IMAPCT OF HYDROPOWER SECTOR ON THE ECONOMY OF SIKKIM

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Submitted in Partial Fulfillment of Degree of Master of Philosophy

FEBRUARY 2015

Sikkim University, 6th Mile Samdur, Tadong, Gangtok, Sikkim

Date: ……………, 2015

DECLARATION

I hereby declare that the research work embodied in the dissertation titled **"IMAPCT OF HYDROPOWER SECTOR ON THE ECONOMY OF SIKKIM"** submitted to **Sikkim University** is my original work. The content of this dissertation or any part of it has neither been submitted nor has been presented anywhere for any other degree, diploma etc.

The entire work of the dissertation has duly acknowledged the work of others wherever and whenever they are used in the thesis

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We declare that this dissertation be placed before the examiners for evaluation.

Head of the Department　　　　　　　　　　Supervisor

CERTIFICATE

This is to certify that the dissertation titled **"IMAPCT OF HYDROPOWER SECTOR ON THE ECONOMY OF SIKKIM"** submitted to the Sikkim University for partial fulfillment of the requirement of the degree of **Master of Philosophy** in Social Science embodies the result of *bona fide* research work carried out by **Anita Subba** under my sincere guidance and direct supervision. No part of the dissertation has been submitted anywhere for any other degree, diploma, scholarship and fellowship

All the assistance and help received the research work have been duly acknowledged by her.

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Acknowledgement

I would like to take this opportunity to acknowledge my sincere gratitude to my supervisor, Dr. Pradyut Guha who encouraged me to undertake the study. This dissertation would not have been possible without his guidance, support and encouragement.

I would like to express sincere thanks to our Head of Department, Dr. Manish Choubey for his suggestion and guidance during the course.

I would like to extend my heart full gratitude to Dr. Komol Singh, Dr. Rajesh Raj S.N. and Dr. Rangalal Mohapatra for their valuable insight and suggestions in the study.

I am further grateful to Sikkim University Library, State Electricity Board, member of DESMI, Lobsang Tamang of Chungthang and Poonam Lepcha from Dikchu for providing data and helping me during my field visit.

Last but not the least; I would like to extend my sincere gratitude to my family, friends for their constant encouragement, patience, and support throughout my dissertation.

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Abbreviations

GW = Giga Watt

MW = Mega Watt

MU = Million Units

MKwh = Mega Kilo Watt hour

Kwh = Kilo Watt hour

GWh = Giga Watt hour

HEP = Hydro-Electric Power Project

BOOT= Build, Own, Operate, Transfer

SGDP = State Gross Domestic Product

NHPC = National Hydroelectric Power Corporation Ltd.

MAHAGENCO = Maharashtra Generating Corporation

SJVNL = Satluj Jal Vidyut Nigam Ltd.

THDC = Tehri Hydroelectric Development Corporation

DESMI = Department of Economics and Statistics Monitoring and Evaluation

CAGR = Compound Annual Growth Rate

Dw-d = Durbin-Watson test

MOSPI = Ministry of Statistics and Programme Implementation

Chapter I

1.1 Introduction

One of the important infrastructural service sectors in any economy is power sector. Electricity as a source of energy has remained essential for human survival as well as a key factor for economic development. Beside household and commercial needs electricity is life blood for various sectors of the economy like the agriculture, industry, transport and communication, information technology, other service sector usage. The energy dependence being common to every sector of the economy justifies the association between energy utilization and the overall economic growth rate in an economy. Hence any deficiency in supply of oil, natural gas and electricity generations may directly constrain the economic activities, thereby the growth rate. The declining supply of these sources of energy not only raises the input prices but also influences the prices of other commodities leading to a rise in overall inflation rate and thereby dampening the aggregate demand and growth rate.

As the population of an economy grows, so does the demand for electricity to satisfy the needs of the growing population. The importance of energy to economic growth was emphasized by William Stanley Jevons (Energy Economics, 2014). As per the Report of Los Alamos National Laboratory (1986) the electricity use and gross national product of any country have been claimed to be strongly correlated.In India, the power sector is viewed as a public utility and basic infrastructure. While undergoing a transition, from a controlled environment to a competitive market driven regime in the post 90s it has to provide affordable, reliable and quality power at reasonable prices to various segments of consumers in the economy. With a population of over 1.2 billion people and increasing, the development of such a system of power supply is crucial for the development of the economy.

Earlier hydropower was used for irrigation and operation of various machines, such as watermills, textile machines and sawmills. But since in 1870's when the first hydroelectric power project was installed in Cragside, Rothbury of England it is marked as an important source of electricity generation (Kumar et al., 2011).It has been observed that in 2008, countries like Albania, Bhutan, Lesotho and Paraguay generated all their electricity from hydropower and in 2010, countries like China, Brazil, The United States, Canada and Russia accounted for approximately 52 per cent of the world installed hydropower capacity (World Watch Institute, 2013).

India's contribution in comparison to the world is very low, however, it has an enormous hydroelectric power potential of around 150,000 MW (Megawatt = 10^6 Watt). In India contribution of electricity generation from Hydro Electric Power Stations has increased from 2194 MU (Million Unit = 10^6 Units) during 1947 to about 113720.29 MU in 2012-13. In case of total electricity consumption the country has experienced an increase of 4182 MU in 1947 to 710673 MU in 2011. Out of the country's total hydropower potential of 150,000 MW, equivalent to 84,044 MW at 60 per cent load factor, 4286 MW (2.88 per cent) is located in Sikkim out of which 13 per cent is developed, 57 per cent is under construction and 30 per cent is yet to develop (Central Electricity Authority, 2013).

1.2 Hydropower as an Energy Sector

Hydropower is a renewable source of energy in the sense that it is relatively economic, pollution free and compatible with the environment (Chandrasekharan, 1995). Hydropower is based on water driving the turbines. As being a water driven source it uses water as its 'fuel' which further release for other purpose like irrigation, domestic use, and industrial use etc, which is why it is a renewable source of energy.

In comparison to other types of generation resources, hydropower plants have exceptionally low costs of operation, are highly reliable, and produce electricity without burning fossil fuels and producing air pollution or carbon dioxide. In addition, they provide voltage control, system regulation and other ancillary services which help to ensure the reliability and electrical integrity of the system. It also avoids the hazards of coal mining and the indirect health effects of coal emission. Compared to nuclear power, hydroelectricity generates no nuclear waste, has none of the dangers associated with uranium mining nor nuclear leaks. Compared to wind farms, hydroelectricity power plants have a more predictable load factor. Hydroelectric plants can be easily regulated to follow variations in power demand. By producing revenues hydro projects has positively contributed towards economy making self-reliance (Tamang et al., 2004). Moreover making irrigation of lands at higher elevations possible through dam facilities and making power available for use on the farm for domestic purposes hydropower directly benefits rural areas.

Although hydropower plays an important role in the electric power system without polluting the environment, it is not free from adverse environmental and social effects which are often ignored in economic cost-benefit analyses. Some large hydropower facilities have always negatively influence the physical and biological environments. Some of the threats outlined where involuntary resettlements, loss of vegetation, change in riverine flow, flow patterns and regimes, health problems, loss of cultural values, marginalization of local people, loss of agricultural lands, drought, and reduction of flow of water in the downstream (Girmay, 2006). Furthermore, although dam contributes to the energy and economy of the state, the people have questioned their impact on the environment and the society. In 2000, The World Commission on Dams estimated that dams had physically displaced 40-80 million people worldwide. Thus hydropower as a source of energy generation has favourable and disfavour-able impact on any economy. Hydropower projects helps in sustainable energy generation, helps the Government in earning revenue directly as well as indirectly, helps employment generation etc. But hydro project creates displacement challenges, loss of agricultural land, loss of vegetation and other socio-economic problem.

1.3 Literature Review

Various studies have been conducted by economist, social scientists, environmentalist, agencies etc, which highlights the positive as well as negative impact of hydropower projects on economy, developmental process, environment and the social change. Aydm (2010) analysed the prospect of generation of hydro energy via increased use of renewable energy resources which can help in reducing carbon emission level. In an attempt to understand the positive and negative impact of hydropower construction in north Sikkim, Purukayastha (2013) stated that it would help in the development process of state other way it may threat the agricultural practises of the Dzongu basin communities. Tamang et al., (2004) mentioned that hydropower project has positively contributed towards achieving economic self-reliance and overall socio economic development of Bhutan in terms of road access, grid electricity, school and hospitals and other income generation scheme, employment opportunities. Hydropower project was identified as the major driving force of economic development of Colombia by Rockwood (1979). Sharma et al., (2007) state that due to fragile nature of topography and delicacy of ecology of the Himalaya, construction of major hydropower projects results in lot of disturbances in terms of an increased extent of geological hazards, such as landslides, rock fall and soil erosion etc. The study looks at the negative impact of such major projects on the surrounding environment of Kullu, Himachal Pradesh. Beck et al., (2012) mentioned that the economic benefits of dams have been assumed to outweigh the costs, thus providing rationale for construction of dams around the world. However, the development of these structures can be accompanied by negative biophysical, socio-economic, and geopolitical impacts; often through the loss of ecosystem services provided by fully functioning aquatic systems. Moreover, impacts of dams can be involuntarily imposed on marginalized peoples whose livelihoods are dependent on riverine resources. Girmay (2006) have highlighted the environmental and social challenges arising out of construction and operation of hydropower projects, which have always negatively, influence the physical and biological environments. Some of the threats outlined where loss of vegetation, change in riverine flow, flow patterns and regimes, involuntary resettlements, health problems, loss of cultural values, marginalisation of local people, loss of agricultural lands, drought, and reduction of flow of water in the downstream. The study expresses the problem with earlier hydropower projects, which have given greater attention on technical, deigns and economic issue of the project rather than their environmental and social impact. The study suggested increased attention on environmental and social issues for a sound and sustainable hydropower energy generation. The social and economic impact of settlement displacement due change in river characteristics from increase economic activities under the preview of hydropower project construction was studied by Bergeten (2006). The study found construction of hydro projects given the way to high economic activity giving the construction phase and negatively affected the local economy in the form of unemployment and poverty in the post construction phase. Sale of land property by unskilled basin villagers made them unemployed in the post construction of hydroelectric project. The study suggested compensation to the individual or community in the form of new house to the resettles, preferential rates of electricity, revenue sharing, and better government policy will be helpful in overcoming the negative impact of such large hydroelectric project for the involuntary resettlement families. Candy and Shepherd (2012) in a study outlined the prospects and problems of hydropower development in Sikkim in the light of benefits such as employment which have been accrued to the rural community from these economic development projects and on the other side affecting adversely on their future livelihoods due to changes in land use and in people's occupations respectively. They argue that there is a need to support new types of land-based economic activities such as reclaims degraded lands, and introduction new products and production methods.

Studies like Bergsten (2006) and Chandy et al., (2012) had common observation about employment. They have found that the construction of hydropower projects has significantly generated employment during the construction period in the construction site. Aydm (2010) and Tamang (2004) views hydropower projects as a revenue generator so as to tackle with countries foreign dependency and to be a country of self sufficient. In the light of the role played by the hydropower project Rockwood (1979), Tamang (2004) and Aydm (2010) believed that such projects has contributed economically on development and growth process of a country. Sathaye (1996) and Aydm (2010) on the other side shares a common views regarding hydropower as being environmentally feasible in terms of carbon emission. They found that electricity generation through hydropower projects has been reliable and efficient. Further Rockwood (1979) and Beck et al., (2012) has common inspection regarding the importance of dam in terms of flood control, irrigation, power generation. They observed that dams has a very important role to play in controlling flood, providing water domestically as well as for irrigation and most importantly power generation. The overview of the positive common work done on hydropower projects by various researchers on the whole suggest that the hydropower projects has both economic as well as environmental advantage. However, every developmental activity has its own negative impacts on the surrounding environment. Settlement displacement is one of the major problems due to the large projects being highlighted in the studies of Bergsten (2006) and Girmay (2006).Studies of Purukayastha (2013), Girmay (2006) and Sharma et al., (2007) outlines the other social and environmental impacts of hydropower projects such as loss of cultural values, religion practices, loss of agricultural land, loss of vegetation, change in river flow and health problems. While on the other side Girmay (2006) studies was solely based on environmental and social challenges, focusing mainly on resettlement and loss of cultural values by conducting field surveys, interviews and group discussion.

Importance of hydropower projects on development and growth process of a country has been addressed in studies of Rockwood (1979), Tamang (2004) and Aydm (2010).Bergsten (2006) and Chandy et al., (2012) examined the importance of hydropower projects on employment generation. Loss of cultural values, religion practices, loss of agricultural land, loss of vegetation, change in river flow and health problems in the wake of development of hydropower sector has been addressed in the studies of Purukayastha (2013), Girmay (2006) and Sharma et al., (2007).The distributional effects of dam construction, and its effects on agricultural productivity have been investigated by Duflo and Pande (2007).

1.4 Research Gap

With the eve of development and with the growing needs of electricity, the government of Sikkim have liberalised their hydropower sector in 2005, which is why it gave an incentive for other private investors to invest in large hydropower project in the state. Thus, in present period, there are 28 large hydropower projects in Sikkim which are either under construction or under operation. Although, Sikkim has the potential of large hydropower projects which is identified as one of the key developmental activities for a sustainable development, we cannot ignore the fact that, Sikkim is a small state covering approximately 7,096 sq km (second smallest state in India after Goa in total area) and half of the citizens are directly or indirectly depends on forest/natural resources for their fodder. Again the sites of most hydropower projects are located in river valleys that are also the habitats for many plants and animal. Moreover, increase in construction of dams and the associated negative impacts have brought attention. Therefore, harassing the forest as well as the river of the state is directly a constraint to the livelihood of the local citizen and to those plants and animals which are resides in the river bed and forest. So, to look at the immediate as well as long run impact of such large hydropower projects in the context of Sikkim it is important to study the macroeconomic relationship between hydropower production with revenue and employment generation but also to see how and what challenges and opportunities that these hydropower projects has brought for the hydropower river dam site communities of Sikkim at primary level. Such an attempt will allow us to judge whether hydropower projects are beneficial or not and to what extent, to the state as a whole and at local level.

Various studies has been undertaken so far to see the epidemic influence of hydropower projects in North East India in general and Sikkim in particular. But there is hardly any study on the relationship between macroeconomic variables (such as revenue, total generation, employment and consumption of electricity from hydropower plants) to the state economy and on the socio economic impact of large hydropower projects in the local economy of the state. Present study is an attempt to bridge that gap.

1.5 Statement of the Problem

Any development project accrues either positive or negative externalities. The nucleus of this study to understand external economies and dis-economise of hydropower industry on the basian communities. The study tries to quantify those externalities from two perspectives: time perspective and locational perspective to find a relative measure.

1.6 Research Questions

The proposed research questions of the present study were;

a) How hydropower sector of Sikkim has contributed towards gross electricity and revenue generation of the state?

b) Whether emergence of hydropower sector has brought any challenges for the hydropower dam site communities in Sikkim?

1.7 Objectives of the Study

Present study was carried with following objectives in mind;

a) To understand the importance of hydropower sector in gross electricity generation, revenue generation of Sikkim.

b) To examine the immediate impact of hydropower project on dam site communities.

1.8 Research Methodology

The research methodology is comprised with following sub sections:

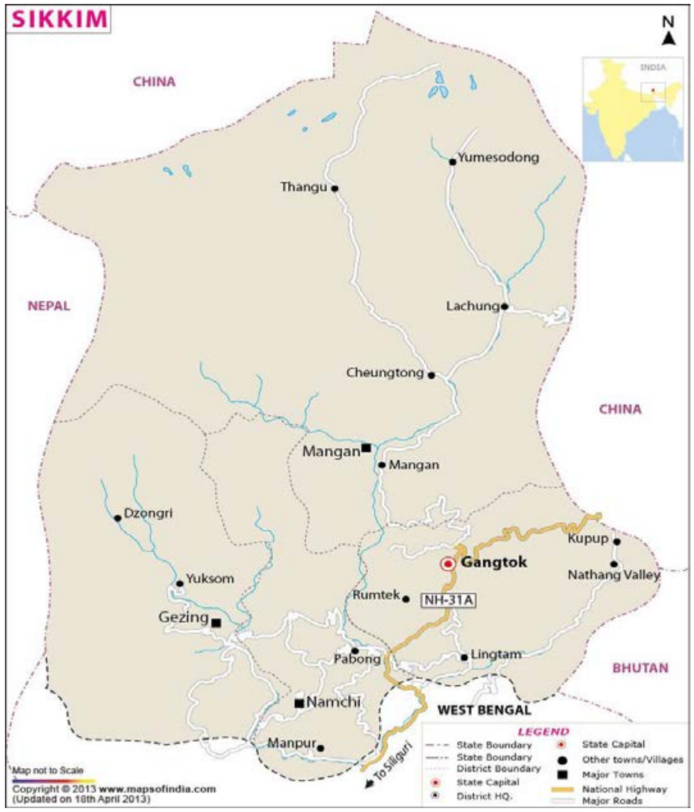
1.8.1 Data source

Present study has been undertaken with both secondary and primary data. The secondary data was cross sectional and time series in nature and were collected from published sources such as Ministry of Statistics and Program Implementation (Government of India), World Energy Resources Survey data, Statistical Hand book of Sikkim (for various years), Statistical record of Sikkim State Electricity board (various issues),Statistical records of Energy and power department of Sikkim, Statistical Records of National Hydroelectric Power Corporation Ltd. (NHPC), Besides, different books, newspapers, articles, journals, magazines and web sites were also consulted for the purpose.

Primary data was quantitative and qualitative in nature and was collected from sampled household with the help of a structured questionnaire during April -July 2014 by conducting personal interview with the head of the household. The data was collected for different sub-periods (pre and post hydropower dam development) and different sub groups (dam site and non-dam site communities). Primary data on dam site communities was collected for two different periods: pre dam (recalled data), post dam (day of survey). Two sub-year was considered for recalled data of dam site communities: Dikchu (prior to the year 2000), and for Chungthang (prior to the year 2007). Data was collected for the aspects such as: personal details, demographic patterns, household status, economic status, and accessibility status. Primary data was collected from non dam site communities on the similar aspects like those collected for dam site households. But, the comparison between dam site and non dam site was made by considering the current data and ignoring the recalled data of dam site household. The tabulated data were panel in nature for pre and post dam development period for dam site household.

1.8.2 Study Area

Sikkim is a tiny state of India located in the foothills of Eastern Himalayas between latitude of 27degree 49” and 28 degree 10” north and the longitudes of 88 degree 28” and 88 degree 55” East. The state is bordered by Nepal to the west, Tibet Autonomous Region of China to the north and east, and Bhutan to the east. The Darjeeling district of West Bengal lies to the south. As per 2011 census Sikkim has 607,688 populations which was 0.05 per cent of the total population of India. Sikkim is the least populous state in India and the second-smallest state after Goa in total area. Sikkim has 0.216 percent (7,096 sq km) of the total land area of India. The density of population in Sikkim is 86 persons/sq km and the sex ratio is 890 females/1000 males (Census 2011). The literacy rate of the state is 81.40 per cent with 86.60 per cent are male literates and 75.60 per cent are female literates (Census 2011). The state comprises total of seven ethnic groups namely, Nepalis, Lepchas (native inhabitants of the land), Bhutias, Tibetan immigrants, Marwaris, Biharis and Bengalis in some proportions.



Dikchu **Chungthang**

Figure 1.1 Map of Study area

The history of power development in Sikkim trace back to late 1960's when the state own micro hydropower plant Jali Power House Rongnichu Stage-I of 2.1 M.W installed capacity was established in Topakhani, East- Sikkim. Since then the state has been successful in establishing ten other such micro hydropower projects along with the two diesel power project. The details are portrayed in the following Table 1.1.

Table 1.1
State own Small Hydropower projects

Sl. NO.	Name of Power Plant	Location	Year of Commissioning	Installed Capacity (MW)
1	Jali Power House Rongnichu Stage-I	Topakhani, East- Sikkim	1966	2.1
2	Rimbi Stage-I	Rimbi, Wast-Sikkim	1970-71	0.6
3	LLHP	Ranipool, East- Sikkim	1979-80	12
4	Rongnichu Stage-II	Topakhani, East- Sikkim	1988-89	2.5
5	Rimbi Stage-II	Rimbi, West- Sikkim	1989-90	1
6	Chaten Micro Hydel	Lachen, North- Sikkim	1989-90	0.1
7	Lachung Micro Hydel	Lachung, North-Sikkim	1991-92	0.2
8	Meyong HEP	Meyong, North- Sikkim	1993-94	4
9	Upper Rongnichu HEP	Nimtar, East- Sikkim	1994-95	8
10	Kalez Khola HEP	Dentam, West- Sikkim	1995-96	2
11	Rabomchu	Rabom, North- Sikkim	2003	3
12	DPH Gtk.	Gangtok, East- Sikkim	1998	4
13	DPH Ranipool	Ranipool, East- Sikkim	1977	1

Source: DESMI, Govt. of Sikkim

Alongside the development of hydropower projects Sikkim has been flourishing with the large hydropower projects in recent years. The first major large hydel project in Sikkim was undertaken by NHPC named Rangit Power station III of 60 MW, commissioned on 1999. Over the period, number of major hydropower projects in Sikkim has been remarkably increased. Till 2013 there were 28 major hydropower projects in Sikkim out of which 4 are under operation and 24 are under construction. These projects will fetch 12 % free power for the first 15 years and 15 % free power after that for a period of 35 years after their completion. With course of time these projects shall be reverted back to the State free of cost in good operating condition. At present, the state is entitled for 12% free power from the project like Teesta Stage V (510 MW), which is owned by NHPC and is in operation giving the State about 300 MU energy free of cost annually.

Table 1.2
Private or Central Government Major Hydropower Projectss

Sl. No.	Name of Scheme	Agency	IC (MW)	Sl. No.	Name of Scheme	Agency	IC (MW)
1	Teesta-I	Himalyan green Energy Pvt. Ltd. New delhi	280	15	Chakhungchu	Amlgamated Transpower (I) Ltd New Delhi	50
2	Teesta-II	Him Urja Infra PVT. Ltd. New Delhi	330	16	Ralong	Amlgamated Transpower (I) Ltd New Delhi	40
3	Teesta-III	Teesta Urja Ltd. New Delhi	1200	17	Rangit-II	Sikkim Ventures Pvt. Ltd. Mumbai	66
4	Teesta-IV	NHPC Ltd. New Delhi	495	18	Rangit-IV	Jal Power Corporation Ltd. Hyderabad	120
5	Teesta-VI	Lanco Energy Pvt Ltd. New Delhi	500	19	Dikchu Jorethang Loop	Sneha Kinetic Power Project Ltd. Hyderabad	96
6	Lachen	NHPC Ltd. New Delhi	210	20	HEP	DANS Energy Pvt. Ltd. New Delhi	96
7	Panan	Himagiri Hydro Energy Pvt. Ltd. , Hyderabad	280	21	Linza	Nirma Chemical Works Ltd. Noida	99
8	Rangyong	BSCPL-SCL Joint Venture hyderabad	117	22	Lachung	Lachung Power Pvt. Ltd. New Delhi	99
9	Rongnichu	Mafhya Bharat Power Corporation Ltd.	96	23	Bimkyong	Teesta Power Pvt. Ltd. New Delhi	99
10	Sada Mangder	Gati Infrastructure Ltd. Hyderabad	71	24	Bop	Chungthang Power Pvt. Ltd. New Delhi	99
11	Chujachen	Gati Infrastructure Ltd. Hyderabad	99	25	Ting Ting Rateychu	SMEC (India) Pvt. Ltd. New Delhi	90
12	Bhasmey	Gati Infrastructure Ltd. Hyderabad	51	26	Bagchachu	Costal Projects Pvt. Ltd.	40
13	Rolep	Amlgamated Transpower (I) Ltd New Delhi	36	27	Tashiding	Shiga Energy Pvt. Ltd.	88
14	Rangit Power station III		60	28	Teesta-V	NHPC Ltd. New Delhi	510

Source: DESMI, Govt. of Sikkim

With the two main rivers Teesta from north and Rangit from west and their tributaries which are snow fed and therefore rich in water resources Sikkim has achieved a remarkable stage in terms of electricity generation in India from hydropower plants. Since the last decades these resources have been supporting enough for generation of electricity through introducing hydropower projects. Out of the country's total hydropower potential of 84,044 MW (at 60% load factor), 4286 MW (2.88%) is located in Sikkim out of which 13 per cent is developed, 57 per cent is under construction and 30 per cent is yet to developed (Central Electricity Authority, 2011).

Table 1.3
Sikkim status of hydro electric capacity (2013)
(In terms of Installed Capacity-above 25 MW)

Region/State	Identified Capacity as per reassessment study (MW)		Capacity Developed		Capacity Under Construction		Capacity yet to be developed	
	Total (MW)	Above 25 MW	(MW)	(%)	(MW)	(%)	(MW)	(%)
Sikkim	4286	4248	570.00	13.42	2421.00	56.99	1257.00	29.59
All India	148701	145320	34705.8	23.88	12372.0	8.51	98242.2	67.60

Source: Central Electricity Authority 2013.

1.8.3 Sampling Plan of the Study

The study was restricted to two hydropower projects (1 operational since 2008 and 1 under construction since 2007). Since Teesta River has six hydro power projects out of which only one is under operation and rest of the five are either under construction or under study (as in Table 1.4).

Table 1.4

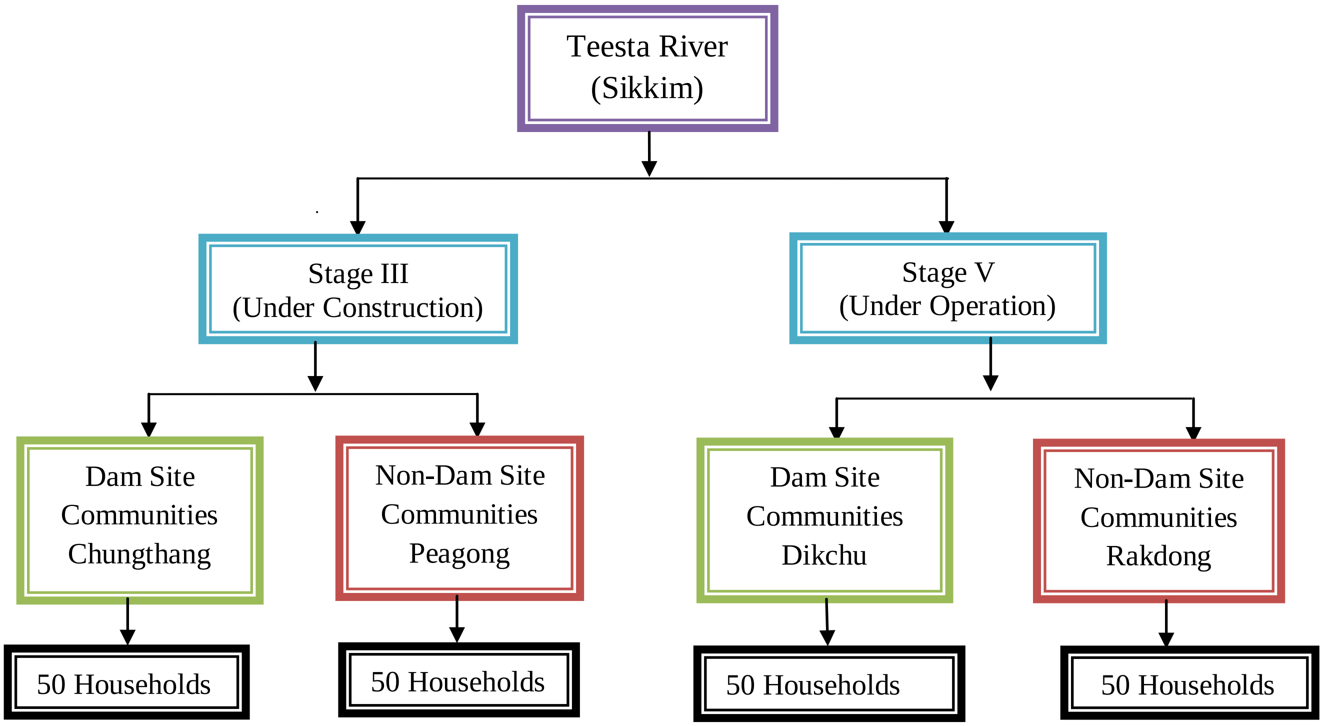
Hydropower Projects in Teesta River

Sl. No	Teesta HEP Stage	Area/Location	Installed Capacity (MW)	Remarks
1	Stage I	Zemu Lakes	320	Under study
2	Stage II	Lachen/Lachung/ Chungthang	750	Survey under way
3	***Stage III***	***Chungthang***	***1200***	***Under Construction***
4	Stage IV	Singhik/Swayam	495	EIA, EMP under study by NHPC
5	***Stage V***	***Dikchu/Shirwani***	***510***	***Under Operation***
6	Stage VI	Shirwani/Rangpo	500	Environment clearance accorded for operation by LANCO

Source: Forest, Environment & Wildlife Management Department, Government of Sikkim, Gangtok

Present study selected Teesta Stage V of 510 MW (under operation) located at Dikchu and Teesta Stage III of 1200 MW (under construction) located at Chungthang were selected. In an attempt to study whether the socio-economic characteristics of dam site communities are different from non dam site communities the study collected both the qualitative and quantitative information's about different socio economic indicators from two inhabitant villages which were at an average distance of 3 to 8 kilometre from the mentioned projects. Present study was based on stratified random sampling method. The sampling plan of the present study has been formulated in Figure 1.2.

Figure 1.2: Sample Plan



1.8.4 Method of Analysis

The contributions of hydropower energy sector towards state exchequer were studied with simple regression analysis. For convenience of estimation the Watt of electricity generated by the existing hydropower projects of Sikkim has been converted into monetary unit (Unit Value of a Watt of Energy = (1 Watt of Energy)*(Per unit price of Energy).The per unit price of electricity generated by hydropower projects of Sikkim has been converted into constant prices[1].

Since the study include recalled data on income, consumption expenditure, savings, and turnover from agriculture, animal husbandry and poultry activities of dam site communities for two different recalled periods 1999 for Dikchu and 2006 for Chungthang inflation adjustment of available data was necessary on these variables.

[1] Constant Price per unit of electricity in ith year = {(Price of per unit of electricity in Z year * CPI of ith year) / CPI of Z year} where, i is current year, Z is base year, CPI is Consumer Price Index (it will be obtained from index of industrial production for different years in particular.

Accordingly the data on income, expenditure and savings were deflated by using Consumers Price Index (CPI). The general Index of the All India Average CPI numbers for Industrial workers with (1982=100) for 1999 was Rs.414 and for 2006 was Rs.579 (Annual Report 2008, GOI, Ministry of Labour & Employment, Labour Bureau). Wholesale Price Index (WPI) was used for deflating the figures of price of agriculture, livestock and poultry activities (Current Statistics, RBI Bulletin 2010). The WPI of agricultural (primary) item for the year 1999 was Rs.159.4 whereas it was Rs. 195.3 for the year 2006 (Current Statistics, RBI Bulletin 2010). The WPI of livestock and poultry activities was Rs.169.4 in the year 1999 while it was Rs.217.4 for the year 2006 (Current Statistics, RBI Bulletin 2010).

The study used descriptive statistics, econometric tools and mathematical technique for analysis of the data as per the need of the study.

Contribution of India and South Asia in global energy generation, source wise gross generation of electricity in India, total production of electricity in Sikkim for the period 1997-2012, electricity consumption in different sectors of Sikkim for the period 2005-2012, revenue receipt from sale of available electricity of Sikkim 2005-2012, gross generation of electricity (2005-2012) has been measured using descriptive statistics and CAGR[2]. Partial correlation was calculated for finding the correlation amongst the source wise electricity generation. For studying impact of different source of electricity in total electricity generation during 1970-2006 differenced multiple regression analysis was conducted. Output elasticity[3] of gross generation during 2006-2012 has been estimated for Sikkim. Percentage share has been examined for of primary, secondary and tertiary in SGDP for the period 2004-2012, share of hydro, diesel and total in manufacturing sector of Sikkim 2004-2012, share of hydro, diesel and total generation in SGDP during 2004-2012, share of hydro, diesel and total generation in total electricity, gas and water supply 2004-2012.

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[2] $Y = Ae^{rt}$; where *r* is growth coefficient, *t* is period of study under consideration, *A* is an efficiency parameter, *Y* is endogenous variable

[3] $\eta_Q = \frac{dQ}{dI}\frac{I}{Q}$ where *Q* is output and *I* is input used

Socio demographic characteristics of respondent have been examined with descriptive statistics, literacy and family type relation with location of settled households was examined with Chi-square test[4]. Percentage share has been used to represent the housing status. Impact on economic status of the dam site communities in the pre and post hydropower development period, whether agricultural and animal husbandry activities has undergone any change in the wake of dam development, accessibility status in of the hydropower neighbouring communities in the pre and post dam situation was tested using paired sample t test[5]. Possible impact of hydropower project on consumption expenditure of the dam site communities an Augmented Keynesian consumption expenditure function was estimated introducing a dichotomous variable with time effect and locational effect. Independent sample t test was conducted to examine how dam site communities are different from non dam site communities (income, expenditure, savings, agricultural and animal husbandry activities). A consumption expenditure function has been estimated introducing locational dummy to find the difference of dam site communities from non dam site communities. Pattern of inequality in the pre and post dam period also amongst dam site and non dam site communities were evaluated with Gini Coefficient.

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[4] The test statistic applied in the analysis is Chi-square (χ^2) test of independence of attributes. Under the null hypothesis of independence of attributes, the statistic given by

$$\chi^2 = \sum_i \left(\frac{(E_i - E_0)^2}{E_0} \right)$$

follows Chi-Square distribution with (r-1) (c-1) degrees of freedom, where E_i is the observed frequencies, E_0, the product of the sum of row i and the sum of column j divided by total number of observation, is the expected frequencies, and r and c are the number of rows and columns respectively.

[5] $$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{[\{(n_1-1)s_1^2 + (n_2-1)s_2^2\} \div n_1 + n_2 - 2](\frac{n_1+n_2}{n_1 n_2})}}$$

where the numerator represents the difference of mean values of two samples 1 and 2, the terms in the denominator such as s_1^2 and s_2^2 are the variance of the two samples, n_1 and n_2 are number of observations in the two samples, $n_1 + n_2$- 2 being the degrees of freedom

CHAPTER II

Hydropower Energy Sector of Sikkim

Present chapter is an attempt to study the place of hydropower in overall electricity generation at three levels: Global situation, National level and Sikkim's context. The analysis has been subdivided into following sub-sections.

2.1 Hydropower Scenario at the Global level

The importance of hydropower in generation of energy is not ignorable as it contributes 15 percent of the global energy. Countries like Brazil, Canada, China, Russia and the United States of America are the leading contributor of hydro energy generated in the world with China alone sharing about 24 percent of the global installed capacity. In countries like Iceland, Nepal and Mozambique hydropower accounts for more than 50 percent of the total energy generation where 27–30 GW of new hydropower and 2–3 GW of pumped storage capacity was commissioned during 2012 (World Energy Council, 2013:17).

Public policy like carbon dioxide penalties and lavish renewable energy support has helped the growth of hydropower sector in the world. There has been an increase in aggregate hydropower capacity globally by 55 percent and the actual generation by 21 per cent during the last two decade (Refer to Table 2.1).

Table 2.1
Hydropower Generation of top five countries

Hydro Power Country	Installed capacity (MW)		Actual Generation (GW)	
	2011	1993	2011	1993
China	231 000	44 600	714 000	138 700
Brazil	82 458	47 265	428 571	252 804
United State of America	77 500	74 418	268 000	267 326
Canada	75 104	61 959	348 110	315 750
Russian Federation	49 700	42 818	180 000	160 630
Rest of the world	430 420	338 204	828 437	1 150 750
World Total	946 182	609 264	2 767 118	2 285 960

Source: World Energy Resources 2013 Survey

Refer to Table 2.2; it can be observed that during 2004 till 2011 the contribution of South Asia and India in global electricity generation has been recorded as 4.93 per cent and 4.22 per cent respectively.

Table 2.2
Share of India and South Asia in Global Energy Generation

	Electricity Generated (2004-2011)	Hydro (1971-2011)	
	Total (Kwh)	Total (Kwh)	CAGR in percentage
World	158,614,019,405,150.00	580438415000000.00	2.84
South Asia	7,813,696,000,000.00 (4.93)	3630709000000.00 (0.63)	3.77
India	6692887000000.00 (4.22)	2747247000000.00 (0.47)	3.40

Source: Self estimates on the basis of data compiled from world Development Indicators, World Bank, 2013
Note: Figures in the bracket are the percentage share in World total

The CAGR as estimated in Table 2.2 reveals that during 1971 till 2011 the electricity generation from hydropower of the world has registered a growth rate of 2.84 per cent per annum, while it was 3.77 per cent per annum for South Asia nations. The annual average growth of electricity generated from hydro in India during 1971 till 2011 was 3.4 percent per annum.

It is also evident from above Table that South Asia has 0.63 per cent share in world's electricity production from hydro during 1971-2011.Important to mention that the India share 0.47 per cent in total electricity generation from hydropower of the world for the period of study. Thus the importance of the country in electricity generation through hydropower is not ignorable at the global level.

2.2 National Scenario of Hydropower

India is endowed with economically exploitable and viable hydro potential assessed to be about 84044 MW at 60% load factor. Beginning of hydro-electric power development in India trace back to 1897 when a small Hydro-Electric Plant (130 Kw) was established near Darjeeling. Since then, development of hydro-electric power in the country has made rapid strides. The hydel installed capacity which was only 508 MW in 1947 with 12 Hydro Electric (H.E.) Stations, 51 units and the maximum unit size of 22

MW at Bhira H.E. Project under Tata's, has risen to 39491.40 MW (as on 31.03.2013) with the maximum unit size of 250 MW at Koyna Stage-IV under MAHAGENCO, Nathpa Jhakri under SJVNL and Tehri under THDC. Contribution of electricity generation from Hydro Electric Power Stations has risen from 2194 MU during 1947 to about 113720.29 MU in 2012-13. In case of total electricity consumption the country has experienced an increase of 4182 MU in 1947 to 710673 MU in 2011. (Ministry of Power, Central Electricity Authority, 2013).The descriptive statistics of power generated from different sources being presented in Table 2.3.

Table 2.3
Source Wise Gross Generation of Electricity in India (1970-2006)

Descriptive Statistics/ CAGR (in %)	Thermal GWh[6]	Hydro GWh	Nuclear GWh	Others GWh	Total GWh
Mean	207160.4	59205.84	7365.432	28502.30	302234.0
Std. Dev.	163990.3	21455.47	5928.19	23461.66	212430.7
CV	126.32	275.95	124.24	121.48	142.27
CAGR (in %)	8.74 (0.0000)	3.43 (0.0000)	7.20 (0.0000)	8.38 (0.0000)	7.32 (0.0000)
Observations	37	37	37	37	37

Sources: Self estimates on the basis of data compiled from MOSPI, Central Statistical organization, Govt. of India, 2013

Refer to Table 2.3 it can observed the descriptive statistics of electricity generated from different sources in India during 1970-2007. The average electricity generated from thermal power was found to be 207160.4 GWh where as it was 59205.84 GWh from hydropower and 7365.432 GWh from nuclear sources and 28502.30 GWh from other sources. Such average indicates that thermal energy has taken the lion share in total energy generation of the country where as nuclear energy has been the least contributor towards the total energy generation of the country. The average of total electricity generated in India during 1970-2006 stood at 302234.5 GWh. On the basis of the value of standard deviation it can be stated that there was a high variation in the

[6] Giga Watt hour , 1 GWh= 10^6 Kwh

power generation from thermal sources during 1970-2006 at the national level. The other source (viz wind, oil, gas) of electricity generation has been observed to be most consistent amongst the different sources of power generation in India for the period of study.

The CAGR as estimated in Table 2.3 reveals that other sources of energy registered highest growth in terms of electricity generation in India during 1970-2006 with the growth of energy generated from hydropower has been recorded to be least. During the period of study the electricity generated from thermal power has registered a growth rate of 8.34 percent per annum, while it was only 3.43 percent annually from hydropower. The annual average growth of electricity generated from nuclear power was 7.2 percent per annum and it was 8.38 percent per annum from other sources. The average growth of total electricity generated from all sources in India during 1970-2006 was recorded to be 7.32 per cent per annum.

The pattern of correlation between different sources of electricity generated with total electricity generated in the country being presented in Table 2.4.

Table 2.4
Correlation Matrix of Source wise Electricity Generation

	Thermal	Hydro	Nuclear	Others
Thermal	1.00000			
Hydro	0.89562	1.00000		
Nuclear	0.95972	0.7843	1.00000	
Others	0.99653	0.87622	0.96911	1.00000

From Table 2.4 it can be understood that electricity generated from hydro has high positive correlation with thermal during 1970 till 2006 in India. The correlation between these two sources has been observed to be 0.9 per cent. On the other hand correlation between hydro and the other sources of electricity has been recorded as 0.88 per cent.

However, the correlation between hydro with nuclear has been observed to be relatively low (identically 0.78 per cent correlation) when compared with thermal and others.

Such kind of positive correlation between hydro and thermal may be because of the fact that generation of electricity from hydro takes place in the sloping land (hilly region e.g. Himachal Pradesh, Shillong, Sikkim, Arunachal Pradesh, Utter Pradesh, Maharashtra, Jammu & Kashmir, Madhaya Pradesh, West Bengal) and also because of the fact that thermal basically includes coal, lignite, wind etc. where the coal, lignite and wind normally is available in plenty in some of the hilly regions (e.g. Meghalaya, Arunachal Pradesh). Thus, generation of electricity from hydro has strong correlation with thermal. Whereas, nuclear as a source of electricity is mainly found in plain region which is why it shares relatively weak correlation with high generation of electricity through hydro.

In India the generation of electricity from hydropower sources is mostly practiced by the hilly states (e.g. Meghalaya, Arunachal Pradesh, Sikkim).Although, thermal as a source of electricity is mostly generated by hilly region but the use of coal and lignite has come to be used for energy generation in plains regions of India (e.g. Bihar, Assam, west Bengal, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu, Karnataka, Gujarat).

Now, we can understand the importance of hydropower in energy generation during 1970-2006 is not ignorable.

Given the nature of data being time series, stationarity test (ADF[7] test) has been conducted to examine whether the data has any spuriousness to move together overtime. The result has being presented in Table 2.5.

[7] *Augmented Dickey-Fuller Test whose null hypothesis states that the data has unit root*

Table 2.5
Unit Root Test of energy generation from various sources in India during (1970-2006)

Sources of Electricity	Level	1st difference	2nd difference
Thermal	-0.61 (0.85)	-1.15 (0.68)	-8.4*** (0.00)
Hydro	0.3 (0.98)	-5.02*** (0.00)	
Nuclear	0.72 (0.99)	-4.85*** (0.00)	
Others	1.25 (1)	-2.69 (0.09)	-7.65*** (0.00)
Total	8.86 (1.00)	-1.48 (0.53)	-5.79*** (0.00)

Sources: Self estimates on the basis of data compiled from MOSPI, Central Statistical organization, Govt. of India (2013)
Note: Figures in the parenthesis are the probability value of respective estimates
*** Significant at 0.01 per cent level.
** Significant at 0.05 per cent level.

Refer to Table 2.5 it can be observed that all the variables of the study are non stationary in nature for the original data. The stationarity of the data on electricity generated from hydro and nuclear power across 37 years time period were arrived after first differencing. Whereas, the stationary figures for thermal and other sources of energy arrived after second differencing.

In an attempt to study the impact of different sources of electricity production on total electricity generated in India during 1970-2006 the following multiple regression model was fitted taking into account the degree of non-stationarity

$$\Delta^2 TEG_t = \beta_0 + \beta_1 \Delta^2 EGT_{1t} + \beta_2 \Delta EGH_{2t} + \beta_3 \Delta EGN_{3t} + \beta_4 \Delta^2 EGO_{4t} + ERR_t \quad (1)$$

Where, TEG_t is total electricity generated in India, EGT_{1t} is electricity generated from thermal power, EGH_{2t} is electricity generated from hydro power, EGN_{3t} is electricity generated from nuclear plant, EGO_{4t} is electricity generated from other sources (e.g. solar, wind,); t is the period of study (1970-2006); $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$ are the intercept and slope coefficients; Δ is first difference; Δ^2 is the second difference; ERR_t is well behaved error term

The OLS estimate of fitted equation (1) is presented in Table 2.6.

Table 2.6
Source wise influence on Total Electricity Generation in India

Endogenous Variable: *Total Electricity Generated* (1970-2006)	
Intercept / Explanatory variables	Estimated Coefficient
Intercept	4999.27*** (1450.72)
Δ^2X_{1t}	0.43** (0.15)
ΔX_{2t}	-0.07 (0.14)
ΔX_{3t}	-0.73 (0.86)
Δ^2X_{4t}	3.81*** (0.87)
R^2	0.83
Dw-d	2.02
Period of Study	37 years

Sources: Self estimates on the basis of data compiled from MOSPI, Central Statistical organization, Govt. of India (2013)
Note: Figures in the parenthesis are the standard error of respective estimates
*** Significant at 0.01 per cent level,** significant at 0.05 per cent level

Refer to Table 2.6; it can be observed that the estimated regression line fits the data well in terms of R^2 value. About 83 per cent variation of the total electricity generation is explained by electricity generated from all the four sources and remaining 17 per cent remains unexplained. Amongst different sources of electricity, it has been observed except thermal and other sources the hydropower has not been observed to have significant impact on total electricity generation of the India during 1970-2006. One of the reasons for such result may be due to the fact that thermal electricity has been the major sources of electricity in India beside other sources. However, electricity generated from hydropower and nuclear has not been found to be statistically significant because hydro power is normally produced only in some restricted states of India (mostly the hilly states of India) whereas the nuclear energy is basically imported from foreign nations. Over the period of study holding all other sources (hydro power, nuclear plant, and other sources) as constant a 1 percent increase in electricity generated from thermal power project has led on an average to about 0.43 percent increase in total electricity generation of the country. Such trend indicates the significance of thermal power in total electricity generation of the country. A study done by Krishnan and Nischal, (2003), found that in India the electricity sector is dominated by the thermal sector almost accounting for 71 per cent of installed capacity. They stated that Indian is blessed with abundant coal mines and as coal being the most leading/main contributor (contributing approximately 60 per cent of the total installed capacity) the thermal power share in total electricity has been always on the top. The energy generation from other sources (viz wind, oil, gas etc.) also observed to have significant impact on total electricity generation of the country during 1970-2006. Holding power generation from thermal, hydro and nuclear sources as constant, a 1 percent increase in electricity generated from other sources has helped to increase the total electricity generation of the country by 3.8 percent during the period of study.

However, the power generated through hydro and nuclear sources has not significantly contributed towards the total electricity generation of the country for the study period.

The contribution of nuclear energy in total power generation is low may be because of the fact that in India nuclear energy is mostly imported from foreign nation (such as USA, Russia, France, Canada etc.). Thus, India being an importer of nuclear energy which is not available in abundance causes in a small share in total electricity generation. The overall significance is established and found to be significant. The results have been found to be satisfactory in terms of DW-d value implying presence of non-autocorrelation.

2.3 Hydropower Scenario of Sikkim

In view of the fact that, although state has such a large number of major hydropower projects out of which only four are under operation that too commissioned in just two years back (except Rangit Power station III which was commissioned in the year 1999) such as Rongnichu HEP and Chujachen HEP were under operation since 2013, thus it was not possible to undertake analysis for those operational project due to non availability of data at length. With the limitation of availability of time series data for large private power projects the present study restrict in analyzing the secondary data to only those projects which are under the state government. While analyzing the data on production of gross electricity the study has considered only those project which are under that state government whereas on the other side while analyzing the consumption and revenue part of the state electricity the study has considered the total available electricity which is inclusive of imported or purchased electricity as well as free share from the large operational project.

Table 2.7

Total Production of Electricity in Sikkim (1997-2012)

Descriptive Statistics/CAGR (in %)	Hydro (MKwh)	Diesel (MKwh)	Total (MKwh)
Mean	40.31	0.49	40.8
Std. Dev.	15.05	0.69	15.34
CV	267.9	80.41	265.95
CAGR (%)	-7.6		-7.76
Electricity Generated (MKwh)	644.89 (98.80)	7.83 (1.2)	652.72
Observations	16	16	16

Sources: Self estimates on the basis of data compiled from Energy & Power Department, Sikkim 2013

Note: Figures in the bracket are the percentage share in Sikkim total

Table 2.7 shows the descriptive statistics of electricity generated from hydro and diesel in Sikkim during 1997-2012. The average electricity generated from hydropower was found to be 40.30563 MKwh whereas as it was 0.489375 MKwh from diesel power. Therefore it is evident from the Table 2.7 that hydropower has greater shares in gross electricity generation of Sikkim, where hydropower accounts for 98.80 per cent of total electricity generated in state whereas diesel contribution for the same has been recorded very low at only 7.83 per cent. This is basically because Sikkim has only 2 diesel power station while there is 12 hydropower stations under state currently under operation. The average of total electricity generated in Sikkim during 1997-2012 stood at 40.8 MKwh. On the basis of the value of standard deviation it can be stated that there was a high variation in the power generation from hydropower during 1970-2012 at the state level. During 1979 till 2012, diesel power has been observed to be consistent as compare to hydro power in generation of electricity of Sikkim.

The estimated CAGR reveals that Sikkim has experienced a decline in terms of annual average electricity generation in total -7.76 per annum as well as from hydropower -7.6 per annum during the study period. This can be because of the fact that in the year 2003, the new Electricity Act, 2003 came into force, which facilitated development of Hydropower Projects liberally. Further, the ministry of power clarified that in case NHPC is unable to meet the requests of the state Government, the state would be well within its right to either allot the projects to independent power producers or to develop the projects under joint sector in partnership with developers. Thus based on the new liberal policy, the cabinet of the state met on 25.05.2004 and decided to speed up the efforts to tap the hydropower potential in the State. Accordingly, a Hydro Power Committee was constituted on 15.06.2004 to expedite development of the hydroelectric projects in Sikkim. The Government of Sikkim, thereafter, announced the power policy, which proposed that the projects above 25 MW capacity would be developed on BOOT basis under joint sector with Government of Sikkim holding 25% of equity share in the projects and the partners would have to arrange the funds for equity participation by Government, the loan would be repaid by the government. Such liberalization in large power projects may be one of the reason behind the decline in the production of state own small hydropower plants. Moreover, as per the state power department, decline in the production of electricity by state own small hydropower projects are partially due to the low investment and low capacity of generation. Some of the state own hydropower projects are under renovation since 2011.

Table 2.8

Electricity Consumption by Different Sectors in Sikkim (2005-2012)

(MKwh)

	Domestic	Industry	Commercial	Public Light	Bulk Supply	Others (Free Supply)	Outside the State (Exported)	Grand Total
Mean	64.38	111.66	43.47	2.47	26.22	34.50	444.6	727.29
Std. Dev.	6.84	33.52	6.57	0.51	8.81	20.94	73.84	29.53
CV	941.78	333.12	661.49	492.33	297.63	164.79	602.09	2463.14
CAGR (in %)	2.03	7.73	4.88	8.75	1.04	-18.3	4.09	21.03
Observations	5	5	5	5	5	5	5	5

Sources: Self estimates on the basis of data compiled from Energy & Power Department, Sikkim 2013

Because of the state power policy along with the agreement signed with the other power company, the government of Sikkim is entitled with the 12 per cent of free electricity for the first 15 years from the operational projects. Again, in order to meet the current need of electricity in the state, the government of Sikkim imports the electricity from different sources (such as central sector, private sector, state utilities etc.) Therefore, the total available electricity in the state is sum total of electricity from the free share and the purchase from the different sources.

Refer to the Table 2.8; it has been observed that the available electricity (purchased and free share from the operational projects in the state) has been utilized in both domestic and commercial purpose of the state besides using in industry, public lights, bulk supply and free supply. Some amount of the available electricity is also exported outside the state. From the data it has been observed major amount of available electricity is exported outside the state which we can be understood is an important source of revenue for the government of Sikkim. The remainder of the electricity is utilized in the different sectors as mentioned. It has been observed that the industry is the major consumer (mean consumption is 111.66 MKwh) of the available electricity generated, whereas the domestic consumption and the commercial consumption took the second and third position. Thus, we can understand the importance of the power sector in the process of revenue generation and functioning of the economy of the Sikkim.

Table 2.9

Revenue Receipt from Sale of available Electricity in Sikkim (2005-2012)

(In Crore)

Descriptive Statistics/CAGR (in Percentage)	Within State	Outside State	TOTAL
Mean	52.84	169.85	222.69
Std. Dev.	19.05	74.29	80.13
CV	277.37	228.64	277.91
CAGR	15.60	18.89	27.19
Observations	7	7	7

Sources: Self estimates on the basis of data compiled from Energy & Power Department, Sikkim 2013

Table 2.9 shows the estimates the revenue receipt from sale of the available electricity in Sikkim during the year 2005 till 2012. On an average rupees 52.84 crore of revenue receipt has been received by the state government within state while it is recorded as rupees 169.85 crore from outside the state during the period of study. In total rupees 222.69 crore has been recorded as revenue receipt received by the state government from the available electricity within state. The CAGR estimated in the above Table depicts that the total revenue receipt collected by the government has been found to be growing at 27.19 per cent per annum annually. Both within state and outside state registered a positive annual average growth rate in terms of revenue receipt from sale of available electricity in state (identically 15.6 percent and 18.9 percent respectively).

The descriptive statistics of State own micro hydro and diesel plants and its different input used in power generation is being presented in the Table 2.10.

Table 2.10
Gross Generation of Electricity (2005-2012)

Descriptive Statistics	GG (MKwh)	AC (Hydro) (MKwh)	NE (Numbers)	TR (in Crore)
Mean	34.06	0.13	3770.88	29.07
Std. Dev.	14.68	0.06	98.26	9.78
C.V	232.07	203.33	3837.55	297.22
Observations	8	8	8	8

Sources: Self estimates on the basis of data compiled from Energy & Power Department, Sikkim 2013
Note: Auxiliary consumption (AC) for Diesel plant was not available, therefore auxiliary consumption is only consist of Hydro plants.
GG: Gross Generation from hydro and diesel, NE: Number of Employee in the state own power projects, TR: Total Revenue Expenditure on state own power projects.

Refer to Table 2.10 it can be observed that, 34.06 MKwh of electricity has been produced on an average by the state own power project of Sikkim during 2005-2012. For the same period of study auxiliary consumption of the hydropower project on the other hand witness an average of 0.13 MKwh of electricity. About 3770.88 number of labour were employed on an average during the period of study in the state own power projects and the revenue expenditure incurred in generation of electricity of the state own power projects during the period was Rs. 29.07 crore on an average. There was high variation in number of employment (employee) in electricity production during 2005 till 2012 as per the value of standard deviation. The auxiliary consumption has been the most consistent among all other factor input in generation of electricity in Sikkim during 2005-2012.

Table 2.11
Correlation Matrix

	GG	AC(Hydro)	NE	TR
GG	1			
AC (Hydro)	0.88	1		
NE	-0.97	-0.89	1	
TR	-0.69	-0.89	0.72	1

From Table 2.11 it can be understood that the auxiliary consumption is the input which has a positive correlation of 0.89 percent with gross generation of electricity during 2005-2012 in Sikkim. On the other hand correlation has been recorded as negative between gross generation of electricity with number of employment and total revenue expenditure, registering correlation as -0.97 per cent and -0.69 per cent respectively. Such kind of negative correlation between gross generation with number of employment and total revenue expenditure may be because of the fact that in Sikkim most of the state own hydropower project has been went under renovation since 2011. Moreover, the reason behind such decline in the production of electricity by the state owned power project may be partially due to the liberalization of the power sector in the state in 2005. Since, it has been observed from the available data that after the year 2005 the production of state own power projects are not reaching that margin where they are there before the year.

The output elasticity[8] of gross electricity generated in Sikkim has been estimated separately for the different inputs such as auxiliary consumption, employment, and revenue expenditure was estimated with following formulae, if the production function contains only one input, then the output elasticity is also an indicator of the degree of

[8] Is the percentage change of output (or production of a single firm) divided by the percentage change of an input. If the $\eta_Q > 1$ then production experiences increasing returns to scale. If the $\eta_Q < 1$, then production experiences decreasing returns to scale. If $\eta_Q = 1$, then production operates under constant returns to scale. Mathematically expressed as $\frac{d(\log Q)}{d(\log I)}$

returns to scale. Output elasticity is defined as the percentage change in output per one percent change in all the inputs. The formula for estimation was,

$$\eta_Q = \frac{dQ}{dI}\frac{I}{Q}$$

Where η_Q stands for output elasticity for gross generation of electricity, I represent the inputs in the process of generation and Q stands for gross generation of electricity. The estimated values being represented in table as follows;

Table 2.12
Output Elasticity of Gross Generation

Year	e_{ag}[9] (Hydro)	e_{eg}[10] (Hydro + Diesel)	e_{teg}[11] (Hydro + Diesel)
2006	NA	25.17	3.79
2007	1.79	13.28	1.22
2008	0.13	6.15	158.01
2009	0.98	13.16	0.73
2010	0.93	NA	0.45
2011	0.71	35.24	8.87
2012	1.79	39.68	18.69

Sources: Self estimates on the basis of data compiled from Energy & Power Department, Sikkim 2013
Note: NA stands for data was unavailable and hence elasticity was not calculated

For the different years of reference period the elasticity of gross generation for auxiliary consumption has been observed to be less than unity (indicating operation of decreasing returns to scale in gross generation for change in auxiliary consumption). However, there was increasing returns to scale was operative in gross generation in the years such as 2007 and 2012.Such trend may be due to the fact that in the mid years the power consumption in hydropower sector in gross generation had went up in Sikkim with a recovery in returns in recent years as observed in Figure 2.1.

The elasticity of gross generation for number of employment has been recorded to be higher than unity for the different years of the reference period indicating the fact that operation of increasing returns in gross electricity with change in employment of labour

[9] Elasticity of gross generation for auxiliary consumption
[10] Elasticity of gross generation for number of employment
[11] Elasticity of gross generation for total revenue expenditure

in the state. The elasticity value has maintained continuous increasing trend over the years as observed in Figure 2.2.

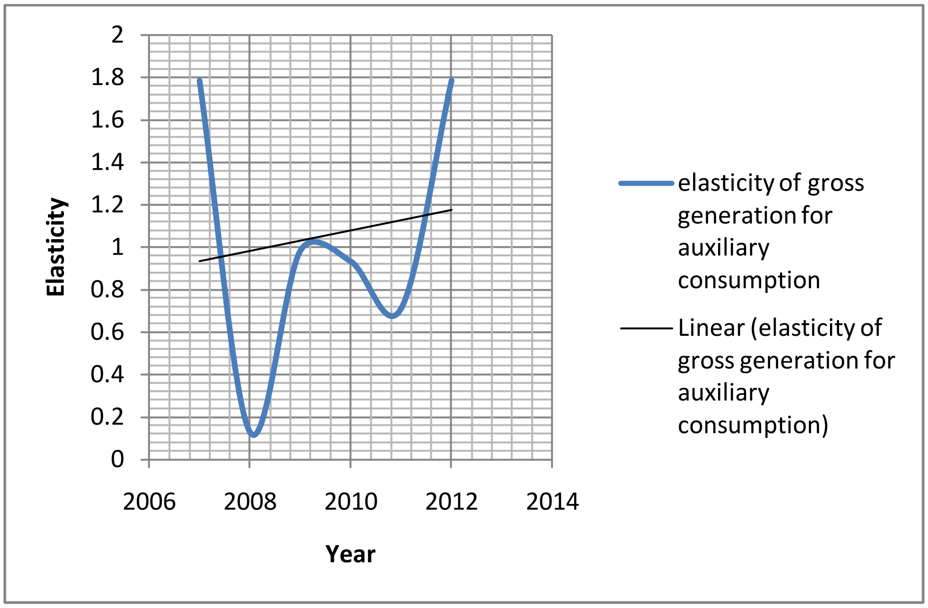

Figure 2.1

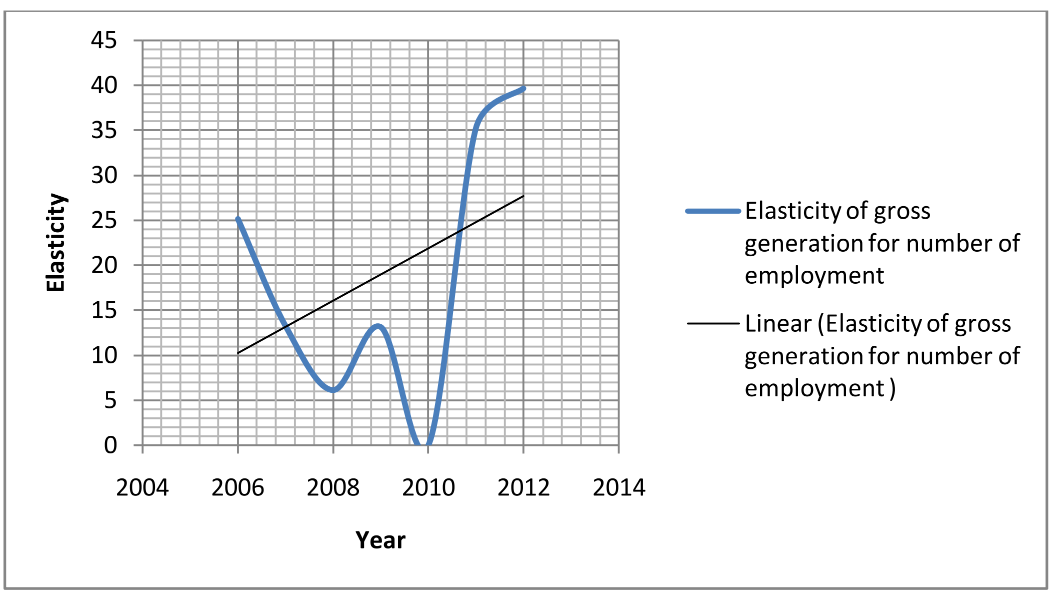

Figure 2.2

Refer to Table 2.12 it can be observed that there was operation of increasing returns to scale in terms of the value elasticity of gross generation for total revenue expenditure for most the years of the reference period except for 2009 and 2010.

2.4 Share of Hydropower in State Gross Domestic Product of Sikkim

Table 2.13
Percentage Share of Primary, Secondary and Tertiary sector in State Gross Domestic Product

Year	% Share of Primary in SGDP	% Share of Secondary in SGDP	% share of Tertiary in SGDP
2004	18.71	28.72	52.58
2005	17.74	29.25	53.01
2006	16.76	29.54	53.7
2007	16.18	30.18	53.64
2008	14.56	34.94	50.51
2009	8.74	55.03	36.22
2010	8.44	59.12	32.44
2011	8.26	58.89	32.85
2012	8.26	58.8	33.03

Source: Self estimates on the basis of data compiled from Energy and Power Department (Government of Sikkim)

Refer to Table 2.13 it has been observed there has been a considerable increase of percentage share of secondary sector in the SGDP of Sikkim while compared with primary and tertiary sectors during the period of the study 2004 till 2012. It has increased from 28.72 per cent in 2004 to 58.71 per cent in 2012, whereas the percentage share of primary sector has declined from 18.71 per cent in 2004 to 8.26 per cent in 2012 and also the share of tertiary sector has declined from58.52 per cent in 2004 to 33.03 per cent in 2012.

Thus it can be understood that the importance of secondary sector in Sikkim economy has continued to increase whereas that of primary and tertiary sector had declined during the period of study. Such trend may be due to the increasing growth of the industry and manufacturing industries has helped in increasing the revenue generation for the state. Whereas the growth of service sector and the importance of primary sectors has even went down from a low growth rate.

Table 2.14
Percentage Share of Hydro, Diesel and Total generation of Electricity in Manufacturing Sector

Year	% Share of Hydro in Manufacturing	% Share of Diesel in Manufacturing	% Share of Total Generation in Manufacturing	% share of construction in Manufacturing	% MR	% MU
2004	0.15	0.00	0.15	66.97	6.75	6.70
2005	0.11	0.00	0.12	67.91	6.21	6.11
2006	0.11	0.00	0.11	65.79	6.18	6.21
2007	0.15	0.00	0.15	61.93	6.47	6.46
2008	0.13	0.00	0.13	44.43	5.43	5.03
2009	0.04	0.00	0.04	18	49.79	1.9
2010	0.05	0.00	0.05	15.84	61.16	1.67
2011	0.03	0.00	0.03	20.32	58.86	1.63
2012	0.00	0.00	0.00	21.77	59.38	1.61

Source: Self estimates on the basis of data compiled from Energy and Power Department (Government of Sikkim)
Total Generation = Revenue generation (Hydro Power + Diesel Power)

Refer to Table 2.14; during the period of study 2004 till 2012 it has been observed that the share of construction activities in contributing revenue towards the secondary sector has remain high while compare with the contribution from hydropower and diesel power. Although the percentage share of construction has declined from 66.97 per cent in 2004 to 21.77 per cent in 2012. However, the percentage share has remained high while compared with the share of hydropower and the share of diesel power during the two sub periods.

The percentage share of hydropower and diesel power in total revenue generation of the state has remained low during the period of study; the same is true when we take the breakup of the two power generating sector in the total secondary sector of the state for the period of study. Given the data limitation the present study is conducted with the hydropower revenue generation figures of state owned power projects which are relatively small in scale and capacity. Hence, although the percentage shares of hydropower in revenue generation towards secondary sector is positive but has been observed to be meager for the period of the study.

Interesting to note that, the percentage share of registered manufacturing sector in the revenue generation of secondary sector of the state has been continued to increase from 6.57 per cent in 2004 to 59.38 per cent in 2012. Whereas, the share of the unregistered manufacturing sector in the secondary sector of the state has declined successively from 6.7 per cent in 2004 to 1.61 per cent in 2012.

Thus from the present analysis we can understand that construction activities has taken a lead role in the revenue generation process of the secondary sector of the state. However, the share of state owned hydropower project and diesel power projects has remained low in the process of revenue generation towards the secondary sector. Such trend may be because of the increasing importance of construction activities in the development process of the state in recent years.

The share of registered manufacturing sector in revenue generation towards secondary sector has increased while that of unregistered sector has declined during the period of study may be due to the fact that the process of licensing of industries has increase the importance of registration in commerce and trade.

Table 2.15
Percentage Share of Hydro, Diesel and total generation of Electricity in State Gross Domestic Product

Year	% Share of Hydro in SGDP	% Share of Diesel in SGDP	% share of total Generation in SGDP
2004	0.04	0.00	0.04
2005	0.03	0.00	0.03
2006	0.03	0.00	0.03
2007	0.04	0.00	0.04
2008	0.05	0.00	0.05
2009	0.02	0.00	0.02
2010	0.03	0.00	0.03
2011	0.02	0.00	0.02
2012	0.00	0.00	0.00

Source: Self estimates on the basis of data compiled from Energy and Power Department (Government of Sikkim)

Refer to Table 2.15; it can be observed that the share of hydropower (state owned) and diesel power in revenue generation towards the SGDP of Sikkim has remained meager during the period of study, which may be because of the fact that the hydropower and diesel power are excluding the private projects revenue generation.

Table 2.16
Percentage Share of Hydro, Diesel and total generation of Electricity in Total Electricity, Gas and Water Supply

Year	% share of hydro in EGWS	% share of Diesel in EGWS	% Share of total generation in EGWS
2004	0.76	0.00	0.76
2005	0.58	0.00	0.59
2006	0.49	0.00	0.49
2007	0.58	0.00	0.58
2008	0.29	0.00	0.29
2009	0.14	0.00	0.14
2010	0.21	0.00	0.22
2011	0.14	0.00	0.14
2012	0.03	0.00	0.03

Source: Self estimates on the basis of data compiled from Energy and Power Department (Government of Sikkim)

Refer to Table 2.16; we can observe the percentage share of hydropower although is higher than the diesel share in revenue generation towards electricity gas and water supply however, the percentage has remained low during the period of study such trend may be because of the current data being used for the state owned power projects only.

Amongst the various nations generating hydropower China stood at the top around the world in terms of installed capacity and actual generation of electricity from hydropower during 2011. The average growth of electricity generated from all sources in the world during 1971-2011 was 2.84 per annum whereas it was 3.77 per cent and 3.4 per cent per annum for the South Asia and India respectively. In India thermal electricity has been the dominating among different source of electricity generation during the period of 1970-2006 followed by hydropower in second position and other sources (wind, gas, petroleum). During 1997 till 2012, Sikkim has experienced a decline in annual average electricity generation form hydropower for the state owned projects. Competition from large projects and closure of small projects can be understood as one of the reason for such trend. Apart from using the available electricity within the state, Sikkim has been managed to export some share of it to outside the state. Domestically, industries were primarily using electricity generated in Sikkim at large scale. There has been an increase in annual average revenue from electricity generation of Sikkim both from sale within the state and outside Sikkim during 2005-2012.

CHAPTER III

Immediate Impact of Hydropower Project on Basin Communities'

The present chapter made an attempt to study the immediate impact of hydropower project on dam site communities' of Sikkim. The river Teesta is the life line of Sikkim. The river rises in mountainous terrain and is formed mainly by the union of two hill streams Lachen Chhu and Lachung Chhu at Chungthang in North Sikkim. The river is 196 miles (315 Km) long; covering the whole length of the state which at the end enters the plains of West Bengal at Sevoke. The study was restricted to 2 dams (1 operational since 2008 and 1 under construction since 2007). Since Teesta River has six hydropower projects out of which only one is under operation and rest of the five are either under construction or under study. Present study selected two hydropower projects - Teesta V of 510 MW (under operation) and Teesta III of 1200 MW (under construction) for understanding the impact of large hydropower project on the local economy.

Quantitative information about different socio economic indicators of the dam site communities' and non dam site communities' household were collected in the wake of the hydropower project. In an attempt to study whether the socio-economic characteristics of dam site communities' are different from non dam site communities' the study collected micro information's on socio economic characteristics from two inhabitant villages[12] which are in average distance of at least 3 to 8 kilometre away from the project area. Present chapter has been divided into following sub-sections:

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[12] village in a distance of 3 km to 5 Km from the project area of Chungthang, Rakdong village in a distance of 8 km from the project are of Dikchu

3.1 Pre and Post Project Scenario of the Dam-Site Communities

3.1.1 Socio demographic characteristics of the Respondent

The average age of the respondent of the dam site communities' in the study area was found to be 49 years. About 73 per cent of the respondents were male while another 27 per cent were female amongst the communities' in the dam site. Taking caste distribution into account it was found that 52 per cent of the respondent were Hindu and another 48 were on non Hindu (Buddhist and Christian). As per the response of the dam site communities', those families were third generation resident. About 58 per cent of families were nuclear family and another 42 per cent of families were joint family. The average family size of the communities' in the dam site of the study area was 5 (Refer to Table 3.1).

Table 3.1
Socio- Demographic Characteristic of Respondent

Head		Dam site communities'			Non-Dam site communities'		
		N	Mean	Percentage	N	Mean	Percentage
Age			49.07			51.51	
Gender	Male	73		73	69		69
	Female	27		27	31		31
Religion	Hindu	52		52	46		46
	Non Hindu	48		48	54		54
Generation			2.8			3.25	
Family Size			5.07			5.63	
Family Type	Joint Family	42		42	48		48
	Nuclear Family	58		58	52		52
Education	Literate	74		73	64		64
	Illiterate	26		27	36		36
Year of Schooling		74	9.07		64	8.22	
Number of household		100		100	100		100

Source: Self Estimates based on Household survey, April – September 2014

Again in case of the non-dam site communities' the average age of the respondent has been observed to be 52 years with 69 per cent of respondent being male and rest of the 31 per cent were female. About 46 per cent of the respondent has been observed to be Hindu by religion while 54 per cent of the respondents were non Hindu (Buddhist and Christian). The respondent of non dam site communities' was mostly of 3rd generation resident and about 52 per cent of the families have been observed to be nuclear family while 48 per cent were joint family. The average family size of non dam site communities was 6.

Thus we can understand that the respondent of non dam site communities' were relatively older compared with dam site communities' respondent. The female respondents were more in case of non dam site communities' household than the hydropower dam site communities' household. The dam site communities' households were found to be mostly Hindu by religion when compared with the non dam site communities' household. Third generation of household had occupied both the locations. The percentage of nuclear family has been observed to be higher in case of hydropower dam site communities' household while the non dam site communities' household has larger family size when compared with dam site communities' household. In an attempt to study whether literacy and the nature of family of the two locations are influenced by each other the Pearson Chi-Square test has been conducted as presented in Table 3.2.

Table 3.2
Independence of Literacy and Family Type Attributes

Location	Literate	Illiterate	Pearson Chi-Square
Non-Dam site communities'	64	36	0.36
Dam site communities'	73	27	(0.35)
H_0: Education of dam site communities' is independent of education of the non-dam site communities'			
Location	Nuclear Family	Joint Family	Pearson Chi-Square
Non-Dam site communities'	52	48	0.22
Dam site communities'	58	42	(0.395)
H_0: Family types of both locations are independent of each other			

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets are the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level

From the results arrived at Table 3.2, we can state that literacy rate of the location's are independent of each other and the family type of the locations are also independent of each other. Thus, dam site communities' and non-dam site communities' have no relation in terms of literacy and type of the family. Implying that construction of dam has no influence on the qualitative factors (literacy and the nature of family) of the dam site communities.

3.1.2 Housing Status of the Respondent

The housing status of the hydropower dam site communities' in the pre and post project scenario has been presented in Table 3.3. Prior to the inception of project about 50 per cent of the household had their own house where as 46 per cent of the household lived in rented house and the remaining 4 per cent household occupied in government provided quarters. There has been 1 percent decline the number of household occupying their own house and 5 percent fall in the number of household occupying rented house. Remaining 6 per cent and 4 per cent of the household were government quarters and the project quarters. Hence a very marginal percentage of household have left their house in the wake of project construction.

In terms of the type of the house, it can be observed that prior to the project 64 percent of households used to lives in a pucca house about 9 percent used to live kattcha kharpila while another 27 percent in semi pucca type of houses. There has been an increase in percentage of household living in pucca house with a fall in other two categories in the post project scenario. The percentage of household living in a pucca, semi pucca and katcha khaprail type of houses were 73 per cent, 19 per cent and 8 per cent respectively in the wake of hydropower dam operation.

Table 3.3

Housing Status of Dam site communities' and Non-Dam site communities'

	Heads		Dam site communities		Non-Dam site communities
			Pre	Post	
Ownership of House (in Percentage)	Own		50	49	60
	Rent		46	41	33
	Govt.		4	6	7
	Project		0	4	0
Type of House	Katcha Khaprail		9	8	10
	Semi Pucca		27	19	25
	Pucca		64	73	65
	Average Number of Rooms		6.6	7.16	7.43
	Average number of rooms cracked[13]		0	6.55	0
	Electrified		100	100	100
	Non-Electrified		0	0	0
	Roadside		52	59	48
	Away from roadside		48	41	52
	No Damage		100	85	100
	Damage		0	15	0
	Number of Household		100	100	100

Source: Self Estimates based on Household survey, April – July 2014

The average number of rooms per household in pre dam period was 6.6 (approximately 7) rooms which increased to 7.16 (approximately 8) rooms per household in the study area with the inception of hydropower project in Sikkim. Hence, we can understand that there has been an increase in the number of the rooms in the wake of hydropower projects.

In terms of household electrification no change being observed in pre and post hydropower project period. The percentage of household in roadside has increased by 7 percent with the inception of hydropower projects. It has been observed that about 62 per cent of the total dam site communities' household have been facing problem in terms of

[13] Out of total household 62 per cent of the household reported that there is crack in their rooms.

crack in their houses (with an average of 6.55 approximately 7 rooms per household being cracked). About 15 per cent of the household reported that their houses and surrounding area has been shrinking with the inception of the hydropower project.

Thus there has been some loss in ownership of private property although small in margin in the wake of development of hydropower projects in the study area while on the other side no influence has been seen on the subject of the qualitative factor. Emergence of hydropower project in the study area has helped to reduce the percentage of household living in rented house by occupying 2 percent of the household in power project quarters. There has been an increase in the number of household living in pucca house with a fall in household living in semi pucca and kattcha khaprail type of house with the inception of hydropower projects in the area of study. Such changes indicate that there has been some improvement in terms of standard of living of the communities in the wake of dam. Increased number of household in roadside bought negative externality in terms of pollution.

While considering the housing status of the non dam site communities' it has been observed that 60 per cent of the households were staying in their own house, 33 per cent living in a rented house and the remaining 7 per cent were livings in a government quarters. Hence the percentage of household having personal house were higher than household occupied in rented house or quarters. About 10 per cent of the household were living in a katcha khaprail house, 25 per cent of the households occupied semi pucca and 65 per cent of the household occupied in pucca house. The average number of rooms per household was 7. Important to note that number of rooms cracked and any damages other than crack were zero for the non dam site communities' household. About 48 percent of non dam site communities' were residing in the road side and remaining 52 per cent were residing away from the road side.

Thus we can understand that the communities' who were away from dam site were occupied in their own houses with number of household staying in rented house was less amongst non dam site communities'. However, with the emergence of hydropower projects, has helped to offer project quarters to its workers. Although the average number of rooms for the communities' residing nearby dam and those who are away from dam has not been observed to be significantly different, but significant difference being observed between them in terms of number of rooms cracked. On an average 4.06 rooms of the communities' in the surrounding of dam were reported to be cracked in the wake of hydropower project. A significant percentage of dam site communities' household were staying in road side area while the percentage was larger for household residing away from roadside amongst non dam site communities'. Such differences may be an indication that inception of the hydropower project has lead to congestion of space for further expansion or construction compelling families to shift near road side houses.

3.1.3 Economic Status of the Respondent

In an attempt to understand whether the economic status of the dam site communities' household has undergone any change or not with the emergence of hydropower project in the study area of Sikkim paired sample t test being conducted as reported in Table 3.4.

Table 3.4
Impact on the economic status of the dam site communities'

Variables	Average, Observations	Hydropower Dam site communities'			
		Pre	Post	MD	T
Income	Mean	10.37	10.52	0.16	-2.153** (0.034)
	N	99	99		
Consumption Expenditure	Mean	6.15	7.34	1.2	-12.145*** (0.000)
	N	97	97		
Savings	Mean	4.25	3.19	-1.06	8.252*** (0.000)
	N	97	97		

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets is the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level
MD stands for mean difference

It has been observed from above table that the mean difference of variables such as income, expenditure and saving of the dam site communities' household are statistically significantly different between the pre and post hydropower project periods. The average annual income of the dam site communities' respondent in the pre hydropower project was Rs. 10370 and in the post hydropower projects it was Rs. 10520 with mean difference being 160. Thus there has been an increase in income of the dam site communities' household in the wake of hydropower projects. Followed by rise in income there has been an increase in consumption expenditure from Rs. 6150 to Rs. 7340 during pre and post dam periods with the mean difference being Rs.1200.

However there has been a decline in annual savings of the dam site communities' household in the wake of development hydropower project in the study area. The annual savings of the dam site communities' has declined from Rs.4250 in the pre hydropower development period to Rs. 3190 in the post hydropower development period with the mean difference was being Rs. 1060.

The reason for increased income of the dam site communities' household in the wake of hydropower development period may be due to increased economic activity with the emergence of hydropower project in the study area. Some of the respondent has reported that with the establishment of such large project has offered an opportunity to start small fast food shop, beverage shop, battelnut shop etc. and on the other hand some of the respondent reported that due to increase in number of population their daily selling has gone up. Further hike in nominal wage rate from Rs. 150 per day in pre-hydropower project to Rs. 325 per day in post hydropower project has a very significant contribution in such increase in income according to the respondent.

One of the reasons for increased consumption expenditure amongst the dam site communities' in the study area may be because of the increased expenditure for repairing and fixing of damages in the house building. Also, the expenditure in fuel wood has increased amongst the dam site communities' as inception of the large power project has lead to deforestation as those communities' used to depend on forest for fodder. Large project requires large area for which the villagers willingly or unwillingly sold off their land which they were previously used to depend for fodder and agricultural activities. Due to deforestation and loss of their land the quantity of fuel wood decreased and in addition to increasing demand for the fuel wood there was hike in the price of the fuel wood resulting in increase in the price of the fuel wood. Such loss not only increase expenditure but also highlights the loss which incorporates the loss of environment and livelihood for rural people whose daily survival is depends on that forest.

To test for the possible impact of hydropower project on consumption expenditure of the dam site communities' an augmented Keynesian consumption expenditure function was estimated introducing a dichotomous variable with time effect and locational effect. To test for the presence of a possible non-monotonic possible impact of hydropower project on consumption expenditure of the dam site communities' the augmented Keynesian consumption expenditure function estimated by running a regression of the following generic form:

$$Cons_{ilt} = \beta_0 + \beta_1\, Inc_{ilt} + \beta_2\, Time_{il} + \beta_3\, (Inc * Time)_{ilt} + \phi_{it} + Err_{ilt}$$

Where, C stands for consumption expenditure[14], Y stand for Income[15], Time is dummy such that D=1 stands for the period of post dam development period and D=0 stands for the period of pre dam development, i stands for number of household that is 100, 1 stands location that is Dikchu and 2 stand for Chungthang, t stands for time period under consideration, here in this case pre hydropower development period and post hydropower development period, Err is well behaved error term, ϕ stands for locational effect, β_0 ,β_1 , β_2, β_3 are intercept and slope coefficient's. Three different models has been estimated for the specified augumented Keynesian consumption function and reported in Table 3.5.

Refer to Table 3.5 it can be observed from the value of R^2 that 32 percent variation in consumption expenditure of dam site communities' household being explained by income and time dummy variable remaining 68 percent being captured by error term. Although the R^2 being low but still makes sense since the overall significance being established and observed to be highly significant. The estimated coefficient of explanatory variables along with the intercept term has been observed to be statistically significant. Considering the model 1 the results suggest that ceteris paribus as income of the dam site communities' household goes up by 1 percent on an average the household consumption expenditures go up by 0.07 percent. The semi elasticity for the time dummy

[14] Figures arrived after deflating at (1982=100) prices and then log transformation

[15] Figures arrived after deflating at (1982=100) prices and then log transformation

regrssor[16] indicates that post dam consumption expenditure of the dam site communities' communities' has increased by 232.27 percent. The median consumption expenditure of the dam site communities' household in post dam period was Rs.223.13.

Table 3.5
Consumption Function Analysis in Pre and Post Dam Periods

Endogenous Variable: Consumption Expenditure						
Variable	Model 1		Model 2		Model 3	
	Dummy	Estimated Coefficients	Dummy	Estimated Coefficients	Dummy	Estimated Coefficients
Income		0.07* (0.04)		0.00 (0.05)		0.01 (0.05)
Time	Y	1.20*** (0.13)	Y	-1.91 (1.35)	Y	-1.8 (1.35)
Income *Time	N	-	Y	0.3** (0.13)	Y	0.29** (0.13)
Locational Effect	N	-	N	-	Y	0.23* (0.13)
Constant		5.41*** (0.38)		6.09*** (0.49)		5.88*** (0.51)
R^2		0.32		0.34		0.35
Estimated $F_{(2,194)}$		44.70***		30.71***		25.23***
N		197		197		197

Source: Self estimate on the basis of data from Field Survey, April- July 2014
Note: Figures in the parenthesis are the robust standard errors
*** stands for significant at 0.01 percent level, ** stands for significant at 0.05 percent level

If we take into account the model with slope dummy (that is model 2) shows that 34 percent variation in consumption expenditure of dam site communities' household being explained by income and time dummy variable remaining 66 percent being captured by error term. Since the overall significance has being established, so low value of R^2 still makes some sense. The estimated slope dummy coefficient of explanatory variable along with the intercept term has been observed to be statistically significant. Thus as income goes up by 1 percent on an average in the post intervention period the

[16] The semi elasticity for a dummy regressor can be obtained directly by the device suggested by Halvorsen and Plamquist. Halvorsen, R. and Plamquist, R. ( ), The Interpretation of Dummy variable in Semilogarithimic Equations, *American Economic Review*, Vol.70, No.3, pp.474-475.

consumption expenditure of the hydropower dam site communities' household increased by 0.3 percent.

3.1.4 Agricultural and Animal Husbandry Activities

There has been a decline in the availability of land from 2.48 acres in the pre hydropower project development period to 1.23 acres in the post hydropower development period. The reason behind such decline in the total area of land is the fact that the dam site communities' households had to sell their land to the hydropower project authority with the advent of such development (as in Table 3.6).

Table 3.6
Agricultural and Animal Husbandry Activities

Variables		Hydropower Dam site communities'			
		Pre	Post	MD	T
Total Land Available (in Acres)	Mean	2.48	1.23	-1.36	6.5***
	N	57	51		(0.00)
Agricultural Activities (Rs.)	Mean	8.77	5.32	-3.45	6.45***
	N	55	55		(0.00)
Livestock Activities (Rs.)	Mean	10.34	7.14	-3.2	6.68***
	N	65	65		(0.00)
Poultry Activities (Rs.)	Mean	10.30	7.31	-2.99	4.86***
	N	48	48		(0.00)

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets is the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level
MD is Mean difference

The result of paired sample t test reveals that agricultural activities, poultry and livestock activities are statistically significantly different between the pre and post hydropower project period. Before the project, 55 per cent of the household were practicing the agricultural activities with the annual average return of Rs. 6432.32 which has declined to Rs.204.27 in the intervention period. Although, the percentage of household practicing the agricultural activities has remain same but the average return from such activities has been observed to decline significantly in the wake of development of hydropower project. Similarly, in terms of livestock activities it has been observed that in both the period the percentage of the household practicing such activities is same i.e. 65 per cent but the returns from the same in pre and post project period were observed to be different such as Rs. 10340 and Rs. 7140 respectively with the mean difference being Rs. 3200. Poultry activities on the other side were practicing by 48 per cent of the total household for both the considered period with average earning of Rs. 10300 in pre project period and Rs. 7310 in post project period with mean difference being 2990.

Thus, from the above comparison we can infer that for the dam site communities' there have been some negative changes in the post hydropower project period when compared to the pre hydropower project period in terms of agricultural, livestock and poultry activities. Most of the respondent those who were practicing agriculture and animal husbandry informed that such development (specially the stagnant water, tunnelling and frequent blasting) has bought harmful impact on their land and surroundings. They observe that now a day's their seeds are not even growing properly or the seeds are decaying while on the other side hen and goat are finding difficult to survive which was not the same case when the project was not there. Although, present study has not made effort to study the environmental damages caused by the project but we cannot ignore the local respondent opinion regarding surrounding impact caused by such project. Thus it is clear that large project has some local environmental as well as economical impact.

3.1.5 Accessibility Status

Local convenience is one of the most important factors for every people in order to live a comfortable and an easy life. Because, a school or a hospital in a distance is more time consuming as well as energy to reach respective destination. Thus, to underline, whether changes prior to the project in local convenience has occurred or not is necessary. Following section is devoted for the same. In order to check whether the accessibility for different considered destinations are statistically different in pre and post project period or not Paired sample t-test has been applied on the mean values.

Table 3.7 represents the results of t-test which clearly indicate that distance of the school, buried place and police post are statistically, significantly different in pre and post project period. The government school in Dikchu is relocated of around 1 kilometer away from the initial location whereas police post in both the location has been shifted to nearby dam site communities' location. It will we worth to note the mean difference of buried place which is -12.83 indicating that for the dam site communities' household the buried place in the post project period is far as compared to the pre project period.

Such results are a sign of indication that in the wake of project students now requires more time to reach school and return back to home as well as they needs more energy as compare to pre dam period. Loss of time and energy can directly be a constraint to their study.

Table 3.7
Change in accessibility factors of Dam site communities'

Variables	Chungthang		Dikchu			
	Pre	Post	Pre	Post	M.D	T
Market	0	0	25.58	25.56	0.02	0.06 (0.95)
Bank	0	0	0.74	0.72	0.02	0.12 (0.90)
School	0	0	0.76	1.72	-0.96	-5.55*** (0.00)
Post Office	0	0	0.74	0.72	0.02	0.12 (0.91)
Health Services	0	0	0.82	0.72	0.1	0.73 (0.47)
Police Post	1	0	1.7	0.72	0.98	5.62*** (0.00)
Buried Place	1.02	2.08	0.64	2.98	-2.34	-12.83*** (0.00)

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets is the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level
Note: t cannot be computed because the standard deviations of both groups are 0 in Chungthang

3.2 Comparison between Dam Site and Non Dam Site Communities

3.2.1 Economic differences between dam site communities' and non-dam site communities'

The Table below shows the comparison of various economic variables between the dam site communities' and non-dam site communities' in order to examine whether these economic characteristic has under gone change or not in the wake of the hydropower project for which the independent sample t test has been applied. Having the following results, it can be said that all the considered economic variables such as income, expenditure and savings are statistically significantly different between the dam site communities' and non dam site communities' household.

Table 3.8
Economic differences between the Hydropower Dam site communities' and Non-Dam site communities'

Variables	Average, Observations	Dam site communities'	Non-Dam site communities'	M.D	t
Income	Mean	10.51	9.8	-0.71	-5.51874*** (0.000)
	N	100	100		
Expenditure	Mean	7.34	4.75	-2.59	-11.1788*** (0.000)
	N	97	100		
Savings	Mean	3.26	5.05	1.8	7.495905*** (0.000)
	N	96	100		

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets is the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level

It can be observed that the average income of the dam site communities' household is approximately Rs. 10510 while that of the non dam site communities' household is Rs. 9800 with the mean difference being Rs. -710 whereas the average expenditure of the dam site communities' household is registered as Rs. 7340 while that of the non dam site communities' households is Rs. 4750 with the mean difference being

Rs. -2590. Similarly, the average saving of the dam site communities' household is Rs. 3260 while that of the non dam site communities' household is Rs. 5050 with the mean difference being Rs. 1800.

The above analysis reveals that both the income and expenditure of the dam site communities' household are relatively higher than that of the non-dam site communities' household whereas savings on the other side is found to be higher for the non- dam site communities' household. Greater income opportunities for dam site communities have facilitated their income to raise while compare to the non-dam site communities. As we don't have control to family size in both the communities' higher consumption pattern of the dam site communities may direct towards a higher family size as well as to their personal preferences in such communities.

3.2.2 Agricultural and Animal Husbandry Activities of Dam Site and Non Dam Site communities'

Table 3.9
Differences in Agricultural and Animal Husbandry Activities between Dam site communities' and Non-Dam site communities'

Variables	Average, Observations	Dam site communities'	Non-Dam site communities'	M.D	T
Agricultural Activities	Mean	7.28	9.59	2.30	5.66*** (0.00)
	N	41	62		
Poultry Activities	Mean	9.75	9.71	-0.04	-0.29 (0.77)
	N	36	62		
Livestock Activities	Mean	9.47	9.55	0.07	0.59 (0.56)
	N	49	77		

Source: Self Estimates based on Household survey, April – September 2014
Note: Figures in the brackets is the significance level
*** Significant at 0.01 percent level, ** significant at 0.05 percent level

The results signify that only the agricultural activities is statistically significantly different between the dam site communities' and non dam site communities' household where the mean return of the agricultural activities for the dam site communities' households is Rs. 7280 while that of the non dam site communities' household is Rs.

9590 with the mean difference of 2300. The reason behind such results may be due to the loss of agricultural land of the dam site communities which was loss because of large area requirement for such large project. On the other hand, respondent have reported that due to stagnant of water in dam their crops are not growing well. However, the poultry activities and the livestock activities are not found to be statistically significantly different between the dam site communities' and non-dam site communities'.

In an attempt to study whether consumption expenditure of the hydropower dam site communities' are different or not from hydropower non dam site communities' an augmented Keynesian consumption function has been estimated introducing a dichotomous variable in the equation. The consumption function specified for the purpose was;

$$\ln Cons_i = \ln\{a\ Inc_i^b\} + \text{Location}_i + Err_i$$

where,

Cons is consumption expenditure[17], *Inc* in Income[18], Location is a dummy such that: Location =1 stands for non dam site communities' communities' and Location = 0 stands for dam site communities'. And *a* is an efficiency parameter, *b* is income share; Err is well behaved error term.

i = 1, 2,….197

The estimated regression line is presented in Table 3.10;

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[17] Figures arrived after deflating at (1982=100) prices

[18] Figures arrived after deflating at (1982=100) prices

Table 3.10
Consumption Function Analysis for Hydropower Phepripherial and Non-Phepripherial Communities

Endogenous Variable: Consumption Expenditure	
Variable	Coefficient Estimated
Income	0.3** (0.14)
Location	2.37*** (0.25)
Constant	1.82 (1.35)
R^2	0.41
Estimated $F_{(2,194)}$	66.78***
N	197

Source: Self estimate on the basis of data from Field Survey, April- July 2014
Note: Figures in the parenthesis are the robust standard errors
*** stands for significant at 0.01 percent level, ** stands for significant at 0.05 percent level, * stands for significant at .10 percent level

Refer to Table 3.10 it can be observed that an increase in income of dam site communities by 1 units resulted in consumption expenditure of the dam site communities by 0.3 units. The estimated dummy slope coefficient was found to be statistically significant. The estimated line shows considerable degree of fitness in terms of R^2 value. The overall significance is established.

3.3 Pattern of Inequality in Income

In order to check whether income inequalities exists in dam site and non dam site communities a simple examination has been done through calculating Gini coefficient.

Table 3.11
Income Inequality

Dam site communities'	Non-Dam site communities'
0.16	0.15

Source: Self estimate on the basis of data from Field Survey, April- July 2014

Table 3.12
Income Inequality among the Dam site Communities

Pre Dam	Post Dam
0.15	0.16

Source: Self estimate on the basis of data from Field Survey, April- July 2014

From the Table it can be observed that the income inequality was relatively higher amongst the dam site communities while compared with the non dam site communities. Also the development of the hydropower project in the study area has resulted in increase in the level of inequality amongst the dam site communities.

Thus from the present chapter it has been observed that the respondent of non dam site communities' were relatively older compared with dam site communities' respondent. The female respondents were more in case of non dam site communities' household than the hydropower dam site communities' household. The dam site communities' households were found to be mostly Hindu by religion when compared with the non dam site communities' household. Third generation of household had occupied both the locations. The percentage of nuclear family has been observed to be higher in case of hydropower dam site communities' household while the non dam site communities' household has larger family size when compared with dam site communities' household. Literacy rate and nature of family in the study area has been observed to be independent of the locations.

There has been some loss in ownership of private property although small in margin in the wake of development of hydropower projects in the study area while on the other side no influence has been seen on the subject of the qualitative factor. Emergence of hydropower project in the study area has helped to reduce the percentage of household living in rented house by occupying 2 percent of the household in power project quarters. There has been an increase in the number of household living in pucca house with a fall in household living in semi pucca and kattcha khaprail type of house with the inception of hydropower projects in the area of study. Such changes indicate that there has been some improvement in terms of standard of living of the communities in the wake of dam.

Increased number of household in roadside bought negative externality in terms of pollution.

Thus the communities' who were away from dam site were occupied in their own houses with number of household staying in rented house was less amongst non dam site communities'. However, with the emergence of hydropower projects, has helped to offer project quarters to its workers. Although the average number of rooms for the communities' residing nearby dam and those who are away from dam has not been observed to be significantly different, but significant difference being observed between them in terms of number of rooms cracked. On an average 4.06 rooms of the communities' in the surrounding of dam were reported to be cracked in the wake of hydropower project. A significant percentage of dam site communities' household were staying in road side area while the percentage was larger for household residing away from roadside amongst non dam site communities'. Such differences may be an indication that inception of the hydropower project has lead to congestion of space for further expansion or construction compelling families to shift near road side houses.

There has been an increase in income of the dam site communities in the wake of hydropower project. The increased economic activity and increase in the nominal wage rate during the period of hydropower development may be one of the reasons for such change in income of the household. Followed by increased in income consumption expenditure has also shown a substantial increase in the transition period. Similar result was found through estimation of the augmented Keynesian consumption expenditure function. The reasons for increased consumption expenditure amongst the dam site communities' in the study area may be because of the increased expenditure for repairing and fixing of damages in the house building. Also, the expenditure in fuel wood has increased amongst the dam site communities' as inception of the large power project has lead to deforestation as those communities' used to depend on forest for fodder. There has been considerable decline in savings pattern amongst the hydropower neighboring communities in the wake of development of hydropower project in the study area. In terms of agricultural, livestock and poultry activities there have been some negative changes in the post hydropower project period when compared to the pre hydropower project period for the dam site communities. Most of the respondent those who were practicing agriculture and animal husbandry informed that such development (specially the stagnant water, tunneling and frequent blasting) has bought harmful impact on their land and surroundings. They observe that now a day's their seeds are not even growing properly or the seeds are decaying while on the other side hen and goat are finding difficult to survive which was not the same case when the project was not there. Although, present study has not made effort to study the environmental damages caused by the project but we cannot ignore the local respondent opinion regarding surrounding impact caused by such project. Thus it is clear that large project has some local environmental as well as economical impact. The accessability status from public utilities for the dam site communities has not under gone significant change except in case of the distance from school and buried places in the wake of hydropower development.

The income and expenditure of the dam site communities' household are relatively higher than that of the non-dam site communities' household whereas savings on the other side is found to be higher for the non- dam site communities' household. This was evident from the estimated regression model with locational dummy which has shown that dam site communities were subject of larger consumption expenditure with increase in income compared with non dam site communities. Greater income opportunities for dam site communities have facilitated their income to raise while compare to the non-dam site communities. As we don't have control to family size in both the communities' higher consumption pattern of the dam site communities may direct towards a higher family size as well as to their personal preferences in such communities. The incomes from agricultural activities were found to be is statistically significantly different between the dam site communities' and non dam site communities. The non dam site communities were making more income from agricultural activities. The income inequality was relatively higher amongst the dam site communities while compared with the non dam site communities. Also the development of the hydropower project in the study area has resulted in increase in the level of inequality amongst the dam site communities.

Chapter IV

Conclusion

Out of many source of electricity production, Sikkim practices only two of them which are Diesel and Hydro. Sikkim being rich in water resources and at the same time being a hilly state, it has a great potential of hydropower plants. In addition, electricity generation in Sikkim is dominated by the hydropower. Although there are some studies attempted to examine the macroeconomic indicators such as revenue, total generation, employment and consumption of electricity from hydropower projects in Sikkim. But limited studies have been initiated to understand the immediate impact of development of hydropower project on the dam site communities. Any development project accrues either positive or negative externalities. The nucleus of present study was to understand external economies and dis-economise of hydropower industry on the basian communities taking Sikkim as a case study. The study tries to quantify those externalities from two perspectives: time perspective and locational perspective to find a relative measure with a proposed objective of examining the immediate impact of hydropower project on hydropower project dam site communities. An attempt was also made in the study to understand the importance of hydro power sector in gross electricity generation, revenue generation of Sikkim.

Amongst the various nations generating hydropower China stood at the top around the world in terms of installed capacity and actual generation of electricity from hydropower during 2011. The average growth of electricity generated from all sources in the world during 1971-2011 was 2.84 per annum whereas it was 3.77 per cent and 3.4 per cent per annum for the South Asia and India respectively. In India thermal electricity has been the dominating among different source of electricity generation during the period of 1970-2006 followed by hydropower in second position and other sources (wind, gas, petroleum). During 1997 till 2012, Sikkim has experienced a decline in annual average electricity generation form hydropower for the state owned projects. Competition from large projects and closure of small projects can be understood as one of the reason for such trend. Apart from using the available electricity within the state, Sikkim has been managed to export some share of it to outside the state. Domestically, industries were primarily using electricity generated in Sikkim at large scale. There has been an increase in annual average revenue from electricity generation of Sikkim both from sale within the state and outside Sikkim during 2005-2012.

The respondent of non dam site communities' were relatively older compared with dam site communities' respondent. The female respondents were more in case of non dam site communities' household than the hydropower dam site communities' household. The dam site communities' households were found to be mostly Hindu by religion when compared with the non dam site communities' household. Third generation of household had occupied both the locations. The percentage of nuclear family has been observed to be higher in case of hydropower dam site communities' household while the non dam site communities' household has larger family size when compared with dam site communities' household. Literacy rate and nature of family in the study area has been observed to be independent of the locations.

There has been some loss in ownership of private property although small in margin in the wake of development of hydropower projects in the study area while on the other side no influence has been seen on the subject of the qualitative factor. Emergence of hydropower project in the study area has helped to reduce the percentage of household living in rented house by occupying 2 percent of the household in power project quarters. There has been an increase in the number of household living in pucca house with a fall in household living in semi pucca and kattcha khaprail type of house with the inception of hydropower projects in the area of study. Such changes indicate that there has been some improvement in terms of standard of living of the communities in the wake of dam. Increased number of household in roadside bought negative externality in terms of pollution.

Thus the communities' who were away from dam site were occupied in their own houses with number of household staying in rented house was less amongst non dam site communities'. However, with the emergence of hydropower projects, has helped to offer project quarters to its workers. Although the average number of rooms for the communities' residing nearby dam and those who are away from dam has not been observed to be significantly different, but significant difference being observed between them in terms of number of rooms cracked. On an average 4.06 rooms of the communities' in the surrounding of dam were reported to be cracked in the wake of hydropower project. A significant percentage of dam site communities' household were staying in road side area while the percentage was larger for household residing away from roadside amongst non dam site communities'. Such differences may be an indication that inception of the hydropower project has lead to congestion of space for further expansion or construction compelling families to shift near road side houses.

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