy, hydropower, solar energy, wind power, nuclear energy, coal etc. are exploited. There is a huge potential for hydropower generation in the state of Himachal Pradesh (HP). Out of the total identified hydropower potential of 27436 MW, around 87% is harness able. However, only 41% has been harnessed so far. Contemporary HPPs exist in different scales. They are classified into large (i.e., > 25 MW), small (i.e., 5-25 MW) and mini-micro (i.e., < 5 MW). HPPs might cause positive and/or negative impacts on environment i.e., river/stream, forests, animals, humans etc.

In the present study, impacts of 5 HPPs on different environmental factors were analyzed. One large (66 MW), two small (10 MW & 6MW) and two mini-micro (4.8 MW & 4.5 MW) HPPs were considered. Questionnaire was prepared and communicated to various experts including academicians, regulatory officials, environmentalists, project managers and local public affected by the projects. Major factors considered for evaluation of impacts included Air/ Noise, Land, Water, Biological and Human environment. Twenty-two sub factors were considered: air quality, noise levels, land forms and land use, seismology, geology, water quality and water resources, surface water hydrology, ground water hydrology, flooding, sedimentation, flora and fauna (terrestrial & aquatic), resettlement-relocation, accidental risk/human health, services/facilities, aesthetics, archeological/ cultural/ historical resources and economy.

Likert scale was used to quantitatively assess the negative impacts. Fuzzy logic approach was used to assess the risks. ANOVA was applied to compare the possible impacts; factors wise and project wise respectively. The negative impacts are scored between 0 – 4; 0 for no impact and 4 for extremely high impact. 1 and 2 correspond to low and medium impact. A Risk assessment was made due to the negative impacts on the overall environment. Risk index values ranged from 1 to 4. Risk index between 1- 1.5 is for low risk, 1.6 - 2.5 for medium risk, 2.6 - 3.5 for high risk and 3.6 - 4 for extremely high risk.

Based on the analysis of the results, it is found that there are no major significant negative impacts of HPPs on environment. Medium, low and no negative impacts were found. The results of risk assessment are showing that low to medium risks are identified. Medium risk is only in the case of large project. For small and mini-micro projects the value of risk is within low risk. However, the cumulative impacts of all HPPs (large, small, mini-micro) on total environment is also of low range i.e. 0.609~1.

Keywords: Hydro Power Projects, Negative impacts, Environmental Factors, Impact Analysis, Risk Assessment.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABBREVIATIONS

AHEC	Alternate Hydro Energy Centre
CO_2	Carbon dioxide
DO	Dissolved Oxygen
DoE	Directorate of Energy
DPR	Detailed Project Report
E	Degree of Error
E-Flow	Environmental – Flow
EIA	Environmental Impact Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environment Protection Act
FA	Fuzzy Assessment
FG	Fuzzy Grading
GHG	Green House Gases
H.P.	Himachal Pradesh
HEP	Hydro Electric Project
HPPCL	Himachal Pradesh Power Corporation Limited
HPPs	Hydro Power Projects
HPSEBL	Himachal Pradesh State Electricity Board Limited
I	Input Matrix
IFS	Indian Forest Service
IIT	Indian Institute of Technology
kW	Kilowatt
kWh	Kilowatt- hour
LUCP	Large Under Construction Project

MCP	Micro Commissioned Project
MD	Membership Degree
MNRE	Ministry of New and Renewable Energy
MoEF	Ministry of Environment and Forest
MUCP	Micro Under Construction Project
MW	Megawatt
NFS	Natural Flow Section
NIT	National Institute of Technology
R	Risk Index
RDS	Reduced Discharge Section
RI	Relative Importance
RoR	Run - of - River
SCP1	Small Commissioned Project 1
SCP2	Small Commissioned Project 2
SHPPs	Small Hydro Power Projects
SIA	Social Impact Assessment
SJVNL	Satluj Jal Vidyut Nigam Limit

1

CHAPTER

INTRODUCTION

1.1 GENERAL

Hydro Power Projects are constructed to use the water power to generate electricity. Power is derived from the energy of falling water or fast running water by converting its kinetic energy into mechanical energy, which is then further converted into electrical energy. In the ancient time the Hydro Power was used to grind flour & for other things. But later on it was used for the electricity generation. It is a renewable source of energy. Among all resources of electricity generation, HPPs are considered as very good resources because these projects cause very less harm to the environment than other conventional resources like thermal power, nuclear power, petrol and coal etc.

In the world the demand of electricity is increasing day by day both in developed and developing countries. The first power station or HPP having capacity of 12.5 were constructed near Niagara fall in 1882. Now many mini, micro, small and large HPPs has been constructed. In developing countries like India they play a vital role for enhancing the economy of nation and meet the power requirement. Moreover these HPPs also provide the facility for irrigation, flood control, water supply, fishery etc.

This rapid development of projects has both negative and positive impact on environment. Along with various benefits of projects some serious issues like dewatering of rivers, alteration in habitats, displacement of peoples, effects to terrestrial and aquatic plants or animals have been noticed.

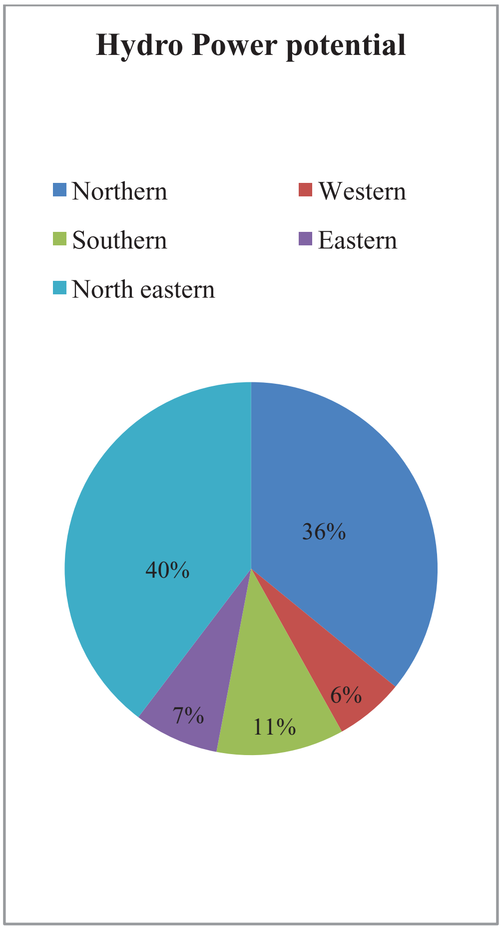
1.2 HYDRO POWER PROJECTS IN INDIA

The India has very good status of Hydro Power potential. Asia's First Hydro-electric Power station is located at the Shivanasamudra waterfall in year 1902. It was built in Karnataka on the bank of river Kaveri. India's first Hydro Power station is established in Darjeeling in 1998 having capacity of 130 kW, now there are number of HPPs in the India. The region wise Hydro Power potential of India is different which is given in Table 1.1. The table below does not consist of schemes below 3 MW up to March 2003 and after that up to 5MW under construction. In this identified capacity of Hydro Power in different region is further divided according to the various Hydro Power stages like developed capacity, capacity under construction, capacity yet to be developed.

Table 1.1: Region - wise break-up of Hydro Power potential in the country

Region	Identified Capacity (MW)	Capacity Developed (MW)	Capacity under construction (MW)	Capacity yet to be developed (MW)
Northern	53395	13771.9	6734	32889.1
Western	8928	5803.8	400	2724.2
Southern	16458	9394.8	786	6277.3
Eastern	10949	3049.4	2211	5688.7
North eastern	58971	1202.7	2724	55044.3
All India	148701	33222.5	12855	102623.5

(Source: Central Electricity Authority)



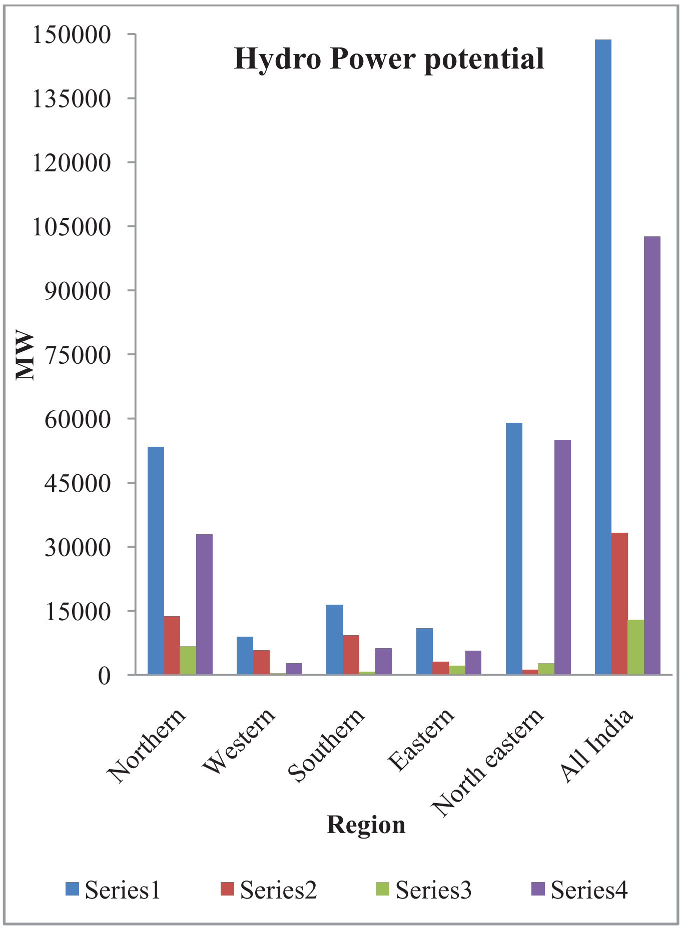


Figure 1.1: Hydro Power potential in India

From above Figure 1.1 it is clear that the maximum Hydro Power potential in India is of northern eastern region. In Western region of India Hydro potential is minimum. Also series 1, 2, 3, 4 in bar chart are for identified capacity, capacity developed, capacity under construction and capacity yet to be developed respectively. Also a Figure 1.1 show that the capacity developed is highest in northern region. Also Ministry of New and Renewable Energy (MNRE) categorize the hydro project into mini, micro, small and large. In India the classification of HPPs according to their Capacity is given in Table 1.2.

Table 1.2: Classification of Hydro Power Project in India

Sr. No.	**Scale**	**Capacity (MW)**
1	Micro	0.01- 0.1
2	Mini	0.1-5
3	Small	5-25
4	Large	>25

(Source: MNRE)

In India there are 29 States and each state have different number of projects and capacity of HPPs. Table 1.3 shows the list of HPPs in each state of India. In this the total no. of large Projects, their Capacity and total no. of small projects, their Capacity for different states in India are given. This shows that no. of large Projects is highest in Tamilnadu and maximum no. of small Projects is in Arunachal Pradesh.

Table 1.3: State - wise list of Large and Small Hydro Power Projects in India

STATE	**LARGE**		**SMALL**	
	NO. OF PROJECTS	**TOTAL CAPACITY(MW)**	**NO. OF PROJECTS**	**TOTAL CAPACITY(MW)**
PUNJAB	10	2376	234	390.02
HIMACHAL PRADESH	23	9459	547	2268.41
J&K	12	2692	246	1411.72
UTTRAKHAND	18	3332.15	458	1609.25
WEST BENGAL	8	1476.5	203	393.79

RAJASTHAN	4	411	67	63.17
GUJRAT	4	1990	292	196.97
MADHYA PRADESH	10	2395	99	400.58
CHATTISGARH	1	120	164	706.62
MAHARASHTRA	13	2887	253	762.58
ANDHRA PRADESH	15	4016.5	489	552.29
KARNATAKA	16	3666.2	128	643.16
KERALA	13	1881.5	247	708.10
TAMILNADU	27	2315.5	176	499.31
JHARKHAND	4	273.2	103	208.95
ORISSA	6	2027.5	222	295.47
SIKKIM	3	680	91	265.54
ASSAM	2	375	60	213.84
MEGHALAYA	8	995	102	229.81
MANIPUR	1	105	113	109.10
UTTAR PRADESH	4	502	220	292.16
ARUNACHAL PRADESH	2	1005	566	1333.04
NAGALAND	1	75	99	196.98
TRIPURA	1	15	13	46.86

(Source: MNRE)

The Hydro Power plants in India having large Capacity are shown in Plate 1.1. My area of concern for HPPs is Himachal Pradesh a state in Northern India. Its area is 55670 sq km and coordinates (Shimla): 31°6’12” N 77°10’20”E. So in Plate 1.1 three large Hydro Power plants in Himachal Pradesh are shown.

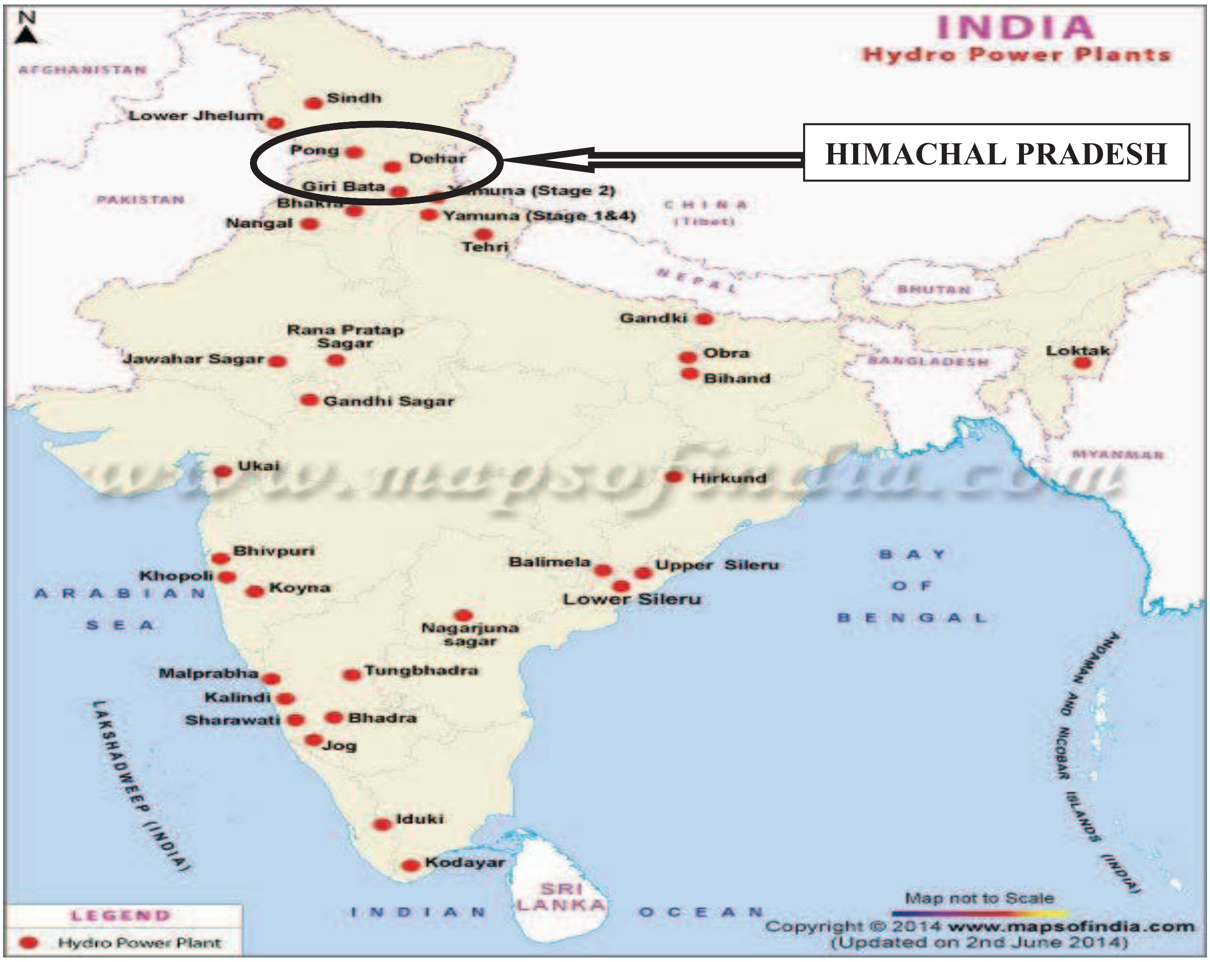


Plate 1.1: Hydro Power Plants in India
(Source: Maps of India.com, 2014)

1.3 HYDRO POWER PROJECTS IN HIMACHAL PRADESH

For study, the Hydro Power Projects at Himachal Pradesh, India are considered. The mountainous state i.e. Himachal is a in the western Himalayas. The drainage system of Himachal is both from rivers and glacier. In the total national Hydro Power potential the Himachal Pradesh contributes about 15.5% (Kumar and Katoch, 2014). In Himachal Pradesh the HPPs are categorized into 3 parts as shown in Table 1.4.

Table 1.4: Classifications of Hydro Power Projects in Himachal Pradesh

Sr. No.	Scale	Capacity (MW)
1	Mini & micro	up to 5
2	Renewable	5-25
3	Major	>25

(Source: Directorate of energy)

Hydro Power potential in Himachal Pradesh is shown in Table 1.5. In this potential is shown for different stages of HPPs. Plate 1.2 shows the River Basin wise Hydro Power potential in five main rivers of Himachal Pradesh. The Hydro Power potential of each river is given in it.

Table 1.5: Status of Hydro Power potential in Himachal Pradesh (in MW)

Total identified Hydro Power Potential	27436
Harness able Potential	±24000
Harnessed so far	10042
Foregone Potential	755
Construction Stage	2893
Clearances/Investigation Stage	7673
Allotment Stage	2500

(Source: Directorate of energy)

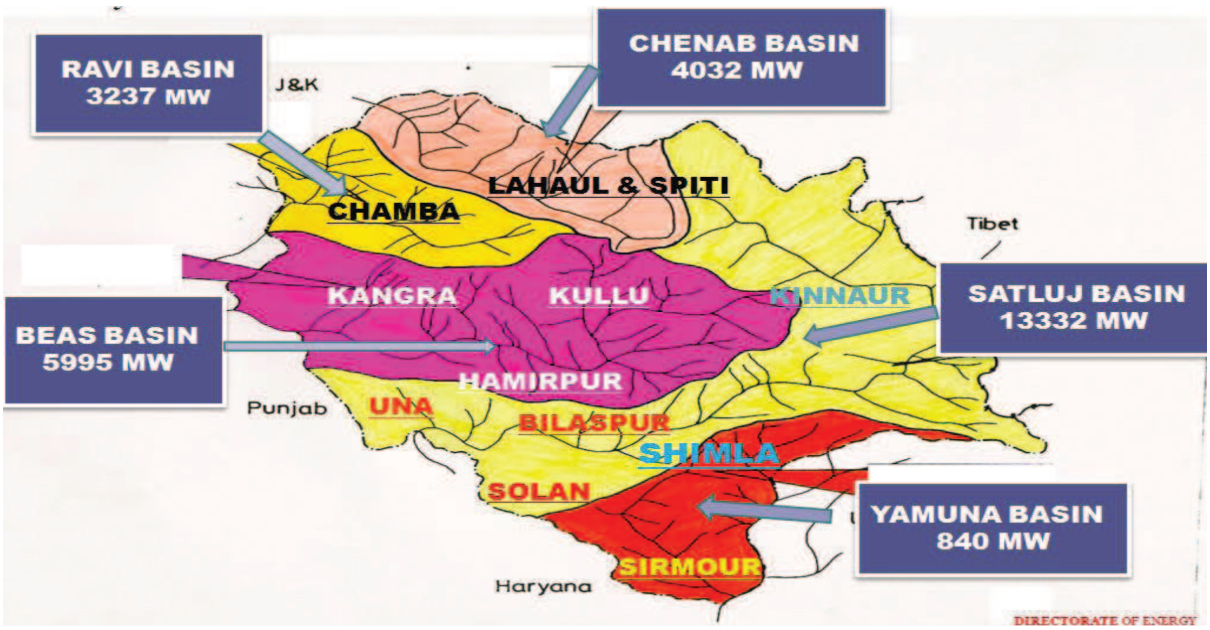


Plate 1.2: Basin - wise Hydro Power potential in Himachal Pradesh
(Source: Directorate of energy)

The HPPs in H.P. according to their capacity are given in Table1.6. In this Table numbers of projects according to their category are shown. Also number of project and capacity according to their stages like commissioned, under construction and at the stage of clearance and investigation are also given. So in Himachal Pradesh there are total mini micro HPPs identified are 679, small are 70 and large are 74. And total number of Hydro Power Projects in H.P. is 823 having total Capacity 21151.73 MW.

Table 1.6: Hydro Power Projects in Himachal Pradesh

Sr. No.	Category	Commissioned		Under Construction		At Various Stage of Clearance & Investigation		Grand Total	
		No. of Projects	Capacity in MW	No. of Projects	Capacity in MW	No. of Projects	Capacity in MW	No. of Projects	Capacity in MW
1	0 to 5 MW	90	283.72	41	148.65	548	1184.91	679	1617.28
2	5 to 25 MW	18	213.85	20	286.60	32	458.20	70	958.65
3	Above 25 MW	22	9577.73	12	2215.40	40	6623.50	74	18416.63
4	Yamuna Projects (Himachal Share)		131.57					0	131.57
	Ranjeet Sagar Dam (Himachal Share)		27.6					0	27.60
	Total	130	10234.47	73	2650.65	620	8266.61	823	21151.73

(Source: Directorate of energy)

The state of Himachal Pradesh is committed for the expeditious development of entire harness able potential available in the State by way of environmentally and socially sustainable Hydro Power Development in the State. During the development of the Hydro Power it is essential that the impacts on Environment be studied, accessed and mitigated accordingly. Because development and mitigation of the impacts are two processes, which should simultaneously go together for having a proper balance between development and destruction.

In this work the different case studies in Himachal Pradesh are taken for analysis of negative impacts and for the Risk assessment of projects for environmental factors, subjected to negative impacts of hydro power production. These case studies are taken from different location in H.P. The HPPs selected are of different scale i.e. mini-micro, small and large scale projects. The five HPPs are considered under study in which two mini-micro HPPs (one is under construction and another is commissioned), two small HPPs (both are commissioned), and one large HPPs (under construction).

1.4 NEED OF STUDY:

Hydro power projects help in the development of the nation's economic status but from past decade the impact of these on environment and society are arising. The activities like construction, operation etc. effects the environment both physically and biologically. The rapid development of hydro power projects is causing, the losses of vegetation, cultural values, agricultural land, change river flow pattern, resettlement, health problem, reduction of flow downstream, etc. So it becomes necessary to take steps to minimize or mitigate these issues so that hydro power projects become sound and sustainable energy source. For this it is necessary to find the factors which are influenced by project's activities, also the range of negative impact to know about the intensity of impacts.

1.5 HYDRO POWER PROJECT'S RESEARCH COMPONENTS

Different HPPs research components to be covered to analyse the impacts and assess the risks:

A. Air/Noise Environment
   a. Air/Climatology
   b. Noise
B. Land Environment
   a. Land form
   b. Land use
   c. Seismology
   d. Geology
C. Water Environment
   a. Water Quality
   b. Water resources
   c. Surface water hydrology
   d. Ground water hydrology
   e. Flooding
   f. Sedimentation
D. Biological Environment
   a. Terrestrial fauna
   b. Aquatic fauna

   c. Terrestrial flora
   d. Aquatic flora
E. Human Environment
   a. Relocation-Resettlement
   b. Accident risk/ Human health
   c. Community facilities/Services
   d. Aesthetics
   e. Archaeological/Cultural/Historical Resources
   f. Economy

1.6 OBJECTIVES

A. An analysis of major significant negative impacts of hydro power projects on environmental factors.
B. Risk assessment of hydropower projects for environmental factors subjected to detrimental impacts using Fuzzy Logic approach.
C. Comparison of impacts on various factors associated with mini-micro, small and large hydro power projects.

1.7 SCOPE OF STUDY

While there are both beneficial and adverse impacts of hydro power projects, of different magnitudes and significances, however in the present study only adverse impacts are considered. Scope of the study is limited to run off the river Hydro Power Projects. All the case studies under consideration are RoR. For impact analysis Likert scale and for risk assessment fuzzy logic approach is used.

1.8 CHAPTERIZATION

1 Chapter (Introduction): This chapter discusses the HPPs in India/Himachal Pradesh, need of study, research components, objectives and scope of study.

2 Chapter (Literature Review): In this chapter, a literature work related to Hydro Power projects impacts, summary of literature review and research gap identified are presented.

3 Chapter (Study Area): In this chapter the projects considered under study, with their scale, capacity, phase and location are given.

4 Chapter (Methodology): In this chapter the methods, approaches are discussed, used for the data collection, analysis and assessment of data.

5 Chapter (Results and Discussions): This chapter contains the data collection, data analysis, comparison between projects for their negative impacts on different factors /sub factors and the results of risk assessment.

6 Chapter (Conclusions and Future Scope): This chapter summarizes all impacts and risk factors findings and comparison results during the study along with future scope of work for different research components.

2
CHAPTER
LITERATURE REVIEW

2.1 GENERAL

This chapter deals with the brief idea of Hydro Power Projects' impacts on environment. Also the Research Review which have been referred during the study of projects. The research gaps have also been discussed.

2.2 RESEARCH PAPERS

Zang, J. et al. (2015), "Review on the externalities of hydropower: A comparison between large and Small Hydro Power Projects in Tibet based on the CO_2 equivalent." In this study the comparison between the impact of large hydro project and Small Hydro Power Project (SHPP) is done by relating them to GHG activity. In this the inventory is establish for hydropower development. According to this inventory the impact due to HPPs are classified in three categories – Civil Work, Reservoir Impoundment and Cumulative impacts. In this the author have find all the activities or impacts under these three classes and relate them with greenhouse gas activities and finally transformed into the CO_2 equivalent directly or indirectly. Total externality for HPP and carbon emission amount by various impact or externalities are calculated using equations. In this both direct and indirect emission, reduction and carbon neutral are found. The data required for calculation of externality are collected from statistical materials of the Water conservation bureau and the Tibetan Environmental Protection Bureau through personal communication. The amount of civil works per unit installed capacity for small HPP is remarkable large in results than the large HPPs. So the externalities of civil work for SHPP are higher than large HPP. But the externalities due to reservoir impoundment and cumulative impacts for small HPP are significantly less. Together with these three types the externalities for SHPP are significantly less than those for large HPPs. Hence it will make SHPPs better suitable for environment and having low carbon energy than large HPPs in Tibet. To meet huge hydroelectricity demand large HPP are essential. So to make balance between negative externality and positive ones due to large HPP it is suggested to increase the power density of project.

Sharma, A.K. et al. (2015), "Resource potential and development of SHPPs in Jammu and Kashmir in the western Himalayan region: India." In this study the hydro policies, environmental issues, social issues, economical issues and other challenges related to SHPPs in Jammu and Kashmir are discussed. Many researchers reported that small hydropower plant are more environment-friendly source of energy than large hydropower plant because for large hydropower plant big reservoir is constructed which affects large area and eco balance also. The river flow is less affected in case of small hydropower plants have less effect on surrounding and aquatic life. Small hydropower plants are more feasible in Himalayan regions and are more acceptable to the local because of small construction period, less displacement, less land requirement, less deforestation, less investment, job opportunities and power supply. Analysis is done on the basis of examination articles, reports, and other pertinent material on web. Only 16% of the identified potential is still exploited in Jammu and Kashmir. The development of small hydropower plant in Jammu and Kashmir is challenging due to social, economic and environmental factors. The environmental factor can be resolved by providing mitigation measure by concurrency the issues with environmental experts. Steps can be taken are like maintain minimum amount of water flow, disposal of excavated earth from construction of hydro project, use the excavated mud for construction purpose, E-flow arguments, guidelines for small hydropower project. EIA, EMP, SIA needed to be addressed for projects and mandatory EIA clearance rate before development of project. The more critical factors for delaying the projects development are objection certificate, other clearances, lack of facility, etc. These can be resolved by adopting simplified and time bound mechanism. Also Indus Valley Water Treaty Argument must be reviewed by both the country to minimize the adverse effects. To minimize the financial factors interested private parties can be attracted. Small hydropower plant development in Jammu and Kashmir will help to improving the socio-economic conduction of people of the state.

Wagner, B. et al. (2015), "A review of hydropower in Austria: Past, present and future Development." In this study an overview of the historical development of HPPs in Austria and its future economic and environmental challenges are given. Hydropower has provided electricity from many decades. The raped development had affected the environment and society so it leads to a prevention of a further development. Stricter guidelines and criteria for the construction and operation were developed which makes the new development more difficult. Then in 1980 and 1990 small hydropower plants are constructed on small and medium rivers. Run of Rivers (RoR) plants are high in no. than storage and pumped storage plants. The no. of small hydropower plants are more than the large one but 86.2% of annual generation is provided by large hydropower plants and 13.8% share is of small hydropower plants. Currently 5200 plant exist, it includes the projects which cover the national electricity needs and generate electricity for own consumption.

Kumar, D. et al. (2015), "Sustainability Suspense of Small Hydro Power Projects: A study from Western Himalayan region of India." SHPPs are generally considered as sustainable, green environment friendly. But there is suspense regarding their overall sustainability mainly in Himalayan regions. In these regions the SHPPs developed are generally run of the River so have less impacts. But due to lack of proper planning and monitoring they would cause long term socio- environmental impacts. This study presents the SHPPs development in Beas river basin of Himachal Pradesh (H.P.) in India. In this study 3 main objectives are covered. The first one is identifying the factors which affects the sustainability of SHPPs in Himalayan regions. For this three sustainability indicators are considered like Social, Environmental and Economic consideration. So results shows that the sustainability issues with respect to SHPPs are not small and SHPPs have been identified as main pressure point in sustainable development. The 2nd Objective is to undertake 5 SHPPs from Beas river basin of H.P. for case study. From 5, 2 Projects were in operation & 3 were in under construction stage. For research study of DPR of SHPPs under study, hydro power policies, newspapers, reports, extensive field study is done. The 3rd objective is to record the discussion with project developers. So the results show that there is lack of Project understanding and awareness about SHPPs and people. So there is need to educate the people regarding social and environmental development. Also design the SHPPs policies that truly sustainable SHPPs development scenario will emerge.

Kucukali, S. (2014), "Environmental risk assessment of Small Hydro Power plants: A case study for Tefen Small Hydro Power plant on Filyos River." In this study the Tefen Hydro Power plant on Filyos River was considered. This plant has been in operation in north western turkey since 2011. For risk assessment multi-criteria tool was used. The criteria used are environmental flow, water quality, fish passage and protection, watershed protection, threatened and endangered species. For study the field survey was conducted in 2011 to Tefen hydro power plant. In this study the adverse impacts of hydro power plant on the riparian environment, the river bed dried in the bypass reach, decrease flow velocity lead to decrease in dissolved oxygen (DO), change the morphology of river downstream, sediment transport characteristics, insufficient flow depth in fish passage.

Benejam, L.et al. (2014), "Ecological impacts of small hydropower plants on headwater stream fish: from individual to community effects." In this 16 SHPPs study is done. The study of fish population and habitat features on control and impacted reaches is done. It was found pressure of refuges for fish, poorer habitat quality, more pools and less riffles, shallower water levels are present and at control reaches higher fish abundance, large mean fish size and better fish condition are observed. To mitigate their impact on the fresh water biota and ecosystem services to achieve good ecological status. It is essential to apply environmental flow and other measures such as building effective fish passes. Also there is need to improve biological indices and monitoring programs.

Kumar, D. et al. (2014), "Sustainability Indicators for Run of the River (RoR) Hydropower Projects in Hydro rich regions of India." In this study related with the sustainability of RoR HPPs in hydro rich region of India where these RoR projects are being developed on a large scale. For this list of sustainability indicator has compiled, which helps the policy makers and designers to take decision while constructing RoR projects. RoR projects flood only small area, less interference with fish migration, less sedimentation, less costly than other. So it is generalized that RoR projects are fast and sustainable than the storage or reservoir based projects. Three aspects as economic consideration, social aspects and environmental consideration are combined to make a project overall sustainable. The assessment of sustainability of a HPP is done by using some indicators/ parameters. These indicators are called sustainability indicators. Sustainability indicators are classified into two ways:-

1). Basis of 'three pillar concept' of sustainability which include Social indicators, Environmental or Ecological indicators and Economic indicators.

2). Basis of measurability which include Quantitative indicators and Qualitative indicators.

For RoR HPPs the four main sources Literature review, Expert/Professional opinion, Site visits and Perception survey are considered in the selection of Sustainability indicators. Very little Literature is available related to Sustainability indicators for RoR Projects. In this study there are 49 Sustainability indicators for RoR Large and Small Projects from which 25 are Qualitative and 24 are Quantitative indicators. Suggested indicators for RoR Project may help in development of decision making tool. These are applicable for Hydro rich regions of India and Similar regions throughout the world.

Hennig, T. et al. (2013), "Review of Yunnan's hydropower development. Comparing small and large hydropower projects regarding their environmental implications and socio-economic consequences." In this study the current status of HPPs and their environmental and socio-economic consequences are analyzed. China is the world's fastest growing hydropower country having engineering and technical expertise. China is economically strong enough to develop large and expensive hydro projects. Yunnan is predicted as the hydro battery of china having the hydropower capacity more than Canada or United States in future. The main control on large hydropower development is of central and local government only minor role is of private sector. China is currently constructing most large hydro projects. The main drivers of SHPPs are local and private entrepreneurs. SHPP helps in socio-economic development of rural area. But now SHPPs cascade development causes serious direct and indirect consequences. The effected people argue that they cannot oppose SHPP development they are not allowed in options of decision making. SHPP are generally considered as environmentally sound renewable energy sources but the large no. of diversion type projects cause dewatered section for long stretches and cause cumulative environmental impact. It shows that SHPPs developments have weak environmental and institutional control. The cumulative biophysical impacts of SHPP are more than that of large hydropower project.

Kiber, K.M. et.al. (2013), "Cumulative biophysical impact of small and large hydropower development, Nu river China." This study is done to investigate the cumulative biophysical effects of small (<150MW) and large hydropower dam in china's Nu River basin. The research shows that the biophysical impacts of small hydropower may exceed those of large hydropower particularly in case of habitat and hydrologic change. Mean cumulative effect to habitat diversity, estimated as the number of riparian and terrestrial habitats affected is larger for small dams than for large dams by two orders of magnitude. The results indicate that small and large hydropower dams as defined by Chinese Hydro Project laws affect aquatic ecosystems in different ways. As diversity of habitats, influence to lands designated as conservation and biodiversity priorities, modification of hydrologic regimes and water quality. It was reported that greater cumulative effects for large dams related to total land inundation, potential sediment transport disruption and potential for reservoir induced seismicity. So study indicates that there is need to further and more rigorous investigation of the cumulative effects of SHP and cumulative effects of large Hydro Power Project and small

Hydro Power Project, so that to develop coupled water and energy policies that more accurately define and support low – impact Hydro Power development.

Zelenakova, M. et al. (2013), "Small Hydropower Plant Environmental Impact Assessment- Case Study." In this study the impact indicators are selected for the EIA of project. Hydropower Plant Project has many environmental impacts caused due to existing impossible or partially through migration barrier at the stream. Methodology used is assessment. For the assessment of impact on environment set of indicators are required. Risk assessment includes identification analysis and evaluation of risk. Risk assessment is based on multi criteria analysis since risk may cover wide range. In this study 16 key indicators are considered. For all this indicators 4 classes are defined based on literature studying, knowledge and experiences. So the risk is calculated by multiplying the all classes of indicators. Risk index or risk is also classified into acceptable, negligible, significant and considerable risk for EIA process. So a case study of SHPP is done and value of risk index is calculated which is inacceptable range. So by this study a methodology is proposed for risk rating and decision making process.

Bakken, T.H. et al. (2012), "Development of small verses large hydropower in Norway comparison of environmental impacts." In this study the comparison of small and large hydropower plant is done. The comparison of environmental impacts due to large hydropower plant and small hydropower plant is done by keeping the volume of energy produced by both is same. For comparison 3 large hydropower plants and 27 small hydropower plants are considered. From 3 large hydropower plants the average environmental impacts and 27 small hydropower plants the accumulated impacts of all are compared. To eliminate effect on impacts due to difference in topography, climate or type of ecosystem the plants are selected from same region with similar bio-geographical characteristics. The environmental impacts of plants are identified from EIAs reports. The least many important and most frequently reported impacts are prepared. The environmental factors are selected and then impacts of hydropower projects on these factors are categories varying from very large negative impact to very large positive impact. From the results is clear that large hydropower plants have fewer and slightly less adverse impacts than many small scale hydropower plants, having similar volume of energy production. The negative impact of large hydro development than SHPPs are mostly on water temperature, humidity and positive impacts are on natural resources fish recreation, soil erosion, sediment transportation, ice conditions/ local-climate. In other environment factors both large hydro projects and SHPPs have similar impacts.

Kucukali, S. (2011), "Risk assessment of river type hydropower plants by using fuzzy logic approach."In this study the fuzzy set concepts are used for the risk assessment of hydro power projects and expert judgments have been used instead of probabilistic reasoning. First by using the data from expert interviews, field studies and literature review the eleven classes of risk factors of project are determined. These factors were site geology, land use, environmental issues, grid connection, social acceptance, financial, natural hazards, laws and regulatory changes, terrorism, access to infrastructure, revenue. A survey was conducted to determine the relative importance of risk factors. For this 14 experience experts were participated. They were asked to grade the importance of risk factors between 1 to 4 where 1 represent low and 4 very high. The result shows that most concerned risk is site geology and environmental issues. Then risk index(R) value is calculated. The value of R lies in range 1.2 to 2.8 where R value between 1.2 to 1.6 indicate low risk, 1.6 to 2 indicates medium risk, 2 to 2.4 high risk and 2.4 to 2.8 on a real case hydropower project. This shows that the proposed methodology can be easily applied to quantify risk rating.

Baskaya, S. et al. (2011), "The Principal negative environmental impacts of small hydropower projects in Turkey." In this study the environmental impacts of SHPPs are find out. In recent years the construction of SHPP increasing, they may cause some environmental impacts at local and regional level. For study purpose 40 SHPPs are considered in which 4 in the operation, 22 under construction and 14 under evaluation stage. In these plants, major negative environmental effects which are globally recognized were harm to fish population, loss of aquatic habitat, significant change in natural flow regimes and deterioration of the landscape. The major problems in projects in which are in production phase are environmental flow, habitat deterioration, fish and wildlife passages rehabilitation and restoration, power lines, visual population, waste, dust and noise. 14 plants that are in the process of license application assessment are located in protected areas and ecotourism regions. It is clear that there would be serious problems due to the improper location and the design of the plants. Turkish governments have taken precautions for environmental issues but these are not adequate.

Saxena, P. et al. (2010), "Hydropower Development in India". In this study the current status of hydropower development in India is shown. Also the performance of SHPP stations is checked. Hydropower contributes 25% in the installed capacity of power generation i.e. 37066 MW from 146509 MW and share of small projects are 2820 MW. In 2008-2009 the electricity consumption was 733 kWh / person and which was expected 1000 kWh / power in year 2011-2012. The potential of SHPP is estimated at about 15384 MW in 5718 identified sites. Government of India has been encouraging private sector for hydropower construction. In 2008 the Government of India has provided to meet the needs of remote isolated areas. HPPs are classified according capacity.

Pico- 5 kW & Below
Micro- 100kW & Below
Mini-2000 kW & Below
Small- 28000 kW & Below
Medium- 100,000kW & Below
Large- above 100,000 kW

The MNRE decided that 2% of total grid power capacity should be from Small Hydro Projects which is 1400 MW in 2007-12. A target of increase capacity by 500 MW / year has been fixed. So it was realized that the Small Hydro Power helps in providing the solution for the problem of electricity in rural, hilly area & remote area. Also it is economical than grid system. These Projects provide other facilities like Education, Irrigation, Pumping or overall development of area. At AHEC IIT Roorkee laboratory of International level is being established for the testing, design and performance of project. Also series of Standards guidelines & manuals on Hydro project are issued both by International Organization & national statutory bodies.

Sharma, S.K. et al. (2009), "Site Suitability and Environmental Impact Assessment of Rampur Hydroelectric Project, Himachal Pradesh (India)." In this study the positive and negative impacts of river valley projects are discussed. The Dam construction cause severe damage to our environment so people oppose them. For the evaluation of environmental impacts the comparison of environmental quality during construction and operation phase of project is done. By MOEF under EPA, 1986 the impact assessment is done for such large projects comprehensive studies of impact like displacement of tribal people, biodiversity, wildlife, water logging & salinization, reservoir induced seismicity, sedimentation, hazards microclimatic changes and health is done. This study is done to prepare an EMP so as to minimize the negative impacts and to enhance positive impacts and for this sustainability of water resources projects is required. To make the sustainable project it is necessary to inform the public about benefits of dam construction and also provide mitigation for negative impacts. Small scale projects also help to solve this problem.

Sharma, M.P. (2007), "Environment Impacts of Small Hydro Power Projects". In this study the environmental impacts of Small Hydro Power Projects are discussed by considering the EIA of six Small Hydro Projects in the State of Uttarakhand. Small Hydro Power Projects are considered as clean and environmental friendly in nature. In this the author has discussed the advantages of Small Hydro Power, barriers in the development of Small Hydro Project, EIA process in India regulatory framework, EIA of Small Hydropower Projects, EMP. Impact of Small Hydro Projects on Ecological resources and human environment. The complete EIA process is explained in this study. EMP has been worked out with financial estimates to monitor the mitigation resources. The case study of six Small Hydro Projects in the state of Uttarakhand for EIA is done during pre construction phase, construction phase and operation phase. After study it is found that the negative environmental impacts of Small Hydro Projects are of low to medium range and positive impacts are on health and economy and are of high range. So it is concluded that Small Hydro Projects have no significant negative impact on surrounding environment.

Thoradeniya, B. et al. (2007), "Social and Environmental Impacts of a Mini-Hydro Project on the Ma Oya Basin in Sri Lanka." In this research the identification and qualification of social and environmental impacts of mini – hydro projects are studied. It is assumed that mini – Hydropower Projects have negligible negative social and environmental impacts, so in this case study of Ma Oya river basin in Sri Lanka are taken. So in this study the negative impacts & positive impacts found areas. The two most negative impacts were the disposal by tourists and filling of trees and the breach of promises made an employment, reconstruction of affected houses.

Pinho, P. et al. (2007), "The Quality of Portuguese Environmental Impact Studies: The case of Small Hydropower Projects." In this study is done to assess the quality of EIA studies carried out for Small Hydro Project in Portugal. In this one year research an extensive survey was carried out. This analysis of EIA report in EIA process of Small Hydro Project, under the old and the new national EIA legislation is done. The main aspects are described. The methodology for evaluation is EIA reports prepared for projects so that range of factors & condition that may influence the quality of EIA. The aim of this paper is not about significant impact out evaluation of EIA reports of Small Hydro Project. EIA reports of 13 Small Hydro Projects are considered. From these 7 are Run of the River and 5 are storage and 1 is multi objective project. For evaluation of EIA report design of the evaluation criteria from literature review is carried out 12 criteria are selected. The evaluation results shows that need to strengthen and improve the present EIA practice and also strengthen the rate of the EIA commissions.

Sinclair, A.J. ((2003), "Assessing the impacts of Micro – Hydro Development in the Kullu District, Himachal Pradesh, India." In this study the impact of micro hydro projects on environment are discussed. In Himachal Pradesh the consumption and exploitation of Hydropower potential rapidly exceed to meet the demand of power in nation. For the study purpose two projects were considered: - Kothi ((200 kW) and Solong (100 kW). Interviews of local peoples were conducted. Approximately 35 households for kothi and 20 for solong were participating in this and the results come were that the projects have little impact on the local environment. The projects cause mostly the trees due to Deforestation and affect the field crop due to blasting. In environment concerns issues found were loss and damage to trees, stream diversion, noise, lack of facilities of sewage for workers. The social issues like lack of public participation and positive affect were noticed.

Sinclair, A. J., (2000), "public involvement in environmental impact assessment: a case study of hydro development in Kullu District, Himachal Pradesh, India."In this study the change in the Environmental Protection Act in 1997 are discussed. At that time the procedure for public hearing is established as a component of EIA. The three cases of Kullu District are considered where the public hearing is done. The primary data collection methods were qualitative interviews, document reviews and participant observation. Result shows that the environmental impact assessment is in its nascent stages in Himalaya region in India. There is a failed record of EIA and public participation because the information available was found to be difficult to access and not user friendly. Hearing occurs at the operational level. No decision is made according to the conclusion comes from public hearing and had occurred prior to public hearing. There is hindrance in serious public involvement due to lack of education and environment awareness, lack of basic services such as school, hospitals, and etc. people concerns mainly related to the safety issues, socio-economic issues, and job opportunities and very little with the environmental impacts. Sometimes local people are aware and concerned about their environment but then due to lack of resources they do not participate in decision making process. In developing countries people have the time, willingness, organization and resources to participate. This is also possible in some parts of India but in high mountain rural areas extra steps must be taken to facilitate public participation.

Kubecka, J. et al. (1997), "Adverse ecological effects of small hydropower stations in the Czech Republic: Bypass Plants." In this study is carried out to find the adverse effect of Small Hydropower stations. For this 23 bypasses or mill stream type SHPs are selected and study of 4 locations if available for each Small hydropower plants is done. It was found that the most SHPs task a high percentage of the stream discharge i.e. turbine intake capacity was usually bigger than average yearly discharge of the stream at a given point. So abstraction of a significant proportion of the discharge decreases the flooded area of the Reduced Discharge Section (RDS). The effects of flow diversion on benthic and fish fauna are like the spring value of abundance of macrozoobenthas were slightly lower in RDS's than the natural flow section (NFS). This investigation is done in four Small Hydropower Projects. Also in diversity and biomass of macrozoobenthas especially in the spring is noticed. Also it was noticed that there is average individual weight and fish biomass decreased four times in RDS's. The decrease of average size of fish was recorded in 20 of 23 Small Hydropower Projects. So it was clear that the Small Hydropower Projects built on small streams causes more damage. So for this some investigation measures like maintain the minimum discharge in stream etc need to be legally imposed by which the negative impacts of Small Hydropower Projects would be reduced.

2.3 SUMMARY OF LITERATURE REVIEW

Current EIA system fails to address and mitigate the large impacts of dam building. To overcome these shortcomings it requires improving the project EIA.

Provide sound information to politicians, planners, public about environment and socio-economic implication.

Improve public involvement, extra steps to facilitate public participation.

In risk assessment of hydro power projects the most important risks are related to site-geology & environmental issues.

Single small hydro project when compared with large hydro project, then its environmental & social impacts are less than large one.

Many small hydro projects when compared with one or two large projects, then its impacts on environment and society are more than the impacts of large projects.

2.4 RESEARCH GAP IDENTIFIED

Till date the comparison was made between small and large hydro power projects and in the present study the comparison of mini-micro along with large and small hydro power projects will considered. In this study the fuzzy logic approach will be used for assessment of risks due to environmental factors. Risk assessment will be done for post project monitoring.

3

CHAPTER

STUDY AREA

3.1 PROJECTS UNDER CONSIDERATION

For this study six hydro power projects are considered and all are RoR. These projects are of different scales and are from different locations in Himachal Pradesh. The location of all projects in different districts of H.P. is shown in the Plate 3.1. In this the circle represents the mini-micro hydro power projects, triangle shows small hydro power projects and square represents the large hydro power projects. The dark symbols are for the projects which are commissioned or are on operation phase, light symbols are for projects which are still in under construction phase. The description about these projects is given in Table 3.1.

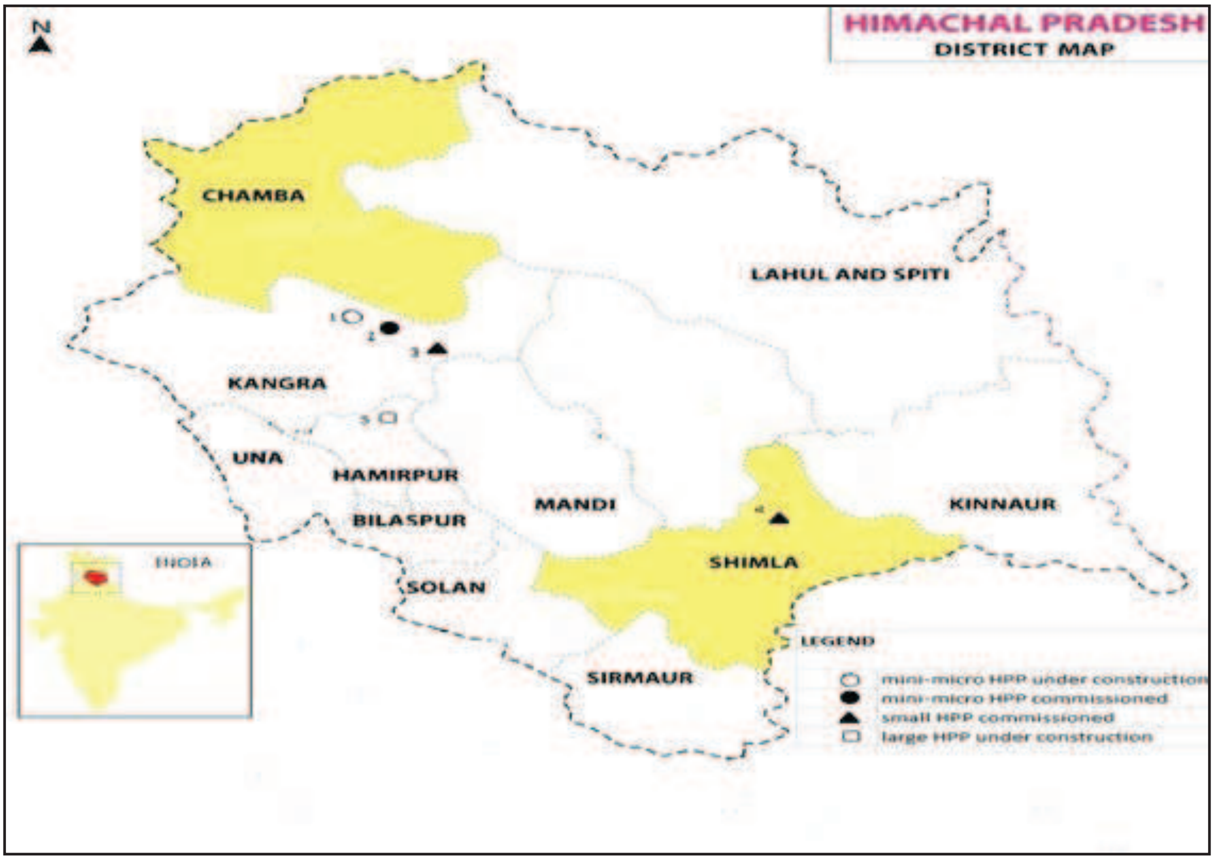


Plate 3.1: Run of River Hydro Power Projects in Himachal Pradesh considered under study

In this table the salient features like their name, scale, capacity, phase and river/stream of all projects with their location are given.

Table 3.1: Run of River HPPs in Himachal Pradesh under study

Sr. No.	Name of Project	Scale	Capacity	Phase	District	River/ Stream
1	Indira Priyadharshini Hydro Power Ltd. (Manuni-II)	Mini-Micro	4.8 MW	Under construction	Kangra	Manuni Tributary of River Beas
2	Dharamshala Hydro Power Ltd. (Maujhi)	Mini-Micro	4.5 MW	Commissioned	Kangra	Maujhi Tributary of River Beas
3	Podigy Hydro Power Pvt. Ltd. (Baner-II)	Small	6 MW	Commissioned	Kangra	Baner Khud Tributary of River Beas
4	Ganvi Stage- II	Small	10 MW	Commissioned	Shimla	Ganvi-Tributary of River Satluj
5	Dhaulasidh Hydro Electric Project	Large	66 MW	Under construction	Hamirpur	Beas

4

CHAPTER

METHODOLOGY

4.1 INTRODUCTION

This chapter deals with the methods and approaches used in this study to find the environmental factors subjected to major negative impacts of hydro power projects and risk assessment of projects respectively. Probability and non probability sample are two different ways to collect data but in the present study the 'non probability sample' method is used because only those people are considered who directly or indirectly deals with HPPs' environmental impacts. For impact analysis the Likert scale is used. The fuzzy logic approach is used for the risk assessment. Also for comparison between the projects, factors/sub factors the Anova is used. These methods and approaches have been discussed in detail and also the parameters incorporated have also been explained. Mainly there are five main environmental factors have considered i.e. Air/Noise, Land, Water, Biological and Human.

4.2 DETERMINATION OF ENVIRONMENTAL FACTORS

To identify the environmental factors which are influenced by the HPPs in Himachal Pradesh the study of EIA guidelines/reports, detail project reports of Hydro Projects, study of official reports (in which issues regarding Hydro Power Projects were discussed), study of reference books for EIA, study of literature given by various researchers have been studied.

4.3 QUESTIONNAIRE DESIGN

Questionnaire survey form has been prepared to get the response or to know the views of peoples who deal with environmental, social, economical impacts of HPP development (Canter, 1996). It is the most common method for the collection of quantitative data. In questionnaire five main environmental factors are considered for the risk assessment. Also there are 22 sub factors. These factors and sub factors are considered for two phases of HPPs, the one is during construction phase and another is during operational phase. I have divided the impacts into two classes, the one is negative impacts and the 2nd one is No impact. The negative impacts are further divided in to extreme high, high, medium and low negative impacts. These impacts are scored as extreme high-4, high-3, medium-2, low-1 and no impacts-0 score. In this study five projects of different scale are considered in which one large, two small and two are mini-micro.

Peoples who are considered for the feedback are experts (in this field), projects' staff and the peoples from the vicinity of HPPs. Questionnaire are sent to the experts through by mails and by hand, also in projects under consideration the personnel interview of projects managers/staff and of public residing near the projects are taken. The questionnaire for field visit is prepared both in English and Hindi. The questionnaire is in precise form for field visit than the questionnaire for experts. For localities or peoples near vicinity of HPPs (under consideration), the questionnaire is prepared in Hindi language so that local people can easily understand it and can give their feedback. The questionnaire for experts is given in Appendix-I and for project's managers/staff and for public feedback during field visit is given in Appendix -III and Appendix -IV respectively. Also the experts are further from various fields like Academicians, Regulatory officials, environmentalists as given in Appendix -II.

4.4 SURVEY FORM

The expert survey form for the selection of weights of each factor is given in Appendix-V. A survey form is prepared to find the relative importance of the 22 sub environmental factors. The results of relative importance are used for giving the weight age to these sub factors during the risk assessment. The experts are requested to give weightage to these factors normalized to a 1-5 scale depending upon their importance. Where 1 represent the very low importance and 5 represent the very high importance. Based on this data, analysis has been carried out with the help of Microsoft Excel.

4.5 PARAMETERS

In the study five main environmental factors and 22 sub factors are considered. They are defined in broad terms, and cover most major concerns of all individuals.

4.5.1 AIR/NOISE ENVIRONMENT

This physical factor of environment is further divided into air/climatology and noise. Both sub factors are discussed in brief respectively as follows:

- **Air/Climatology**

This factor is considered because during construction phase air pollution due to fuel combustion, activities like tunneling, crushing, excavation of the HEP channel, boring, blasting, movement of vehicles carrying construction material occurs. Also during operational phase the odour and gases or GHG due to biodegradation in water are produced. But the main air pollution occurs only in construction phase. Muck dumping in an area can also pollute the air of surrounding areas. Due to the impoundment of water the temperature and relative humidity also changes.

- **Noise**

This factor is considered because blasting can cause adverse impact on wildlife, especially along the alignment of the tunnel operation. Operation of equipment in construction activities can also have impact on noise level. Excessive Noise Pollution harms the people who work on HPPs.

4.5.2 LAND ENVIRONMENT

This physical factor of environment is consisting of land form, land use, seismology and geology. The HPPs cause alteration in the stability characteristics of land. All these sub factors are discussed as follow:

- **Land form**

This factor is considered to know about the changes in topography, stream channel, soil stability and on future use of site cause due to HPPs activities. The activities like excavation of tunnels, heavy blasting can have impact on stability of topography, surrounding area or embankment also cause disruption or displacement of soil and soil erosion. So HPPs can destruct, modify the unique physical features or future uses of sites on a long term basis.

- **Land Use**

This factor is considered because HPP construction increases the use of natural resources like forest land, agricultural land are used also land for dumping of muck is used. The surrounding land area is also used for temporary and permanent colonies for employs and workers of HPPs. This will deplete the natural resources also can change the crapping pattern.

Large quantity of muck is expected to be generated as a result of tunneling operations, roads construction and it has to be dumped and disposed off.

- **Seismology**

The factor is considered because the Himachal Pradesh state comes in higher seismic zone and this region has been affected with a number of strong earthquakes. Also HPPs can induce risk of earthquakes by creation of large water bodies and due to water pressure in reservoir.

- **Geology**

This factor is considered for risk assessment because it is very important to identify the existing surface and sub surface geological condition of sites which are selected for project construction and the surrounding of project area. If some serious geological defects are found in the site then they may cause difficulties.

4.5.3 WATER ENVIRONMENT

Water environment involves the water quality, water resources, surface water hydrology, ground water hydrology, flooding and sedimentation, described as:

- **Water Quality**

This factor is considered because in the working of HPPs is completely by water and the alteration in surface water quality, ground water quality, and downstream water quality can occur. This can be happened by the activities like impoundment of water, addition of human and animal toxic in water, decrease in dissolved Oxygen level of water.

- **Water Resources**

This factor is considered because the HPPs are constructed on water resources. So it causes impoundment, control or modify the water bodies. Due to impoundment water is also occurs due to evaporation. Other effects like variation in ground water table, decrease in flow of river, water usage for drinking, irrigation etc are caused by these projects.

- **Surface Water Hydrology**

It includes the drainage pattern, rate and amount of surface water runoff. HPPs development causes changes in drainage pattern of water, current or water movement in fresh water. It can also alter the rainfall or snowfall pattern of the areas where the projects have been developed.

- **Ground Water Hydrology**

This factor is considered because due to the impoundment or due to construction of weir/dam in river. The rate of infiltration of water to ground alters. The Hydro Power Project developments cause alteration of the direction and flow of ground water. It may also cause impact on existing ground water table.

- **Flooding**

HPPs can control the flood but its advantage is for downstream areas only, at upstream due to large water level the risk increases. So it is necessary to find the alteration caused to the course or flow of flood water and also exposure of people or properly to the water related hazards such as flooding.

- **Sedimentation**

Sedimentation process occurs in the HPPs when impoundment or reservoir is constructed. During the flood large sedimentation occurs in river, and important minerals get deposited in upstream causes the deficiency of necessary mineral at downstream.

4.5.4 BIOLOGICAL ENVIRONMENT

This biological factor of environment is further divided into terrestrial flora, aquatic flora, terrestrial fauna and aquatic fauna. All sub factors are discussed in brief as follows:

- **Terrestrial Flora**

The development of HPP can change the diversity and productivity of species. Also alters the number of any species of plants. Sometimes due to development some new species are introduced into area which affects the existing species.

- **Aquatic Flora**

Hydro Power Project alters the aquatic flora. To check whether the projects promotes or demote the growth of aquatic weeds such as Hyacinths.

- **Terrestrial Fauna/Animals**

Due to Hydro Power Projects new species of animals can introduced into the area which affects the movement migration of existing animals. Project can introduce disease vectors into the area due to hydrological changes. Due to project development harm to endangered species and habitats of animals can occurs.

- **Aquatic Animals**

Due to construction of weir/dam a barrier creates in the movement of migratory fishes and cause harm on fish habitats. Hydro Power Project can cause impact on micro organisms/bacteriological activities.

4.5.5 HUMAN ENVIRONMENT

Human environment involves the relocation-resettlement, accident risk/human health, community facilities/services, aesthetics, Archaeological, Cultural and Historical Resources, economy, described as:

- **Relocation-Resettlement**

This factor is considered because many times the residential area and land of people comes under the coverage area of Hydro Power Project development. Due to which the people have to relocate or resettle in new areas. Hence the Hydro Project alters the location or distribution of Human Population in the area.

- **Accident Risk/Human Health**

This factor is considered because Hydro Project development have Health and Accidental risk to the workers involved in construction activities and operational activities. In this the risk due to terrorism is also involved which effects the national security. Migrant workers in Hydro Power Project may also suffer from Psychological strain due to change in life style or working conditions.

- **Community Facilities/Services**

Hydro Project development can change the local and regional economic condition. The projects result in community facilities/services like hospitals, free medicines, road facility, electricity etc.

- **Aesthetics**

Due to development of Hydro Power Projects character or the visibility of the vicinity varies. Constructional activities destroy the natural beauty of surrounding areas.

- **Archaeological, Cultural and Historical Resources**

Hydro Power Projects can affect the cultural sites, structures. Project can affects the objects or building of historic significance.

- **Economy**

The Hydro Power Project development can alter the land value of the nearby area. Projects do have ability to change the socio – economical condition of people.

4.6 THE LIKERT SCALE

For the analysis of negative impacts for each sub factors the Likert scale/Rating scale has been used (Thodal, 2014). The example is provided here to know how this scale is used:

Factors/Sub Factors	Extreme high negative impact	High negative impact	Medium negative impact	Low negative impact	No negative impact
Air					
Noise					

Air is one sub factor here, like wise all 21 sub factors. Different people have different feedback for one particular sub factor. To get the average value of impact for all sub factors the formula has been used as:

$$\text{Final score/impact} = \frac{X_0S_0 + X_1S_1 + X_2S_2 + X_3S_3 + X_4S_4}{\text{Total}}$$

Where;

X_0, X_1, X_2, X_3, X_4 = number of responses for no, medium, high, extreme high negative impacts respectively.

S_0, S_1, S_2, S_3, S_4 = score for no, low, medium, high, extreme high negative impacts respectively.

4.7 FUZZY LOGIC APPROACH

To overcome the uncertainties and subjectivity in the processes of factors scoring, the Fuzzy logic approach has used (Ucar, 2004). In this study for the collection of total 28 responses has been done for each HPP. An evaluation criterion for all sub factors according to the scoring of impact is prepared (Kucukali, 2011). The risk evaluation of all projects has done based on this evaluation criteria presented in Appendix -VI.

For each 22 sub environmental factors, an input matrix of 1x5 is developed. Each column in the matrix is corresponding scores 0 to 5. If there is any risk sub factor which contains the score of 3 the input matrix (I) for that particular factor is:

$$I = [0 \quad 0 \quad 0 \quad 1 \quad 0] \qquad \text{(i)}$$

Where; I= input matrix/membership grading matrix.

Data acquisition method is known to a great extent to be subject to uncertainty and involves bias. The way the collection process and the group of experts invited to participate in the process cause uncertainty and bias in data (Bilal, 1998).

In this study 28 responses were collected and there was variation in the responses for all sub factors. The average score for each factor is found out by using Likert scale as explained earlier. We cannot ignore the responses which have alteration with the average score so for this the degree of error (E) in the assessment process has been considered.

So, if score for risk sub factor is 3 then after considering the error the following fuzzy grading matrix (FG) is formed:

$$FG = [E_0 \quad E_1 \quad E_2 \quad 1 \quad E_4]$$

Where; E_0, E_1, E_2, E_4= degree of error for responses having score 0,1,2,4 respectively.

Similarly for other scores,

$$FG = \text{Score} \left\{ \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \end{matrix} \right. \begin{pmatrix} 1 & E_1 & E_2 & E_3 & E_4 \\ E_0 & 1 & E_2 & E_3 & E_4 \\ E_0 & E_1 & 1 & E_3 & E_4 \\ E_0 & E_1 & E_2 & 1 & E_4 \\ E_0 & E_1 & E_2 & E_3 & 1 \end{pmatrix} \qquad \text{(ii)}$$

Where; FG = fuzzy grading matrix.

E_3= degree of error for responses having score 3.

The fuzzy assessment matrix (FA) is obtained by multiplying fuzzy grading matrix (FG) with weightage of sub factors (w). This weightage of all sub factors is calculated by analyzing the responses of survey form for relative importance filled by experts.

FA = FG x w

Let FA =

$$\begin{pmatrix} a1 & b1 & c1 & d1 & e1 \\ a2 & b2 & c2 & d2 & e2 \\ . & . & . & . & . \\ . & . & . & . & . \\ . & . & . & . & . \\ . & . & . & . & . \\ a22 & b22 & c22 & d22 & e22 \end{pmatrix} \quad \text{..................................(iii)}$$

The membership degree matrix (MD) is obtained by summing the all the rows resulting in a one single row matrix.

So, MD = [A B C D E]………………………….……………………...(iv)

Where; A = a1 + a2 + …… a22

B = b1 + b2 + …… b22

C = c1 + c2 + …… c22

D = d1 + d2 + …… d22

E = e1 + e2 + …… e22

Now the Risk Index (R) will be computed as;

$$R = \frac{1 \text{ x } A_{12} + 2 \text{ x } A_{23} + 3 \text{ x } A_{34} + 4 \text{ x } A_{45}}{A_T} \quad \text{...(v)}$$

Where ;

1, 2, 3, 4, 5 are membership degrees.

A_{12}: is the area under the curve between the membership degrees 1, 2 and is calculated as

$$A_{12} = \frac{A + B}{2}$$

A_{23}: is the area under the curve between the membership degrees 2, 3 and is calculated as

$$A_{23} = \frac{B + C}{2}$$

A_{34}: is the area under the curve between the membership degrees 3, 4 and is calculated as

$$A_{34} = \frac{C + D}{2}$$

A_{45}: is the area under the curve between the membership degrees 4, 5 and is calculated as

$$A_{45} = \frac{D + E}{2}$$

And $$A_T = A_{12} + A_{23} + A_{34} + A_{45}$$

4.8 ANOVA: TWO-FACTOR WITH REPLICATION

Two-way ANOVA analysis tool can be used when there are one measurement variable and two nominal variables. Each value of both nominal variables is in combination with each other (McDonald, 2014). Further it is of two types the one is two-factor with replication and another anova two-factors without replication. In this study anova: two-factor with replication is used for doing the comparison between mini-micro, small, large HPPs along with environmental factors/sub factors , on Microsoft excel. In the present study the measurement variable is negative impacts and nominal variables are sub environmental factors and HPPs along with 28 samples for all sub factors.

5

CHAPTER

RESULTS AND DISCUSSION

5.1 GENERAL

This chapter narrates the process of data collection through questionnaire, survey forms and covers the analysis of all collected data. During data collection, how the data are collected and from where to collect the data are discussed over here. There are three types of data collection. One is inventory data, in which we are collecting data from Government offices which already exist. And the other is field data, which we are getting from field by conducting a survey of individuals regarding various issues. Comparison for all the factors/ sub factors is given for each HPP.

5.2 SAMPLE DISTRIBUTION

Foe study purpose five HPPs are considered, in which two projects are mini-micro (one under construction and another commissioned) two small (both commissioned) and one large (under construction). Total 28 numbers of samples are collected for each HPP. In 28 samples 10 responses/samples are taken from experts (in this field), 3 from project's staff and 15 from localities people of the project under consideration.

5.3 RESULTS AND DISCUSSION

Collected data is analysed to get the results, to fulfill the objectives. First the analysis of the collected responses has been done to find the major significant negative impacts on any environmental factor for each HPP. Then these analysed impacts for each sub factor are used in the risk assessment process to find the risk, associated with these projects development. To find the relative impacts of projects in all factors/sub factors the comparison of analysed impacts is done.

5.3.1 ANALYSIS FOR MAJOR SIGNIFICANT NEGATIVE IMPACTS

An analysis of negative impacts is done by using Likert scale. In Table 5.1 the analysed negative impacts of each hydro power projects on sub environmental factors are given.

Table 5.1: Negative impacts of Hydro Power Projects on environmental factors

Sr. No.	Factors	Mini/Micro		Small		Large
		Construction Phase	Operation Phase	(1) Operation Phase	(2) Operation Phase	Construction Phase
1	Air/Climatology	1	0	0	1	1
2	Noise	1	1	1	1	1
3	Land form	0	0	0	1	1
4	Land use	1	0	1	1	1
5	Seismology	0	0	0	1	1
6	Geology	1	1	1	1	2
7	Water quality	1	0	0	0	1
8	Water resources	0	1	1	0	1
9	Surface water hydrology	0	1	1	0	1
10	Ground water hydrology	0	0	0	0	1
11	Flooding	0	0	0	0	1
12	Sedimentation	0	0	1	1	1
13	Flora/terrestrial	1	1	1	1	1
14	Aquatic flora	0	0	0	0	1
15	Fauna/terrestrial animals	1	1	0	1	1
16	Aquatic animals	0	1	1	0	1
17	Relocation-resettlement	0	0	0	0	1
18	Accident risk/human	0	0	0	0	1

	health					
19	Community facilities/services	0	0	0	0	1
20	Aesthetics	1	1	1	1	2
21	Archaeological cultural and historical resources	0	0	0	1	0
22	Economy	0	0	0	0	1

Where; 0= no negative impact of HPPs.

1= low negative impact of HPPs

2= medium negative impact of HPPs.

After analyzing the collected data it has been found that there is no major significant negative impact of any Hydro Power Project (under consideration) on any sub environmental factor. The no impact to low negative impacts has been found for mini-micro, small HPPs. In large HPP medium negative impact to no impact has been found.

5.3.2 RISK ASSESSMENT OF HYDRO POWER PROJECTS

5.3.2.1 Relative Importance

A survey is conducted with the experts having the experience and who deals with the Hydro Power Projects development and with their impacts on environment, social and economical factors. The number of environmental factors considered for survey are 22 and 37 experts have given their response to the survey form related to the importance of each factor with respect to other factors. The analysis of collected data form experts have been done to find the relative importance of each sub factor. The results of analysis have been used in the risk assessment of Hydro Power Projects for giving the weightage to the sub factors. The result comes out from the experts view is shown in Figure 5.1. After the analysis of responses it has cleared that the relative importance of geology, water resources and economy (sub environmental factors) is the higher than the other risk factors in case of hydro power projects development.

RELATIVE IMPORTANCE (RI)

NO. OF FACTORS = 22
SCALE= 1 to 5
NO. OF RESPONSE= 37

Sr.No.	FACTORS	RESPONSE																																								
	Factors	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15	R16	R17	R18	R19	R20	R21	R22	R23	R24	R25	R26	R27	R28	R29	R30	R31	R32	R33	R34	R35	R36	R37	SUM	Avg. Score	Relative Importance	RI
1	Air/Climatology	2	2	2	2	2	2	3	2	2	1	1	1	4	2	3	1	2	3	4	5	5	2	1	1	2	3	5	2	3	3	4	1	2	3	1	2	2	88	2.3783784	0.03343465	3.34
2	Noise	1	1	1	1	1	1	5	2	2	1	1	2	3	2	3	2	1	1	3	4	4	2	1	2	3	3	3	4	2	4	3	1	1	2	1	1	3	78	2.1081081	0.029635258	2.96
3	Land form	4	3	1	2	2	2	4	3	3	3	1	2	3	2	4	3	3	3	4	3	4	3	3	3	2	2	4	3	4	3	2	2	4	4	4	5	3	110	2.972973	0.041793313	4.18
4	Land use	2	2	1	3	2	3	4	4	4	4	2	2	3	5	5	3	5	4	4	4	4	3	3	4	3	3	5	2	2	2	2	2	2	5	2	4	2	116	3.1351351	0.044072948	4.41
5	Seismology	5	5	4	3	3	3	5	5	4	1	3	2	5	3	5	4	5	3	4	2	5	5	5	5	2	2	1	4	3	4	5	3	5	5	5	3	5	141	3.8108108	0.053571429	5.36
6	Geology	5	4	3	4	4	4	4	5	5	1	1	4	5	4	5	1	4	2	5	3	5	5	5	5	2	4	5	5	5	5	4	3	5	5	4	5	4	149	4.027027	0.056610942	5.66
7	Water quality	4	2	4	4	4	4	4	3	3	5	1	2	4	3	4	1	3	4	2	2	5	5	4	4	1	4	1	1	4	1	5	2	4	3	4	4	5	120	3.2432432	0.045592705	4.56
8	Water resources	5	3	5	5	5	5	4	5	5	4	5	3	3	2	4	5	3	2	4	5	5	5	5	5	1	4	3	1	5	2	4	2	5	4	5	5	5	148	4	0.056231003	5.62
9	Surface water hydrology	5	4	5	5	5	4	5	5	4	2	3	5	4	3	3	1	4	3	4	4	4	3	3	3	2	3	3	1	4	1	4	3	5	4	5	3	3	132	3.5675676	0.050151976	5.02
10	Ground water hydrology	5	1	4	2	2	4	5	2	2	3	1	3	3	3	3	1	3	3	3	4	3	2	2	2	2	2	3	3	4	3	4	2	5	2	4	2	2	104	2.8108108	0.039513678	3.95
11	Flooding	5	3	4	1	3	1	5	5	5	1	4	5	5	4	5	1	5	5	5	2	5	4	5	4	3	2	4	2	4	2	5	3	5	5	5	4	5	141	3.8108108	0.053571429	5.36
12	Sedimentation	3	4	4	4	4	4	4	4	4	5	5	5	5	3	4	3	4	2	5	1	5	5	5	5	2	2	2	3	3	3	4	3	3	5	4	5	4	140	3.7837838	0.053191489	5.32
13	TerrestrialFlora/plants	4	1	3	3	3	3	4	4	4	1	1	3	4	3	3	1	4	2	4	1	5	4	4	5	2	2	2	2	4	2	4	3	4	4	3	4	3	113	3.0540541	0.042933131	4.29
14	Aquatic flora	2	1	3	1	1	3	4	4	4	1	1	4	4	4	3	2	4	2	3	1	4	3	3	2	3	3	2	3	4	3	4	3	2	4	1	1	1	98	2.6486486	0.037234043	3.72
15	Terrestrial Fauna/animals	4	1	3	3	3	3	3	4	4	2	1	4	4	3	3	1	2	4	4	3	4	3	3	2	2	2	2	4	4	4	4	3	4	2	3	3	3	111	3	0.042173252	4.22
16	Aquatic animals	3	1	4	4	1	4	4	4	4	3	1	4	4	4	3	1	2	3	3	2	4	4	4	2	3	4	2	3	4	3	5	4	3	3	4	3	4	118	3.1891892	0.044832827	4.48
17	Relocation- resettlement	5	4	4	2	2	2	4	5	5	3	1	5	4	2	2	1	3	4	4	3	4	4	4	3	2	4	5	4	3	4	4	4	5	5	2	4	2	128	3.4594595	0.048632219	4.86
18	Accident risk/human health	5	3	3	1	1	1	5	3	3	1	1	4	5	2	4	1	3	5	5	4	5	5	4	4	3	4	5	2	4	2	5	2	5	4	3	1	1	119	3.2162162	0.045212766	4.52
19	Community Facilities/services	3	3	4	1	1	2	4	3	3	5	5	5	3	2	2	5	1	2	4	2	5	5	4	3	2	2	5	5	4	5	4	2	3	1	1	3	5	119	3.2162162	0.045212766	4.52
20	Aesthetics	3	2	5	4	4	4	3	1	1	5	5	5	3	2	2	5	2	1	2	2	5	3	3	5	3	3	5	4	3	4	3	3	3	2	4	1	2	117	3.1621622	0.044452888	4.45
21	Archaeological/cultural/historical resources	4	2	4	2	2	2	3	4	2	1	1	5	3	3	2	1	1	2	4	2	5	2	2	3	2	2	5	2	3	2	2	3	4	1	2	2	2	94	2.5405405	0.035714286	3.57
22	Economy	5	5	4	5	4	5	3	5	5	5	5	5	4	3	3	5	2	3	4	4	5	5	5	5	3	4	1	4	5	4	2	3	5	1	4	4	4	148	4	0.056231003	5.62
																																							Total Avg.	71.135135		

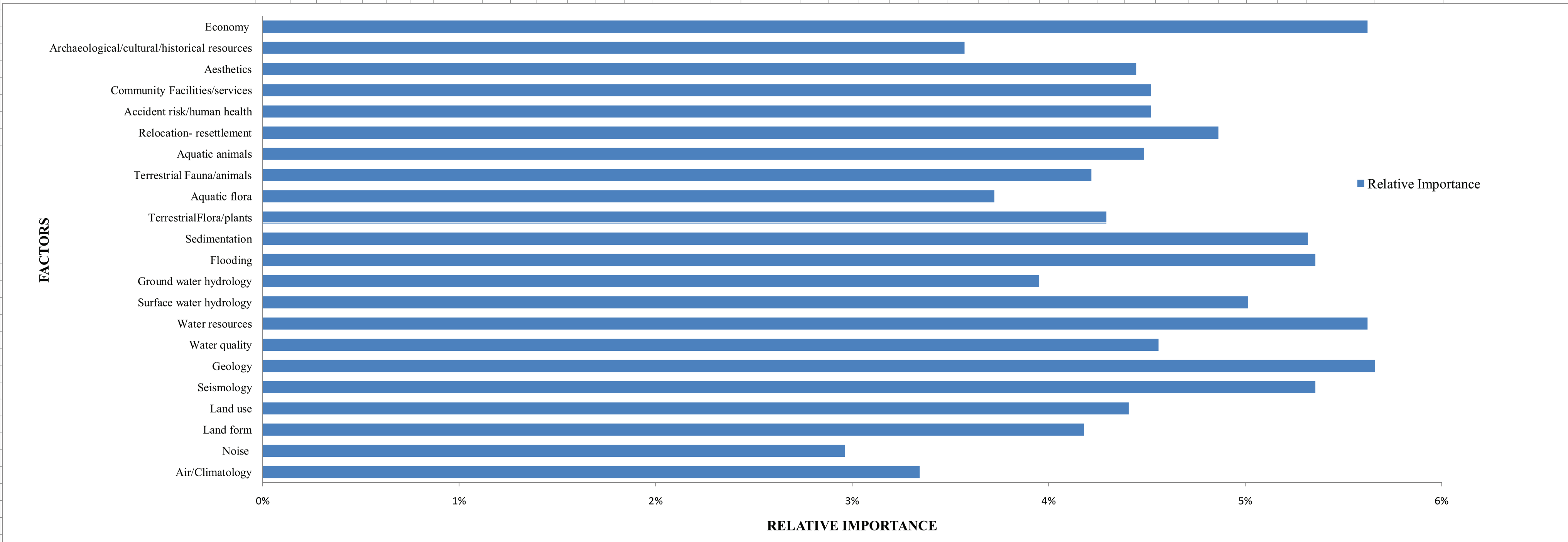


Figure 4.1: Relative Importance of Risk Factors

5.3.2.2 Micro HPP, Under Construction (MUCP)

NAME-	INDIRA PRIYADHARSHINI HYDRO POWER(P) Ltd. (MANUNI-II)	NO. OF FACTORS= 22	**SCORE:-**
INSTALLED CAPACITY-	4.8 MW	MAX. SCORE= 4	NO IMAPCT- 0
PHASE-	**UNDER CONSTRUCTION**	NO. OF RESPONSES= 28	LOW NEGATIVE IMPACT- 1
STATE-	HIMACHAL PRADESH		MEDIUM NEGATIVE IMPACT- 2
DISTRICT-	KANGRA		HIGH NEGATIVE IMPACT- 3
STREAM-	MANUNI		EXTREME HIGH NEGATIVE IMPACT- 4

Sr. No.	FACTORS	RESPONSES																												SUM	IMPACT	SCORE
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	D1	D2	D3	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15			
1	Air/Climatology	1	0	0	1	1	0	1	1	1	0	0	1	0	0	1	1	1	0	1	0	1	1	1	0	0	1	0	1	16	0.5714286	1
2	Noise	1	0	0	1	1	0	2	2	0	1	2	1	1	0	0	1	0	0	1	0	1	1	0	0	0	1	0	1	18	0.6428571	1
3	Land form	1	0	0	1	1	0	1	2	1	1	1	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	1	12	0.4285714	0
4	Land use	2	0	0	2	1	0	2	1	2	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	0	1	0	0	16	0.5714286	1
5	Seismology	1	0	0	2	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	7	0.25	0
6	Geology	2	1	0	1	1	0	2	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	0.9642857	1
7	Water quality	1	0	0	1	0	0	2	2	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	24	0.8571429	1
8	Water resources	1	1	0	1	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
9	Surface water hydrology	1	1	0	1	1	0	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.3214286	0
10	Ground water hydrology	1	0	0	2	1	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.3214286	0
11	Flooding	1	1	0	2	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.2857143	0
12	Sedimentation	1	1	0	2	1	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	10	0.3571429	0
13	Flora/ terrestrial plants	1	0	0	1	1	0	1	1	0	1	0	1	1	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	25	0.8928571	1
14	Aquatic flora	1	1	0	0	0	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	8	0.2857143	0
15	Fauna / terrestrial animals	1	0	0	1	0	0	1	1	0	1	0	0	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	18	0.6428571	1
16	Aquatic animals	1	1	0	0	1	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	10	0.3571429	0
17	Relocation- resettlement	0	1	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.1428571	0
18	Accident risk/ human health	0	0	0	0	1	0	1	2	0	0	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
19	Community Facilities/ services	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.1428571	0
20	Aesthetics	1	1	0	2	3	1	2	2	0	1	2	1	1	2	1	1	1	1	1	1	2	1	1	1	1	1	1	1	34	1.2142857	1
21	Archaeological cultural and historical resources	0	0	0	1	1	0	2	1	0	1	1	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	1	11	0.3928571	0
22	Economy	0	0	0	2	0	0	1	2	0	1	1	0	0	0	1	0	0	0	0	0	0	1	0	1	0	1	1	1	13	0.4642857	0

RISK ASSESSMENT

Sr. No.	FACTORS	SCORE	RI (w)	INPUT MATRIX (I)					FUZZY GRADING MATRIX (FG)					FUZZY ASSESSMENT MATRIX (FA)= (FG) * (w)				
1	Air/Climatology	1	0.033	0	1	0	0	0	0.4	1	0	0	0	0.013	0.033	0	0	0
2	Noise	1	0.03	0	1	0	0	0	0.5	1	0.1	0	0	0.015	0.03	0.003	0	0
3	Land form	0	0.042	1	0	0	0	0	1	0.4	0	0	0	0.042	0.017	0	0	0
4	Land use	1	0.044	0	1	0	0	0	0.6	1	0.1	0	0	0.026	0.044	0.004	0	0
5	Seismology	0	0.054	1	0	0	0	0	1	0.2	0	0	0	0.054	0.011	0	0	0
6	Geology	1	0.057	0	1	0	0	0	0.1	1	0	0	0	0.006	0.057	0	0	0
7	Water quality	1	0.046	0	1	0	0	0	0.2	1	0	0	0	0.009	0.046	0	0	0
8	Water resources	0	0.056	1	0	0	0	0	1	0.2	0	0	0	0.056	0.011	0	0	0
9	Surface water hydrology	0	0.05	1	0	0	0	0	1	0.3	0	0	0	0.05	0.015	0	0	0
10	Ground water hydrology	0	0.04	1	0	0	0	0	1	0.1	0.1	0	0	0.04	0.004	0.004	0	0
11	Flooding	0	0.054	1	0	0	0	0	1	0.1	0.1	0	0	0.054	0.005	0.005	0	0
12	Sedimentation	0	0.053	1	0	0	0	0	1	0.1	0.1	0	0	0.053	0.005	0.005	0	0
13	Flora/ terrestrial plants	1	0.043	0	1	0	0	0	0.2	1	0.1	0	0	0.009	0.043	0.004	0	0
14	Aquatic flora	0	0.037	1	0	0	0	0	1	0.2	0	0	0	0.037	0.007	0	0	0
15	Fauna / terrestrial animals	1	0.042	0	1	0	0	0	0.4	1	0	0	0	0.017	0.042	0	0	0
16	Aquatic animals	0	0.045	1	0	0	0	0	1	0.3	0	0	0	0.045	0.014	0	0	0
17	Relocation- resettlement	0	0.049	1	0	0	0	0	1	0.1	0	0	0	0.049	0.005	0	0	0
18	Accident risk/ human health	0	0.045	1	0	0	0	0	1	0.2	0	0	0	0.045	0.009	0	0	0
19	Community Facilities/ services	0	0.045	1	0	0	0	0	1	0.1	0	0	0	0.045	0.005	0	0	0
20	Aesthetics	1	0.044	0	1	0	0	0	0.1	1	0.2	0	0	0.004	0.044	0.009	0	0
21	Archaeological cultural and historical resources	0	0.035	1	0	0	0	0	1	0.3	0	0	0	0.035	0.011	0	0	0
22	Economy	0	0.056	1	0	0	0	0	1	0.3	0.1	0	0	0.056	0.017	0.006	0	0
									MEMBERSHIP DEGREE MATRIX				(MD)	0.76	0.474	0.041	0	0

RISK INDEX, R =	$[(1^* A_{12})+(2^* A_{23})+(3^* A_{34})+(4^* A_{45})] / A_T$			A_{12}	0.617
=	1.333221608			A_{23}	0.257
				A_{34}	0.02
Result-	Low Negative Impact	1-1.5	Low Risk	A_{45}	0
				A_T	0.895

5.3.2.3 Micro HPP, Commissioned (MCP)

NAME-	DHARAMSHALA HYDRO POWER Ltd. (MAUJHI)	NO. OF FACTORS=	22	**SCORE:-**	
INSTALLED CAPACITY-	4.5 MW	MAX. SCORE=	4	NO IMAPCT-	0
PHASE-	**COMMISSIONED**	NO. OF RESPONSES=	28	LOW NEGATIVE IMPACT-	1
STATE-	HIMACHAL PRADESH			MEDIUM NEGATIVE IMPACT-	2
DISTRICT-	KANGRA			HIGH NEGATIVE IMPACT-	3
STREAM-	MAUJHI			EXTREME HIGH NEGATIVE IMPACT-	4

RESPONSES

Sr. No.	FACTORS	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	D1	D2	D3	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	SUM	IMPACT	SCORE
1	Air/Climatology	1	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	6	0.214286	0
2	Noise	1	0	0	1	0	0	1	1	0	0	2	1	1	1	0	0	0	1	1	1	1	1	0	1	0	0	0	0	15	0.535714	1
3	Land form	1	0	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	7	0.25	0
4	Land use	1	0	0	0	1	0	1	1	1	0	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	10	0.357143	0
5	Seismology	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.035714	0
6	Geology	2	0	0	0	3	0	1	1	0	1	0	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	1	1	20	0.714286	1
7	Water quality	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	1	0	0	0	8	0.285714	0
8	Water resources	1	0	0	0	2	0	1	1	0	1	0	0	0	1	2	1	2	1	1	2	1	1	1	1	1	0	0	1	22	0.785714	1
9	Surface water hydrology	1	1	0	0	2	0	1	1	0	1	1	1	1	2	1	1	2	1	1	2	1	1	1	1	1	1	1	1	28	1	1
10	Ground water hydrology	1	0	0	0	1	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.214286	0
11	Flooding	1	0	0	0	3	0	1	2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0.357143	0
12	Sedimentation	0	1	0	1	4	0	1	2	0	1	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	12	0.428571	0
13	Flora/ terrestrial plants	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	0	1	1	1	14	0.5	1
14	Aquatic flora	1	1	0	0	1	0	1	2	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	9	0.321429	0
15	Fauna / terrestrial animals	1	0	0	0	1	0	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	18	0.642857	1
16	Aquatic animals	1	1	0	0	2	0	1	2	0	0	0	0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	21	0.75	1
17	Relocation- resettlement	0	0	0	0	2	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.178571	0
18	Accident risk/ human health	0	0	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0.107143	0
19	Community Facilities/ services	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0.071429	0
20	Aesthetics	1	1	0	1	1	1	1	1	0	0	1	1	0	1	0	1	1	1	0	1	1	1	1	1	0	0	0	0	18	0.642857	1
21	Archaeological cultural and historical resources	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0.035714	0
22	Economy	0	0	0	0	2	0	0	2	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	9	0.321429	0

RISK ASSESSMENT

Sr. No.	FACTORS	SCORE	RI (w)	INPUT MATRIX (I)					FUZZY GRADING MATRIX (FG)					FUZZY ASSESSMENT MATRIX (FA)= (FG)* (w)				
1	Air/Climatology	0	0.033	1	0	0	0	0	1	0.2	0	0	0	0.033	0.007	0	0	0
2	Noise	1	0.03	0	1	0	0	0	0.5	1	0	0	0	0.015	0.03	0	0	0
3	Land form	0	0.042	1	0	0	0	0	1	0.2	0	0	0	0.042	0.008	0	0	0
4	Land use	0	0.044	1	0	0	0	0	1	0.4	0	0	0	0.044	0.018	0	0	0
5	Seismology	0	0.054	1	0	0	0	0	1	0	0	0	0	0.054	0	0	0	0
6	Geology	1	0.057	0	1	0	0	0	0.4	1	0	0	0	0.023	0.057	0	0	0
7	Water quality	0	0.046	1	0	0	0	0	1	0.3	0	0	0	0.046	0.014	0	0	0
8	Water resources	1	0.056	0	1	0	0	0	0.4	1	0.1	0	0	0.022	0.056	0.006	0	0
9	Surface water hydrology	1	0.05	0	1	0	0	0	0.1	1	0.1	0	0	0.005	0.05	0.005	0	0
10	Ground water hydrology	0	0.04	1	0	0	0	0	1	0.1	0	0	0	0.04	0.004	0	0	0
11	Flooding	0	0.054	1	0	0	0	0	1	0.2	0	0	0	0.054	0.011	0	0	0
12	Sedimentation	0	0.053	1	0	0	0	0	1	0.2	0	0	0	0.053	0.011	0	0	0
13	Flora/ terrestrial plants	1	0.043	0	1	0	0	0	0.5	1	0	0	0	0.022	0.043	0	0	0
14	Aquatic flora	0	0.037	1	0	0	0	0	1	0.3	0	0	0	0.037	0.011	0	0	0
15	Fauna / terrestrial animals	1	0.042	0	1	0	0	0	0.4	1	0	0	0	0.017	0.042	0	0	0
16	Aquatic animals	1	0.045	0	1	0	0	0	0.3	1	0	0	0	0.014	0.045	0	0	0
17	Relocation- resettlement	0	0.049	1	0	0	0	0	1	0.1	0	0	0	0.049	0.005	0	0	0
18	Accident risk/ human health	0	0.045	1	0	0	0	0	1	0.1	0	0	0	0.045	0.005	0	0	0
19	Community Facilities/ services	0	0.045	1	0	0	0	0	1	0.1	0	0	0	0.045	0.005	0	0	0
20	Aesthetics	1	0.044	0	1	0	0	0	0.4	1	0	0	0	0.018	0.044	0	0	0
21	Archaeological cultural and historical resources	0	0.035	1	0	0	0	0	1	0	0	0	0	0.035	0	0	0	0
22	Economy	0	0.056	1	0	0	0	0	1	0.2	0.1	0	0	0.056	0.011	0.006	0	0
						MEMBERSHIP DEGREE MATRIX						(MD)	0.768	0.475	0.016	0	0
RISK INDEX, R =	$[(1^* A_{12})+(2^* A_{23})+(3^* A_{34})+(4^* A_{45})] / A_T$											A_{12}	0.621				
=	1.2992											A_{23}	0.246				
												A_{34}	0.008				
Result-	Low Negative Impact	1-1.5	Low Risk									A_{45}	0				
												A_T	0.875				

5.3.2.4 Small HPP 1, Commissioned (SCP1)

NAME-	PODIGY HYDRO POWER Pvt. Ltd. (BANER-II)	NO. OF FACTORS= 22	SCORE:-	
INSTALLED CAPACITY-	6 MW	MAX. SCORE= 4	NO IMAPCT-	0
PHASE-	**COMMISSIONED**	NO. OF RESPONSES= 28	LOW NEGATIVE IMPACT-	1
STATE-	HIMACHAL PRADESH		MEDIUM NEGATIVE IMPACT-	2
DISTRICT-	KANGRA		HIGH NEGATIVE IMPACT-	3
STREAM-	BANER KHUD		EXTREME HIGH NEGATIVE IMPACT-	4

Sr. No.	FACTORS	RESPONSES																														
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	D1	D2	D3	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	SUM	IMPACT	SCORE
1	Air/Climatology	0	0	0	1	0	0	1	1	0	2	1	1	1	0	0	1	1	0	0	0	1	0	0	0	0	1	1	0	13	0.464286	0
2	Noise	1	0	0	0	0	0	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	0	0	0	1	1	1	18	0.642857	1
3	Land form	1	0	0	1	2	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
4	Land use	1	0	0	2	1	0	1	1	1	1	1	1	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	1	21	0.75	1
5	Seismology	1	0	0	1	0	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.214286	0
6	Geology	2	1	0	3	3	0	1	1	2	2	0	0	1	1	0	1	1	1	1	1	1	1	1	0	1	1	1	1	29	1.035714	1
7	Water quality	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	1	0	11	0.392857	0
8	Water resources	1	0	1	2	2	0	1	0	1	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24	0.857143	1
9	Surface water hydrology	1	0	0	2	2	0	1	2	0	2	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	25	0.892857	1
10	Ground water hydrology	1	0	1	3	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0.357143	0
11	Flooding	0	0	0	2	4	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.321429	0
12	Sedimentation	0	0	0	3	4	1	1	2	0	2	0	0	0	0	0	1	0	0	0	1	1	0	0	0	0	0	1	0	17	0.607143	1
13	Flora/ terrestrial plants	1	0	1	0	0	0	1	0	0	1	0	0	1	0	0	1	1	0	1	1	1	1	0	0	1	1	1	0	14	0.5	1
14	Aquatic flora	0	0	1	0	1	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0.285714	0
15	Fauna / terrestrial animals	1	0	0	2	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	10	0.357143	0
16	Aquatic animals	1	0	0	3	2	0	1	1	0	2	0	0	0	0	0	1	1	1	1	0	0	1	0	0	1	1	1	1	19	0.678571	1
17	Relocation- resettlement	1	0	0	1	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.285714	0
18	Accident risk/ human health	0	0	0	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.178571	0
19	Community Facilities/ services	2	0	0	2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
20	Aesthetics	3	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	27	0.964286	1
21	Archaeological cultural and historical resources	1	0	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0.142857	0
22	Economy	0	0	0	3	2	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0

RISK ASSESSMENT

Sr. No.	FACTORS	SCORE	RI (w)	INPUT MATRIX (I)					FUZZY GRADING MATRIX (FG)					FUZZY ASSESSMENT MATRIX (FA)= (FG) * (w)				
1	Air/Climatology	0	0.033	1	0	0	0	0	1	0.4	0	0	0	0.033	0.013	0	0	0
2	Noise	1	0.03	0	1	0	0	0	0.4	1	0	0	0	0.012	0.03	0	0	0
3	Land form	0	0.042	1	0	0	0	0	1	0.2	0	0	0	0.042	0.008	0	0	0
4	Land use	1	0.044	0	1	0	0	0	0.3	1	0	0	0	0.013	0.044	0	0	0
5	Seismology	0	0.054	1	0	0	0	0	1	0.1	0	0	0	0.054	0.005	0	0	0
6	Geology	1	0.057	0	1	0	0	0	0.2	1	0.1	0.1	0	0.011	0.057	0.0057	0.006	0
7	Water quality	0	0.046	1	0	0	0	0	1	0.4	0	0	0	0.046	0.018	0	0	0
8	Water resources	1	0.056	0	1	0	0	0	0.2	1	0.1	0	0	0.011	0.056	0.0056	0	0
9	Surface water hydrology	1	0.05	0	1	0	0	0	0.3	1	0.1	0	0	0.015	0.05	0.005	0	0
10	Ground water hydrology	0	0.04	1	0	0	0	0	1	0.3	0	0	0	0.04	0.012	0	0	0
11	Flooding	0	0.054	1	0	0	0	0	1	0	0.1	0	0	0.054	0	0.0054	0	0
12	Sedimentation	1	0.053	0	1	0	0	0	0.6	1	0.1	0	0	0.032	0.053	0.0053	0	0
13	Flora/ terrestrial plants	1	0.043	0	1	0	0	0	0.5	1	0	0	0	0.022	0.043	0	0	0
14	Aquatic flora	0	0.037	1	0	0	0	0	1	0.2	0	0	0	0.037	0.007	0	0	0
15	Fauna / terrestrial animals	0	0.042	1	0	0	0	0	1	0.3	0	0	0	0.042	0.013	0	0	0
16	Aquatic animals	1	0.045	0	1	0	0	0	0.5	1	0.1	0	0	0.023	0.045	0.0045	0	0
17	Relocation- resettlement	0	0.049	1	0	0	0	0	1	0.1	0	0	0	0.049	0.005	0	0	0
18	Accident risk/ human health	0	0.045	1	0	0	0	0	1	0.1	0	0	0	0.045	0.005	0	0	0
19	Community Facilities/ services	0	0.045	1	0	0	0	0	1	0.1	0.1	0	0	0.045	0.005	0.0045	0	0
20	Aesthetics	1	0.044	0	1	0	0	0	0.1	1	0	0	0	0.004	0.044	0	0	0
21	Archaeological cultural and historical resources	0	0.035	1	0	0	0	0	1	0.1	0	0	0	0.035	0.004	0	0	0
22	Economy	0	0.056	1	0	0	0	0	1	0.1	0	0	0	0.056	0.006	0	0	0
									MEMBERSHIP DEGREE MATRIX				(MD)	0.721	0.522	0.036	0.006	0

A_{12}	0.622
A_{23}	0.279
A_{34}	0.021
A_{45}	0.003
A_T	0.925

RISK INDEX, R = $[(1^* A_{12})+ (2^* A_{23})+ (3^* A_{34})+ (4^* A_{45})] / A_T$

= 1.356316245

Result- Low Negative Impact 1-1.5 Low Risk

5.3.2.5 Small HPP 2, Commissioned (SCP2)

NAME-	GANVI STAGE- II	NO. OF FACTORS=	22
INSTALLED CAPACITY-	10 MW	MAX. SCORE=	4
PHASE-	**UNDER CONSTRUCTION**	NO. OF RESPONSES=	28
STATE-	HIMACHAL PRADESH		
DISTRICT-	SHIMLA		
STREAM-	GANVI- TRIBUTARY OF RIVER SATLUJ		

SCORE:-	
NO IMAPCT-	0
LOW NEGATIVE IMPACT-	1
MEDIUM NEGATIVE IMPACT-	2
HIGH NEGATIVE IMPACT-	3
EXTREME HIGH NEGATIVE IMPACT-	4

RESPONSES

Sr. No.	FACTORS	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	D1	D2	D3	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	SUM	IMPACT	SCORE
1	Air/Climatology	0	0	0	1	0	0	1	1	0	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	23	0.82143	1
2	Noise	1	0	0	0	0	0	1	1	0	1	2	2	1	1	2	1	2	2	1	2	2	1	1	1	1	2	2	1	31	1.10714	1
3	Land form	1	0	0	1	2	0	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	24	0.85714	1
4	Land use	1	0	0	2	1	0	1	1	1	1	1	1	0	1	1	1	1	0	0	0	1	0	1	1	1	0	1	1	20	0.71429	1
5	Seismology	1	0	0	1	0	0	1	1	0	2	1	0	0	1	1	1	1	0	0	0	0	0	0	1	1	0	1	0	14	0.5	1
6	Geology	2	1	0	3	3	0	1	1	2	2	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	31	1.10714	1
7	Water quality	0	0	0	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0.21429	0
8	Water resources	1	0	1	2	2	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	12	0.42857	0
9	Surface water hydrology	1	0	0	2	2	0	1	2	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0.42857	0
10	Ground water hydrology	1	0	1	3	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0.35714	0
11	Flooding	0	0	0	2	4	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.32143	0
12	Sedimentation	0	0	0	3	4	1	1	2	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	14	0.5	1
13	Flora/ terrestrial plants	1	0	1	0	0	0	1	0	0	1	1	1	0	1	0	1	1	1	0	0	1	1	1	1	1	1	0	0	16	0.57143	1
14	Aquatic flora	0	0	1	0	1	0	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
15	Fauna / terrestrial animals	1	0	0	2	1	0	1	1	0	1	0	1	0	1	0	1	1	1	1	0	1	1	1	1	1	1	1	0	20	0.71429	1
16	Aquatic animals	1	0	0	3	2	0	1	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0.35714	0
17	Relocation- resettlement	1	0	0	1	2	1	0	0	3	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	0.32143	0
18	Accident risk/ human health	0	0	0	2	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0.17857	0
19	Community Facilities/ services	2	0	0	2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.25	0
20	Aesthetics	3	1	1	1	1	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	1	1	1	1	1	1	1	1	19	0.67857	1
21	Archaeological cultural and historical resources	1	0	0	1	1	0	0	0	0	1	0	0	0	1	1	1	1	0	0	0	1	1	0	1	1	1	1	0	14	0.5	1
22	Economy	0	0	0	3	2	0	1	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	1	0	0	0	11	0.39286	0

RISK ASSESSMENT

Sr. No.	FACTORS	SCORE	RI (w)	INPUT MATRIX (I)					FUZZY GRADING MATRIX (FG)					FUZZY ASSESSMENT MATRIX (FA)= (FG)* (w)				
1	Air/Climatology	1	0.033	0	1	0	0	0	0.2	1	0	0	0	0.007	0.033	0	0	0
2	Noise	1	0.03	0	1	0	0	0	0.2	1	0.3	0	0	0.006	0.03	0.009	0	0
3	Land form	1	0.042	0	1	0	0	0	0.2	1	0.1	0	0	0.008	0.042	0.004	0	0
4	Land use	1	0.044	0	1	0	0	0	0.3	1	0	0	0	0.013	0.044	0	0	0
5	Seismology	1	0.054	0	1	0	0	0	0.5	1	0	0	0	0.027	0.054	0	0	0
6	Geology	1	0.057	0	1	0	0	0	0.1	1	0.1	0.1	0	0.006	0.057	0.006	0.006	0
7	Water quality	0	0.046	1	0	0	0	0	1	0.2	0	0	0	0.046	0.009	0	0	0
8	Water resources	0	0.056	1	0	0	0	0	1	0.3	0.1	0	0	0.056	0.017	0.006	0	0
9	Surface water hydrology	0	0.05	1	0	0	0	0	1	0.1	0.1	0	0	0.05	0.005	0.005	0	0
10	Ground water hydrology	0	0.04	1	0	0	0	0	1	0.3	0	0	0	0.04	0.012	0	0	0
11	Flooding	0	0.054	1	0	0	0	0	1	0	0.1	0	0	0.054	0	0.005	0	0
12	Sedimentation	1	0.053	0	1	0	0	0	0.8	1	0.1	0	0	0.042	0.053	0.005	0	0
13	Flora/ terrestrial plants	1	0.043	0	1	0	0	0	0.4	1	0	0	0	0.017	0.043	0	0	0
14	Aquatic flora	0	0.037	1	0	0	0	0	1	0.2	0	0	0	0.037	0.007	0	0	0
15	Fauna / terrestrial animals	1	0.042	0	1	0	0	0	0.3	1	0	0	0	0.013	0.042	0	0	0
16	Aquatic animals	0	0.045	1	0	0	0	0	1	0.1	0.1	0	0	0.045	0.005	0.005	0	0
17	Relocation- resettlement	0	0.049	1	0	0	0	0	1	0.1	0	0	0	0.049	0.005	0	0	0
18	Accident risk/ human health	0	0.045	1	0	0	0	0	1	0.1	0	0	0	0.045	0.005	0	0	0
19	Community Facilities/ services	0	0.045	1	0	0	0	0	1	0.1	0.1	0	0	0.045	0.005	0.005	0	0
20	Aesthetics	1	0.044	0	1	0	0	0	0.4	1	0	0	0	0.018	0.044	0	0	0
21	Archaeological cultural and historical resources	1	0.035	0	1	0	0	0	0.5	1	0	0	0	0.018	0.035	0	0	0
22	Economy	0	0.056	1	0	0	0	0	1	0.2	0	0	0	0.056	0.011	0	0	0
									MEMBERSHIP DEGREE MATRIX				(MD)	0.697	0.557	0.049	0.006	0

RISK INDEX, R =	[(1* A_{12})+ (2* A_{23})+ (3* A_{34})+ (4* A_{45})] / A_T			A_{12}	0.627
=	1.381624154			A_{23}	0.303
				A_{34}	0.027
Result-	Low Negative Impact	1-1.5	Low Risk	A_{45}	0.003
				A_T	0.961

5.3.2.6 LARGE HPP, UNDER CONSTRUCTION (LUCP)

NAME-	DHAULASIDH H.E. PROJECT	NO. OF FACTORS=	22
INSTALLED CAPACITY-	66 MW	MAX. SCORE=	4
PHASE-	**UNDER CONSTRUCTION**	NO. OF RESPONSES=	28
STATE-	HIMACHAL PRADESH	**SCORE:-**	
DISTRICT-	HAMIRPUR	NO IMAPCT-	0
STREAM/RIVER-	BEAS	LOW NEGATIVE IMPACT-	1
		MEDIUM NEGATIVE IMPACT-	2
		HIGH NEGATIVE IMPACT-	3
		EXTREME HIGH NEGATIVE IMPACT-	4

Sr. No.	**FACTORS**	**RESPONSES**																														
		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	D1	D2	D3	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	SUM	IMPACT	SCORE
1	Air/Climatology	1	0	0	1	1	1	1	3	1	1	3	2	2	0	2	2	1	2	2	1	2	2	2	2	1	2	2	2	42	1.5	2
2	Noise	1	0	1	1	2	2	2	3	0	4	2	1	2	0	1	0	0	0	1	0	1	0	0	0	1	0	1	1	27	0.964286	1
3	Land form	1	1	0	1	2	1	1	2	1	3	2	2	3	0	2	2	1	1	1	0	1	2	0	1	1	1	2	1	36	1.285714	1
4	Land use	1	1	0	2	2	1	1	2	2	4	1	2	0	0	1	2	1	1	1	0	1	2	1	1	2	1	2	1	36	1.285714	1
5	Seismology	0	1	0	3	0	1	1	2	0	4	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0.642857	1
6	Geology	3	2	0	2	1	2	2	3	2	4	2	2	0	1	1	1	1	1	1	1	2	1	1	1	1	1	1	2	42	1.5	2
7	Water quality	0	1	0	1	0	1	1	2	0	2	2	1	1	0	1	1	0	2	1	0	1	3	2	1	1	1	0	1	27	0.964286	1
8	Water resources	0	1	0	1	1	1	2	2	0	2	2	2	2	0	2	1	2	1	2	0	2	2	2	0	2	2	1	3	38	1.357143	1
9	Surface water hydrology	0	1	0	1	1	1	1	2	1	3	2	2	0	0	1	1	2	1	1	0	1	1	1	1	1	1	1	2	30	1.071429	1
10	Ground water hydrology	1	0	1	2	1	2	2	4	0	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0.785714	1
11	Flooding	1	1	0	2	0	1	0	3	0	3	0	3	0	0	2	0	1	0	2	0	1	2	0	1	1	2	1	1	28	1	1
12	Sedimentation	0	2	0	3	1	3	1	3	0	2	1	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	21	0.75	1
13	Flora/ terrestrial plants	1	0	1	1	1	1	1	2	1	3	1	1	0	0	2	2	1	2	2	1	1	1	1	1	2	1	2	2	35	1.25	1
14	Aquatic flora	1	1	1	0	0	0	0	2	3	4	3	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	19	0.678571	1
15	Fauna / terrestrial animals	0	1	1	1	0	1	1	2	1	2	1	1	1	0	1	1	0	1	1	0	0	1	1	1	1	0	0	1	22	0.785714	1
16	Aquatic animals	1	1	1	0	0	2	1	2	1	4	3	2	2	0	1	1	1	2	1	0	0	1	1	1	0	1	0	1	31	1.107143	1
17	Relocation- resettlement	3	1	1	1	1	0	0	4	3	4	0	2	1	0	1	2	0	1	2	0	0	2	0	0	1	0	0	1	31	1.107143	1
18	Accident risk/ human health	1	0	0	0	0	2	1	3	0	4	1	1	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	16	0.571429	1
19	Community Facilities/ services	1	2	0	2	1	1	0	2	0	1	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0.571429	1
20	Aesthetics	1	1	0	3	3	1	1	3	2	3	0	4	0	0	2	1	1	2	3	1	2	2	2	2	2	1	2	1	46	1.642857	2
21	Archaeological cultural and historical resources	0	0	0	1	0	2	0	2	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0.285714	0
22	Economy	2	2	0	2	0	2	1	3	0	3	3	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25	0.892857	1

RISK ASSESSMENT

Sr. No.	**FACTORS**	SCORE	RI (w)	INPUT MATRIX (I)					FUZZY GRADING MATRIX (FG)					FUZZY ASSESSMENT MATRIX (FA)= (FG)* (w)				
1	Air/Climatology	2	0.033	0	0	1	0	0	0.1	0.4	1	0	0	0.0033	0.0132	0.033	0	0
2	Noise	1	0.03	0	1	0	0	0	0.4	1	0.2	0	0	0.012	0.03	0.006	0	0
3	Land form	1	0.042	0	1	0	0	0	0.1	1	0.3	0.1	0	0.0042	0.042	0.0126	0.0042	0
4	Land use	1	0.044	0	1	0	0	0	0.1	1	0.3	0	0	0.0044	0.044	0.0132	0	0
5	Seismology	1	0.054	0	1	0	0	0	0.7	1	0	0.1	0	0.0378	0.054	0	0.0054	0
6	Geology	2	0.057	0	0	1	0	0	0.1	0.5	1	0.1	0	0.0057	0.0285	0.057	0.0057	0
7	Water quality	1	0.046	0	1	0	0	0	0.3	1	0.2	0	0	0.0138	0.046	0.0092	0	0
8	Water resources	1	0.056	0	1	0	0	0	0.2	1	0.5	0	0	0.0112	0.056	0.028	0	0
9	Surface water hydrology	1	0.05	0	1	0	0	0	0.2	1	0.8	0	0	0.01	0.05	0.04	0	0
10	Ground water hydrology	1	0.04	0	1	0	0	0	0.6	1	0.1	0.1	0	0.024	0.04	0.004	0.004	0
11	Flooding	1	0.054	0	1	0	0	0	0.4	1	0.2	0.1	0	0.0216	0.054	0.0108	0.0054	0
12	Sedimentation	1	0.053	0	1	0	0	0	0.6	1	0.1	0.1	0	0.0318	0.053	0.0053	0.0053	0
13	Flora/ terrestrial plants	1	0.043	0	1	0	0	0	0.1	1	0.3	0	0	0.0043	0.043	0.0129	0	0
14	Aquatic flora	1	0.037	0	1	0	0	0	0.6	1	0.1	0.1	0	0.0222	0.037	0.0037	0.0037	0
15	Fauna / terrestrial animals	1	0.042	0	1	0	0	0	0.3	1	0.1	0	0	0.0126	0.042	0.0042	0	0
16	Aquatic animals	1	0.045	0	1	0	0	0	0.2	1	0.2	0	0	0.009	0.045	0.009	0	0
17	Relocation- resettlement	1	0.049	0	1	0	0	0	0.4	1	0.1	0.1	0.1	0.0196	0.049	0.0049	0.0049	0.0049
18	Accident risk/ human health	1	0.045	0	1	0	0	0	0.6	1	0	0	0	0.027	0.045	0	0	0
19	Community Facilities/ services	1	0.045	0	1	0	0	0	0.7	1	0.1	0	0	0.0315	0.045	0.0045	0	0
20	Aesthetics	2	0.044	0	0	1	0	0	0.1	0.3	1	0.2	0	0.0044	0.0132	0.044	0.0088	0
21	Archaeological cultural and historical resources	0	0.035	1	0	0	0	0	1	0.1	0.1	0	0	0.035	0.0035	0.0035	0	0
22	Economy	1	0.056	0	1	0	0	0	0.6	1	0.1	0.1	0	0.0336	0.056	0.0056	0.0056	0
							MEMBERSHIP DEGREE MATRIX				(MD)	0.379	0.8894	0.3114	0.053	0.0049
											A_{12}	0.6342				
											A_{23}	0.6004				
											A_{34}	0.1822				
											A_{45}	0.029				
											A_T	1.4458				

RISK INDEX, R = $[(1^* A_{12}) + (2^* A_{23}) + (3^* A_{34}) + (4^* A_{45})] / A_T$

= 1.72740792

Result- Moderate Negative Impact | 1.6-2.5 | Medium Risk

5.3.3 COMPARISON

Comparison of impacts on various factors/sub factors associated with mini-micro, small and large HPPs is analysed by using two ways anova with replication on Microsoft excel.

5.3.3.1 Air/Noise Environment – Mini - Micro, Small & Large projects

The negative impacts of different HPPs on Air/Noise Environment (air/climatology & noise as sub factors) are given in Table 5.2. The comparison of impacts due to different HPPs on Air/Noise Environment is shown in Figure 5.2 to 5.4. The cumulative impacts of all projects are shown in Figure 5.5.

Table 5.2: Impact of HPPs on Air/Noise Environment

Projects / Factors/ Sub Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Air	0.571	0.21	0.46	0.82	1.5	0.71
Noise	0.643	0.54	0.64	1.11	0.96	0.78
Air/Noise Environment	0.61	0.38	0.55	0.96	1.23	

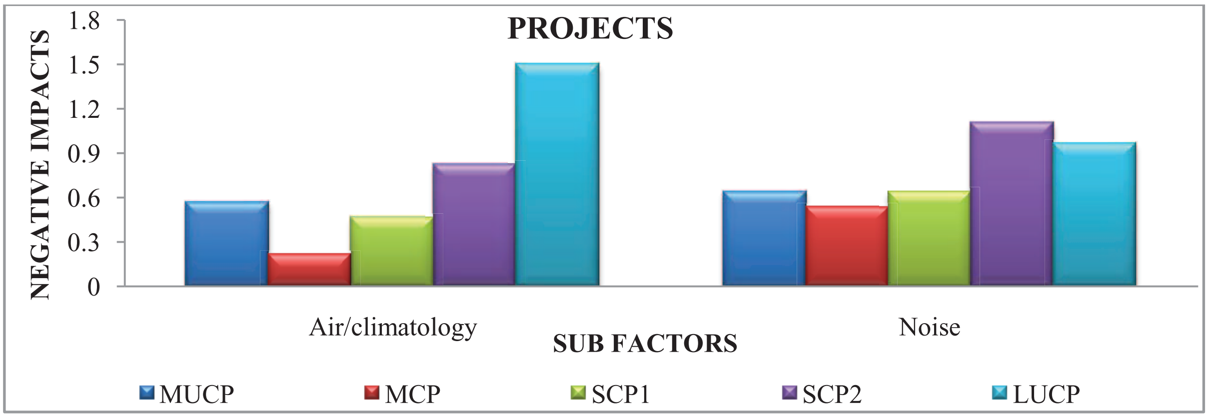


Figure 5.2: Impact of individual HPPs on air/ climatology & noise

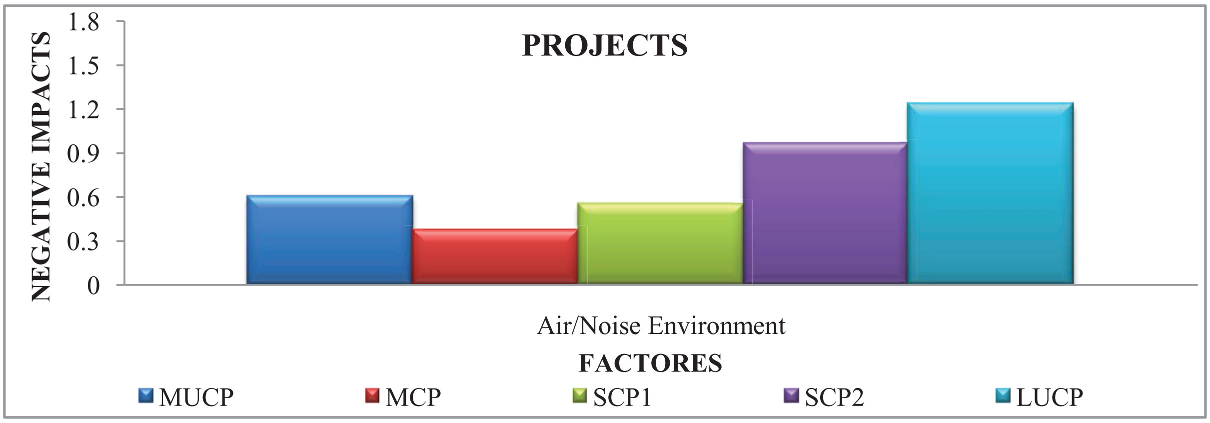


Figure 5.3: Impact of individual HPPs on Air/Noise Environment

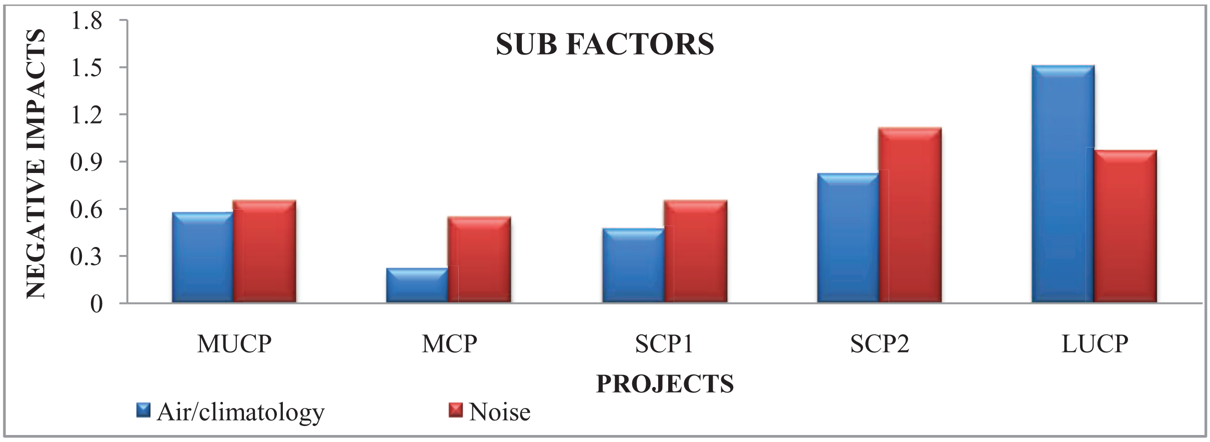


Figure 5.4: Impact on air/climatology & noise due to each project

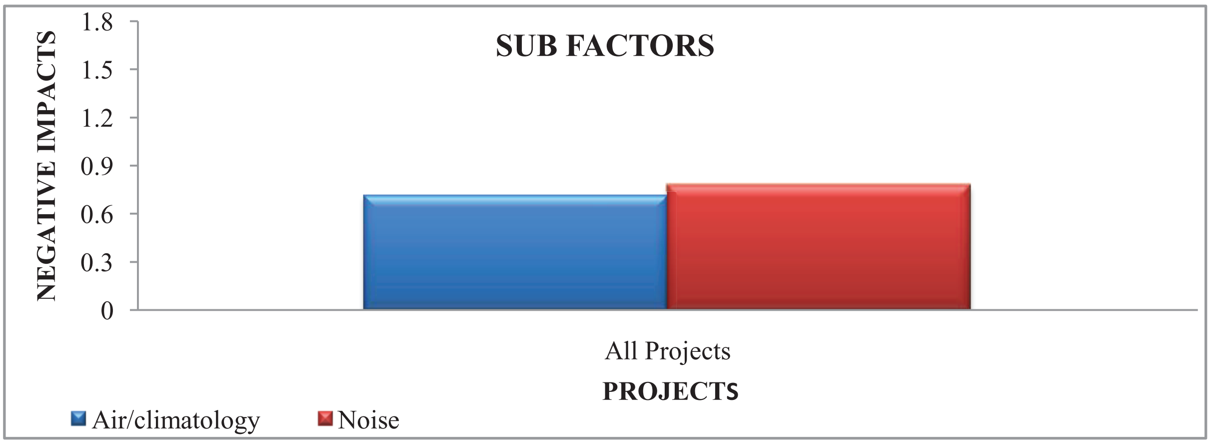


Figure 5.5: Cumulative negative impact on air/ climatology & noise due to all projects

5.3.3.2 Land Environment – Mini - Micro, Small & Large projects

The negative impacts of different HPPs on Land Environment (land form, land use, seismology & geology as sub factors) are given in Table 5.3. The comparison of impacts due to different HPPs on Land Environment is shown in Figure 5.6 to 5.8. The cumulative impacts of all projects are shown in Figure 5.9.

Table 5.3: Impact of HPPs on Land Environment

Projects / Factors/ Sub Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Land Form	0.43	0.25	0.25	0.86	1.29	0.61
Land Use	0.57	0.36	0.75	0.71	1.29	0.74
Seismology	0.25	0.04	0.21	0.5	0.64	0.33
Geology	0.96	0.71	1.04	1.11	1.5	1.06
Land Environment	0.55	0.34	0.56	0.79	1.18	

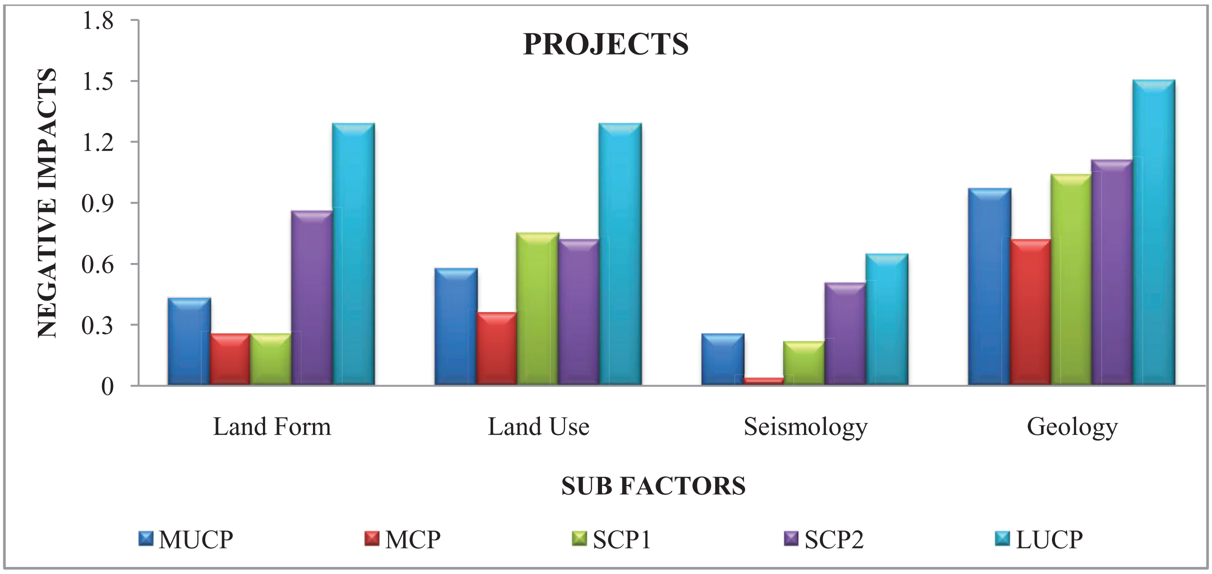


Figure 5.6: Impact of individual HPPs on land form, land use, seismology & geology

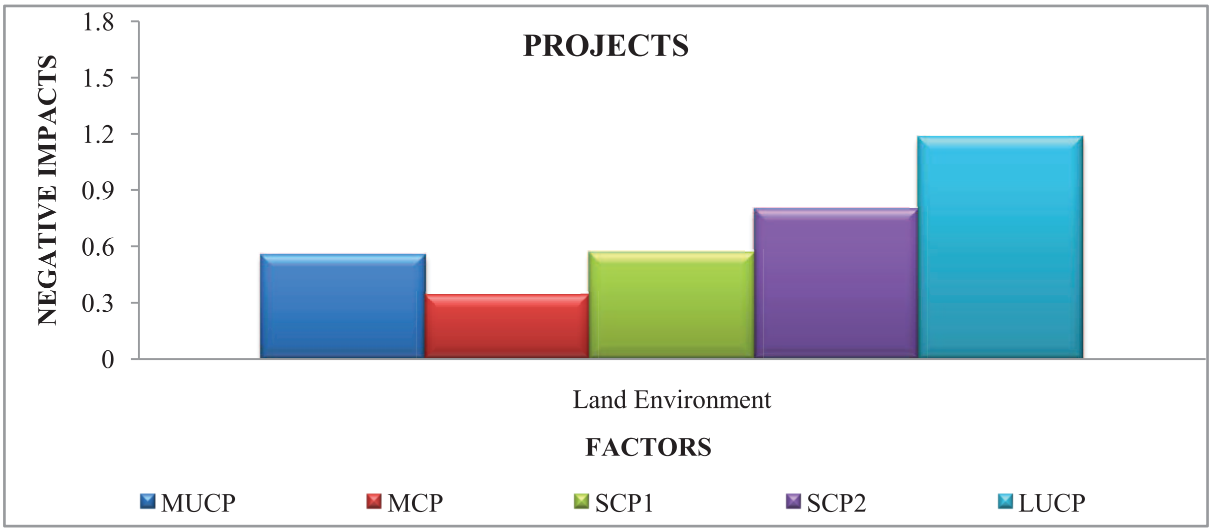


Figure 5.7: Impact of individual HPPs on Land Environment

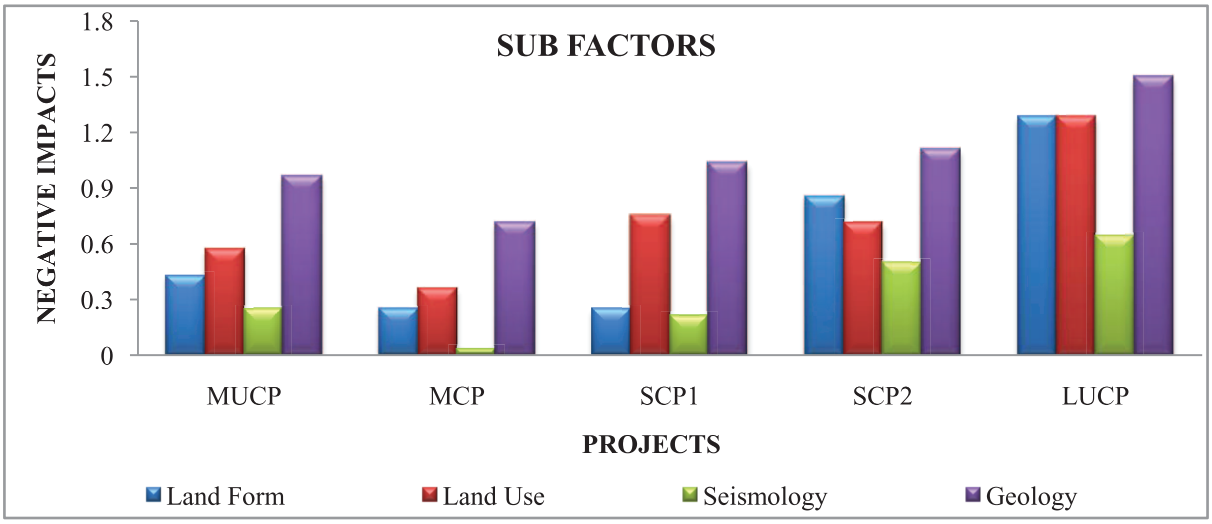


Figure 5.8: Impact on land form, land use, seismology & geology due to each project

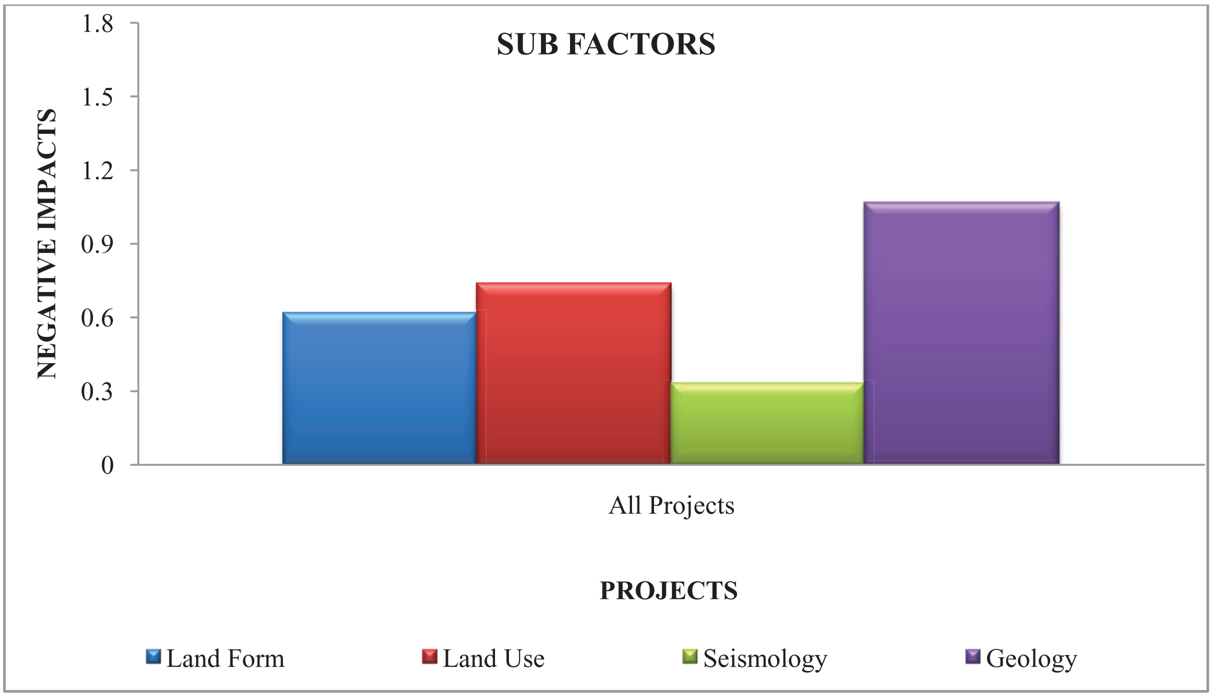


Figure 5.9: Cumulative negative impact on land form, land use, seismology & geology due to all projects

5.3.3.3 Water Environment – Mini - Micro, Small & Large projects

The negative impacts of different HPPs on Water Environment (water quality, water resources, surface water hydrology, ground water hydrology, flooding & sedimentation as sub factors) are given in Table 5.4. The comparison of impacts due to different HPPs on Water Environment is shown in Figure 5.10 to 5.12. The cumulative impacts of all projects are shown in Figure 5.13.

Table 5.4: Impact of HPPs on Water Environment

Projects / Factors/ Sub Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Water Quality	0.86	0.29	0.39	0.21	0.96	0.54
Water Resources	0.25	0.79	0.86	0.43	1.36	0.74
Surface Water Hydrology	0.32	1	0.89	0.43	1.07	0.74
Ground Water Hydrology	0.32	0.21	0.36	0.36	0.79	0.41
Flooding	0.29	0.36	0.32	0.32	1	0.46
Sedimentation	0.38	0.43	0.61	0.5	0.75	0.53
Water Environment	0.4	0.51	0.57	0.38	1	

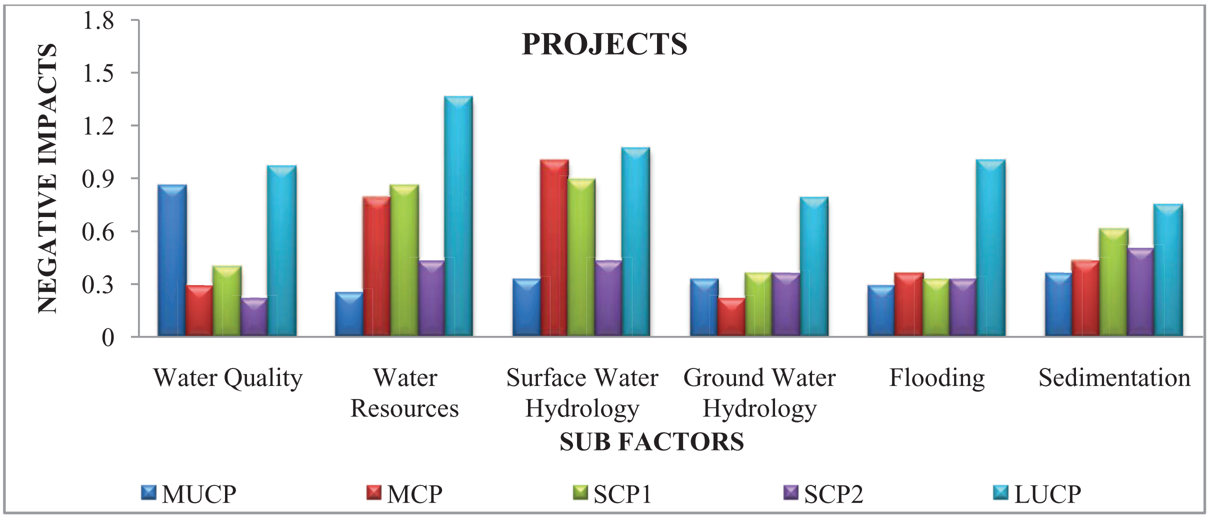


Figure 5.10: Impact of individual HPPs on water quality, water resources, surface water hydrology, ground water hydrology, flooding & sedimentation

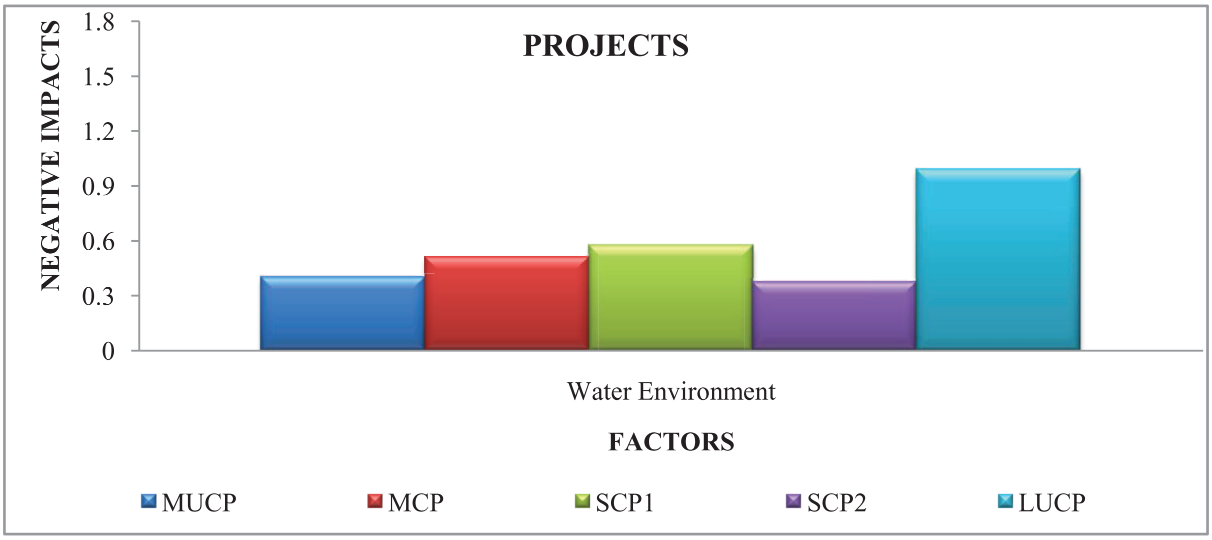


Figure 5.11: Impact of individual HPPs on Water Environment

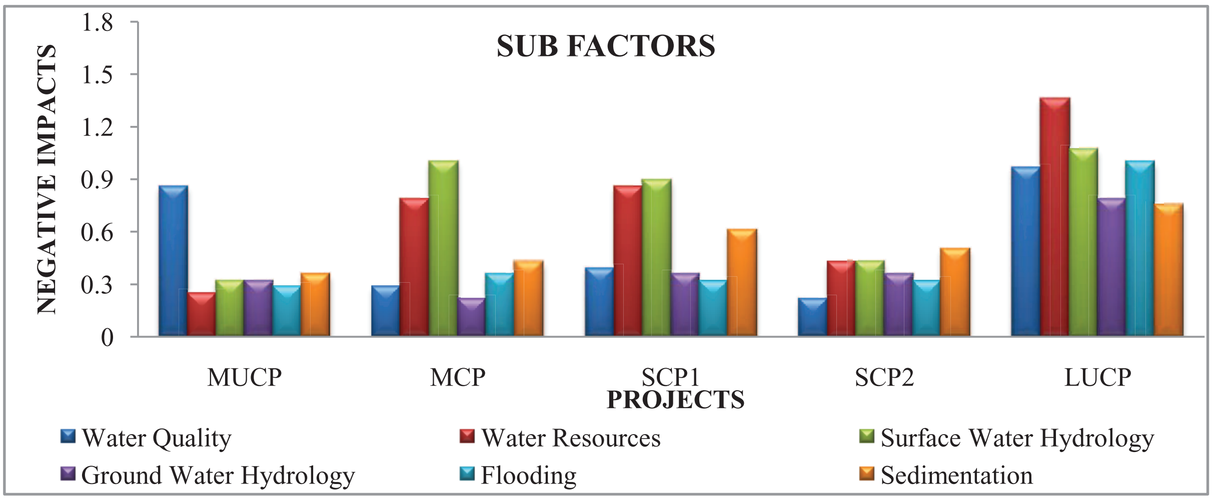


Figure 5.12: Impact on water quality, water resources, surface water hydrology, ground water hydrology, flooding & sedimentation due to each project

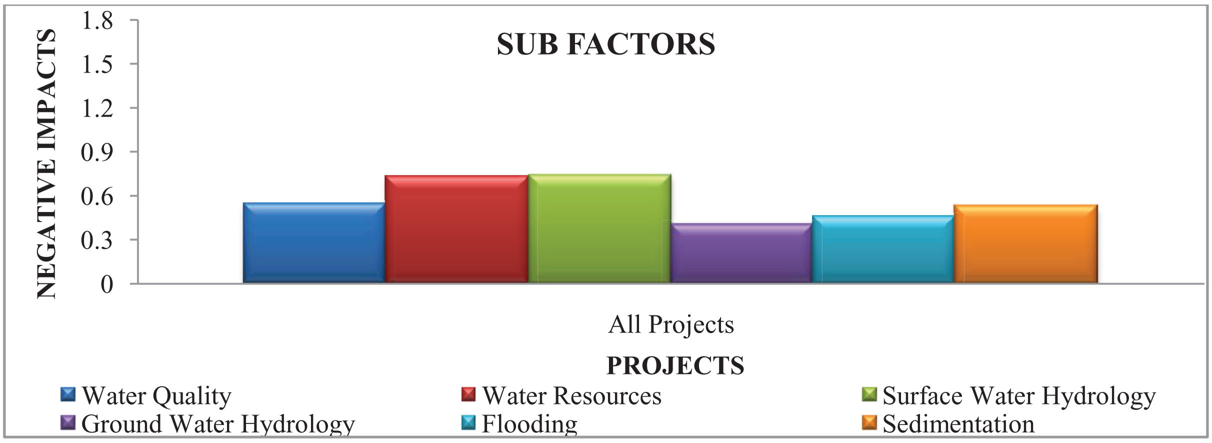


Figure 5.13: Cumulative negative impact on water quality, water resources, surface water hydrology, ground water hydrology, flooding & sedimentation due to all projects

5.3.3.4 Biological Environment – Mini - Micro, Small & Large projects

The negative impacts of different HPPs on Biological Environment (terrestrial flora, aquatic flora, terrestrial fauna & aquatic fauna as sub factors) are given in Table 5.5. The comparison of impacts due to different HPPs on Biological Environment is shown in Figure 5.14 to 5.16. The cumulative impacts of all projects are shown in Figure 5.17.

Table 5.5: Impact of HPPs on Biological Environment

Factors/ Sub Factors \ Projects	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Terrestrial Plants	0.89	0.5	0.5	0.57	1.25	0.74
Aquatic Flora	0.29	0.32	0.29	0.25	0.68	0.36
Terrestrial Animals	0.64	0.64	0.36	0.71	0.79	0.63
Aquatic Animals	0.38	0.75	0.68	0.36	1.11	0.65
Biological Environment	0.54	0.55	0.46	0.47	0.96	

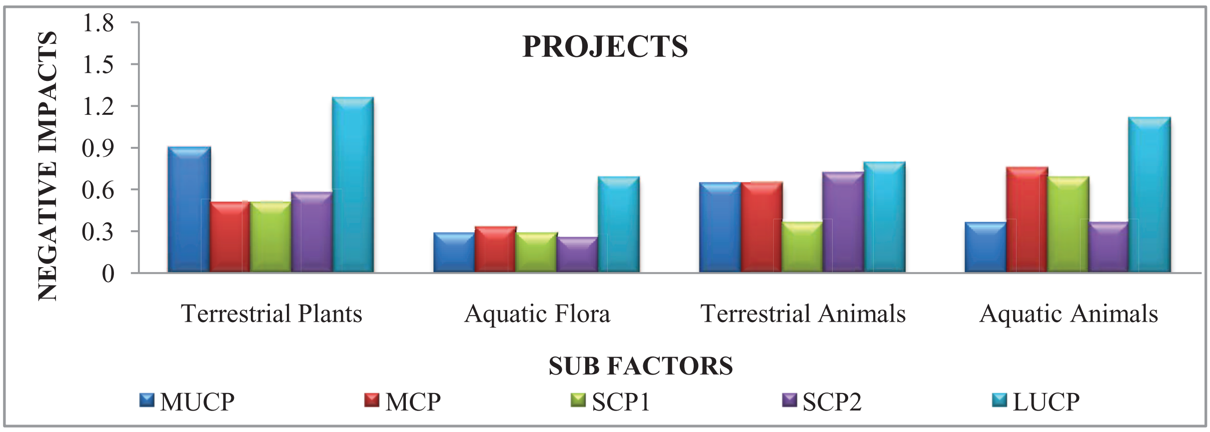


Figure 5.14: Impact of individual HPPs on terrestrial flora, aquatic flora, terrestrial fauna & aquatic fauna

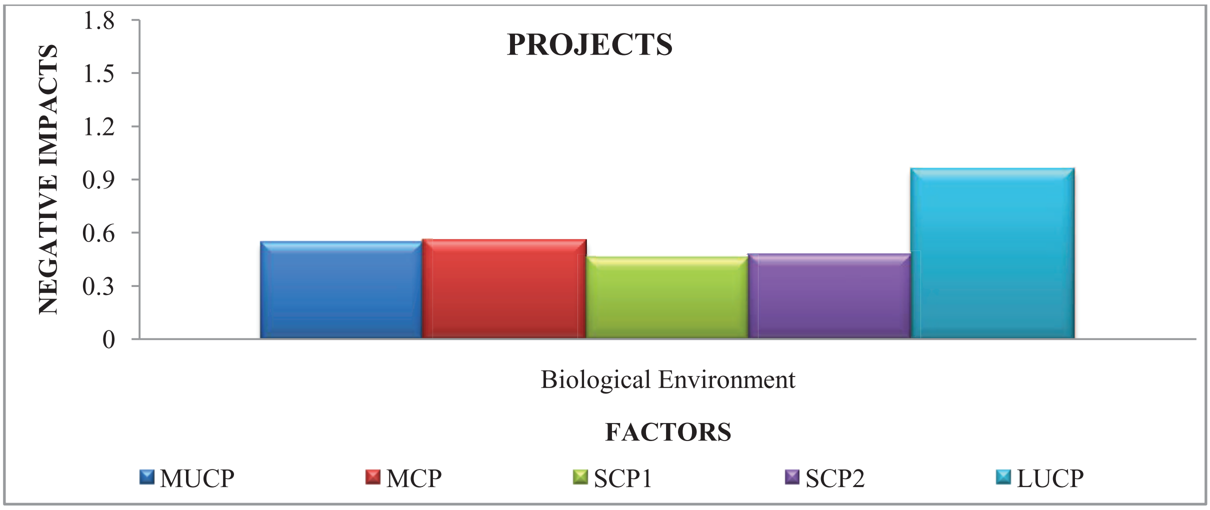


Figure 5.15: Impact of individual HPPs on Biological Environment

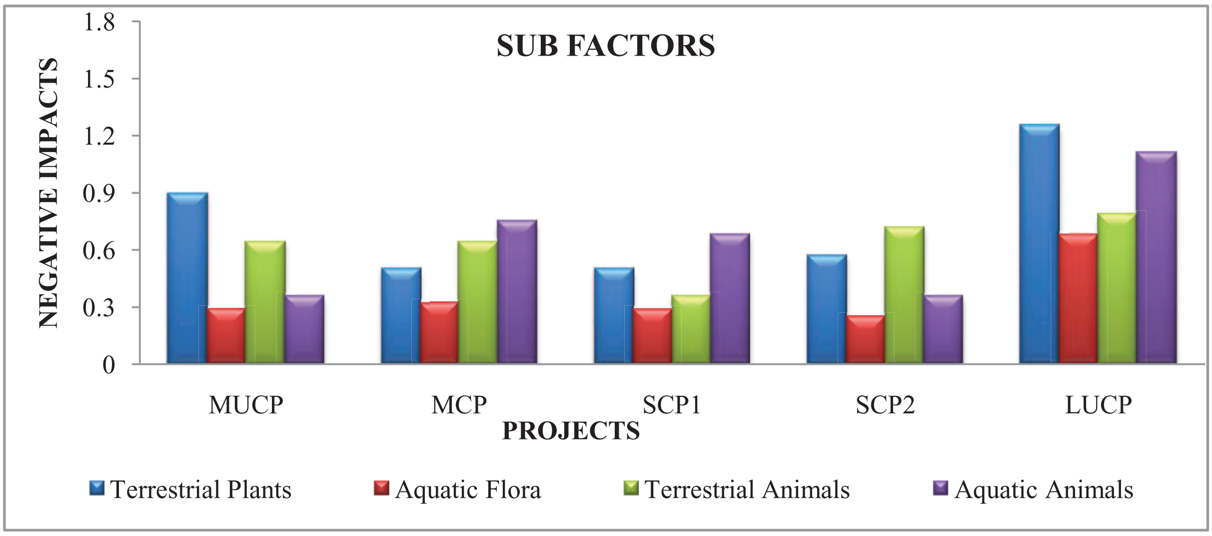


Figure 5.16: Impact on terrestrial flora, aquatic flora, terrestrial fauna & aquatic fauna due to each project

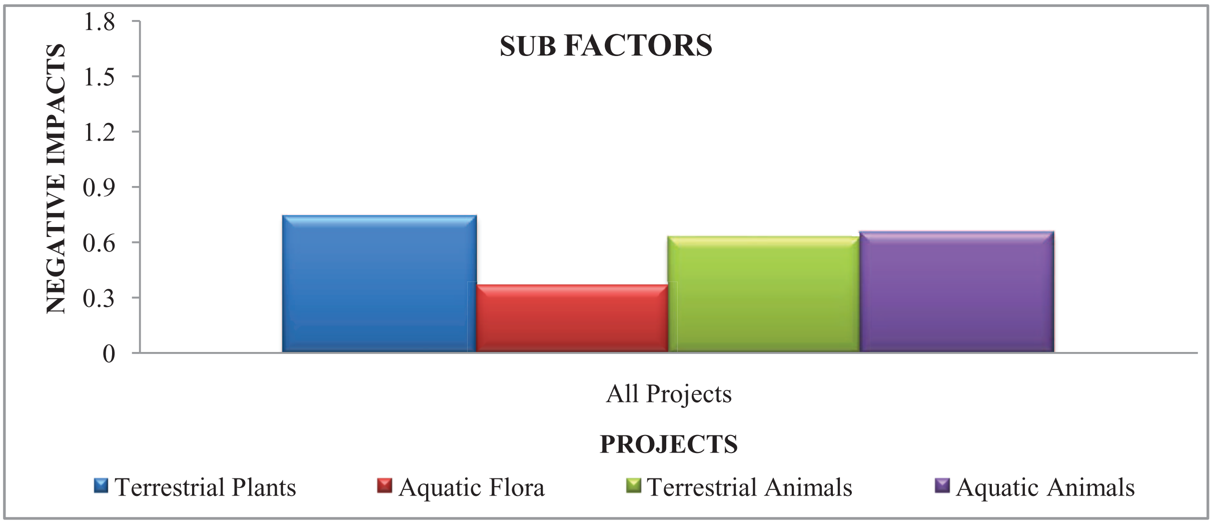


Figure 5.17: Cumulative negative impact on terrestrial flora, aquatic flora, terrestrial fauna & aquatic fauna due to all projects

5.3.3.5 Human Environment – Mini - Micro, Small & Large projects

The negative impacts of different HPPs on Human Environment (relocation-resettlement, accident risk/ human health, community facilities/ services, aesthetics, archaeological/ cultural/ historical resources, economy as sub factors) are given in Table 5.6. The comparison of impacts due to different HPPs on Human Environment is shown in Figure 5.18 to 5.20. The cumulative impacts of all projects are shown in Figure 5.21.

Table 5.6: Impact of HPPs on Human Environment

Projects / Factors/ Sub Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Relocation- Resettlement	0.14	0.18	0.29	0.32	1.11	0.41
Accident Risk/ Human Health	0.25	0.11	0.18	0.18	0.57	0.26
Community Facilities /Services	0.14	0.07	0.25	0.25	0.57	0.26
Aesthetics	1.21	0.64	0.96	0.68	1.64	1.03
Archaeological/ Cultural/Historical Resources	0.4	0.04	0.14	0.5	0.29	0.27
Economy	0.46	0.32	0.25	0.39	0.89	0.46
Human Environment	0.43	0.23	0.35	0.39	0.85	

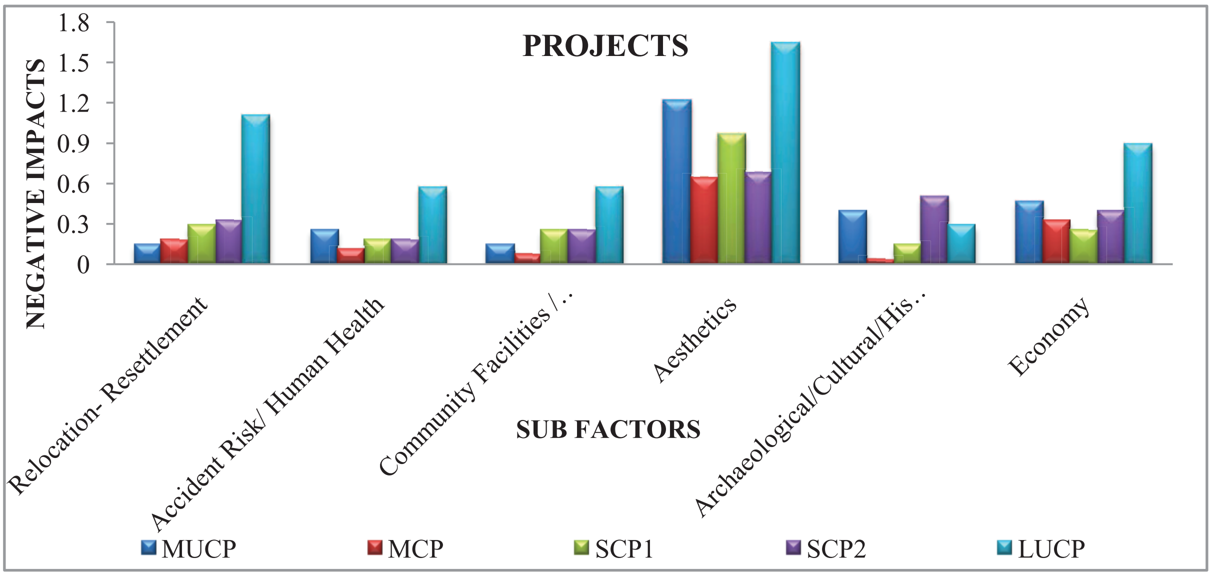


Figure 5.18: Impact of individual HPPs on relocation-resettlement, accident risk/ human health, community facilities/ services, aesthetics, archaeological/ cultural/ historical resources, economy

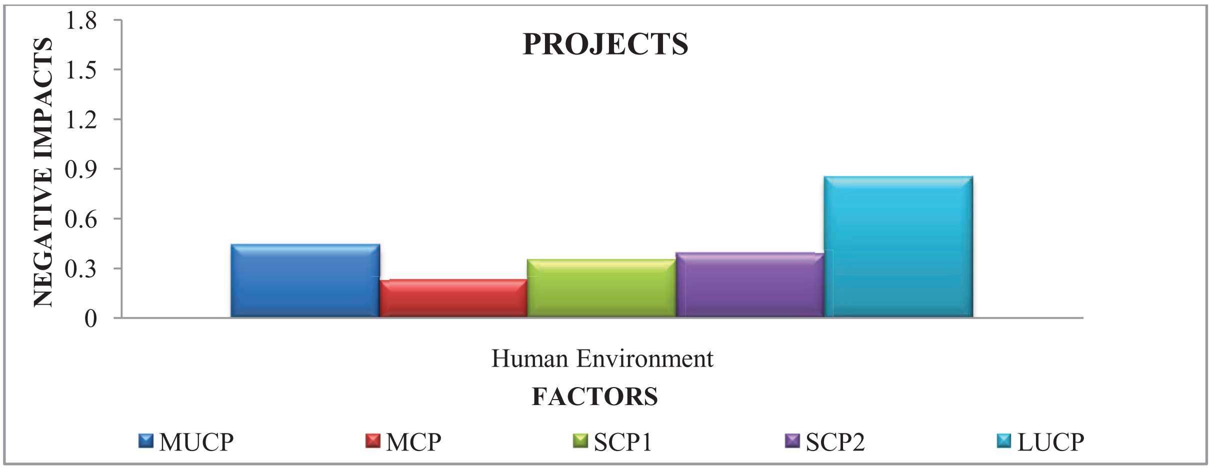


Figure 5.19 Impact of individual HPPs on Human Environment

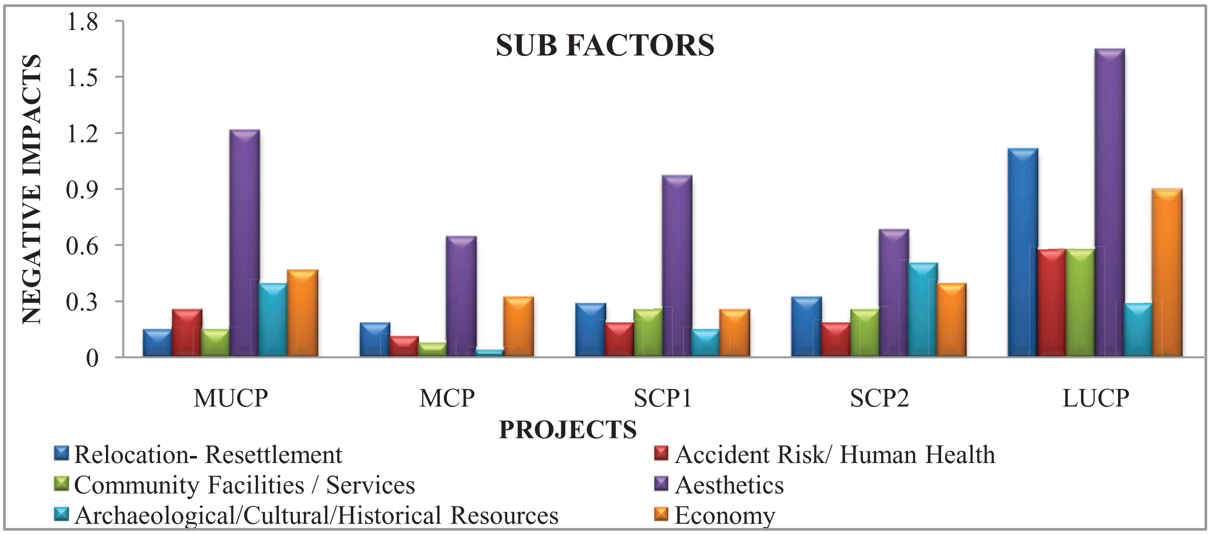


Figure 5.20: Impact on relocation-resettlement, accident risk/ human health, community facilities/ services, aesthetics, archaeological/ cultural/ historical resources, economy due to each project

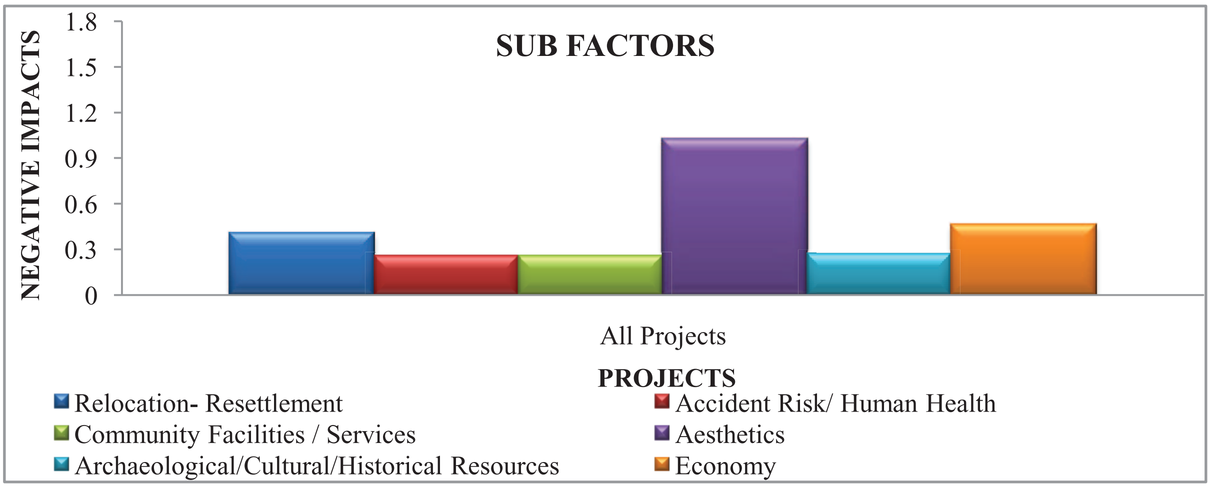


Figure 5.21: Cumulative negative impact on relocation-resettlement, accident risk/ human health, community facilities/ services, aesthetics, archaeological/ cultural/ historical resources, economy due to all projects

5.3.3.6 Summary of Impacts Scores on Total Environment

A summary of impact scores of individual projects on several environmental sub factors under consideration are presented in Table 5.7 and Figure 5.22. The average impact score of all the projects (i.e., mini-micro, small, large - both under construction & commissioned) on each environmental sub factor are tabulated in the last column of Table 5.7. In order to compare the magnitude of impacts based on the nature of the project (i.e., scale & phase), the impacts scores under each project were averaged.

It is evidence that LUCP has highest impact score on all environmental sub factors except noise and archeological/cultural/historical resources sub factors. However SCP2 has highest impact score on noise & archeological/cultural/historical resources sub factors (Figure 5.22).

Large scale projects during construction phase is found to cause more negative impacts as compare to other projects on total environment (Figure 5.23).

Considering the impact of individual HPP on several environmental sub factors (Figure 5.24) the following observations are made:

- MUCP & LUCP have significant negative impacts for aesthetics.
- Small commissioned projects have significant impact on geology & noise.
- MCP has highest negative impacts on surface water hydrology.

Based on the above observations, it can be concluded that there is no coordination between impacts on a particular environmental sub factors.

The cumulative negative impacts of all projects on all sub factors are shown in Figure 5.25. All projects have highest cumulative negative impact on geology.

A summary of impact scores of individual projects on several environmental factors under consideration are presented in Table 5.8 and Figure 5.26. The average impact score of all the projects (i.e., mini-micro, small, large - both under construction & commissioned) on each environmental factor are tabulated in the last column of Table 5.8. In order to compare the magnitude of impacts based on the nature of the project (i.e., scale & phase), the impacts scores under each project were averaged.

It is evidence that LUCP has highest impact score on all environmental factors (Figure 5.26).

Considering the impact of individual HPP on several environmental factors (Figure 5.27) the following observations are made:

- MUCP, SCP2 & LUCP have significant negative impacts for Air/Noise Environment.
- SCP1 have significant impact on Water Environment.
- MCP has highest negative impacts on Biological Environment.

Based on the above observations, it can be concluded that there is no coordination between impacts on a particular environmental factors.

The cumulative negative impacts of all projects on all factors are shown in Figure 5.28. All projects have highest cumulative negative impact on Air/Noise Environment. The cumulative impact of all HPPs on total environment is of low range i.e., 0.609 ≈1 (Figure 5.29).

Table 5.7: Summary of Impact score on Total Environmental sub factors

Projects / Sub Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Air/Climatology	0.57	0.21	0.46	0.82	1.5	0.71
Noise	0.64	0.54	0.64	1.11	0.96	0.78
Land Form	0.43	0.25	0.25	0.86	1.29	0.61
Land Use	0.57	0.36	0.75	0.71	1.29	0.74
Seismology	0.25	0.03	0.21	0.5	0.64	0.33
Geology	0.96	0.71	1.04	1.11	1.5	1.06
Water Quality	0.86	0.29	0.39	0.21	0.96	0.54
Water Resources	0.25	0.79	0.86	0.43	1.36	0.74
Surface Water Hydrology	0.32	1	0.89	0.43	1.07	0.74
Ground Water Hydrology	0.32	0.21	0.36	0.36	0.79	0.41
Flooding	0.29	0.36	0.32	0.32	1	0.46
Sedimentation	0.36	0.43	0.61	0.5	0.75	0.53
Terrestrial Plants	0.89	0.5	0.5	0.57	1.25	0.74
Aquatic Flora	0.29	0.32	0.29	0.25	0.68	0.36

Terrestrial Animals	0.64	0.64	0.36	0.71	0.79	0.63
Aquatic Animals	0.36	0.75	0.68	0.36	1.11	0.65
Relocation – Resettlement	0.14	0.18	0.29	0.32	1.11	0.41
Accident Risk / Human Health	0.25	0.12	0.18	0.18	0.57	0.26
Community Facilities / Services	0.14	0.07	0.25	0.25	0.57	0.26
Aesthetics	1.21	0.64	0.96	0.68	1.64	1.0283
Archaeological/ Cultural/ Historical Resources	0.39	0.04	0.14	0.5	0.29	0.27
Economy	0.46	0.32	0.25	0.39	0.89	0.46
Total Environment	0.48	0.4	0.48	0.52	1	

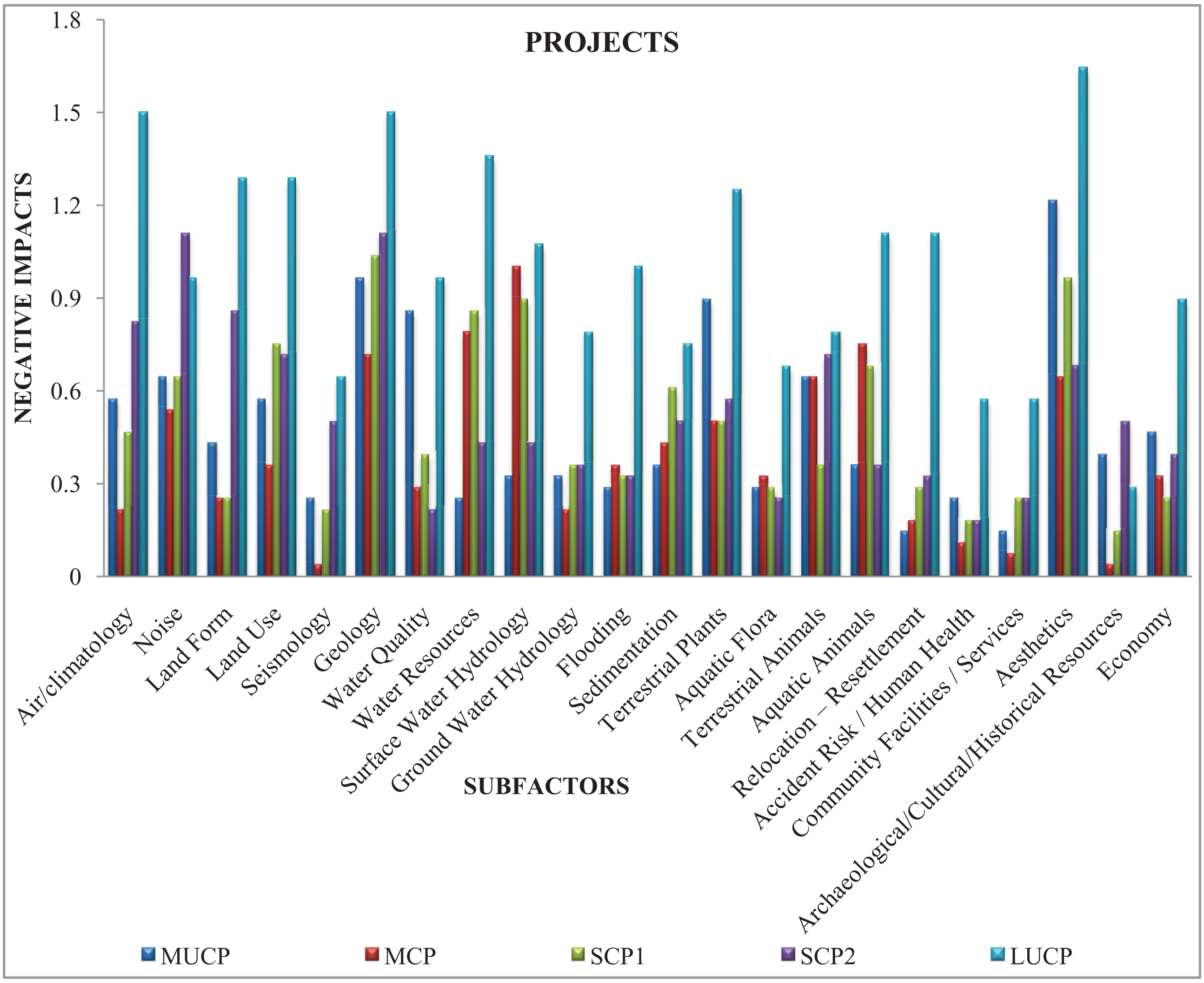


Figure 5.22: Impact of individual HPPs on all sub factors

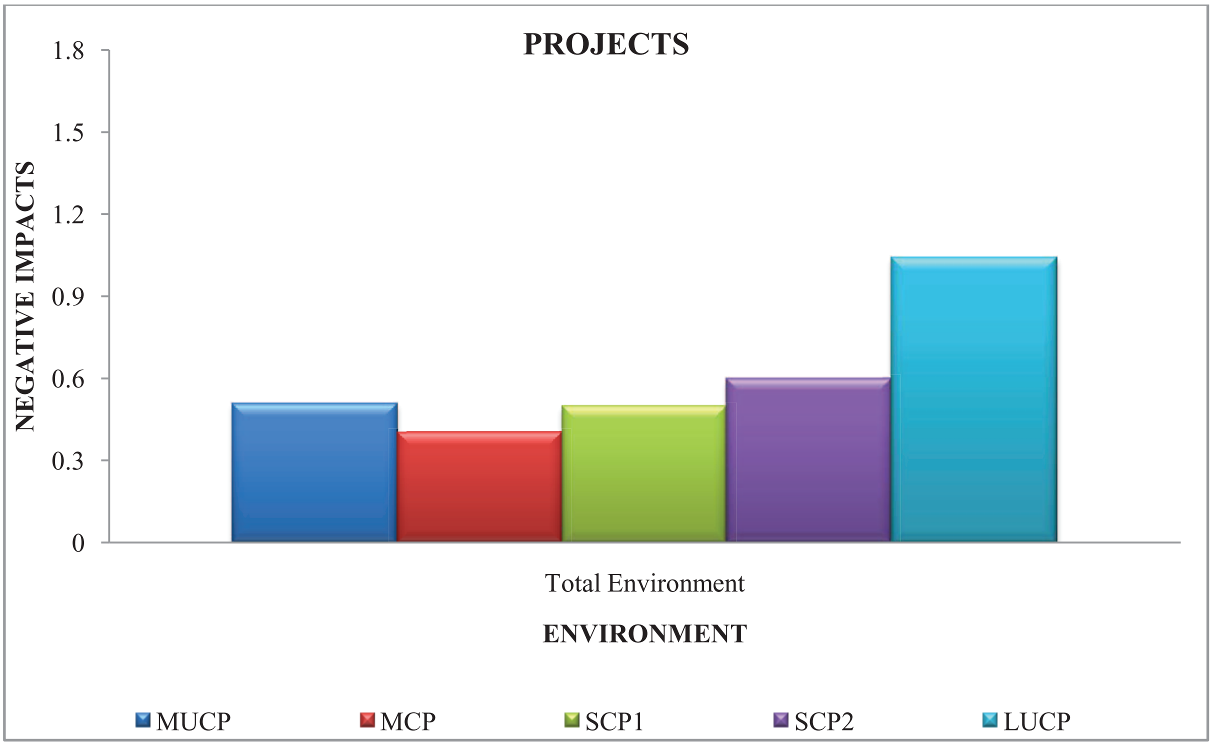


Figure 5.23: Impact of individual HPPs on Total Environment

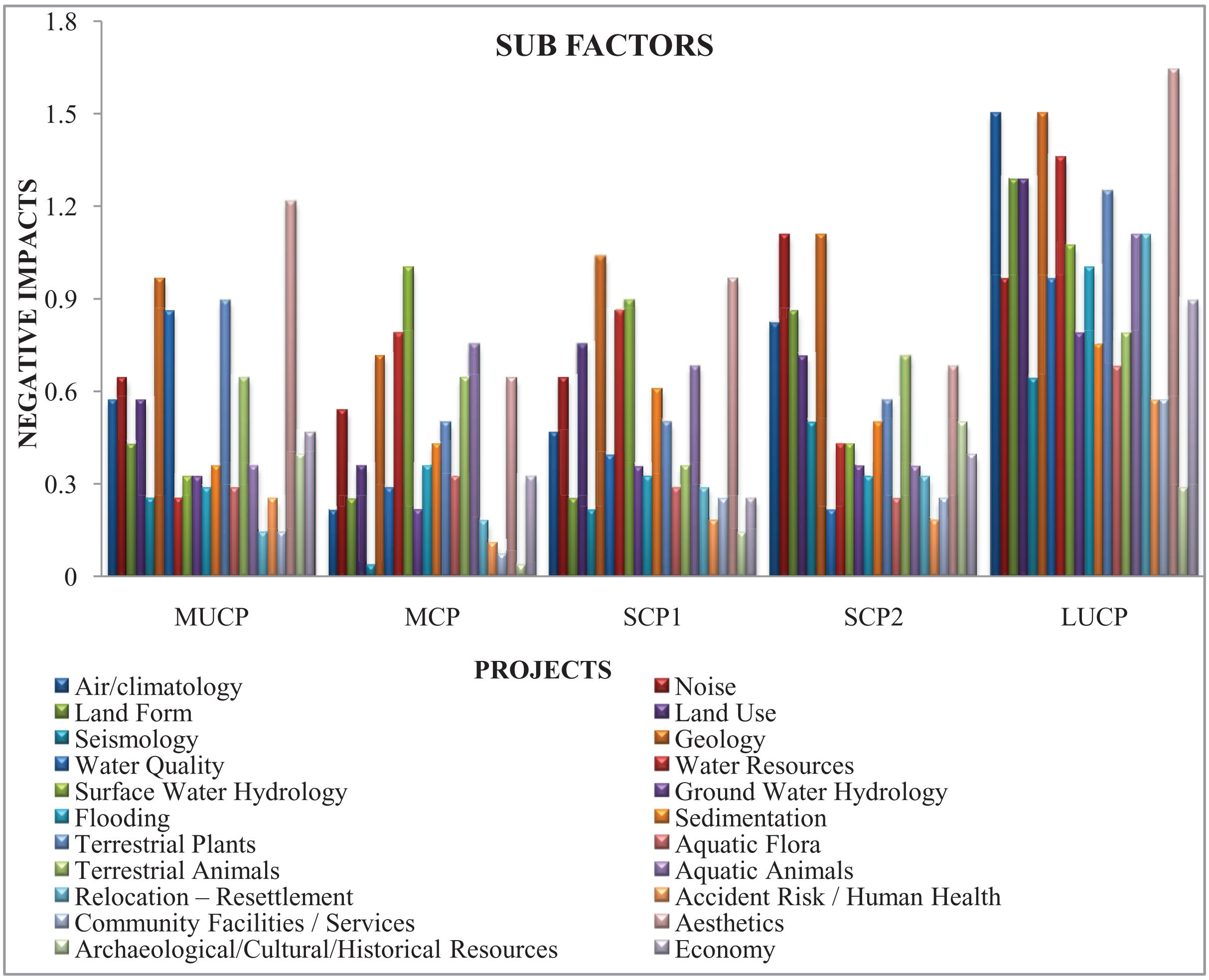


Figure 5.24: Impact on all sub factors due to each project

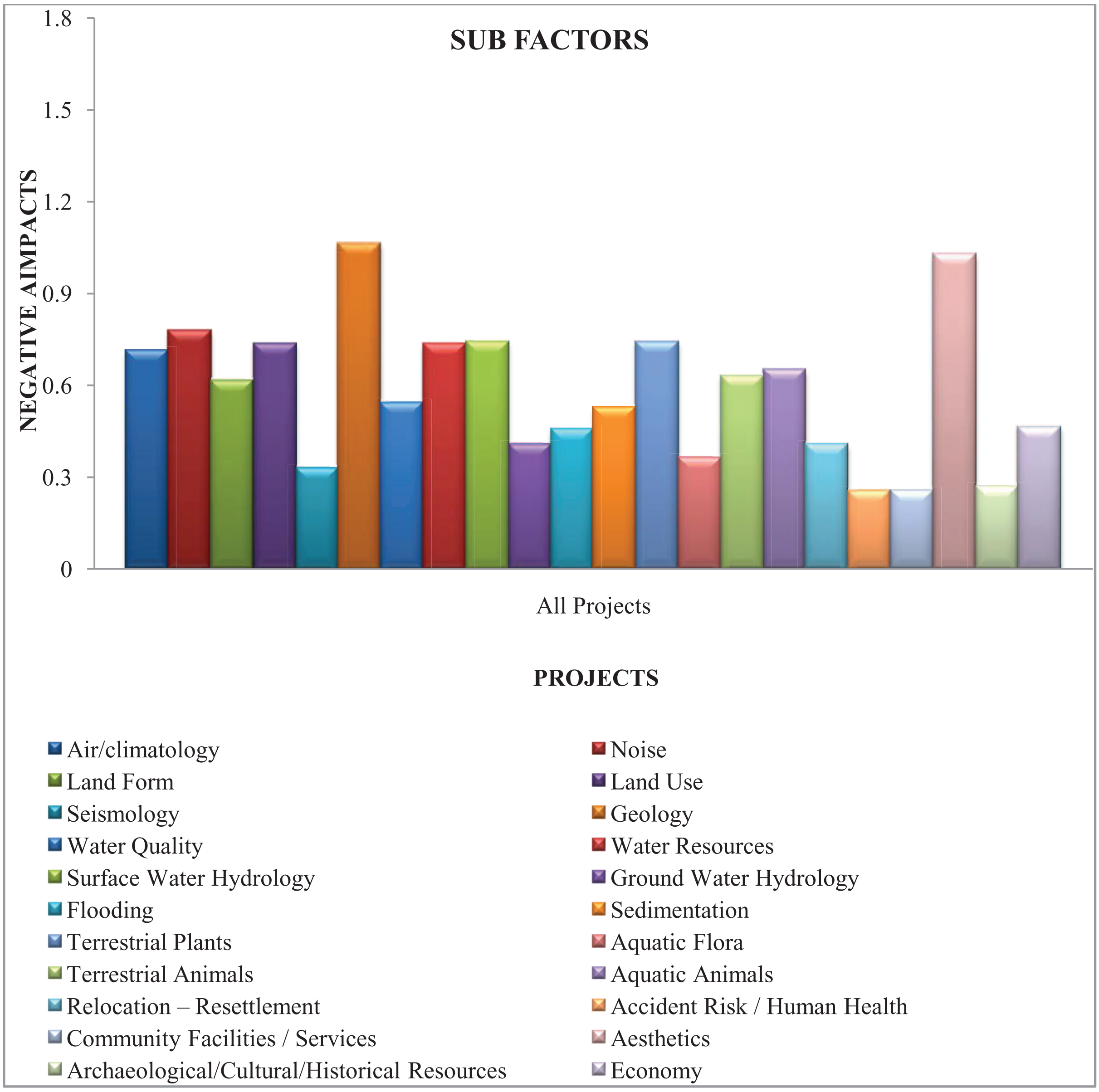


Figure 5.25: Cumulative negative impact on all sub factors due to all projects

Table 5.8: Summary of Impact score on Total Environmental factors

Projects / Factors	MUCP	MCP	SCP1	SCP2	LUCP	All Projects
Air/Noise Environment	0.61	0.38	0.55	0.96	1.23	0.75
Land Environment	0.55	0.34	0.56	0.79	1.18	0.69
Water Environment	0.4	0.51	0.57	0.38	1	0.57
Biological Environment	0.54	0.55	0.46	0.47	0.96	0.6
Human Environment	0.43	0.23	0.35	0.39	0.85	0.45
Total Environment	0.51	0.40	0.5	0.6	1.04	

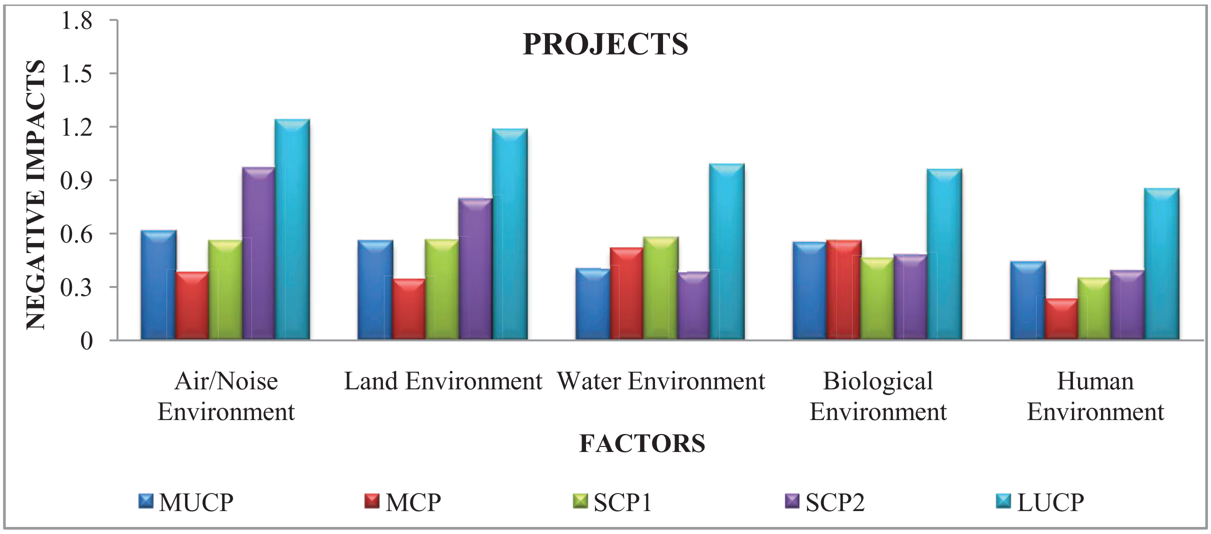


Figure 5.26: Impact of individual HPPs on all major factors

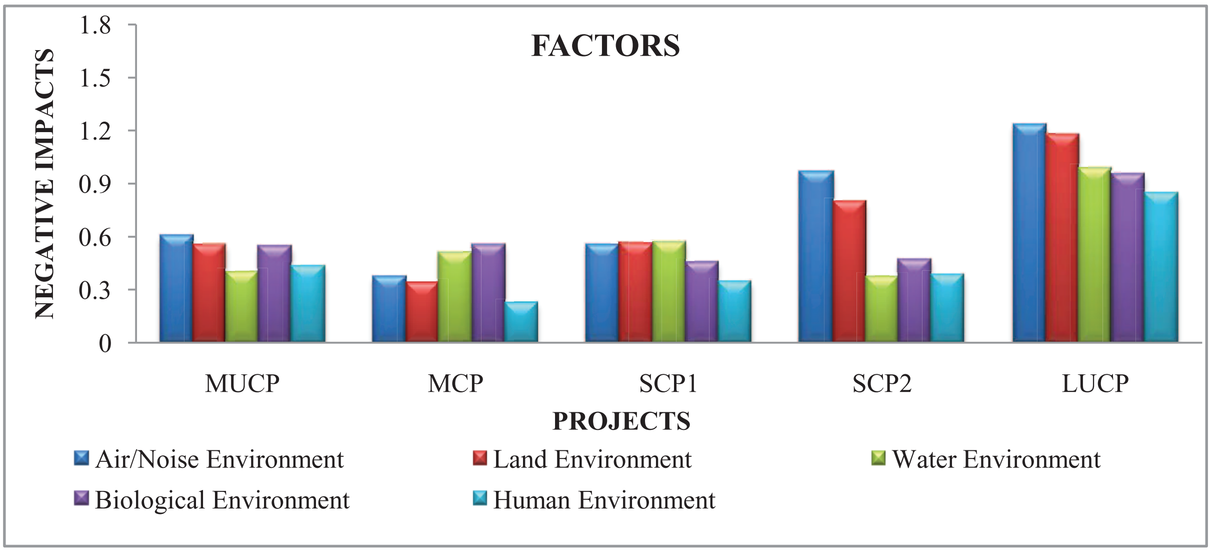


Figure 5.27: Impact on Air/Noise, Land, Water, Biological and Human Environment due to each project

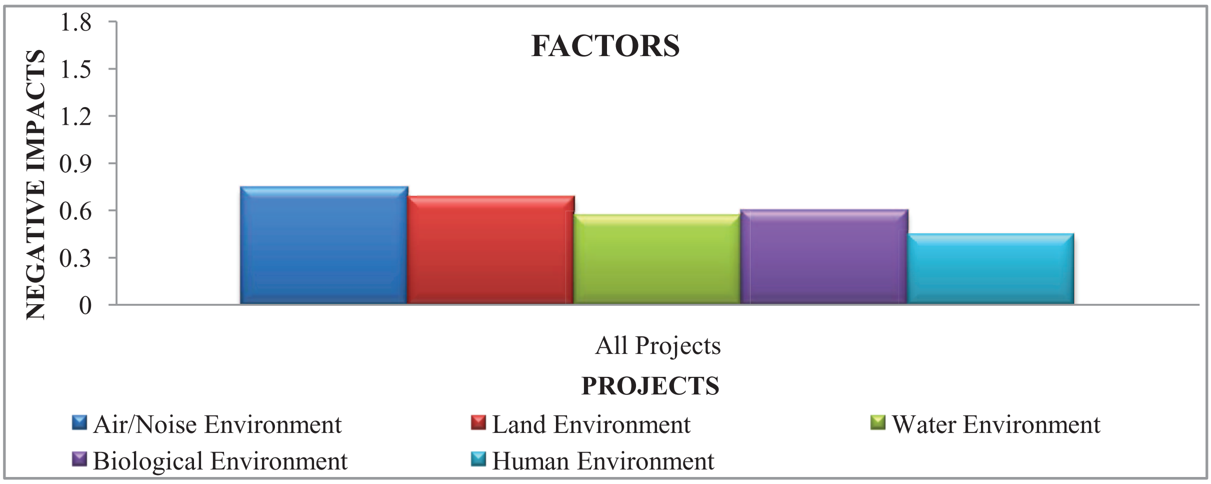


Figure 5.28: Cumulative negative impact on environmental factors due to all projects

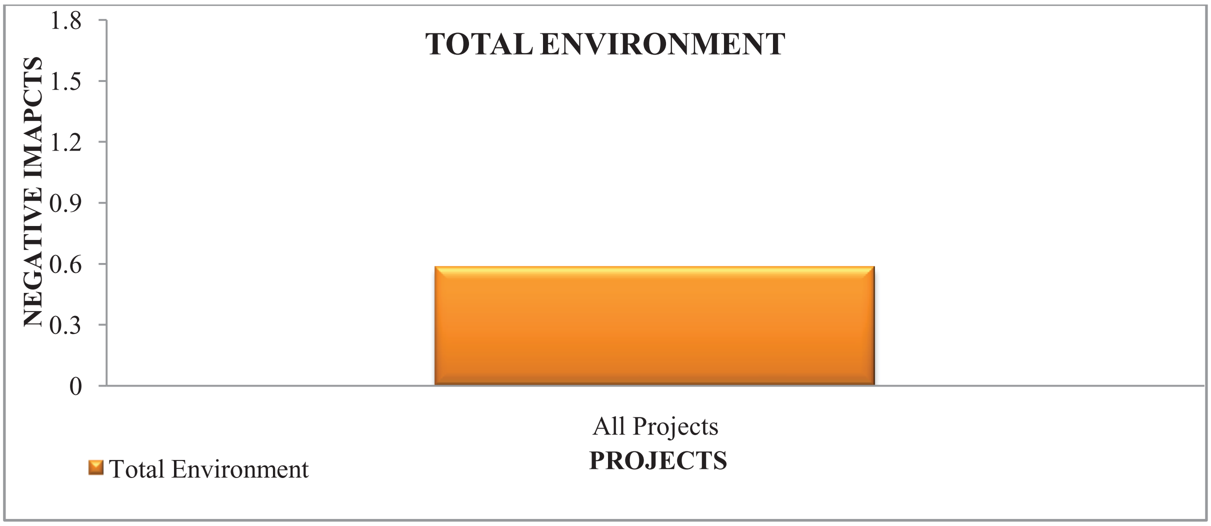


Figure 5.29: Cumulative negative impact on total environment due to all projects

The impacts created during the project construction are temporary and shorter. Impacts generated by projects on Air/Noise Environment are temporary and of medium significance, which subsequently affects aesthetics of region. However commissioned projects might have significant impact on Biological, Water and Air/Noise Environment, on sub factors like surface water hydrology, geology and noise. The cumulative impact of all HPPs on total environment is low.

6

CHAPTER

CONCLUSIONS

6.1 CONCLUSIONS

Hydropower Projects (HPPs) in Himachal Pradesh were evaluated for significant negative impacts on environment during several phases (i.e., under construction phase and commissioned phase) of the project. One large scale (66 MW), two small scale (10 MW & 6MW), two mini-micro (4.8 MW & 4.5 MW) projects were considered for study. Questionnaire was prepared and communicated to various respondents (i.e., experts) including academicians, regulatory officials, environmentalists, project managers and local public affected by the projects. Environmental factors considered for evaluation of impacts included Air/Noise, Land, Water, Biological and Human environment. Likert scale was used to quantitatively assess the negative impacts. Fuzzy logic approach was used to assess the risks due to negative environmental impacts. ANOVA was applied to compare the possible impacts; factor wise and project wise respectively.

Following conclusions were drawn based on the above study:

1. The responses obtained from the respondents indicate that there are no major significant negative impacts (i.e., Impact Score 3 – High; Impact Score 4 – Extremely High) of HPPs under consideration.
2. Mini-Micro Projects (< 5 MW) were found to have low negative-impact to no-impact (i.e., Impact Score 1- 0) either during construction phase or commissioned phase.
3. Small HPPs (5 – 25 MW) were found to have low negative-impact to no-impact (i.e., Impact Score 1- 0) during commissioned phase.
4. Large HPP of 66 MW was found to have medium negative impact to no impact (i.e., 2 to 0) during construction phase. The medium negative impacts relate to geology and aesthetical factors.
5. Fuzzy logic approach gives fuzzy outcomes rather than crisp values. The outcome of fuzzy logic analysis indicates the following:

Sr. No.	Type of Project	Capacity	Risk Index	Range	Risk
i.	Micro Under construction	4.8 MW	1.33	1-1.5	Low
ii.	Micro Commissioned	4.5 MW	1.29	1-1.5	Low
iii.	Small Commissioned 1	6 MW	1.35	1-1.5	Low
iv.	Small Commissioned 2	10 MW	1.38	1-1.5	Low
v.	Large Under Construction	66 MW	1.72	1.6-2.5	Medium

*High Risk = 2.6 – 3.5; Extremely High Risk = 3.6 – 4.0

6. On total environment, each environment factors and all sub factors except noise and archeological/ cultural/ historical resources the highest negative impact score is for LUCP. However SCP2 has highest impact score on noise and archeological/cultural/historical resources.
7. During comparison of impacts among the various HPPs, the negative impacts were independent of the project type and project phase. The highest negative impact on environmental factors due to HPPs (individual & cumulative) either during construction phase or during commissioned phase are as follows:

Sr. No.	Type of Project	Factor	Impact Score
i.	MUCP	Air/Noise Environment	0.6
ii.	MCP	Biological Environment	0.5
iii.	SCP1	Water Environment	0.5
iv.	SCP2	Air/Noise Environment	0.9
v	LUCP	Air/Noise Environment	1.2
vi	All Projects	Air/Noise Environment	0.7

8. The highest negative impacts on sub environmental factors due to HPPs (individual & cumulative) either during construction phase or during commissioned phase are as follows:

Sr. No.	Type of Project	Sub Factor	Impact Score
i.	MUCP	Aesthetics	1.2

ii.	MCP	Surface Water Hydrology	1
iii.	SCP1	Geology	1
iv.	SCP2	Geology/ Noise	1.1
v	LUCP	Aesthetics	1.6
vi	All Projects	Geology	1.1

9. The overall negative impacts on total environment was found to be high (i.e., 1.04) for large HPP as compared to small and mini-micro HPPs (i.e., 0.4 – 0.6). However, the cumulative impacts of all HPPs (large, small, mini-micro) on total environment is of low range i.e. 0.609~1.

6.2 FUTURE SCOPE OF STUDY

The future scope of study is summarized as under:

1. Post project monitoring may be conducted to assess the impacts of HPPs
2. Cumulative risk assessment of the negative impacts on stream having multiple Hydro Power Projects needs to be studied.
3. Cumulative impact assessment in the area/section where there are number of HPPs of different scale are present.

REFERENCES

Bakken, T.H., Sundt, H., Ruud, A. &Harby, A. (2012). "Development of small versus large hydropower in Norway- comparison of environmental impacts." *Energy Procedia*, 20, pages 185-199.

Baskaya, S., Baskaya, E. and Sari, A. (2011). "The principal negative environmental impacts of small hydropower plants in Turkey." *African Journal of Agricultural Research*, Vol. 6(14), pages 3284-3290.

Benejam, L., Saura-Mas, S., Bardina, M., Sola, C., Munne, A. and Garcia-Berthou, E. (2014). "Ecological impacts of small hydropower plants on headwater stream fish: from individual to community effects." *Ecology of freshwater fish*, pages 1-12.

Bilal, M.A. (1998). "Uncertainty Modeling & Analysis in Civil Engineering." Boca Raton, CRC Press.

Hennig, T., Wang, W., Feng, Y., Ou, X., He, D. (2013). "Review of Yunnan's hydropower development. Comparing small and large hydropower projects regarding their environmental implications and socio-economic consequences." *Renewable and Sustainable Energy Reviews*, 27, pages 585-595.

Kibler, K. M. and Tullos, D. D. (2013). "Cumulative biophysical impact of small and large hydropower development, Nu River, China." *Water Resource Research*, Vol. 49, pages 3104-3118.

Kubecka, J., Matena, J. and Hartvich, P. (1997). "Adverse Ecological Effects of Small Hydropower Stations in the Czech Republic: 1. Bypass palnts." *Regulated River Research & Management*, Vol. 13, pages 101-113.

Kucukali, S. (2011). "Risk assessment of river-type hydropower plants by using fuzzy logic approach." *World Renewable Energy Congress*, pages 1432-1439.

Kucukali, S. (2014). "Environmental risk assessment of small hydropower (SHP) plants: A case study for Tefen SHP plant on Filtos River." *Energy for Sustainable Development*, pages 102-110.

Kumar, D., Katoch, S.S. (2014). "Sustainability indicators for run of the river (RoR) hydropower projects in hydro rich regions of India." *Renewable and sustainable energy Reviews*, 35, pages 101-108.

Kumar, D., Katoch, S.S. (2015). "Sustainability suspense of small hydropower projects: A study from western Himalayan region of India." *Renewable Energy*, 76, pages 220-233.

Pinho, P., Maia, R., Monterroso, A. (2007). "The quality of Portuguese Environmental Impact Studies: The case of small hydropower projects." *Environmental Impact Assessment Review*, 27, pages 189-205.

Saxena, P., Kumar, A. (2010). "Hydro Power development in India." *IGHEM*, pages 1-6.

Sharma, A.K., Thakur, N.S. (2015). "Resource potential and development of small hydro power projects in Jammu and Kashmir in the western Himalayan region: India." *Renewable and Sustainable Energy Reviews*, 52, pages 1354-1368.

Sharma, M. P. (2007). "Environmental Impacts of Small Hydro Power Projects." *International Conference on Small Hydropower- Hydro Sri Lanka*, pages 1-9.

Sharma, S. K., Kaushik, A., Kaushik, C.P., Sharma, A. (2009). "Site suitability and environmental impact assessment of Rampur hydroelectric project, Himachal Pradesh (India)." *Journal of Environmental Research and Development*, Vol. 3, No. 3, pages 928-935.

Sinclair, A. J. (2003). "Assessing the Impact of Micro-Hydro Development in the Kullu District, Himachal Pradesh, India." *Mountain Research and Development*, Vol. 23, number 1, pages 11-13.

Sinclair, A.J. &Diduck, A.P., MNRM (2000). "Public involvement in environmental impact assessment: a case study of hydro development in Kullu District, Himachal Pradesh, India." *Impact Assessment and Project Appraisal*, Vol. 18, number 1, pages 63-75.

Thodal, E.M. (2014). "Investigating the transitional period between upper secondary school and the situation at the university focusing in expectations, academic proficiency, the role of literature and students reading habits." University of Stavanger, pages 85.

Thoradeniya, B., Ranasinghe, M. and Wijesekera, N T S (2007). "Social and Environmental Impacts of a Mini- hydro project on the Ma Oya Basin in Sri Lanka." *International Conference on Small Hydropower*, pages 1-10.

Ucar, B. (2004). “Coastal Scenic Evaluation by application of Fuzzy Logic Mathematics.” M.Sc. Thesis, Department of Civil Engineering, pages 125.

Wagner, B., Hauer, C., Schoder, A., Habersack, H. (2015). “A review of hydropower in Austria: Past, present and future development.” *Renewable and Sustainable Energy Reviews*, 50, pages 304-314.

Zelenakova, M., Zvijakova, L., Purcz, P. (2013). “Small Hydropower Plant- Environmental Impact Assessment-Case Study.” *International Journal of Emerging Technology and Advanced Engineering*, Vol. 3, pages 35-42.

Zhang, J., Xu, L., Li, X. (2015). “Review on the externalities of hydropower: A comparison between large and small hydropower projects in Tibet based on CO_2 equivalent.” *Renewable and Sustainable Energy Reviews*, 50, pages 176-185.

BOOKS

Canter, L.W. (1996). “*Environmental Impact Assessment (2nd edition)*.” McGraw- Hill Series in water resources and environmental engineering.

McDonald, J.H. (2014). “*Handbook of biological statistics (3rd edition)*.” Sparky House Publishing, Balti more, Maryland, pages 173-179.

WEBLIOGRAPHY

Maps of India.com, (Computer Software),
< http://www.mapsofindia.com/map/india/hydropowerproject.htm> (02 June, 2014)

APPENDIX-I

QUESTIONNAIRE FOR EXPERTS

Assessment for Large/Small/ Mini-Micro Hydro Power Project.

NOTE: *IT IS REQUESTED THAT THE INFORMATION MAY PLEASE BE GIVEN IN REFERENCE OF RUN OF THE RIVER HPPs AS PER APPLICABILITY.*

S. No.	ENVIRONMENTAL /SOCIAL IMPACTS	DURING CONSTRUCTION PHASE					DURING OPERATIONAL PHASE					COMMENTS
		NEGATIVE IMPACTS					NEGATIVE IMPACTS					
		Extreme High (4)	High (3)	Medium (2)	Low (1)	No (0)	Extreme High (4)	High (3)	Medium (2)	Low (1)	No (0)	
(I)	AIR/NOISE ENVIRONMENT											
DO THE PROJECT												
1	Air/Climatology :											
•	Cause air pollutant emissions which exceed national or state standards or cause deterioration of ambient air quality?											
•	Create Objectionable odors & production of green house gases due to anaerobic decomposition?											
•	Cause emissions of hazardous air pollutants regulated under the Clean Air Prevention and Control of Pollution Act 1981, 1987?											
•	Cause air pollution in surrounding areas due to muck dumping?											
•	Alter climate with respect to temperature and relative humidity in the surrounding area?											
DO THE PROJECT												
2	Noise :											
•	Cause noise pollution which exceed Noise Pollution Roles,2000?											
•	Expose people to excessive noise?											
(II)	LAND ENVIRONMENT											
DO THE PROJECT												
3	Land form :											
•	Result in impact on stability of topography/surrounding area and embankments due to excavation of tunnels?											

•	Cause extensive disruption to or displacement of soil due to heavy blasting?											
•	Cause change in ground contours, shorelines, stream channels, or river banks?											
•	Create any impact to land classified as prime or unique farmland?											
•	Cause destruction, covering or modification of unique physical features?											
•	Increase wind or water erosion of soil?											
•	Alter the foreclosure on future uses of site on a long-term basis?											
DO THE PROJECT												
4	**Land use :**											
•	Increase the rate of use of natural resources?											
•	Deplete natural resources?											
•	Create any impact caused by temporary or permanent working colonies construction in surrounding areas?											
•	Cause impact on horticulture, agriculture and cropping pattern?											
•	Cause alteration in land use and stability of slopes due to Muck dumping?											
•	Result in impact on or construction in a wetland or inland floodplain?											
DO THE PROJECT												
5	**Seismology :**											
•	Cause risk when projects are constructed on higher seismic zone?											
•	Induce risk of earthquakes by creation of large water bodies?											
•	Increase seismic activity in the area due to water pressure in reservoir?											
DO THE PROJECT												
6	**Geology :**											
•	Result in impacts on the geomorphologic properties of river?											

(III)	WATER ENVIRONMENT										
DO THE PROJECT											
7	**Water quality :**										
•	Change the quality of water resources, regulated under the Water Prevention and Control of Pollution Act, 1974, 1988?										
•	Cause alteration of surface water quality within, adjacent to, or near the project area?										
•	Cause contamination of public water supplies?										
•	Cause alteration in ground water quality?										
•	Cause any change in quality of impounded water?										
•	Cause any change in permissible or tolerable water uses?										
•	Change water quality due to addition of human and animal toxic in water?										
•	Cause impacts on dissolved oxygen of water during its retaining in the reservoir and while passing through the machines and close water conductor system?										
•	Changes the quality of water at downstream due to stopping the flow of nutrient?										
DO THE PROJECT											
8	**Water resources :**										
•	Cause impoundment, control or modification of any body of water?										
•	Cause water loss due to evaporation?										
•	Cause downstream effects in term of decreased flow into river?										
•	Result in change in local ground water level?										
•	Cause inundation of mineral resources?										
•	Create any impact on water usages for drinking?										

•	Cause problem of inadequate Environmental flow.											
•	Create any impacts on water usages for irrigation?											
•	Cause any impacts of Muck dumping on existing water resources?											
•	Results in impacts of exploration of tunnels on the natural water resources?											
DO THE PROJECT												
9	**Surface water hydrology :**											
•	Change in drainage patterns, the rate and amount of surface water runoff?											
•	Change in currents or water movement in fresh water?											
•	Cause impacts on rainfall and snowfall pattern?											
DO THE PROJECT												
10	**Ground water hydrology :**											
•	Cause alteration of the direction or rate of flow of groundwater?											
•	Results in any impacts on existing ground water table?											
DO THE PROJECT												
11	**Flooding :**											
•	Cause alteration to the course or flow of flood waters?											
•	Cause exposure of people or property to water-related hazards such as flooding?											
•	Cause impact on river bed due to high sedimentation of flood water.											
DO THE PROJECT												
12	**Sedimentation :**											
•	Results in impacts of sedimentation, silting on upstream and downstream of dam?											
(IV)	**BIOLOGICAL ENVIRONMENT**											
DO THE PROJECT												
13	**Flora/ terrestrial plants :**											
•	Change the diversity or productivity of species or number of any species of plants?											
•	Reduce the numbers											

	or affect the habitat of any State, rare, endangered species of plants?											
•	Cause any impact on forest resources within, adjacent to, or near the project area, regulated under the Forest Conservation Act, 1980, 1988?											
•	Reduce acreage or create damage to any agricultural crop?											
•	Introduce new species of plants into area or create a barrier to the normal replenishment of existing species?											
DO THE PROJECT												
14	**Aquatic flora :**											
•	Promote/ demote growth of aquatic weeds such as water hyacinths?											
DO THE PROJECT												
15	**Fauna / terrestrial animals :**											
•	Reduce the habitat or numbers of any State, rare, or endangered species of animals?											
•	Introduce new species of animals into the area or create a barrier to the migration and movement of animals?											
•	Cause attraction, entrapment, or impingement of animal life?											
•	Harm existing wildlife habitats, regulated under the Wildlife Protection Act, 1980?											
•	Introduce new disease vectors into the area from upstream as a result of hydrological changes?											
•	Cause emigration resulting in human-wildlife interaction problems?											
DO THE PROJECT												
16	**Aquatic animals :**											
•	Change in number and types of fish?											
•	Create a barrier to the movement of migratory fish?											
•	Harm existing fish habitats?											

•	Affects commercial fisheries or aqua cultural resources or production?										
•	Cause any impact on micro organisms/ bacteriological activities?										
(V)	**HUMAN ENVIRONMENT**										
DO THE PROJECT											
17	**Relocation-resettlement :**										
•	Alter the location or distribution of human population in the area?										
DO THE PROJECT											
18	**Accident risk/ human health :**										
•	Cause risk to the national security?										
•	Expose people to potential health hazards and risk of explosion?										
•	Expose the migrant workers to psychological strains and traumas from changes in living and working conditions?										
DO THE PROJECT											
19	**Community Facilities/ services**										
•	Result in changes in community facilities, services or institutions?										
•	Creates new opportunities for recreational experiences?										
•	Have any adverse effect on local or regional economic conditions, e.g., tourism, local income levels, land values or employment?										
DO THE PROJECT											
20	**Aesthetics :**										
•	Create an aesthetically offensive site open to the public view?										
•	Significantly change the visual scale or character of the vicinity?										
DO THE PROJECT											
21	**Archaeological, cultural and historical resources**										
•	Affect any site or structure of historic significance?										

•	Affect any known archaeological or paleontological site?											
•	Alter cultural sites, structures, objects or buildings?											
DO THE PROJECT												
22	**Economy**											
•	Affect the socio-economic development of the area.											
•	Affects the land values of area.											

APPENDIX-II

LIST OF EXPERTS

Sr. No.	Name	Designation	Institute/ Sector	Place
(I).EXPERT IN THE FIELD				
1.	Er. R. N. Sharma	Ex. Executive Director	SJVNL	Shimla
2.	Er. C.M. Walia	Ex Member (E) & Ex Director (E)	HPSEB HPPCL	Shimla
3.	Er. H.M. Dharula	Chief Engineer (Energy)	Directorate of Energy	Shimla
4.	Er. M. G. Thakur	S. E.	DoE	Shimla
5.	Sh. K. L. Thakur	Director	Himurja	Shimla
(II). ENVIRONMENTAL EXPERT				
6.	Sh. Rakesh Sood	Chief Environment Specialist	HPPCL	Shimla
7.	Er. D. K. Sharma	Sr. Environment Engineer	H.P. State Pollution Control Board	Shimla
8.	Sh. Vinod Kumar Tiwari, IFS	Chief Conservator of Forest	Himachal Pradesh Forest department	Shimla
9.	Dr. Arun Kumar (Academicians)	Professor & Chair Professor	IIT Roorkee & MNRE	Roorkee
10.	Dr. Dharmendra	Assistant Professor	NIT Hamirpur	Hamirpur

ANNEXURE-III

QUESTIONNAIRE FOR PROJECTS MANAGERS DURING FIELD VISIT

EXPERT OPINION SURVEY FORM
M. Tech (ENVIRONMENTAL ENGINEERING)
CIVIL ENGINEERING DEPARTMENT
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

DISSERTATION TITLE: HYDRO POWER PROJECTS IN HIMACHAL PRADESH- . Review and Analysis of Impacts and Risks.

By: ANAMIKA GANDHI ADMISSION NO. 142757 (EE)

Supervised by: Dr. VEERESH S. GALI (Professor)

I, Anamika Gandhi, student of M.Tech. (Environmental Engineering) collecting following information for my M. Tech. dissertation, hereby declare that the data collection will be used purely for academic purpose only. Thanking you for your kind support.

NAME: ____________________
EDUCATION QUALIFICATION: ____________________
OCCUPATION: ____________________
DESIGNATION: ____________________
CONTACT: ____________________

You are requested that the information may please be given in reference of Run of the River Hydro Power Project as per applicability, the weight age to Environmental/Social factors normalized to **extreme high** to **no** impact scale depending upon the impacts on them.

NOTE: **EH** Represents extreme high impact.
H Represents high impact.
M Represents medium impact.
L Represents low impact.
N Represents no impact.

Sr. NO.	ENVIRONMENTAL/SOCIAL FACTORS	NEGATIVE IMPACT				N	COMMENT
		EH	H	M	L		
(I)	**AIR / NOISE ENVIRONMENT**						
1.	Air / Climatology:						
•	Does the Project cause air pollution due to construction activities (excavation, tunneling, blasting), muck dumping, bad odours due to decomposition (water and Organic matter)?						
•	Does the project cause change in temperature and humidity?						
2.	Noise:						
•	Does the Project cause noise pollution due to construction activities, exposure of people to noise / excessive noise?						
(II)	**LAND ENVIRONMENT**						
3.	Land Form:						
•	Does the Project cause displacement of soil, attraction in stability of topography / surrounding area / embankment and change future use of site?						
4.	Land Use:						
•	Does the Project alter the use like formation of temporary and permanent working colonies and changes the cropping pattern, agriculture and horticulture land?						
5.	Seismology:						
•	Does the Project cause risk of earthquake due to excavation, blasting, heavy structure construction activities?						
6.	Geology:						
•	Does the Project cause change in geomorphologic properties of rivers and land?						
(III)	**WATER ENVIRONMENT**						
7.	Water Quality:						
•	Does the Project alter the quality of surface water, groundwater bodies and water quality for public supplies?						
•	Does the Project decrease nutrients in water?						
8.	Water Resources:						
•	Does the Project alter the water resources due to evaporation lose, less river flow in downstream, reduction in ground water level and discharge of water below E- Flow from upstream?						
9.	Surface Water Hydrology:						
•	Does the Project alter the rate and amount of surface water / fresh water flow (river / rainfall / snowfall)?						
10.	Ground Water Hydrology:						
•	Does the Project alter the rate and amount of ground water?						
11.	Flooding:						

•	Does the Project cause exposure of People and property to flood?						
12.	Sedimentation:						
•	Does the Project result in sedimentation and problems related to sedimentation – like flushing of water contain more silt, solid particle and decrease water quality and lack of nutrient in downstream due to impoundment of water in upstream?						
(IV)	**BIOLOGICAL ENVIRONMENT**						
13.	Flora / Terrestrial Plants:						
•	Does the Project alter the productivity and number of plant species due to damage due to existing species or presence of new species?						
14.	Aquatic Flora:						
•	Does the Project alter the promotion / demotion of aquatic weeds?						
15.	Fauna / Terrestrial Animals:						
•	Does the Project alter animal habitation, their species and productivity?						
•	Does the Project introduce the vectors causing disease, human and wild life interaction?						
16.	Aquatic Animals:						
•	Does the Project alter the number, type of fish and affect the fish habitats?						
•	Does the Project create problem in movement, migration of fish and microbial activities?						
(V)	**HUMAN ENVIRONMENT:**						
17.	Relocation – Resettlement:						
•	Does the Project cause alteration in human civilization and population distribution?						
18.	Accident risk / Human health:						
•	Does the Project expose people (from surrounding area / migrant workers) to potential health hazards and risk of explosion?						
19.	Community Facilities / services:						
•	Does the Project result in change in community facilities, services of institutions (Tourism, Job opportunity, medical, and education facilities)?						
20.	Aesthetics:						
•	Does the Project create an aesthetically offensive site and causes significant change in the visual scale of the vicinity?						
21.	Archaeological, Cultural and Historical Resources:						
•	Does the Project affect any cultural site, historical building or structure?						
22.	Economy:						
•	Does the Project affect the socio – economic development and land value of area?						

APPENDIX-IV

QUESTIONNAIRE FOR PUBLIC FEEDBACK

HOUSEHOLD SURVEY FORM
M. Tech (ENVIRONMENTAL ENGINEERING)
CIVIL ENGINEERING DEPARTMENT
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

DISSERTATION TITLE: HYDRO POWER PROJECTS IN HIMACHAL PRADESH- Review and Analysis of Impacts and Risks.

By: ANAMIKA GANDHI ADMISSION NO. 142757 (EE)

Supervised by: Dr. VEERESH S. GALI (Professor)

I, Anamika Gandhi, student of M.Tech. (Environmental Engineering) collecting following information for my M. Tech. dissertation, hereby declare that the data collection will be used purely for academic purpose only. Thanking you for your kind support.

NAME: ____________________
EDUCATION QUALIFICATION: ____________________
OCCUPATION: ____________________
DESIGNATION: ____________
CONTACT: ____________________

You are requested that the information may please be given in reference of Run of the River Hydro Power Project as per applicability, the weight age to Environmental/Social factors normalized to **extreme high** to **no** impact scale depending upon the impacts on them.
NOTE: **EH** Represents extreme high impact. **H** Represents high impact. **M** Represents medium impact. **L** Represents low impact. **N** Represents no impact.

क्रमांक	पर्यावरण/सामाजिक कारक	नकारात्मक प्रभाव				एन	टिप्पणी
		ईएच	एच	एम	एल		
(I)	हवा/ध्वनि पर्यावरण:						
1.	हवा/जलवायु :						
•	क्या यह परियोजना अपनी निर्माण गतिविधियों (खुदाई , सुरंग, नष्ट करना), कूड़ा-कर्कट निपटान की गतिविधियों तथा अपघटन की गतिविधियों (जल और जैविक पदार्थ के सड़ने से बुरी गंध) के कारण वायु प्रदूषण करती है?						
•	क्या यह परियोजना तापमान और आर्द्रता में परिवर्तन का कारण है?						
2.	ध्वनि:						
•	क्या यह परियोजना अपनी निर्माण गतिविधियों से ध्वनि प्रदूषण तथा शोर / अत्याधिक शोर का खतरा लोगों को करती है?						
(II)	भूमि पर्यावरण						
3.	भूमि आकृति:						
•	क्या यह परियोजना मिट्टी के विस्थापन, स्थलाकृति / आसपास के क्षेत्र / तटबंध (बांध) की स्थिरता में तथा निर्माण-स्थान के भविष्य में उपयोग में परिवर्तन करती है?						
4.	भूमि उपयोग:						
•	क्या यह परियोजना अस्थायी और स्थायी काम कर कालोनियों (बस्तियों) के गठन से भूमि के इस्तेमाल में परिवर्तन करती है तथा फसल पद्धति, कृषि और बागवानी की भूमि में परिवर्तन करती है?						
5.	भूकम्प विज्ञान :						
•	क्या यह परियोजना खुदाई भारी संरचना निर्माण आदि गतिविधियों के कारण भूकंप का खतरा पैदा करती है?						
6.	भूविज्ञान:						
•	क्या यह परियोजना नदी और जमीन के भूवैज्ञानिक गुणों में बदलाव करती है?						
(III)	जल पर्यावरण:						
7.	पानी की गुणवत्ता:						
•	क्या यह परियोजना सतही जल (नदी) की गुणवत्ता, भूजल						

	की गुणवत्ता, सार्वजनिक आपूर्ति के पानी की गुणवत्ता में परिवर्तन करती है?						
•	क्या यह परियोजना पानी में पोषक तत्वों की कमी करती है?						
8.	जल संसाधन:						
•	क्या यह परियोजना वाष्पीकरण के कारण, परियोजना स्थान के नीचे की ओर नदी में कम बहाव, भू-जल स्तर में कमी, परियोजना स्थान से पर्यावरणीय- बहाव के स्तर से नीचे पानी की छूट से जल संसाधनों में परिवर्तन करती है?						
9.	सतही जल विज्ञान:						
•	क्या यह परियोजना सतह के पानी/ ताजा पानी (नदी / वर्षा / बर्फबारी) के प्रवाह के दर और मात्रा में परिवर्तन करती है?						
10.	भूजल जल विज्ञान:						
•	क्या यह परियोजना भू-जल की दर और मात्रा में परिवर्तन करती है?						
11.	बाढ़:						
•	क्या यह परियोजना लोगों और संपत्ति को बाढ़ के जोखिम में लाने का कारण बनती है?						
12.	अवसादन						
•	क्या अवसादन (मल जमना) और अवसादन से संबंधित समस्यांए जैसे की- निस्तब्धता(flushed) पानी में अधिक गाद, ठोस कण का होना, पानी की गुणवत्ता में कमी और परियोजना से नीचे की ओर पानी में पोषक तत्वों की कमी परियोजना के परिणाम(नतीजे) हैं?						
(IV)	जैविक पर्यावरण						
13.	पेड़ पौधे/ओषधि/ स्थलीय पौधे:						
•	क्या यह परियोजना मौजूद पौधों की प्रजातियों की क्षति तथा नई प्रजातियों की उपस्थिति के कारण मौजूदा प्रजातियों की उत्पादकता और संख्या में परिवर्तन करती है?						
14.	जलीय वनस्पति						
•	क्या यह परियोजना जलीय खरपतवार की पदोन्नति (तरक़्क़ी)/ पदावनति को बदल देती है?						

15.	जीव / स्थलीय पशु						
•	क्या यह परियोजना पशु बस्तियों, उनकी प्रजातियों और उत्पादकता में परिवर्तन करती है?						
•	क्या यह परियोजना रोग फैलाने वाले कीटो/किटाणुओं का आरंभ करता है, तथा मानव और वन्य जीवन के आमने-सामने का कारण बनती है?						
16.	जलीय जानवर						
•	क्या यह परियोजना मछली की संख्या , प्रकार में परिवर्तन और मछली निवास को प्रभावित करती है?						
•	क्या यह परियोजना में समस्या , मछली के चाल और स्थानान्तरण तथा माइक्रोबियल गतिविधियों में समस्या पैदा करती है?						
(V)	मानव पर्यावरण:						
17.	स्थानांतरण – पुनर्वास:						
•	क्या यह परियोजना मानव सभ्यता और जनसंख्या विभाजन (फैलाव) में परिवर्तन का कारण है?						
18.	दुर्घटना जोखिम / मानव स्वास्थ्य						
•	क्या यह परियोजना लोगों(आस-पास के क्षेत्र / प्रवासी श्रमिकों) को संभावित स्वास्थ्य खतरों और विस्फोट के जोखिम पैदा करती है?						
19.	सामुदायिक सुविधाएं / सेवाएं:						
•	क्या यह परियोजना सामुदायिक सुविधाओं में परिवर्तन, संस्थानों की सेवाएं (पर्यटन, नौकरी अवसर , चिकित्सा, शिक्षा की सुविधा) प्रदान करती है?						
20.	सौंदर्यशास्त्र:						
•	क्या यह परियोजना सौंदर्य की दृष्टि से आक्रामक स्थान (साइट) और आसपास के क्षेत्र के दृश्य पैमाने में महत्वपूर्ण परिवर्तन का कारण बनती है?						
21.	पुरातात्विक, सांस्कृतिक और ऐतिहासिक संसाधन						
•	क्या यह परियोजना किसी भी सांस्कृतिक स्थल , ऐतिहासिक इमारत या संरचना को प्रभावित करती है?						
22.	अर्थव्यवस्था:						
•	क्या यह परियोजना क्षेत्र के सामाजिक-आर्थिक विकास और क्षेत्र के भूमी मूल्यों को प्रभावित करती है?						

APPENDIX-V

SURVEY FORM FOR RELATIVE IMPORTANCE OF ENVIRONMENTAL RISK FACTORES

EXPERT OPINION SURVEY FORM
M. Tech (ENVIRONMENTAL ENGINEERING)
CIVIL ENGINEERING DEPARTMENT
JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

DISSERTATION TITLE: HYDRO POWER PROJECTS IN HIMACHAL PRADESH- . Review and Analysis of Impacts and Risks.

By: ANAMIKA GANDHI ADMISSION NO. 142757 (EE)

Supervised by: Dr. VEERESH S. GALI (Professor)

I, Anamika Gandhi, student of M.Tech. (Environmental Engineering) collecting following information for my M. Tech. dissertation, hereby declare that the data collection will be used purely for academic purpose only. Thanking you for your kind support.

NAME:
EDUCATION QUALIFICATION:
OCCUPATION:
DESIGNATION:
CONTACT:

You are requested to give weightage to risk factors normalized to a 1-5 scale depending upon their importance.
NOTE: **5- Represents very high importance.** **&** **1- Represents very low importance.**

TABLE OF RISK FACTORS

Sr. No.	RISK FACTOR	IMPORTANCE				
		1	2	3	4	5
1.	Air/Climatology					
2.	Noise					
3.	Land form					
4.	Land use					
5.	Seismology					
6.	Geology					
7.	Water quality					
8.	Water resources					
9.	Surface water hydrology					
10.	Ground water hydrology					
11.	Flooding					
12.	Sedimentation					
13.	Flora/ terrestrial plants					
14.	Aquatic flora					
15.	Fauna / terrestrial animals					
16.	Aquatic animals					
17.	Relocation- resettlement					
18.	Accident risk/ human health					
19.	Community Facilities/ services					
20.	Aesthetics					
21.	Archaeological cultural and historical resources					
22.	Economy					

APPENDIX-VI

EVALUATION CRITERIA

Sr. No.	RISK FACTOR	SCORE (0)	SCORE (1)	SCORE (2)	SCORE (3)	SCORE (4)
1	Air/ Climatology	No air pollution and climate change.	An air pollutant emission is low.	An air pollutant emission is medium.	An air pollutant emission is high.	An air pollutant emission is very high.
2	Noise	No noise pollution.	Low noise level.	Medium noise level.	High noise level.	Extreme noise level.
3	Land form	No change.	Disruption to or displacement of soil is low.	Disruption to or displacement of soil is medium.	Disruption to or displacement of soil is high.	Disruption to or displacement of soil is very high.
4	Land use	No change in land use.	Property of treasury.	Forest.	Private property: Agricultural land.	Private property: Residential area.
5	Seismology	No effects on seismology of area.	Risk of earthquake by construction is low.	Risk of earthquake by construction is medium.	Risk of earthquake by construction is high.	Risk of earthquake by construction is extreme.
6	Geology	No change in geology.	Impacts on the geomorphologic properties of river are low.	Impacts on the geomorphologic properties of river are medium.	Impacts on the geomorphologic properties of river are high.	Impacts on the geomorphologic properties of river are very high.
7	Water quality	No change in quality of water.	Change in ground water & surface water quality is less.	Change in ground water & surface water quality is medium.	Change in ground water & surface water quality is high.	Change in ground water & surface water quality is very high.
8	Water resources	No negative impact on water resources.	Impact on natural water resources is low.	Impact on natural water resources is medium.	Impact on natural water resources is high.	Impact on natural water resources is very high.
9	Surface water hydrology	No change in surface water hydrology.	Change in drainage pattern, rate & amount of surface water runoff is low.	Change in drainage pattern, rate & amount of surface water runoff is medium.	Change in drainage pattern, rate & amount of surface water runoff is high.	Change in drainage pattern, rate & amount of surface water runoff is very high.
10	Ground water hydrology	No negative impact on ground water hydrology.	Impact on rate of flow & on existing ground	Impact on rate of flow & on existing ground	Impact on rate of flow & on existing ground	Impact on rate of flow & on existing ground

			water table is low.	water table is medium.	water table is high.	water table is extreme.
11	Flooding	Cause no flooding impacts.	Exposure of people & property to flood is less.	Exposure of people & property to flood is medium.	Exposure of people & property to flood is high.	Exposure of people & property to flood is very high.
12	Sedimentation	Cause no impacts of sedimentation.	Impacts of sedimentation & silting are low.	Impacts of sedimentation & silting are medium.	Impacts of sedimentation & silting are high.	Impacts of sedimentation & silting are very high.
13	Flora/ terrestrial plants	No negative impacts on terrestrial plants.	Effects on habitats and diversity or productivity of species are low.	Effects on habitats and diversity or productivity of species are medium.	Effects on habitats and diversity or productivity of species are high.	Effects on habitats and diversity or productivity of species are very high.
14	Aquatic flora	No negative impacts on aquatic flora.	Impacts on aquatic flora are low.	Impacts on aquatic flora are medium.	Impacts on aquatic flora are high.	Impacts on aquatic flora are very high.
15	Fauna / terrestrial animals	No negative impacts on terrestrial animals.	Effects on terrestrial animal/ fauna are low.	Effects on terrestrial animal/ fauna are medium.	Effects on terrestrial animal/ fauna are high.	Effects on terrestrial animal/ fauna are very high.
16	Aquatic animals	No negative impacts on aquatic animals.	Impacts on number and type of fish and microorganisms are low.	Impacts on number and type of fish and microorganisms are medium.	Impacts on number and type of fish and microorganisms are high.	Impacts on number and type of fish and microorganisms are very high.
17	Relocation-resettlement	No alteration in location and distribution in human population.	Alteration in location or distribution of human population is low.	Alteration in location or distribution of human population is medium.	Alteration in location or distribution of human population is high.	Alteration in location or distribution of human population is very high.
18	Accident risk/ human health	Cause no accident risk and other human health issues.	Health hazards and risk of explosion are low.	Health hazards and risk of explosion are medium.	Health hazards and risk of explosion are high.	Health hazards and risk of explosion are extreme.
19	Community Facilities/ services	No negative impacts on services and community facilities.	Bad effect on services and facilities are low.	Bad effect on services and facilities are medium.	Bad effect on services and facilities are high.	Bad effect on services and facilities are very high.

20	Aesthetics	No aesthetical changes.	Change in visual scale or character of the vicinity are less.	Change in visual scale or character of the vicinity are medium.	Change in visual scale or character of the vicinity are high.	Change in visual scale or character of the vicinity are extreme.
21	Archaeological cultural and historical resources	No negative impacts.	Effects on cultural & historic sites and structures are low.	Effects on cultural & historic sites and structures are medium.	Effects on cultural & historic sites and structures are high.	Effects on cultural & historic sites and structures are very high.
22	Economy	No changes in land value and economy.	Effects on the land values and economic condition are low.	Effects on the land values and economic condition are moderate.	Effects on the land values and economic condition are high.	Effects on the land values and economic condition are very high.

(Source: Kucukali, 2011)