Hydropower and Climate Variability: Issues of Adaptation in Upper Tista Catchment

A Dissertation Submitted

To

Sikkim University

In Partial Fulfilment of the Requirement for the

Degree of Master of Philosophy

By

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Declaration

I, Navin Rai, do hereby declare that the dissertation entitled **"Hydropower and Climate Variability: Issues of Adaptation in Upper Tista Catchment"** is the record of work done by me, that the contents of this did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and this dissertation has not been submitted by me to any other University or Institute.

This is being submitted in partial fulfilment of the requirement for the award of the **Degree of Master of Philosophy**, to the Department of Geography, School of Human Sciences, Sikkim University.

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This is to certify that the dissertation entitled **"Hydropower and Climate Variability: Issues of Adaptation in Upper Tista Catchment"** submitted to Sikkim University in partial fulfilment of the requirements for the degree of Master of Philosophy in Geography is the result of bonafide research work carried out by **Mr. Navin Rai** under my guidance and supervision. No part of the dissertation has been submitted for any other degree, diploma, associateship and fellowship.

All the assistance and help received during the course of the investigation have been duly acknowledged by him.

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Hydropower and Climate Variability: Issues of Adaptation in Upper Tista Catchment

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- **Navin Rai**

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ACRONYMS

ACT= Affected Citizen of Teesta

ADB= Asian Development Bank

CDM=Clean Development Mechanism

CEA= Central Electricity Authority

CER= Certified Emission Reduction

CIFRI= Central Inland Fisheries Research Institute

CMFRI= Central Marine Fisheries Research Institute

EIA= Environmental Assessment Report

FGD= Focus Group Discussion

GHG= Green House Gases

GPU= Gram Panchayat Unit

GLOF= Glacial Lake Outburst Flood

HEP= Hydro Electric Project

HKH= Hindu Kush Himalaya

ICIMOD= International Centre for Integrated Mountain Development

IET= International Emission Trading

IMD= Indian Meteorological Department

INDC= Intended Nationally Determined Contributions

IPCC= Intergovernmental Panel on Climate Change

JI= Joint Implementation

MGNREGA= Mahatma Gandhi National Rural Employment Guarantee Act

MW= Mega Watt

NGO=Non Governmental Organisation

NHPC= National Hydroelectric Power Corporation

PRA= Participatory Rural Appraisal

SANDRP= South Asia Network on Dams, River and People

SAPCC= Sikkim Action Plan on Climate Change

SHP= Small Hydropower Plant

SIA= Social Impact Assessment

TW= Tera Watt

UNDP= United Nations Development Programme

UNFCC= United Nations Framework Convention on Climate Change

WCD= World Commission on Dam

WCED= World Commission on Environment and Development

CONTENTS

Chapter 1: Introduction

1.1 Introduction

In the face of climatic variability, the Kyoto protocol (1998) declared profoundly that GHGs are major sources of global warming and environmental degradation and there should be an alternative for fossil fuel based energy. Since, then the hydropower is globally considered as win-win and green energy to tackle increasing GHGs emission from fossil fuel based energy. Generally, the role of hydropower dam in the world is increasing to fulfil growing demands for clean, reliable, and affordable energy with least production of pollution.

With the rapid growth in the level of human economic activities, the capacities of natural storage systems like in aquifers and ponds started to prove inadequate for the human beings. Therefore, the technology of hydropower dams was first used in developed part of the world i.e., Europe and North America and then gradually transferred to developing countries, notably homes of ancient civilisations like Egypt, China and India. (Bandyopadhyay, Mandal and Perveen 2002).

Worldwide, 3288 TWh of hydropower was produced in 2008 which measured over 16% of global electricity production and the overall technical potential for hydropower is estimated to be more than 16400 TWh/yr.[1] There were over 45,000 large dams been built till the year 2000 in the world and nearly half the world's river had been obstructed by large hydropower dam (WCD 2000).

Similarly, hydropower is the second most important source of energy in India, the total hydropower potential assessed by CEA is approximately 148701 MW, of which

[1]www.iea.org (accessed 03.11.2016)

Economic Potential works out to 84,044 MW at a probable installed capacity of 60% load factor which when fully developed would result in an installed capacity of about 150,000 MW on the basis of probable average load factor (Dsouza and Syiemlieh 2015). At the same time, however, the unforeseen, underestimated or ignored consequences of the large hydropower dam projects, in the long run, have systematically started to emerge, threatening to damage the positive image of large dams (Bandyopadhyay, Mandal and Perveen 2002).

As far as climate variability is concerned, the climate change projections across the HKH region indicates an increase in temperature, with an increased number of extremely hot days, as well as a wide range of changes in precipitation and an increase in heavy precipitation events (Vaidya, et al. 2014).

Similarly, Sikkim Himalaya has also been experiencing climatic variability in the form of untimely rainfall, and extreme events. In fact, climate variability fluctuates the river water flows and the safety of hydropower dams in view of these increased flows is a major cause of concerns (Dharmadhikary 2008). One of the most shocking news for the people of Himalaya is that most of the glaciers in Himalayas is projected to be melted by 2035 as glaciers in Himalayas are receding faster than anywhere in world (Bates, et al. 2008:17). Therefore, even if a big dam is able to survive higher flows, bigger floods are likely to lead to higher backwaters and increased submergence problem (Dharmadhikary 2008). On the other hand in case of water, decrease in the river would lead to water shortages at lower riparian areas and consequences would be socio-environmental turmoil.

As one amongst the many issues, degradation of water resources has emerged as a threat to human security around Tista River Basin. The central point of arguments

stands out with the processes of ‘dam building’ in upper catchment areas of River Tista. Apart from natural causes of insecurity such as the increase in global temperature, drying of natural springs, and melting of glaciers, Sikkim Himalaya has witnessed haphazard development of hydro power projects which has immensely accentuated the environmental problems in the region.

Therefore, the paradoxical nature of development in Sikkim Himalaya which resulting into mere quantative changes with lots of cultural and environmental related issues has brought public repulsion to the hydropower development. On the other hand, the issues of global warming and climate variability have challenged the intensity of human actions. In the midst of all these challenges, the very issues of adaptation and mitigation are indeed necessary to understand. Therefore, this dissertation focuses on building a greater understanding of how people quest to adapt themselves in the midst of changes that the nature has brought on and further exacerbated by human actions such as hydropower projects.

1.2 Statement of the Problem

The merger of Sikkim with Indian union in 1975 and implementation of different developmental projects in the state was obvious. One of them was development of hydro power dams in perennial river Tista and its tributaries. The hydropower energy is nationally perceived as a ‘win-win’ and ‘green energy’ to fulfil growing energy needs and to cut down GHGs from the atmosphere. Therefore, Sikkim, has allotted

hydropower projects with a calculated installed capacity of 5252.7 MW mainly by capitalizing the water of River Tista and their tributaries[2].

But it has become an arguing factor that the water projects (dam) in the Himalayan region are thought of primarily in the context of mere hydropower generation, which can be perceived as an opportunity driven approach (Vaidya 2015) whereas the hydropower as a developmental pathway in the Himalaya is becoming a central point of controversy because of its social and environmental impacts. Therefore, one of the important rationales of the study is to understand local environmental impacts of Hydropower project.

Furthermore, the accelerated dam construction in Upper Tista Catchment area meant for mere hydropower generation (electricity) left the region to face extreme water scarcity during dry winter season. The social and environmental activists are more concerns of environmental degradation and socio-cultural unrest because of environmental insecurity aggravated by dam building process. However, it has been observed that the problems arise due to the hydropower development and its direct impacts on the environment of geologically fragile landscapes of Sikkim Himalaya.

Meanwhile, in recent scenario of Sikkim Himalaya, it has been also recorded under Sikkim Action Plan on Climate Change (SAPCC) the changing environment of the region is due to climatic variability. Therefore, the cascading hydropower dams and changing climate in Sikkim Himalaya has brought a new debate, the debate here is about how the global perceptions of hydropower dam as a clean and sustainable energy appeared unsustainable from the ground reality?

[2]Ministry of DONER http:// www.mdoner.gov.in/content/hydro-powerprojects#Mar12 (Accessed:8/8/2016)

In Sikkim Himalaya the effective developmental races of hydropower dam construction started from 1990s onwards and various issues of environmental and social security have centred around the dams construction. Additionally, some of the perennial streams have now turned seasonal and many are drying up during summer months. The villagers relate this problem directly to the tunnelling activity going on beneath their land.[3]

The indigenous Lepchas of Sikkim are opposing the construction of large number of hydro power plants that will destroy their invaluable land and environment by using Gandhian methods of protest (Arora 2008). In fact, change is a feature of earth's climate, but faster rate of change due to increased human interference is a great concern to all. The people of the region are more concerns because the Tista River Basin is environmentally insecure by dual drivers i.e. climate variability and hydropower development. Therefore, this research also intends to study peoples' perception around hydropower and climatic variability in Upper Tista Catchment.

Large number of population lives along the bank of the Tista River Basin within Sikkim Himalaya and beyond. Therefore, without adaptation strategy for changing environment, large parts of these areas can be inundated and affected. There is also large-scale economic activity along the bank which can be affected by water level rise and fall, in particular, and are sensitive to climate variability due to water level rise and changes in rainfall and river stream flow.

In many of these areas, the pressure on environment by climate variability is already high and hydropower development is likely to worsen the situation. The indigenous people are the direct victims of both hydropower and climate variability since their

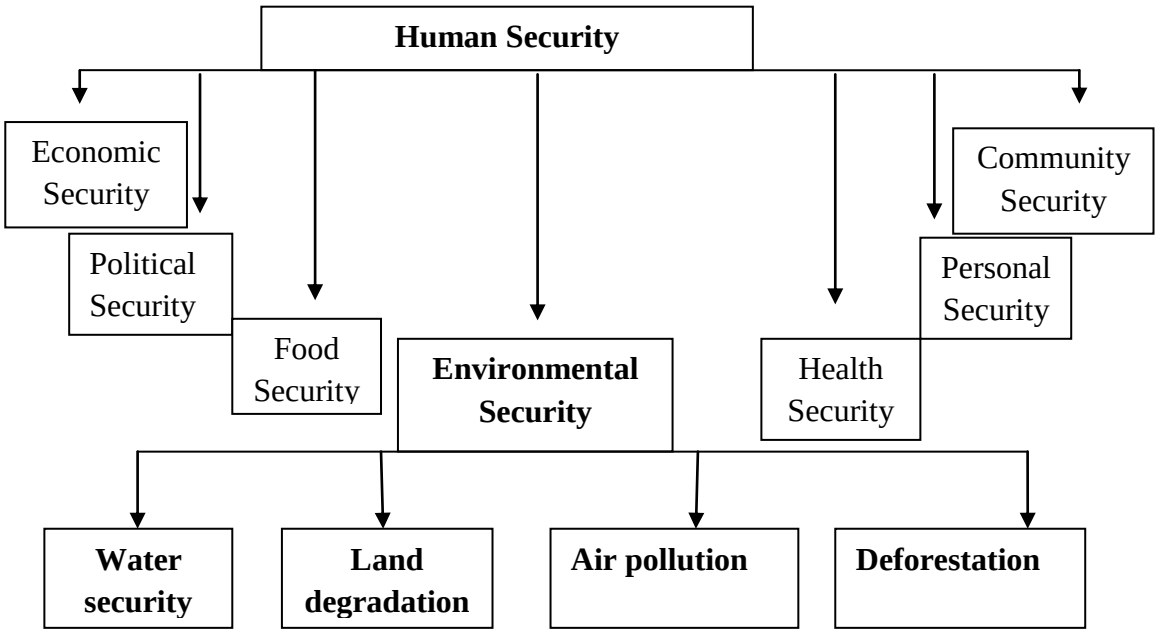
[3] http://www.actsikkim.com/docs/Menon_Vagholikar_Teesta_V_Report.pdf (Accessed: 12/07/2015)

livelihoods are exclusively depends on primary activities. Hence, this study enquires about the adaption strategies practicing by the villagers in the midst of environmental and developmental threats.

1.3 Environmental Security: A Theoretical Framework

In the contemporary scenario of our world, the humanity faces various threats and insecurities. The world is worrying about the global and local level threats from climate change, energy security, food security, and resource security in one side and environmental degradation due to over utilization of natural resources such as water, minerals, forest, and soil in other side. The study is based on environmental security framework to explore the various forms of insecurities being aggravated by hydropower development and climatic variability in upper Tista catchment

Figure 1: Environmental Security Framework



Source: Based on UNDP, 1994

Theoretically, the meaning of security is closely tied with the enhancement military power of a state making it strong and undefeated against external threats coming from similar other states. Therefore, UNDP (1994) came up with a new framework of environmental security. Environmental security emerged as both a concept and a set of policies as a consequence of the end of the Cold War (Allenby 2000). It is fact that the national security is not just about fighting forces and weaponry (Biswas 2011).

New conceptions of security i.e., human security considered that the traditional notion of state-centric security, typically defined by military aspects, was insufficient to address and explain emerging threats such as environmental loss and green house gas emission. Therefore, during 1980s the broader national security definition dived beyond the traditional conception including global environmental issues like resource scarcities such as (water, land, and food) global warming, ozone depletion, and deforestation (Janouskova, Hak and Oulehlova 2014). Meanwhile, environmental security is a component of larger whole of human security, a relatively new and still somewhat contentious concept, may be defined as the intersection of environmental and national security considerations at a national policy level (Allenby 2000). In addition to this, the environmental security offers an intricate relationship between the contemporary environmental changes in the world and environment-led threats and cooperation (Biswas 2011). Environmental security is the disarmament policy of future (UNDP 1994)

The most fundamental global perspective of environmental security is that, human beings are living beyond the carrying capacity of the earth. And the growing demand and production of natural resources can lead to overexploitation and havoc in the environment. Since, the lifestyles of the people are increasingly transforming and the

carrying capacity of the region depends on population, technology and life style of a people. Environmental security is the current and future availability of goods and services from a healthy environment for human beings and nature. The availability is reduced when there are environmental destruction through overexploitation of natural resources which lead to scarcity and trigger conflict and violence.

The environmental security is indeed a point to be discussed wherein the increasing problem of global warming, acid rain, sea level rise, greenhouse effect, decreasing capacity of the agricultural system, depletion of earth's finite resources and punching holes in the ozone layer as has the need for urgent attention to these problems for solution (Gann 2000).

Most importantly with the end of the cold war in 1990s, the study of international security added a new dimension. Thus, the security discourse experienced a shift from traditional to non-traditional security which incorporates poverty and environmental related problems such as the effects of the environmental degradation on the economy of the society in terms of poverty and food insecurity, diseases and health are quite fundamental. The major environmental changes are degradation and depletion of agricultural land, forests, water, fish etc (Homer-Dixon 1994).

In contemporary scenario in developing countries, one of the greatest environmental threats led by developmental thrust is that to water. During 1990s, it was estimated about 1.3 billion people in the developing world lacked access to clean water and water scarcity is increasingly becoming a factor in ethnic conflict and political tension (UNDP 1994:29). A significant number of less developed countries are facing severe water shortages, with population growth the number of countries in this category is increasing, it was projected that by 2025 there will be approximately 6.5 times as

many people as estimated of 3.5 billion living in water stressed countries (WCD 2000). Therefore, in the midst of rapid developmental race, the extensive demands and exploitations of natural resources led serious environmental concern. The growing environmental problems such as water scarcity, water pollution, soil degradation, pollution etc. and associated issues urgently need an attention.

Within the next fifty years, the planet's human population will probably pass nine billion and global economy output may five times more than today and scarcities of renewable resources will increase sharply. Similarly, coming generation will also see the widespread depletion and degradation of aquifers, rivers and other resources (Homer-Dixon 1994). Therefore, environmental security has quickly become an important issue in this new era of security studies (Allenby 2000).

Ullman (1993) reformulates national security in terms of protecting against events that threatens to degrade the quality of life; among these threats he listed as the environmental deteriorating, natural disasters and inability to meet basic needs. Furthermore, serious global environmental themes like the stratospheric ozone depletion, resource scarcities, global warming, and deforestation appeared on the scene. Therefore, the inclusion of such themes into the security concept meant a complete change of the traditional security paradigm and added the best strategy for addressing the global environmental problems (Janouskova, Hak and Oulehlova 2014).

The environmental conflict is a conflict led by the resources scarcity of a region that caused by an overexploitation of natural resources or the human made disturbance of its normal regeneration rate. Moreover, environmental scarcities are consequences of

overuse of a renewable resource, for instance the Himalayan region have accelerated dam construction.

Therefore, in the contemporary world most of the people today have a feeling of insecurity that arises more from worries about daily life than from the dread of a cataclysmic world event (UNDP 1994). For instances unemployment, drugs, crime, pollution and human rights violations. Moreover, human beings want to rely on a healthy physical environment but in contemporary scenario the environmental security are the emerging concerns of human security all over the world. The environmental insecurities aggravated by developmental activities in the world are increasing nowadays such as water scarcity, land degradation, air pollution, and deforestation.

1.4 Literature Review

1.4.1 Impact of Climate Variability on Water

The climate is warming and this is the unequivocal conclusion of climate scientists (Hall, Stuntz and Abrms 2008). They further discusses as the world gets warmer, it experiences increased regional variability in precipitation, with more frequent heavy precipitation events and more susceptibility to drought. These facts will have profound impacts on freshwater resources as the warmer climate will reduce available water supplies and increase water demand.

The extreme events are occurring throughout the world in the form of untimely rainfall and rise in temperature. Ludwig, et al. (2009) discusses that the most important effect of climate change is the impact that it has on river discharge. Total annual stream flow would be affected by climate change, as well as seasonal patterns (e.g. due to changes in snowmelt period). In general understanding, the impacts are

relatively simple: higher rainfall will result in higher stream flow and reduced rainfall will decrease the stream flow. However the correlation between changes in stream flow and rainfall are very different in different climates.

The report of IPCC (2007) recorded almost all glaciers around the world are shrinking, and significant parts of all glaciers are projected to melt in the coming century. For example, the glaciers of the Tibetan plateau are projected to decrease by 100,000km^2 by 2035. Wherein, half a billion people in India and 250,000 in China depend upon the Himalayan glaciers for their water resources and both the nations are rapidly developing their economy through these perennial water resources.

Hall, Stuntz and Abrms (2008) examined that the warming of earth is evident in average global air and ocean temperatures. They discussed extensively that the polar snow and ice are melting, and the average sea level around the globe is rising. Earth is warming faster than at any time during the twentieth century. Furthermore, Ludwig and Moench (2009) points out the melting of glaciers initially results in increased river runoff, but it will eventually cause lower stream flows when the ice has disappeared. So, in these cases, the initial hydrological response to climate change can give a false impression of the future. This initial increase of stream flow and a sudden drop later is predicted for the Himalayan region in particular. So, such type of river water behaviour would impact the economy and society later or sooner.

Gerlitz, et al. (2015) argued that in recent years the population of the Hindu Kush Himalayas (HKH) has been confronted with rapid social, economic, demographic, and political changes whereas the region is particularly vulnerable to climate change especially in water sector.

In the contemporary scenario the water is impacted a lot by water resource development such as hydropower dams. As far as dam construction is concern most dams are designed based on historical data of river flows, with the assumption that the pattern of flows will remain the same as in the past. But climate change has effectively destroyed this assumption (Dharmaqdhikary 2008). Furthermore, changes in climatic condition would have negative impacts on environment and the society such as shrinking lakes and drying rivers affect livelihoods in agriculture and fisheries. Similarly, deteriorating water quality has harmful consequences for health, and unpredictable disruptions in water flows can exacerbate the effects of droughts and floods. The unpredictable disruption in water flows would have maximum chances to destroy the big hydropower project which may lead catastrophe in the world.

1.4.2 Impact of Hydropower on River Water

Hydropower dams involve the setting up of large infrastructure, which in turn leads to deforestation and disruption of forest ecosystems and reduction of biodiversity. The continuous dam building attitudes of the nation uprooting social conflicts, repeatedly voiced their concerns against the dam builder regarding being mistreated and against their wishes in their pro traditional livelihood attached to environment.

It has been estimated that nearly 5000 large dams were built worldwide in the period from 1970 to 1975 and till 2000 there were around 45000 large dam have constructed (WCD 2000). Similarly, Kyoto protocol (1998) put forth acceleration of the hydropower development in developing countries. Kyoto protocol stressed that CDM can provide a developmental pathway to win-win solution for excessive GHG emission both in developed and developing countries.

Recently, the contestation over dam building emerges rapidly in relation with socio-cultural and environmental insecurity. Even as new dams are being built or planned, the existing hydro-engineering facilities have started affecting the hydrology of the rivers flowing out of the region and their stream-bank erosion and disturbing or depleting aquatic life. Ramanathan and Abeygunawardena (2007) identified that in contemporary scenario the barriers in development of hydropower projects are environmental impacts and rehabilitation issues. For instance, Central Inland Fisheries Research Institute (CIFRI) have come across that Dams have been the sole reason for the collapse of aquatic diversity in India (SANDRP 2013). Furthermore, the hydrological modifications and lack of environmental-flows are causing obstruction to fish migration. The synergistic human-environment interaction during construction, muck disposal, trapping of sediments always leads destruction of habitat.

Most types of projects have environmental implications, while the hydropower dams have major impacts not only on the physical environment around the dam, but also on the people of the area to be flooded, who have to be rehabilitate from their present homes and provided with new accommodations and means of making their living. For instances Colorado, Upper Mississipi, Missoiri, Ohio and Arkanasas River are largest and most modified of the U.S Rivers. The free-flowing nature of stream in the U.S has been dramatically altered specifically through construction of dams (Benke 1990). He further argued that the biotic losses must be great because the physical impact of man on freshwaters specifically streams and rivers has been unprecedented, particularly in developed countries such as U.S.

Lebel, et al. (2009) examines that the indigenous people at the dam sites who are largely dependent on forests and rivers for livelihoods are feeling threatened. It has been estimated that over the past 30 years, the number and impact of flood disasters

has continued to increase across Asia. They critically discusses that this has occurred despite vastly improved abilities to monitor, warn and describe floods. In Thailand, the higher values of infrastructure as well as absolute numbers of people living in flood-prone areas are at risk. In the similar fashion Shiva (2002) argued that climate instability in the form of more extreme floods and droughts, more frequent heat waves and freezing winters is the result of atmospheric pollution aggravated by the wealthier region of the world.

Furthermore, in the face of climate variability the introduction of market institution or water privatization is creating problem in contemporary scenario. Bakker (2005) argues that the resource commodification has become contested. He further discusses that the 1989 privatization of the water supply sector in England and Wales is a much-cited model of market environmentalism wherein water demand management is prioritized over dam building.

Similarly, Shiva (2000) articulated that in most indigenous communities, collective water rights and management was the key for water conservation and harvesting. By creating rules and limits on water use, collective water management ensured sustainability and equity. She strongly argues that water-renewing traditional systems are now decaying. With the advent of globalization, community control of water is being eroded and private exploitation increased.

Ismail Serageldin, vice president of the World Bank, made a much-quoted prediction in 1995 about the future of war: “If the war of this century were fought over oil, the war of the next century will be fought over water” (Shiva 2000).

The indigenous people are against of developmental project like the hydropower dam as it will displace numerous villages and submerge their sacred sites and vanish with their indigenous and cultural history. Shiva (2002) critically argued that the globalised economy is shifting the definition of water from common property to private good, to be extracted and traded freely. Therefore, we are currently facing a global water crisis, which promises to get worse over the next few decades.

1.4.3 Climate Variability and Hydropower

The people of the world are not only impacted by the climatic variability but there are developmental activities like hydropower which directly put pressure to accentuate the regional concerns through socio-cultural and environmental losses. According to a report of the Intergovernmental Panel on Climate Change, the average rise in surface temperature in the past 100 years (1906 to 2005) was 0.74°C but the rate of warming in the last part of 50 years (1956-2005) was little higher (0.13°C/decade) than the rate of warming in the first part of 50 years (0.07°C/decade) (IPCC 2007). Hence, the water is more sensitive to climatic variability.

Large Hydropower dams were long viewed as the best means of providing abundant and cheap non-polluting electrical power, water for irrigation and domestic and industrial consumption, and flood and drought control. It has been identified those twenty years ago, however, the Argentine sociologist Francisco Suarez and his co-authors warned of their harmful effects: coercive displacement of large numbers of poor people, siltation in reservoirs leading to economic inefficiency, salination and water logging in irrigated areas, and the creation of health hazards (Goulet 2005). In the world there have over 45,000 large dams, nearly half the world's river had been

obstructed by large dam and irrigated over 30 percent of the 271 million hectares worldwide (WCD 2000).

The Kyoto Protocol (1998) witnessed as one of the milestones in global efforts to protect the environment from excessive greenhouse gas emission and achieve sustainable development. Therefore, the protocol includes three market-based mechanisms aimed at achieving cost-effective reductions as International Emissions Trading (IET), Joint Implementation (JI), and the Clean Development Mechanism. Among these the Clean Development Mechanism prefers to establish hydropower dams to cut down green house gas emission globally.

The disputes over water use in the contemporary scenario appeared extremely critical, wherein the issues of water diversion, pollution and quality are found in almost all parts of the world. Gaan (2000) strongly argues that these problems are due to reduced water flow through dams and projects constructed by upstream riparian nations to meet their own needs. He further discusses that water diversion, industrial agrochemical pollution, salinization due to excessive extraction of ground water for irrigation, siltation of river bed and flood aggravated by deforestation and soil erosion. Moreover, Jacob and Hurk (2009: 23) explores that the climate change is one of the many changing variables that affect the discharge behaviour of the major European river systems.

Shiva (2002) precisely noted down that the main victims of climate disasters are those who have had the smallest role in creating climate destabilization like coastal communities, small islanders, peasants and pastoral communities. Increase in temperature will lead to crop failures, water shortages, increased disease, flooding, landslides and cyclones. It is also highlighted by (Merrill 2013) that fish health is of

the utmost concern to the tribes in particular as many of them still depend on the river basin as water and food source for their livelihood.

Indeed the industrial revolution of the western countries and gradual adoption by the second and third world countries are not out of context to human world. Out of these, the water resource development in the form of hydropower are emerging as a new contested and problem creator in contemporary world specifically environmental and socio-cultural point of view. Chellaney (2011) pointed out severe intrastate water-sharing disputes in several Asian countries. He examines water wars in Asia also is being highlighted by climate change and environmental degradation in the form of shrinking forests and swamps and the over-damming of rivers which foster a cycle of chronic flooding and droughts. Furthermore, the Himalayan snowmelt that feeds Asia's greatest rivers could be dangerously accelerated by global warming, leading to serious river depletion.

Mustafa (2007) discussed critically that the engineer's single-minded focus on hydropower projects to neglect of the wider set of values that societies attach to water resources in the eastern and western Indus Basin are largely to blame for continuing low-grade conflict in the basin. He believed that despite evidence suggesting that international armed conflict over water does not exist; the potential for political instability over domestic water distribution and development issues is real. Shiva (2002:43-44) encountered that the Orissa's Super cyclone in 1999 was not mere natural disaster rather it was mainly a man-made ecological crisis unleashed by the combined impact of climate change, industrialization, and deforestation. Wherein, the climate change is creating climate extremes in the region where the trees acted as a

barrier against the wind, reduce wind velocities and floods but the trade liberalization is one of the leading reasons why mangroves are vanishing.

The Conflicts over water issues are growing among the countries in the South Asia because of the rapid growing of population. The question of excessive hydropower generation and commercial irrigation is issue of great concern and a source of controversy in South Asia (Khalid 2010). Such type of over utilization of water by any powerful countries or upper riparian can unfold danger to national security. The population rise leading environmental insecurity through excessive resource utilizations are immense in twenty first century, water comes at forefront.

Challeney (2011) explores that the world's fastest growing economies such as China, India, South Korea, and Vietnam, for example are at or near water-stressed conditions. Because aquifers are being drained to dangerously low levels, a number of cities in Asia that rely on groundwater face the spectre of running out of water in the coming years. In an ever-deeper search for water, millions of pump-operated wells threaten to such Asia's subterranean reserves dry, even as the continent confronts river depletion.

Brown, Hammill and McLeman (2007) argues that climate change will act as a 'threat multiplier' that makes existing concerns, such as water scarcity and food insecurity, more complex and intractable. Moreover, he argued as climate change is the mother of all security problems. Climate change represents the latest in a series of environmental drivers of human conflict that have been identified in recent decades, and others including drought, desertification, land degradation, failing water supplies, deforestation, fisheries depletion, and even ozone depletion.

Brown, et al. (2007) found in their study that the water-related problem in Africa is likely to worsen as a result of climate change. Intense rainfall will increase the incidence of flooding in many areas, while reduced overall runoff will exacerbate current water stress, reducing the quality and quantity of water available for domestic and industrial use.

The hydrological cycle is being modified quantitatively and qualitatively in most of the river basins of India as a result of the developmental activities such as construction of dams and reservoirs (Kumar, Singh and Sharma 2005). The growing trend of hydropower development is becoming major concern. The dam conflicts in the past revolved around displacement but as far as today's scenario is concerned the ecological imperative for the protection of nature has added a new dimension to the struggle of displaced people. They are now fighting for their own survival as well as for the survival of their forests, rivers, and land (Shiva 2002). Moreover, as far as hydropower development is concern that only in recent years has development agencies begun to pay attention to the effects their projects have on the environment. Prior to such the development, projects were designed without taking any account of their potential effects on environmental conditions (Hira and Parfitt 2004: 70).

Shiva (2002) found that in 1951, the average water availability in India was 3,450 cubic meters per person per year. By the late 1990s, it had fallen to 1,250 cubic meters. By 2050, it is projected to fall to 760 cubic meters. Since 1970, the global per capita water supply has declined by 33 percent. A country is said to be facing a serious water crisis when available water is lower than 1000 cubic meters per person per year. Below this point, the health and economic development of a nation are

considerably hampered. When the annual water availability per person drops below 500 cubic meters, people's survival is grievously compromised.[4]

Deconinck (2009) added his argument that in the present context, water is a major sources of conflict or security threat in many parts of the world indeed become serious due to population grows, consumption of water rises, resources are threatened by pollution and overconsumption, and alternatives for additional water are very limited.

Throughout India from the perspective of environmentalist, social activist and local people it would not be wrong to say that the Nehrubian Policy to 'Dam as a temple of modern India' witnessed a failure, where the uncountable environmental related issues have germinated specifically among ethnic and traditional communities along and across the different river basin. The tribal people of eastern Himalaya is believed to be environmentally insecure, politically coercive and traditionally diminishing if the water resources developmental project is taken into consideration. They disagree with full flagged dam construction along the river basin proving that the dams are not our temple.

For instance Arora and Kipgen (2012) pointed out a strong opposition of local people in Manipur against dam building in river Barak (Tipaimukh dam). The Banners and placards conveyed the message loudly that 'NEEPCO's move is against the people's wish', 'Never and ever Tipaimukh dam', 'we can live without power but we can't live without land'. As Goulet (2005) discussed that large dams is long viewed as beneficial and essential to development, have become sites of major social conflict.

[4]According to the Falkenmark, region is said to experience "water stress" when annual water supplies drop below 1,700 cubic metres per person per year. At levels between 1,700 and 1,000 cubic metres per person per year, periodic or limited water shortages can be expected. When a country is below 1,000 cubic metres per person per year, the country then faces water scarcity.

He believed that sound global governance can occur only through wider participation of populations affected by large development projects.

However as noted by Shiva (2002) that the damming of two of India's most sacred rivers, the Ganges and the Narmada, has generated vehement protest from women, peasants, and tribal's whose life-support systems have been disrupted and whose sacred sites have been threatened. The people of Narmada Valley are not merely resisting displacement due to the Sardar Sarovar and Narmada Sagar Dams; they are waging war against the destruction of entire civilizations.

Similarly, one of the Hmar tribal area of Manipur have facing the intense problem related to submergence of indigenousness of the people at the Tipaimukh dam on the Barak which was originally designed in 1926 as a flood-control measure for the Cachar Plains and was transformed into a multipurpose hydroelectric project in the 1990s. The river is not merely a lifeline, but is integral to their cultural history and sense of selfhood. Currently, the Hmar are opposing the construction of the Tipaimukh dam on the Barak in Manipur (Arora and Kipgen 2012). These people are against the dam as it will displace numerous Hmar villages and submerge their sacred sites.

Furthermore, Shiva (2002) stated that hydropower dams were a particularly popular means of shifting water control from communities to central governments and colonizing rivers and people whereas access to safe water is fundamental human needs. But there are innumerable incident related to dam construction and its impact on human habitation and direct environmental loss.

As far as developmental trend of India is concerned for the last many years specifically focusing on the mountainous north-eastern states like Sikkim-Darjeeling

Himalaya, Dams have become political symbols of conquest of nature and representative of development in India. Despite hydropower dam being the controversial issue, the planners in Sikkim have identified cascade development of the perennial river waters of Rangit and Tista as the channel for modernising and developing its economy (Arora 2009).

1.4.4 Adaptation Strategies for Livelihood

In the twenty first century the world is facing serious impacts of climatic variability wherein the adaptation initiatives are most important to tackle extreme events. The most extensive overview of existing knowledge on adapting to climate change is the Third Assessment Report (TAR) of IPCC's Climate Change 2001: Impacts, Adaptation and Vulnerability. This volume extensively focuses on the environmental, social and economic consequences of climate change, and potential responses in adapting to it. Furthermore, the special report of IPCC (2012) broadly talked about the adaptation to climate change. It is defined that adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.

Meanwhile, over the past decades, adaptation to climate change has moved away from an academic and theoretical topic to become a main focus of public policy (Yang, et al. 2014). It has been observed the overall decrease in the number of cold days and nights, and an overall increase in the number of warm days and nights, at the global scale and the changes have also occurred at the continental scale (IPCC 2012).

The Himalaya is considered as a water tower of Asia but the region is most vulnerable to climate variability because of the region being located at geologically fragile landscape. In the whole Hindu Kush Himalayan (HKH) region the people faces

severe seasonal water shortages due to variability in rainfall and extreme events exacerbated by the climate change (Vaidya 2015). Similarly, the Himalayan region are experiencing a rapid climate change for the last many years which has likely to significantly impacts on local ecosystems, biodiversity, agriculture, and human well-being (Chaudhary, et al. 2011).

As Aerts and Droogers (2009) suggested that water managers throughout history have a long record of adapting to the impacts of weather and climate through a range of practices such as irrigation, drainage and flood protection strategies. In the twenty first century, climate related problems appeared in the world more extensively. The anthropogenic climate change is associated with substantial risks for society and nature. The two important societal response options for reducing these risks are mitigation of climate change and adaptation to climate change. The impacts of climate change are likely to exacerbate problems and unless appropriate adaptation strategies are adopted, resilience is difficult to achieve.

The changing climate is experiencing in the form change in rainfall patterns and temperature lead to drought, drying of spring and river, change in flowering time of fruits and crops etc. So, adaptation is only alternatives to climate change. Riera (2015) found that in semi-arid regions of Argentina Pampas mostly depend on the rainfall for agriculture is facing greater water stresses according to climate projection. Soybeans are the only crop which can be grown in water stress period in the region, while maize and wheat would not be feasible. As a consequence the agricultural system would tend to monoculture of soybean, resulting in land depletion and decreasing yield. However, in order to protect these consequences the people of the region started a

technique of sustainable use of ground water irrigation to maintain the advantages of the current agriculture.

It has been found that the climate variability impact has largely on water resources and agricultural production on which human beings rely upon. Fandohan and Cuni (2015) studied in their research on local perception of climate change and its impacts on indigenous fruit trees and found that the most farmers and herders in rural Benin experienced that the Indigenous Fruit Trees (IFTs) numbers have declined. It has been observed a general decrease in fruit yield, which they relate to a decline in rainfall quantity and changes in rainfall patterns, increased wind during the flowering period and increased pests. It has reported that some trees that used to fruit twice a year have only fruited once per year in the last few years.

Mubako and Habib (2015) articulated another way of adaptation to climate variability is water management through national governments and catchment management agencies in the Limpopo Basin in Southern Africa. They added the commitment to joint management of water resources between the four riparian nations was formalized through a multilateral agreement to establish the Limpopo Water Course Commission (LIMCOM) in 2003 whose objectives included advising the riparian and providing recommendation, preservation and management of the Limpopo River.

Humankind has used dams for thousands of years for irrigation and management and use of floodwaters. In the modern era captive storage of large volumes of water in hydropower dams have served several other functions such as generation of hydropower and water supplies to expanding urban centres and industries. But recently the contestation over dam building emerges rapidly in relation with environmental insecurity and socio-cultural deterioration.

The climate variability has direct impacts on human and environment. Merrill (2013) explored that many tribes have deep religious and spiritual connections with the land that they inhabit. In many cases, tribes land and water interests have been allocated to them through treaties, federal legislation, and court decisions. Whereas in Himalayan state of India the indigenous Lepchas of Sikkim are using Gandhian methods of protest to prevent construction of hydro projects that will destroy their land and the environment. It was the slogan of the people "Dams over Dzongu will be built over our dead bodies", proclaimed in 2008 during historic satyagraha. Subsequently, on March 10 about 300 Lepchas of Dzongu staged a rally at Gangtok carrying banners demanding an end to all hydel projects in north Sikkim (Arora 2008). Here in the name of economy the cultural values are been undertreated. Furthermore, it has greater impacts on environment, livelihood, and culture of a place.

The reviews of literature incorporating the ideas of climate variability and hydropower dams in the context of human adaptation reveals the paradoxical nature of hydropower dam as green and clean energy. Since, it appears the sifting of pollution from air to land, degradation of the quality of air to the degradation of the quality of soil and environment. Alike other cases, Sikkim has been infected with such paradoxical nature of hydropower dams. The reviews validates the arguments that the adaptive measures stands out in local form which are largely insured by the presence of local resources and people's culture. So, understanding people's culture and their relationship with the land has not been comprehended in available literatures which indeed stands out fundamental in managing the adaptive measures from such menaces.

1.5 Research Questions

1. How do local people build their perceptions of climate variability and hydro power development?

2. How do social groups adapt to the changing environment?

1.6 Research Objectives

1. To critically examine the people's perception around hydropower projects and climate variability in Sikkim Himalaya.

2. To explore the various adaptation initiatives adopted by the local populace in the region to the changing environment.

1.7 Methodology

The research has adopted a mixed methodology to engage both qualitative and quantitative data collection. The qualitative method is based on different tools of Participatory Rural Appraisal (PRA) in order to understand people's perceptions of hydropower development and climatic variability. The research makes use of data generated through field survey in order to better understand the condition of local people and environment. In the study area all over four FGDs and four PRAs have been done with different age groups. The age group ranges from 23 years to 81 years.

Similarly, in order to link and to understand the debate in between Hydropower Development and Climate Variability, the study has used Critical Discourse Analysis (CDA). The purpose of CDA is to analyze opaque as well as transparent structural relationships of dominance, discrimination, power and control" (Blommaert and Bulcaen 2000).

The study is largely guided by the theoretical framework of 'environmental security'. This framework will support in identifying the insecurity that have been unfolding in the study area due to climatic variability and accelerated hydropower dam construction. Moreover, the work is based upon water resource development and largely human-nature relation whereby the environmental insecurity is increasing gradually due to climatic variability and developmental activities.

Analytical Framework

Different tools of PRA have been implemented as (a) Focus group discussion, b) Resource mapping, 3) Critical moments, 4) Seasonal Calendar, 5) Participatory diagramming and 6) crop calendar. Predominantly, the study relies upon the PRA tools. In addition, the quantitative data (map making through ARC GIS, and tables) plays a supporting role for the research.

Participatory Rural Appraisal (PRA) is an approach and methods which can enable local people to share, enhance and analyze their knowledge of life and conditions, to plan and to act (Chambers 1994) and it helps in identifying the critical moments through resource mapping, seasonal calendar, and crop calendar through people's own exercises and experience in the area.

PRA Tools

FGD: The focus group discussions with different age group and gender in order to better understand the perception of hydropower and climate variability from different background.

Participatory diagramming: In this technique people are encouraged to display their knowledge on pie and bar charts and flow diagrams.

Resource Mapping: The Village Resource Map is a tool that helps us to learn about a community and its resource base. The primary concern is not to develop an accurate map but to get useful information about local perceptions of resources. The participants should develop the content of the map according to what is important to them. To learn the villagers' perception of what natural resources are found in the community and how they are used.

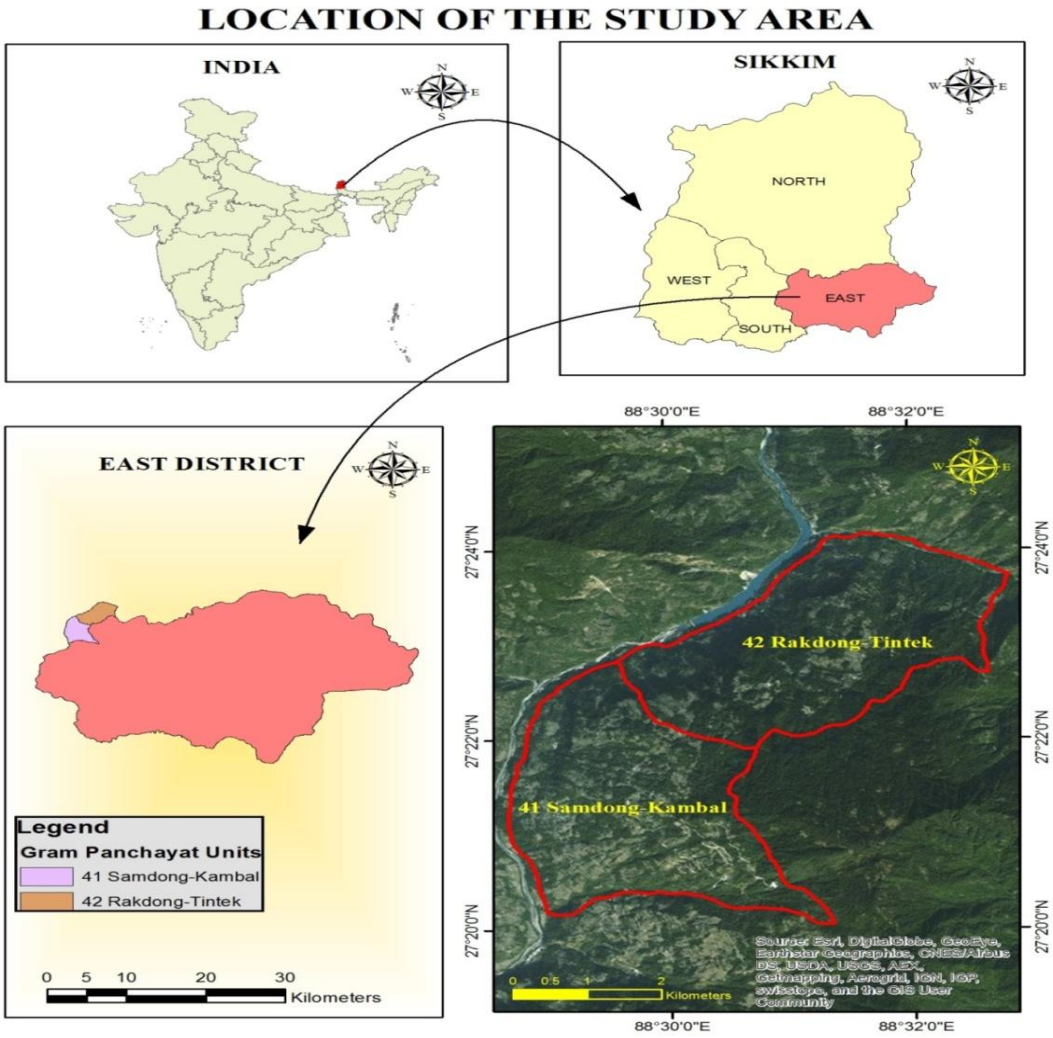
Social Mapping: Social mapping is a PRA method that involves the sketching/drawing of houses, and other social facilities and infrastructure (i.e. dams, temple, stores, rice mills, school, pharmacy, roads, water pumps, and irrigation and recreation facilities) in a village. It helps to visualize and situate the location of households and other social facilities/infrastructure in a village.

Seasonal Calendar: This tool helps to find out and examine variables such as rainfall, animal fodder or pests, and harvesting periods can be drawn to show month-to-month variations and seasonal constraints. Through this tool we can understands the critical moments.

1.8 Study Area

The Samdong-Kambal and Rakdong-Tintek Gram Panchayat Unit (GPUs), East Sikkim have been selected for the purpose of this study. Each GPU has five villages. Lower Samdong, Upper Samdong, Khambal, Raley, and Khese are under the Samdong-Kambal GPU. Similarly, Lower Tintek, Upper Tintek, Lower Rakdong, Upper Rakdong, and Rakday are under the Rakdong-Tintek GPU. The villages are inhabited of different communities with different socio-cultural background. The

different communities inhibiting the villages are Bahun, Chhetri, Rai, Subba, Magar, Bhutia, Lepcha wherein majority are Nepali speaker.



Source: Rural Management and Development Department, Government of Sikkim

Both the GPUs are located in the vicinity of the Tista-V Hydroelectric Project. The main objective of selecting the area is to gain the local perceptions on the hydropower projects as well as climate variability and their impacts on the society and environment.

Chapter 2

Mapping Hydropower and Climate Variability Nexus

2.1 Introduction

The chapter examines and sketches out the discourses on global and local understanding around hydropower and climate variability. In the twenty first century as the world searches for renewable energy in the face of climate variability and most of the countries attempts to explore and expand its power supply by hydropower energy to further enhance its socio-economic development. Hydroelectricity has moved to top of the country's energy agenda.

River damming is increasing at unprecedented rates with millions of reservoirs having been constructed globally in the last century to harness water for electricity generation, domestic or industrial use, food production, navigation, fisheries, and recreational as well as for flood control purposes (Okuku, et al. 2016). It was estimated that over 45000 large dams have been built throughout the world (WCD 2000). But simultaneously most of the people are voicing against the destruction of environment due to huge numbers of hydropower plants.

In the midst of rapid economic developmental race, extensive exploitation of natural resources led serious environmental concerns during 1960s and 70s (The Limits to Growth 1972, Stockholm Conference 1972), during 1980s and 90s (Our Common Future 1987, Earth Summit 1992). Similarly, Kyoto protocol (1998) explored GHGs as the major source of global warming and environmental degradation. Moreover, World Summit on Sustainable Development (2002) focuses on the world attention and direct action towards meeting difficult challenges, including improving people's

lives and conserving our natural resources in a world that is growing in population with ever increasing demands for food, water, shelter, sanitation, energy, health services and economic security. In December 2015, COP21 highlighted the changing climate and in this conference, 195 countries all over the world agreed to limit global warming to well below 2^0C by 2035. In search of alternative ways to precede development in general and energy sources in particular these conferences give priorities to renewable source of energy to mitigate the climate change.

Under the renewable source of energy hydropower dam stands as a best alternative to counteract global warming on earth surface. It has been considered as a 'green energy' or 'win-win energy' from global climate perspective which has been criticized from ground (local) level in relation with environment and culture of a people. It is argued that in the name of clean, green and cheap energy the hydropower reappears to have adverse impacts on the nature as it is deteriorating the environment negatively. Therefore, hydropower as a GHGs controller and clean and green stood as an ill-conceived particularly as the voices arise from the environmentalists, social activists and NGOs.

2.2 Dams as the Challenging Developmental Pathway

Most dams are constructed in remote hilly areas, mostly inhabited by tribal peoples and other weaker sections of the society. Big dams inevitably have huge reservoirs and therefore displace a large number of people (Satyajit 1990).

In spite of negative impacts to environmental and culture, water engineers see these hydropower dams as the main solution to the water management in the country. In long run the large numbers of hydropower dams creates environmental degradation

leading to human insecurity. The anti-dam movements have demanded that a variety of possible technological options, including large dams, need to be re-examined to ensure sustainable water resources development (Bandyopadhyay 2002). Moreover, the concerns here are not merely in the ground of degradation of environment and transfiguration of society and culture but possible addition of GHGs in the atmosphere through big reservoir too. The GHG emissions can significantly exceed comparable coal emissions (Gunkel 2009).

The construction of a hydropower dams along with the impounding of a reservoir, creates certain social and physical changes of environment on which the people are directly or indirectly surviving for last many generations. It is fact, the big dams have enough advantages in economic aspects but in contrast it has tremendous disadvantages in social and environmental aspects.

The concept of sustainable development has been deformed after the CDM started funding for large numbers of big dams in the developing countries wherein the problems appearing on the ground of social and environmental destructions. While considering the big dams in a fragile landscape, the Dharmadhikary (2008) has found that the climatic variability can change the river water volume and it would be difficult to predict the water quantity during monsoon period. Even if a dam is able to survive higher river water flows but the bigger floods are likely to lead to higher backwaters and there would be chances of submergence problem.

The environmentalists always critically argue against large number of big dams. One of the works done by Yellen and Boutt (2015) highlights about ten percent of released

water may be permanently lost during hydro peaking[5] making that water unavailable to downstream in Colorado River. Moreover, hydro peaking of river water levels is disrupting insect's survival and river ecosystems. They further added that prior to the construction of dams; there were almost no major daily changes in river levels. Therefore, anyone who uses water downstream from a dam can face water scarcity due to dam operations. Today large dam projects no longer excite common people, especially those affected by the project.

Nowadays, Small Hydropower Plants (SHP) have been taken as an alternative of large projects as they are considered to have less or no harm to the environment. They can be designed with a small head, generally on small rivers with gentle gradients, generally on small rivers with steep gradients. Specific equipment is necessary to meet fundamental requirements with regard to simplicity, high energy output, maximum reliability, and easy maintenance by non-specialists (Yuksel 2009).

The Challenges of damming are enormous in environmental and social ground. Large dams, long viewed as beneficial and essential to development, have become sites of major social conflict. The great wealth created by globalization is concentrated inequitably in few hands, destroys livelihoods, and excludes many poor individuals, communities, and countries from access to technological and economic progress. Moreover, by promoting economic growth patterns that are highly destructive of natural capital, globalization renders development unsustainable (Goulet 2005:886).

The estimated life expectancy of dam itself is reducing. It is estimated that the life of Bhakra has been almost halved from 88 to 47 years, and Hirakud's life reduced from 110 to 35 years. The National Commission on Agriculture (1976) was very critical of

[5] Hydro peaking refers to releasing of water at hydropower dams to meet peak daily electricity demand.

the area treated under soil conservation (Satyajit 1990:566). Furthermore, the considerable amount of muck will be generated from the excavation of tunnels. Similarly, the transport of massive amounts of cement, boulders, sand, equipment, steel, machinery, and explosives to the construction sites, the building of access roads, blasting, quarrying and crushing are likely to create significant amounts of dust, but this has not been mentioned (Roy 2008). The hydropower technology shifted to developing countries after it has tested in European countries and North-America. After the Kyoto protocol (1998) under CDM most of the developed countries have explored and invested in developing countries specifically in building hydropower dams.

The Himalayan states of India are considered as a power house of India. The government wants to utilise huge unused water resources for the purpose of nation building. In the name of green energy and national economy the environment and culture of the region are in the verge of degrading and declining condition. The environmental insecurity is felt in the region through drying of river water, degradation of fish stock in the river, landslide due to tunnelling, water shortages, transboundary confrontation etc.

Bandyopadhyay (1995) pointed out the question of adequate compensation and resettlement for the involuntarily displaced population. On the other hand the question of higher rates of siltation and lower economic life of the dam and on the seismic risk associated with large dams in the-tectonically active Himalaya. However, the Himalaya is a young folded mountain and geologically fragile landscape, experiencing recurrent earthquake. In one of the works done by Yonghui, et al. (2006) the upper Yangtshe River in China, the construction of dams and storage of large

bodies of water in reservoirs can trigger geological disasters such as landslides. Moreover, in such a mountainous region, the construction of roads for the transportation of materials needed by the projects necessarily undermines slope stability and induces landslides and more serious soil erosion.

Satyajit (1990) identified three cardinal issues around large dams in India. Firstly, the huge social costs are paid by one section while the benefits accrue to others. Secondly, there is other who agrees to the concept of big dams but want proper environmental treatment, efficient planning and proper rehabilitation, while third groups really favour big dams as they exist without questions. But all over India the debate arises from the second issues i.e. environment where the people counteract against the big dams due to environmental degradation.

The environmentalists are indeed criticizing the dams in Indian state of Uttarkhand. They criticize hydropower dam for not assessing the river basin properly. Roy (2008:21) emphasises that there is no assessment of the impact on health and environmental diseases. The likely loses of fuel wood, pasture and other common resources have not been estimated. Furthermore, the people are more concerned of not implementing measures for reservoir management or catchment area treatment or restorations have been specified. He further pointed out there are no disaster management plans and the resultant cumulative effects of river water diversion for various hydroelectric projects have not been assessed for the river valley as well as for downstream projects. Hence, there is worry about water flow where the entire valley water will no longer flow through the river, but through tunnels.

Okuku et al. (2016) explore in their work that most of the respondents (85%) asserted that damming of the River Tana (at Kenya) had directly or indirectly affected some

aspects of their livelihood. They found the total 56% of the respondents observed that flooding occasioned by unexpected release of water from the reservoirs during reservoir management operations with related loss of crops was the greatest negative impact of damming. They further added changes initiated by River Tana damming have resulted in massive famine downstream and this is slowly changing the culture of the local communities from self-reliance to overreliance on government relief food.

Many researchers have identified Hydropower development is not “win-win” and sustainable. However, most uses of the river water for irrigation cropland, damming the river for hydro energy, industrial use, and consumption. If an upstream country uses the water to irrigate its crops or dams the river, it is not available for downstream users: it is likely to leave fisheries unsustainable and downstream agriculture with inadequate irrigation, and increase the risk of floods if dams overflow or break. Liebman call it "trickle-down" economics which means if the water is used heavily by upstream states, it does not trickle to those living downstream (Liebman 2005:288) which can lead to transboundary confrontation.

As far as energy needs and consumption is concern, the Chinese are in forefront to fulfil their growing energy crisis and thriving national economy through hydropower dams. However, Chinese environmentalists fought to prevent developments from intruding and deteriorating upon this ecological system and ethnic minorities, but even though many local officials support the damming of rivers because they believe that hydropower generation will bring economic development, a supply of electricity, and capital investment to the area’s communities (Bellette 2013).

Similarly, the Mekong River is under intense developmental pressure, with multiple upstream dams under construction and downstream dams proposals that in

combination, would dramatically alter ecosystems and human livelihoods. It was argued that a series of dams along the Lower Mekong will exacerbate changes to natural flow patterns that already occur as a result of dam building in China. It has been experiencing the substantial disruption to fisheries, as well as negative implications for the millions of people who depends on the Mekong River for their livelihoods (Grumbine, Dore and Xu 2012). The leading science and policy institutions on climate change have arguably underplayed issues of population and development as factors shaping future climate-related impacts (Roger 2005).

2.3 Growth and Development of Global Environmental Concerns

The extensive exploitation and destruction of natural resources led to serious environmental concerns during 1960s and 70s. The Limits to Growth (1972), attempted to points out the consequences of continued growth in population, resources use, and pollution based on the current trends of resources exploitation.

In the summer of 1970, an international team of researchers at the Massachusetts Institute of Technology began a study of implications of continued worldwide growth. They examined the five basic factors that determine and, in their interactions, ultimately put limits in growth on this planet such as (a) population increase, (b) agricultural production, (c) non-renewable resource depletion, (d) industrial output, and (e) pollution generation. Therefore, the book 'The Limits to Growth' funded by the Club of Rome came up with messages of hope, where human can create a society in which she/he can live indefinitely on earth, if he imposes limits on himself/herself

and his/her production of material good to achieve a state of global equilibrium with population and production in carefully selected balance [6].

In Stockholm 1972, the World Conference on Human Environment conducted the first stock taking of the global impacts on the environment and attempted to address the challenges of preserving and enhancing the human environment (Handl 2012).

In fact, during 1970s and 1980s the world was immensely worrying about the degradation of natural resources due to excessive utilization of resources for growing human needs. To address these growing concerns over the accelerating deterioration of environment and natural resources, the concept of sustainable development was popularized in *Our Common Future*, a report published by the World Commission on Environment and Development in 1987. The classic definition of sustainable development introduced by the Brundtland report as: "development which meets the needs of the present without compromising the ability of future generations to meet their own needs".

The Rio Summit (1992) focused on developing a global framework for addressing environmental degradation through sustainable development. Through the participation of both state and non-state actors, the main themes and agendas of the Rio Summit were condensed into several documents and institutional mechanisms. Rio focused on the notion that environmental protection is an essential element of social and economic development (Handl 2012).

Furthermore, Kyoto protocol (1998) explored GHGs as the major source of global warming and environmental degradation. Therefore, the mechanism of Kyoto

[6] www.clubofrome.org (Accessed: 03/01/2017)

protocol is seen by many as a pathfinder. It is the first global, environmental investment and credit scheme of its kind, providing standardized emissions offset instrument.

In the similar fashion, the World Summit on Sustainable Development (2002) held in South Africa promised to be one of the largest and most important international meetings ever held. It focused on building a commitment at the highest levels of government and society to better implement Agenda 21 and the road map for achieving sustainable development adopted at the 1992 Rio summit[7].

In December 2015, UN Climate Conference also called as COP21 placed historic opportunity to put the world on course to meet the climate change challenges. It highlighted the needs of new model of growth that is safe, durable and beneficial to all. In this conference (COP21), 195 countries all over the world agreed to limit global warming to well below 2^0C by 2035.

It has been accepted that the present scenario of global environmental concerns are due to excessive emissions of GHGs and over-exploitation of natural resources. Generally, the global greenhouse gas (GHG) emissions have grown since pre-industrial times, with an increase of 70% between 1970 and 2004 (IPCC 2007). The human activities during industrial revolution accompanied by excessive competition and extensive use of fossil fuel in the process of industrialisation among the western and later on adoption by eastern countries make world polluted.

The vast majority (80%) of energy today is provided from thermal sources, i.e., coal, gas and oil; but there are growing global concerns regarding the lack of sustainability

[7]www.un.org>summaries>envdevj1 (Accessed: 16/01/2017)

of these forms of energy that bring into question their use in a long-term energy strategy (WCD 2000). Therefore, in order to combat the GHGs from fossil fuel based energy the world searches hydropower as a positive alternative. Wherein hydroelectric power plants capture the energy released by water falling through a vertical distance, and transform this energy into pollution less electricity.

In general, falling water is channelled through a turbine which converts the water's energy into mechanical power. The rotation of the water turbines is transferred to a generator that produces electricity where there is no production of GHGs. This is how the hydropower is perceived as 'win-win' energy in the global context. Therefore, the report of Kyoto protocol (1998) highly formulated the fundamental proposition of checking GHGs through Clean Development Mechanism on earth.

2.4 Global Climate Change Concerns: Adaptation and Mitigation Measures

The fossil fuel based energy during industrial stage put up an adequate awareness of the industrial pollution of air and water. Similarly, the problem of acid rain, the depletion of ozone layer, the warming of the atmosphere and the greenhouse gas emission are burning issues.

Global warming due to the greenhouse effect has become a major cause of concern. It is feared that the earth's average temperature would rise by 1.5^0 to 2.5^0C due to trapping of sun's heat in gases (Baijal and Singh 2000). Climate of the earth is changing and it is claimed that this time changes are occurring because of the anthropogenic factors. Therefore, adaptation and mitigation is obvious to tackle from changes on earth surface.

The UNFCC (2016) addresses the climate change as:

> *Information provided by several Parties indicated concrete areas for undertaking action to address climate change, focusing on, inter alia, renewable energy and energy efficiency, sustainable transport, carbon capture and storage, conservation and sustainable management of forests and reducing non-CO2 gases. Parties highlighted their intention to transform their energy systems and energy consumption patterns and at the same time emphasized the need to enhance carbon sinks*
>
> *(UNFCC (2016), Paragraph 22)*

The climate is warming and this is the unequivocal conclusion of climate scientists (Hall, Stuntz and Abrms 2008). Temperature increase has been most intense in the 1940s, followed by the 1980s. The warming experienced since the early 1980s and such changes caused pronounced effects in the glacial and peri-glacial belts (Haeberli and Beniston 1998).

The report of IPCC (2007) recorded almost all glaciers around the world are shrinking, and significant parts of all glaciers are projected to melt in the coming century. For example, the glaciers of the Tibetan plateau are projected to decrease by 100,000km^2 by 2035 due to global warming. The global warming is caused by the GHGs emitted from the fossil fuel based industries. It has been estimated that anthropogenic GHG emissions have increased from 27 to 49 GtCO2eq/yr (+80 %) between 1970 and 2010; GHG emissions during the last decade of this period were the highest in human history (IPCC 2014).

It is further articulated as the world gets warmer; it experiences increased regional variability in precipitation, with more frequent heavy precipitation events and more susceptibility to drought (Hall, Stuntz and Abrms 2008). There is high confidence that changes in heat waves, glacial retreat, or permafrost degradation will affect high

mountain phenomena such as slope instabilities, movements of mass and glacial lake outburst floods (IPCC 2012).

Climate change in the European Alps during the 20th century has been characterized by increases in minimum temperatures of about 2^0C a more modest increase in maximum temperatures, little trend in precipitation data, and a general decrease of sunshine duration in mid-1980s (Haeberli and Beniston 1998). Agriculture is among the more climate sensitive human activities. Therefore, possible global climatic changes associated with increased atmospheric concentrations of greenhouse gases are likely to affect the efficiency of agricultural production systems (Tobey, Reilly and Kane 1992).

> *"Several of the INDCs highlighted the link between actions to address climate change and development priorities, including social and economic development and poverty eradication. Some Parties highlighted synergies between their development and climate action, while some provided concrete examples of specific co-benefits related to their action to address climate change, including: reduced local air pollution and resulting health benefits; improved access to energy and enhanced energy security; improved water quality and management; social progress, including poverty reduction, increased well-being and job creation; economic diversification; and synergies between adaptation and mitigation actions towards building resilience, in particular in agriculture and forestry, as well as relating to food security"*
>
> *(UNFCC 2016, Paragraph 24*)

Adaptation to Climate Change

Adaptation is the quality of being adapted or adjustment to extent condition. The special report of IPCC 2012 broadly talked about the adaptation to climate change. It is defined that adaptation is the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In

natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate (IPCC 2012).

The adaptation initiatives have become more urgent because resources scarcity will affect nearly two-thirds of the world in the near future. The impacts of climate change are likely to exacerbate these problems and unless appropriate adaptation strategies are adopted, resilience is difficult to achieve (Basu and Shaw 2013). Therefore, adaptation and mitigation are two types of policy response to climate change, which can be complementary, substitutable or independent of each other. Irrespective of the scale of mitigation measures, adaptation measures will be required anyway, due to the inertia in the climate system (IPCC 2007).

Mitigation to Climate Change

The mitigation to climate change is another option to tackle from changing climate. The concept of "mitigation potential" has been developed to assess the scale of GHG reductions that could be made, relative to emission baselines, for a given level of carbon price (IPCC 2007). In the destination of low-carbon energy and climate change mitigation, hydropower is indeed experiencing a new revolution in many parts of the world, despite its vulnerability to climate change and the emissions of greenhouse gases from its reservoirs during construction.

Kyoto protocol (1998) implementing three Kyoto mechanisms in order to mitigate global climate change. These mechanisms are 1) Emissions Trading, known as the Carbon Market, 2) Joint Implementation (JI) and 3) the Clean Development Mechanism (CDM) in order to decrease the overall emission rate of GHGs. There is substantial economic potential for the mitigation of global GHG emissions over the

coming decades that could offset the projected growth of global emissions or reduce emissions below current levels (IPCC 2007).

Furthermore, in Article XII of the Kyoto protocol (1998) defined that Clean Development Mechanism is a crucial instrument to enlist developing countries participation in emissions limitation, to reduce industrialized countries compliance costs, and to facilitate resource and technology transfer.

> *"The purpose of the clean development mechanism shall be to assist Parties not included in Annex I [8] in achieving sustainable development and in contributing to the ultimate objective Of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3"*
>
> *(Article 12, Paragraph '2', Kyoto Protocol, 1998)*

Similarly, 'Climate Change 2014: Mitigation of Climate Change is the third part of the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change'. The volume provides a comprehensive and transparent assessment of relevant options for mitigating climate change through limiting or preventing greenhouse gas (GHG) emissions, as well as activities that reduce their concentrations in the atmosphere (IPCC 2014).

> *COP 21 represented a major milestone in the strengthening of the international response to the threat of climate change. The political momentum of the UNFCCC process culminated in the adoption of the*

[8] Annexure I countries comprises all the developed countries. The parties includes in Annex I shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assign amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012 *(Article 3, paragraph 1)*

Paris Agreement and the participation of over 96 per cent of Parties to the Convention in communicating their INDCs[9].

(UNFCC 2016, paragraph 75)

2.5 Hydropower and Climate Variability: Mapping the Nexus

Healthy rivers are necessary for supporting life on earth. They help to maintain healthy ecosystem and balanced climate but most of the world free flowing rivers have been sacrificed for the big hydropower dams. For instances the river Mekong, the Nile, the Ganges, the Brahmaputra, the Indus, the Arizona and so many. Nowadays government officials and world leader and international organisation like World Bank strongly desired for the construction of big hydropower dams as a source of clean and green energy.

Globally, hydropower is considered as "win-win" energy to reduce Green House Gas emission. The Kyoto protocol (1998) defined that Clean Development Mechanism (CDM) which can provide a developmental pathway to solution for excessive Green House Gas (GHG) emission both in developed and developing countries. Therefore, CDM projects are supposed to reduce greenhouse gas emissions and simultaneously contributing to sustainable development (Erlewein 2010). But ironically, environmentalists and social activists has articulated that how the introduction of CDM projects, merely construction of the large number of big hydropower dams can

[9]This synthesis report on the aggregate effect of the 161 intended nationally determined contributions (INDCs) communicated by 189 Parties by 4 April 2016 provides estimates of the aggregate greenhouse gas emission levels in 2025 and 2030 resulting from the implementation of those INDCs. Those levels are compared with the emission levels in 1990, 2000 and 2010 as well as with emission trajectories consistent with (1) action communicated by Parties for the pre-2020 period and (2) holding the average global temperature rise below 2 ºC and 1.5 ºC above pre-industrial levels. This document identifies and discusses trends that indicate opportunities for enhanced action to address climate change in the longer term. In addition, it synthesizes information relating to adaptation, which was included in the INDCs communicated by 137 Parties.

help to attain sustainable development without assessing the region from the ground. In fact, hydropower dams have enormous impacts on environment. Additionally, the environmental and ecological defects caused by the damming of a river are not addressed in the advocacy of hydropower as green energy (Biswas 1979).

In developing countries CDM has embarked upon the hydropower projects despite having problems in respect of environment and cultural context. The CDM allows emission reduction projects in developing countries to earn certified emission reductions (CERs), each equivalent to 1 ton of carbon dioxide (CO2). CERs can be traded and sold, and used by industrialized countries to meet part of their emission reduction targets under the Kyoto Protocol. The CDM helps host countries (industrialist countries) achieve sustainable development and reduce emissions, while giving industrialized countries some flexibility in how they meet their emission targets.

Erlewein (2010) articulated that yet the CDM does not offer any consistent definition that would clarify the meaning of sustainable development in the context of climate protection projects, not to mention any criteria or indicators that would allow a coherent assessment. The only stated constraint is that GHGs emissions reductions themselves are not considered to be sufficient for meeting the goal of sustainable development. However, even without a CDM specific definition of sustainable development the assumption that dams are generally appropriate for the achievement of this goal can be questioned.

Meanwhile, large hydropower dam also generates GHGs to the atmosphere leading to global warming from submerged biodegradable objects in reservoir water. It is clearly seen that some reservoirs have a global warming potential higher than that of coal use

for energy production (Gunkel 2009). Hence, it is precise to argue that the three mechanism of Kyoto protocol which is aimed to reduce GHG from the atmosphere have come under much criticism. Moreover, the issues of environmental degradation are more relevant due to more deepening and widening with the introduction of newer application of science and ever growing technologies.

The researcher has articulated that the reservoir for the electricity generation and other purposes are also generates GHGs. Many scientific researchers have proven exceptionally that the hydropower dam can generate greenhouse gas. Gunkel (2009) has articulated in his work that the initial carbon evasion from the surface of reservoirs is generally assumed to be largely supported by decomposition of organic carbon stored in the flooded terrestrial ecosystem. There has been an ongoing debate over the importance of reservoirs as GHG sources. Moreover, it has been pointed out that the benefits of a reservoir, including energy production and flood control, must be measured against their impacts on nature.

There has been increasing consensus that, contrary to the historical perception of reservoir as carbon free alternatives to power generation, reservoirs may contribute significantly to global anthropogenic carbon dioxide and methane emission (Teodoru, Yves and Paul 2011).

For reservoirs, two further pathways of GHG emissions must also be mentioned, i.e., emissions by turbines and those by the spillway and the downstream river stretch. If carbon dioxide and methane rich water passes the turbines, carbon dioxide and methane are emitted because of the low water pressure and the air-water mixing, thus promoting degassing (Gunkel 2009: 370). It is clear, however, that reservoir emissions vary greatly between regions and reservoir types and for example, can be

relatively small in boreal regions relative to tropical and sub-tropical system (Teodoru, Yves and Paul 2011).

Similarly, in the face of energy crisis, access to clean water for drinking and personal hygiene is still lacking (Bishwas 1979). This very nature of hydropower dam construction for the purpose of hydroelectricity in the midst of crisis for clean drinking water and major dependence on agriculture has left some ambiguous questions to ask. Such as who benefits from such projects? Whose issues and problems are taken care of? What role does government is playing? Who all are suffering for the sake of someone else? In India most of the cases showed that the people's avoidance to hydropower dam due to excessive socio-environmental impacts.

Therefore, the hydropower as a GHGs controller and clean and green stood as an ill conceived particularly as the voices arise from the environmentalists, social activists and NGOs. While in the global scenario the hydropower always conceived as carbon neutral energy which does not emits GHGs but it is not true in the local scenario. While, the richer countries are in the mood of investing their economy in developing and under developed countries for water resource development (dam building) in order to extract and utilize the energy within and outside the nation where the energy crisis existed. But in local scenario the pictures of hydropower dams perceived as an environment and socio-cultural deteriorating tools.

In the name of carbon offsetting dams, CDM mechanism largely constructions of huge numbers of dams across Indian Sub-continents particularly Himalayan region are appearing confrontational. Reservoirs are man-made lakes that severely impact on

river ecosystems. Hence, it appears the fact that large number of big dams is the root cause of environmental insecurity and issues of non-sustainability.

2.6 Hydropower Development: Understanding Local Environmental Issues

The humans have started dam building process for thousand of year but it increased substantially during the second half of the 20th century and it is estimated that there were around 5000 large dams worldwide in 1950 but the number had increased to 45000 by 2000 (Pandit and Grumbine 2012). Hydropower is currently the world's largest renewable source of electricity, accounting for 6% of the worldwide energy supply or about 15% of the world's electricity[10].

The high growth of population and rising human needs of resources during industrial stage in the world have led extensive competition in terms of high production and consumption of resources in human world. Since then the fuel based industries generated high amounts of GHG to the earth's atmosphere. Therefore, to counteract climate change impacts in the world, the reduction of human induced green house gas emissions must be the target for all further human activities.

Under CDM of Kyoto protocol (1998) the construction of hydropower to meet sustainable power in the world was first priority to meet growing human needs. But the vision of 'clean and green' hydroelectric energy has prevented by some of the results in tropical countries, which exhibit significant greenhouse gas emissions which have led to one of the most intensive and controversial scientific disputes in the environmental science community (Gunkel 2009).

[10]www.iea.org (accessed:03.11.2016)

The global debate about big hydropower dams is overwhelmingly complex because the issues are not merely confined within design, construction and operation of dams themselves but it embrace the range of social and environmental challenges. The Kyoto protocol debate over climate change focuses narrowly on the reduction of greenhouse gas emissions. A common justification for such emissions reductions is that they will lead to a reduction in the future impacts of climate on society. In some mountain areas of the world, river systems are almost completely dammed (Truffer et al. 2001).

The environmentalists, social scientists and social activists identified the major problems of hydropower dams. Therefore, in the context of climate variability and environmental insecurity, the environmentalists put their strong arguments against big dams as (a) deteriorate the environment leading to environmental insecurity for present and future generation, and (b) the possible emission rate of GHG to the atmosphere through dams leading global warming. The indispensable local and regional impacts caused by large dams been voiced by environmentalists, some of which may be quite severe, including extinction of fish populations, loss of aquatic habitats, sinking ground water levels, and deterioration of landscapes (Truffer, et al. 2001).

Over the past 15 years, many developing countries have been adversely affected by environmental and social effects of building large hydropower dams. Consequently, many projects have been delayed or cancelled (Yuksel 2009). It has been critically argued that the constructions of big dams in mountainous state of India are facing vigorous problems in respect of geological and morphological position of ground. All the dam sites fall within Seismic Zone IV and V Where even hard quartzite and granite genesis are found to be shattered, jointed and sheared. Yuksel (2009: 377)

furthermore, discussed critically that the tunnels pass directly through seismically disturbed and geologically active zone. Therefore, he has argued that there is no mention of reservoir-induced seismicity or documentation of existing or potential seismic or geological damage.

China is said to be a fast and enormous dam building country in this contemporary world. The growing concerns in respect of large dams are if China goes ahead with its dam projects, it will substantially affect the flow of the river downstream. Such attitude of China in upstream hurts fisheries and irrigation in the downstream countries, as well as preventing them from building their own hydropower dams (Liebman 2005:289-290). This way of vigorous hydropower development within upper riparian touches the sentiment of the lower riparian nation.

The demand of hydropower energy is increasing day by day but the utmost negative impact being posed by big dams are witnessed in the local level. It has been perceived that dam is considered as the deteriorating agents of the river ecosystem and the environment such as the quality and quantity of river water, aquatic flora and fauna, and unique culture of a place. Similarly, displacement, deforestation, and submergence of the agricultural land are the burning issues. It is seen that most of the large dams built in Indian North eastern states are in remote hilly area where the different tribal people and their unique culture are affected from large dams immensely.

Mostly, the large hydroelectric schemes being planned today are coming up against a great deal of opposition from environmental groups and native people (Yukel 2009). Nearly 90% of Indian Himalayan valleys would be affected by dam building and 27% of these dams would affect undisturbed dense forests (Pandit and Grumbine 2012).

In fact, hydropower dams changes the chemical, physical and biological processes of river ecosystems. They alters free-flowing river systems by reducing river levels, blocking the flow of nutrients, changing water temperature and oxygen levels and preventing fish and wildlife migration (Joyce 1997). There is a potential for loss of precious plants, fish and wildlife if too much water is diverted from natural waterways. Furthermore, the artificial reservoir created by human being could be encouraging the breeding of diseases carrying insects.

Similarly, there emerges lot of problems such as the significant amounts of dust from the site of quarrying, blasting and crushing. Furthermore, transport of massive amounts of cement, boulders, sand, equipment, steel, machinery, and explosives to the construction site but this has not been mentioned. Consequently, when rivers dry up, agriculture is adversely affected in the valleys, fodder for animals vanishes, and the land erodes away (Roy 2008).

In Thailand and Mozambique a variety of environmentalists, social activists, NGOs etc. are opposition to large dam construction as they aspire that do not really need them. The principles of participation, transparency and other highly politicized concepts are central to the Dams and Development report, and anti-dam campaigns in both Thailand and Mozambique have turned to the WCD as a means of legitimizing their claims regarding the lack of a participatory approach on the part of state decision-making processes (Sneddon and Fox 2008).

The participation of local stakeholder and transparency to them are lacking in most of the dam constructions plan in developing countries. The large dams can alters the national and international relation through mismanagement of the river water, for instance the transboundary water conflicts are major cause of these unequal use of

water in this 21st century. As far as in India is concern the most confrontational issues in relation with dam is inter-state and intra-state disputes with regard to use of water resources.

The government of India's CIFRI (Central Inland Fisheries Research Institute) have concluded, dams have been the primary reason for the collapse of aquatic diversity in India, not only because of the hydrological modifications and lack of Environmental-flows, but also because of the obstruction to migration they cause, destruction of habitat during construction, muck disposal, trapping of sediments, destruction of terrestrial (SANDRP 2013: 4).

Similarly, another research done in India by SANDRP (2013) articulated that EIA does not mention the Mohanpuram dam project in Madhya Pradesh is part of Inter-Linking of River scheme. Moreover, the EIA report has not done any downstream impact assessment including the impacts on biodiversity, agriculture, and water security etc. The dam project did not mention about downstream assessment, command area development, and impacts of mining for the project on environment (SANDRP 2013).

The impacts of dams on Riverine biodiversity, including fish biodiversity have been devastating for Indian rivers. This has been stressed many times by fisher folk as well as studies by institute like Central Inland Fisheries Research Institute (CIFRI), Central Marine Fisheries Research Institute (CMFRI) which come up with findings, major concern of dams which have been singled out as the main reason behind fisheries collapse in major rivers like Ganga and its tributaries, Krishna, Mahanadi and Narmada to name a few (SANDRP 2012). It has claimed while some dams are recommended fish ladders or passes, some are not, without assigning any reasons for

such inconsistencies. Decisions of the Expert Appraisal Committee (EAC) seem totally inconsistent, and unscientific.

2.7 Conclusion

This chapter has tried to sketch out the discourse and debate around hydropower project and climate variability. It highlighted the global context of 'hydropower' which is conceived to be a clean and green energy, perceived to have not much global impacts and zero GHGs emission and it leads win-win energy solution throughout the world. But the public avoidance to the hydropower seems fierce in the local level in this contemporary period wherein the big hydropower dam could be good for the atmosphere but not for the ground surface.

The emergence of lots of problems such as submergence and evacuation problems, deforestation and water resources depletion problems, and transboundary water sharing disputes due to dam are distinct in this contemporary period. Herein the problems are not merely confined within a country (intra-state) but the consequences would be inter-state also.

Therefore, hydropower as global acceptance and local resistance are two contrasting propositions. From the global policy perspective for instance Kyoto Protocol (1998) have articulated that hydropower dams has clean and green energy to mitigate global GHGs. Whereas at the local level, people raise the issues of environmental degradation and socio-cultural transformation.

Global acceptance of hydropower dams for the sake of energy leading local avoidance because of environmental insecurity. These issues will be explored and clarified in more details in the next chapter through grounded insights from the field.

. Chapter 3

Climate Variability and Hydropower Development in Sikkim Himalaya: People's Perception

"Since last many years the weather patterns have been changing in the region, sometime erratic rainfall and sometime drought like condition. We are experiencing increasingly warmer condition nowadays. But additionally, during the last 10 years our village is in critical condition because of hydropower dams and its impacts on natural springs, agricultures and livestock"

-Durga Prasad Bhattarai, 64 years old man, farmer of Lower Samdong (Aug. 2016).

3.1 Introduction

The previous chapter examined various forms of hydropower discourses at global and local level and have also reflected the challenges of climate variability and hydropower in different places. This chapter intends to explore various grounded insights of environmental and social insecurity aggravated by hydropower dams in the face of climatic variability in Upper Tista Catchment (Sikkim).

The Tista River originated from Sikkim Himalaya and joins Brahmaputra crossing through two most populous countries i.e., India and Bangladesh. Tista plays a vital role in functioning socio-cultural-economic activities of both the nations and is considered as a lifeline of Sikkim-Darjeeling Himalaya. The total geographical area of this river basin is approximately 12,159 sq. km. In Sikkim Himalaya its area covers around 6930 sq. km. Similarly, it shares about 3225 sq. km in West Bengal and Bangladesh shares 2104 sq. km. of the Tista River Basin (Khawas 2015).

In Sikkim Himalaya, the major challenges that appeared for the environmentalists in contemporary scenario are growing extreme events like untimely rainfall, erratic rainfall, landslides, and droughts. Furthermore, the region has cascading development of hydropower dams to enhance the economy as well as to meet the energy demands. It is found that both climatic variability and cascading hydropower dams are appeared to have negative impression for the environment and the society in long term in the region.

In the face of climatic variability the hydropower dams have deteriorated the environment of a place. Moreover, it has been observed that the construction of massive hydropower projects in ecologically fragile and seismically vulnerable zone have caused changes in land use pattern, involving mainly conversion of agricultural lands and forests to roads, tunnels, buildings and other components of the projects (Chandy, et al. 2012). Similarly, the region is experiencing climatic variability in the form of extreme events wherein the rising temperatures have impacts in many areas including agriculture, water supply, and ecosystem (Bedsworth and Hanak 2010).

This chapter investigates people's perception about climate variability and hydropower dam in general and socio-environmental changes in particular in Upper Tista Catchment. People's perception around hydropower dams and climate variability is studied with the help of Participatory Rural Appraisal (PRA) and extensive FGDs with different communities of different age groups in Rakdong-Tintek and Samdong-Kambal GPUs (East Sikkim) in the vicinity of Tista-V Hydroelectric Project.

3.2 Changing Climate Scenario in Sikkim

3.2.1 Review of Literature

'Climate change' means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC 1994). In Sikkim Himalaya, the problem of dying springs is being increasingly felt across the region because of impacts being caused by climate variability, manifested in the form of rising temperatures, rise in rainfall intensity, reduction in its temporal spread with a marked decline in winter rain (Tambe, et. al. 2012).

As per the record of two decades i.e. 1991-2010, the number of rainy days as well as the annual rainfall at Tadong (Gangtok) has decreased at the rate of 0.72 days/year and 17.77 mm/year respectively (Rahman, et al. 2012). Moreover, the rising average annual mean temperature in Sikkim at a significant manner and rainfall has shown as decreasing annually (Rathore, et.al. 2013).The warming is more pronounced in winter even though considerable warming has been observed in other seasons too. The more cooling of days has been observed in the months of November and December (Mahamuni and Kulkarni 2012).

The change in weather patterns such as the winter precipitation, summer radiation and summer air temperatures directly alters the snow lines during the summer. As a result these changes affect the hydrology of glaciers in the short term and the geometry of glaciers in the longer term (Willis and Bonvin 1995). In Sikkim Himalaya, it has been projected that by 2030s, the average annual temperatures are likely to rise by 1.8 to 2.1^0C with respect to 1970s (SAPCC 2012). Resultantly, both of these changes have

greater potential to alter the magnitude and seasonal pattern of runoff in mountain streams and have significant water resource implication (Willis and Bonvin 1995).

The comprehensive study by Vaidya (2015) discussed that climate change will impact seasonal water supplies more than annual water supplies. Reduction of water supplies during the summer months is likely to affect agriculture and tourism adversely in many areas. It is distinctly seen that climate-related changes are already having severe impacts on people's livelihoods across Sikkim Himalaya, particularly those that are highly dependent on agriculture related activities.

As far as Sikkim Himalaya is concerned, the high levels of impact from climate change was recorded for paddy, maize, wheat, oil seeds, cardamom, ginger, drinking water sources and fodder trees (Sharma and Rai 2012). Therefore, the mountain farming in Sikkim Himalaya is facing higher risk due to declining trend of agricultural productivity due to long winter droughts, difficulty in seed storage and increased pest attacks (Arrawatia and Tambe 2012).

So far, the climate change in Sikkim has been observed in the form of reduction in the temporal spread of rainfall, rise in its intensity and frequent winters droughts. Furthermore, major environmental impacts are manifested in the form of receding glaciers, declining lean season base flow of rivers, streams and springs, higher surface runoff, reduced groundwater recharge (Arrawatia and Tambe 2012). FGDs among the villagers reveal that the winter rain has reduced in recent times. Similarly, summer temperatures have increased over the years and winters are becoming colder for the last 8-10 years in the region.

Table 1: Variation in rainfall (mm) over Gangtok (1951-2005)

Months	1951-80	1961-90	1957-05	Change in Rainfall from 1951-80 to 1961-90	Change in Rainfall from 1961-90 to 1957-2005	Change in Rainfall from 1951-80 to 1957-2005	Projected figures based on 1957-2005
January	40.4	25.5	32.6	-14.9	7.1	-7.8	-2.7
February	50.2	58.6	62.6	8.4	4	12.4	6.5
March	127.1	107.4	135.5	-19.7	28.1	8.4	-12.7
April	270.5	308.7	270.3	38.2	-38.4	-0.2	44.6
May	534.7	533	523.9	-1.7	-9.1	-10.8	50.7
June	650.4	590.9	630.9	-59.5	40	-19.5	-56
July	666.4	662	658	-4.4	-4	-8.4	67.9
August	578.2	552.2	578.9	-26	26.9	0.7	62.3
September	429.3	481.5	464.6	52.2	-16.9	35.3	-41.7
October	180.3	160.7	175.6	-19.6	14.9	-4.7	20.8
November	35.8	36.8	40	/1.0	3.2	4.2	-2
December	17.2	21.6	21.2	4.4	-0.4	4	1.8
Annual	**3580.5**	**3538.9**	**3611.7**	**-42**	**73**	**31**	**49.6**

Source: Information and Public Relations Department, Govt. of Sikkim, 2012 as cited in Arrawatia and Tambe (2012 pp 9)

The historical data of rainfall of Gangtok distinctly shows that there were fluctuations in rainfall patterns. The comparison of figures of 1951-1980 and 1961-1990 reveals decrease in rainfall amount in the months of January, March, May, June, July and August and increase in rainfall in other months with an overall decrease in annual rainfall amount. This is indicative of the higher amounts of rainfall in 1950s or less rainfall in 1990s and overall decrease in winter months, monsoon months and post monsoon months (Seetharaman 2012).

Table 2: Observed Trends in Precipitation and Temperature during the Five Years Period (2006-2010)

Months	% change in Precipitation	Change in Maximum Temperature (in^0 C)	Change in Minimum Temperature (In^{0C})
January	-79	0.4	2.2
February	-30	0.5	2.0
March	-7	-0.1	1.8
April	-18	-0.3	1.6
May	-24	0.2	1.4
June	-7	-0.3	1.3
July	-7	-0.2	1.3
August	-0	-0.4	1.1
September	-9	0.0	1.2
October	-24	-0.3	1.7
November	-41	-0.9	1.8
December	-44	-0.7	1.8
Annual	**-9**	**-0.2**	**1.6**

Source: Information and Public Relations Department, Govt. of Sikkim, 2012 as cited in Arrawatia and Tambe (2012 pp 10)

The five years (2006-10), monthly mean maximum temperature, monthly mean minimum temperature and monthly total rainfalls shows that there has been a marked decrease in rainfall in almost all the seasons with increase in minimum temperature and decrease in maximum temperature respectively.

The warming is more pronounced in winter even though considerable warming has been observed in other seasons too. On annual time scale, the rainfall decreased by about 9% with a small maximum temperature change of (0.2^{o}C) and change in the minimum temperature is considerable with 1.6^{0}C (Seetharam 2012:14). There was variability in rainfall and temperature during the period (2006-2010).

3.2.2 People's Perception

The people's perception of weather patterns of Upper Tista Catchment are extracted with the help of 'weather chart' (Table 3) based on FGDs at Samdong-Kambal and Rakdong-Tintek GPUs (East Sikkim). There were climatic indicators such as rainfall, hailstorm, warm and cold temperature, dry period and landslide in order to extract intricate information regarding the changing climatic conditions of a region. The changing climatic conditions of a region are drawn by comparing the people's perception of the past and the present experiences.

Table 3: Climatic Hazards and Events

Indicators	Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	Past	**	***	***	***	***	***	***	***	***	**	*	*
	Present	*	*	*	**	**	***	***	***	**	**	*	*
Warm Temp.	Past	*	*	*	**	**	**	**	**	**	*	*	*
	Present	*	*	**	***	***	***	***	***	***	**	*	*
Cold Temp.	Past	**	**	**	**	*	*	*	*	*	**	***	***
	Present	***	***	**	*	*	*	*	*	*	*	**	***
Dry Period	Past	*	*	*	*	*	*	*	*	*	**	**	**
	Present	***	***	**	*	*	*	*	*	*	**	***	***
Hail-Storm	Past			*	**	*							
	Present			*	**	*							
Landslides	Past						*	**	**	**	*		
	Present						**	***	***	**	*		

Source: Based on FGDs *Low, ** Medium, *** High

Table 3 reveals that the overall rainfall has reduced drastically in comparison to the past years. As per the people's perception of study area, the overall temperature (hotness) has increased round the year since last 8-10 years, the agricultural productivity has also decreased as compared to earlier years due to increase in temperature. The lower belt of the villages was reportedly facing colder night due to the Tista-V reservoir.

Plate 1: Participants in FGDs from Lower Samdong village

Photography: Chador Lachungpa, 10 August, 2016

The increasing trends of dryness due to increase in temperature, the production of vegetables has gone down. Many people of the villages have left the cultivation of water intensive agriculture such as paddy because of water scarcity during the summer months. They claimed that the water scarcity is further aggravated and accentuated by the tunnelling process of Tista-V Hydroelectric Project. The region experiences extreme water scarcity during the months of November-March. As per

the local residents of Lower Samdong village, the onset of monsoon is observed to be delayed since last 6-7 years but 2015-16 brought timely and good rainfall.

As far as the cold temperature is concerned, the severity (chilling weather) has gone up in the region in the month of December, January and February but during rest of the months the warm temperature are more pronounced. During June, July and August months the intensity of rainfall remains high. It was reported that high intensity rainfall in the monsoon time leads to landslides and soil erosion.

It is said that aggressive landslides in the region is aggravated by hydropower dams, tunnelling and road constructions. There are many stages of Hydropower projects along the Tista and its tributaries in Sikkim Himalaya. Consequently, the people of Upper Tista Catchment have been witnessing many negative impacts of big water projects.

3.3 Hydropower Development in Sikkim Himalaya

In Sikkim, dams are considered as an epitome of modernization and rapid developmental pathway but the unfolding consequences of such development are becoming one of the increasing socio-cultural and environmental concerns. Besides other forms of development including unscientific construction of roads and buildings, the Central and Provincial Governments of India are intensely underway with series of hydropower projects particularly within Sikkim-Darjeeling catchment of the basin. This has resulted in imbalances in the environment and various ecological systems there in (Khawas 2016). The master plan of Sikkim Government to harness perennial river water fully through hydropower dams and provide economic benefits to state has been questioned by the local populace.

A ground experiences also proves that hydropower dams are becoming serious issues of contestation in the region recently (Arora 2007). There are two conflicting perspectives in Sikkim Himalaya in the context of hydropower i.e. developmentalist perspectives who prefers hydropower development as a "bridge to attain socio-economic enhancement" and environmentalists perspective that raises the voice against hydropower development in the region because of environmental destruction.

3.3.1 Growth and Development

The development of hydropower projects in Sikkim started during 1927 with the commissioning of first Micro Hydel project at Ranikhola near Gangtok with the installed capacity of 50 KW. Till the year 1954, operation and maintenance of power supply system were under the supervision of Sikkim Public Works Department. Furthermore, the diesel power house was established and commissioned at Gangtok with a capacity of 257 KW in the year 1957, which was inaugurated by the then Prime Minister of India Pandit Jawaharlal Nehru in the year 1958.

Sikkim joined the Indian union on May 16, 1975 as the 22nd state of India. Since then the power sector has achieved the tremendous pace in terms of installed capacity. With the liberalised power policy, Sikkim has many private developers of hydropower projects. The Energy and Power Department of Sikkim is responsible for the power project in the state in order to meet the ever growing energy requirement as well as generation of revenue.

Sikkim Himalaya region is blessed with lots of perennial natural springs and rivers. Hydropower is therefore, declared as win-win energy source by the Government of Sikkim to harness untapped perennial river water to produce cheap and abundant

power to meet the nation's energy demand and providing economic benefits to the state (Menon, et al. 2003).

Recently, the government of Sikkim (GoS) had started on a program of development that aimed to generate 5000 MW of electricity through construction of hydropower dams, mostly medium-sized hydroelectricity projects. The total hydropower potential in the state so far is estimated to be 5352.7 MW and various hydropower projects are in different stages of implementation[11]. It has been recorded that Sikkim as of now has the highest hydropower density in India i.e. 4/1000 km^2 (Pandit, et al. 2012). But, the hydropower as a developmental pathway in Sikkim has become a central point of controversy especially from environmental, cultural and social perspectives. The speedy construction of hydropower projects in Sikkim has led to enormous environmental and cultural destruction (Arora 2007). Therefore, most of the villagers and environmentalists counteracted the hydropower dam as an unsustainable developmental pathway in Sikkim.

It is accepted generally that the 'sustainable development' as a guiding principle and calls for a convergence of three pillars i.e. economic development, social equity and environmental protection. But growing environmental and social insecurity due to recent trends of economic development through hydropower dams has led to social and environmental unrest in Sikkim Himalaya.

As Indian Himalayan basins are earmarked for widespread dam building, but the aggregate effects of these dams on terrestrial ecosystems are unknown (Pandit, et al. 2012). Hydropower development is believed to be a good for the atmosphere but not for the ground surface. Considering the hydropower as a green and win-win energy

[11] www.powerdepartmentsikkim.com (Accessed: 10/01/2017)

has been criticized from different background such as environmental and socio-cultural aspects.

Therefore, unsustainably constructing hydropower dam is not mutually supportive with climate variability in reality from the ground experiences. So, by seeing and analysing the present trend of water shortages due to over emphasizing on dam building through barrage and run of the River scheme with relatively small pondage across Sikkim Himalayan area[12]which may lead future trouble in terms of socio-cultural and environmental insecurity.

Table 4: Mega Hydropower Projects allotted to Private and Public Sector in Sikkim (2015)

Sl. No.	Name of HE Project	Location	Installed Capacity MW	Developers	Present Status
1	Teesta Stage-II	North Sikkim	330	Him Urga Infra Ltd.	Project capacity reduced to around 150 MW
2	Teesta Stage-III	North Sikkim	1200	Teesta Urja Limited	Advanced stage
3	Teesta Stage-IV	North Sikkim	520	NHPC Ltd.	Public hearing conducted recently
4	Teesta Stage-VI	North Sikkim	500	Lanco Energy Pvt. Ltd.	Advanced stage
5	Panan	North Sikkim	300	Himagiri Hydro Energy Pvt. Ltd.	Construction started
6	Rongnichu	North Sikkim	96	Madhya Bharati Power Corp.	Construction started
7	Sada-Mangder	South/West	71	Gati Infrastructure Ltd.	Construction started
8	Chuzachen	East Sikkim	99	Gati Infrastructure	Completed
9	Rangit-II	West Sikkim	66	Sikkim Hydro Ventures Ltd.	Under construction progress is 8%
10	Rangit-IV	West Sikkim	120	Jal Power Corporation Ltd.	Under construction progress is 65%
11	Dikchu	North/East	96	Sneha Kinetic Power	Under construction

[12] Trial Report on the Draft Hydropower Sustainability Assessment Protocol August 2009, Teesta V, Sikkim, India, NHPC Ltd. (Accessed: 22/4/2014)

12	Jorethang loop	South Sikkim	96	DANS Energy Pvt. Ltd.	Under construction
13	Tashiding	West Sikkim	97	Shiga Energy Pvt. Ltd.	Under construction progress is 14%
14	Kalez Khola-I	West Sikkim	27.5	Cosmic infra Powergen Pvt. Ltd	No work has been initiated
15	Kalez Khola-II	West Sikkim	60	Pentacle Power Pvt. Ltd.	Project under survey and investigation
16	Rahikyong	_	25	Sikkim engineering Pvt. Ltd.	Project under survey and investigation

Source: Annual Report 2014-15, 2015 Energy and power department, Government of Sikkim as cited in Chettri (2015 pp 18).

The germination of maverick history of water-related activism around Tista-V stage started during 2007. During this period the vociferous opposition emerged from local people especially the Lepchas and the Bhutias who questioned against the dam project. It seemed embarrassing factor that the environmental clearance for Tista-V was given in May 1999 on the condition that "no other project in Sikkim will be considered for environmental clearance till the carrying capacity study of the Tista basin is completed" (Bunsha 2008). However, the Ministry of Environment and Forest (MoEF) violated its own condition, and cleared six projects even before the final carrying capacity study was submitted in August 2007.

The hydropower as a developmental pathway in Sikkim is becoming a central point of controversy. Fact is that most of the proposed sites for new dams are located in isolated, environmentally fragile, economically marginal and poorly developed frontier regions (Huber and Joshi 2016). Ironically to the global perception of dam as green energy, the local people perceived it as a destroyer of environment and culture of isolated areas.

Table 5: List of Scrapped project

Sl. No	Name of project	Location	Developer	Installed capacity	Date of MOU	Date of scrapping	Reason
1	Rolep	East Sikkim	Sikkim Power development corp.	36	6/5/01	5/03/08	Delay in execution of project
2	Rangyong	North Sikkim	BSC(P)L SCL JV Engineers and contractors	117	5/6/01	6/04/08	Public claimed that tunnelling leads to landslides which breaks water channels frequently
3	Chakung Chu	North Sikkim	ATIL	50	5/6/01	5/03/08	Social and cultural reason
4	Ralong	South Sikkim	ATIL	40	5/6/01	5/03/08	Technical reason
5	Thankgchi	North Sikkim	Lachung power Pvt. Ltd.	40	MOU not signed	5/03/08	Public Opposition
6	Ratheychu	North Sikkim	Coastal Pvt. Ltd.	40	MOU not signed	4/10/08	Cancelled due to public resistance
7	Bakchachu	North Sikkim	Coastal project Pvt. Ltd.	40	MOU not signed	4/10/08	Cancelled due to public resistance
8	Teesta stage-I	North Sikkim	Himalayan green Energy Pvt.Ltd.	280	05/2/05	10/6/12	Cancelled due to environmental issue and public resistance
9	Lachen	North Sikkim	NHPC	210	01/2/05	21/6/12	Social and cultural issues
10	Bimkyong	North Sikkim	Teesta power Pvt. ltd.	99	18/1/08	16/4/12	Social and cultural issues
11	Bop	North Sikkim	Chungthang power Pvt. Ltd.	99	18/1/08	16/4/12	Land feasibility
12	Lachung	North Sikkim	Lachung power Pvt. Ltd.	99	18/1/08	16/4/12	Social and cultural reason
13	Ting-Ting	West Sikkim	T.T energy Pvt. Ltd.	99	03/9/08	25/1/10	Submergence area, susceptible to erosion

Note: ATIL (Amalgamated trans-power India Limited) as cited in Chhetri (2015 pp 20).

There is contestation that none of the power projects that are constructed in the mountain areas in the north east India are based on the geo-hydrological assessment (Sharma, et al. 2014). The growing emphasis on public participation or real

participation by the affected people from such projects is still lacking or low (WCD 2000). Furthermore, the Environmental Impact Assessment reports are not prepared strictly till the date based on scientific methodologies using latest tools and techniques (Sharma, et al. 2014). Therefore, participatory approach from different social groups (villagers, environmentalists, NGOs, social activists), political leaders, policy makers become vital in present context to achieve secure and sustainable development.

It has been recorded that several projects are currently stranded at different stages in the north-eastern states of India because the states are revisiting their plans in view of local resistance and ecological concerns (Molden, et al. 2014). Similarly, it has been reported some of the plan projects in Sikkim were cancelled due to socio-cultural and environmental concerns.

In Sikkim there was strong contrast, where the Lachenpas families in North Sikkim have passed a unanimous resolution in their traditional panchayat 'dzumsa'[13] condemning the hydro projects and refusing to give away their constitutionally protected ancestral lands. They strongly oppose the project on Social-cultural and humanitarian grounds (Arora 2007).

The Upper Tista catchment has cascading hydropower development which led to social conflicts over diverse issues such as cost-benefit distribution, hazard risks, and indigenous sovereignty (Vaidya 2014). One of the slogans of a social activists in Sikkim (Arora 2007) was- "I will die but won't allow the mega power projects in Dzongu" - Dawa Lepcha. This person has strong opposition to large dams and unfolding scenario of socio-cultural and environmental concerns among the Lepcha tribe in their home land (Dzongu).

[13]Dzumsa is a traditional social governing system of North Sikkim.

The developmental agenda of the state was highly centralised and lacked stakeholder participation. Large scale dam projects are almost without exception sited in poor, rural, and politically, ethnically or socially marginalised communities, ironically structuring the local pain to disproportionately affect already disempowered population. Therefore, hydropower dams are becoming a most debating and controversial in the context of Sikkim Himalaya.

3.3.2 People's Perception around Hydropower

The field visits and interaction with the community people of Samdong-Kambal and Rakdong-Tintek GPU brought up grounded insights of people's perception regarding the hydropower projects. During field work[14] in the study area, the information was collected with the help of Focus Group Discussion (FGDs) and Participatory Rural Appraisal (PRA) among different aged group people in the villages. The age group ranges from 23-80 years.

The people's perception particularly on hydropower projects in upper Tista catchment brings out the grounded insight of public repulsion to hydropower projects. People believed the dam as a 'deteriorating agent of the environment'. It was identified during interaction with the local people that the development of hydropower not only generated hydropower energy but certain controversies, issues and problems too in the process. The environmental insecurity such as drying up of natural springs, landslides, land-sink, and house-land cracks etc. are various forms of issues that originated over the past one decade in Upper Tista Catchment (Sikkim).

[14] The field work in the study area were done in the months of September, October and November 2016.

Plate 2: Tista Stage V Project

Photography: Navin Rai, 10 Aug. 2016

The people perceived river Tista as a lifeline for their village in terms of food security, water security, cultural security and environmental security as a whole. People's perceptions of hydropower dams and their impacts upon the village and adjoining areas across different stages of project development are briefly summarised below with the help of the case study of Tista-V HEP.

Pre-construction Period

The year 2000 and before were considered as pre-construction period where the Tista stage-V was not established. The environment of the place was so perfect with river water, natural springs, forest, and landscape in their natural state. The villagers used to have surplus water for water intensive crops such as paddy and cardamom they produced.

The perceived ideas of hydropower dam was that it brings holistic development in the society by providing different facilities such as job opportunities to the villagers, free

electricity, infrastructure development and revenue generation for the people of villages and the state.

Employment Generation

The hundred per cent (100%) job creation to the locals were the main theme of this project, but what kind of job the villagers would be provided was not mentioned. Many educated youths were unemployed or underemployed in the villages, the slogan of 100% job attracted youths.

Free Electricity and Developmental Programs

Free electricity to the villages after the commissioning of the project has greatly attracted the local people. The politicians promised the villagers to facilitate 100% free electricity. Furthermore, the politicians influenced the people that hydropower companies would carry community and village development projects such as road, school repair, footpath construction, electrification and water supply for villages, and livelihood skill development in project affected areas.

Environmental Safeguards

Villagers did not have ideas about the cracks which would appear in the houses and lands because of tunnelling. The villagers were not informed about the 17 km long stretch of underground tunnelling. Later on the consequences of this tunnelling during construction and post-construction period brought cracks in the houses and land forms. The road construction and blasting transformed the morphology of land due to land vibration which resulted into the uncertain rock falls and debris falls.

As per the people's perception, the villagers did not have any ideas about the tunnelling that would lead to drying up of natural springs wherein, the springs are the only source of water in the villages. The people of the region did not thought of mass destruction of river water ecology and natural springs due to tunnelling and the dam.

Construction Period

The constructional phase of Tista-V started in the year 2000 and project was commissioned in 2008. It is considered as one of the most destructive phases of the project. During construction period people were explicitly voicing against the dam in Lower Samdong, Dikchu and adjoining areas.

While taking FGDs in the impacted villages, a lady Smt. Kopila Bhattarai (Aged 30) (Lower Samdong village) vociferously argued against NHPC survey, as she said...*"They (builder) came to our village without prior information and we tried to block the heavy vehicles of NHPC such as trucks and bulldozers but we could not succeed".*

The year 2001-2 was the initial stage of drying up of natural springs and appearance of cracks in 'kachaa' or 'mud house'. The damages furthermore enlarged after 2011 earthquake which altered widespread tilted and cracks in cemented houses as well. Villagers claimed it was because of fragile landform aggravated by the land vibrations, and blasting during tunnelling period.

The positive images of big hydropower projects as a sustainable form of development for the people and for the region were inculcated by the politician in order to maintain harmony between different social groups and politicians. Therefore, under such circumstances villagers perceived hydropower dam as a sustainable form of water

resources development despite being many public condemnation against dams in and around.

Moreover, some of the local people employed on contractual basis in clerical posts and as what the villagers quote it as casual labour or third grade job. Therefore, the policies of 100% employment facility to the villagers in the projected area were misinterpreted. It did not fulfil neither by NHPC nor by state government.

Administrative Pressure

In the initial stage of construction, most of the stakeholders tried to barricade the road to counteract the unknown people in their locality but in front of authority their effort became futile. They staged strong opposition collectively to resist the dam but result was not effective in front of police. Police as an active member of the authority came to the place and evacuated the people through harsh methods.

Many times, villagers approached the District Collector (DC) to avoid the unnatural destruction through dam construction. But the DC convinced the villagers by showing different socio-economic facilities and opportunities from the company. The MLAs pressurized people to give their consent to the dams (Bunsha 2008). The Sikkim Democratic Front (SDF) Government led by Chief Minister Pawan Chamling is said to be a strong public and development centric from 1994. But the villagers were afraid of speaking against the developmental plans of the government for fear of being victimized.

The people of the region were afraid of the government as they are totally dependent upon it. The victimization strategy of the dissenters, an established practice in

Sikkim's patronage system, helped to enforce consensus and curb organised resistance (Huber and Joshi 2016).

Development Programmes

NHPC compensated unsatisfactorily as well as unequally to the villagers. The government distributed compensation at the rate of merely Rs 3 per square feet of land in and around Lower Samdong village. The range of compensation varies from Rs 3000 to Rs 15000 among the land holder. The resettlement and Rehabilitation (R&R) plan which envisages incentives for the displaced families but is yet to be fully implemented and monitored (Sharma and Pandey 2013).

Issues around Local Environment

There have been perceptions that the Upper Tista Catchment has witnessed changes in amount, timing and intensity of rainfall. Consequently, the cropping patterns are also changing. But almost all the respondents were worried about the acute water problem and changing behaviour of the environment that aggravated by hydropower dam in the region.

At the initial stage of tunnelling and damming of the river, the peripheral areas started getting impacted. Most of the respondents emphasized on the declining trend of agricultural production not from merely climatic variability such as untimely rainfall, drought, hailstorm, erratic rainfall, etc. but by tunnelling as well.

The villagers believed that extensive tunnelling, blasting and road construction which altered natural springs and land use pattern of the project affected area. The region

had plenty of water facilities prior the dam (tunnel) and the villagers had plenty of agricultural production but recent time the production level has declined dramatically.

Due to fragile landscape, the region feared of landslides during rainy season (monsoon season) but the fragility of the landscape is accentuated by the hydropower dam and the underground tunnelling. The people of the region have been experiencing extreme landslides during monsoon period. During conversations (FGDs) with the villagers at Rakdong village one of the respondents Mr. Shiva Lal Rai (aged 64) said *"Nowadays we are experiencing uncertain landslides in the places where we have/had not expected to be occurred".*

The people of the region were worried due to constructional activities which accentuated the region through 'unnatural land vibration'. The village experienced vibration of their land periodically. They faced unnatural uncertainties due to this vibrations which aggravated socio-economic vulnerabilities through fragmentation of houses, and water scarcity. Sharma, et al. (2014) further found in their research that the use of dynamites in road construction, underground tunnelling and cementation work has a terrible impact on springs which alters their occurrence and reduces their discharge.

Post Constructional Period

The post construction period started from 2008 onwards when the project was commissioned. Extreme forms of environmental impacts appeared in the locality such as water insecurity, food insecurity, and environmental insecurity as a whole. Most of the villagers claimed that the region is in vulnerable condition because of its fractured landform created by the dam building process in constructional phase i.e. 2000-2008.

Environmental Insecurities

The people and the environment of study area are extremely affected by Tunnelling and damming. Consequently, almost 80% of the natural springs dried up, and facing acute water problem for household, livestock and agricultural purposes during winter season.

Water insufficiency is the major problem in the villages. To tackle water scarcity, government of Sikkim (irrigation department) has facilitated metalled piped for water but villagers have critical views that merely water pipe does not have any meaning until there is water in the spring. They counteract the government that developmental activities accelerated the water in the spring to dry. Till now government has not facilitated the water to individual stakeholder from perennial and sustained sources. The perennial sources are quite in farther away and are beyond the reach of villagers. Government has built many water tanks within the village but it remains dry throughout the year.

Villagers have placed their complaint against NHPC and the state government about water scarcity in the area but no any effective initiatives have been taken by these bodies so far. A respondent replied during conversation *"We need water urgently in our village for household, livestock and agricultural purposes since our village have lost almost 80% of spring water".*

Extensive landslides have become a common disaster in the region during rainy season. Some of the houses are tilted and fractured because of unstable land due to underground tunnel. All of them have been compensated with certain amount during pre-constructional period but the damages are still experienced after the dam has been

commissioned. In this context the villagers have common complaints that ‘who will pay us if our houses and land property damages now’.

Plate 3: Cracks in Rock near Tista-V

Photography: Navin Rai, 10th August, 2016.

During pre-constructional period there were no massive disasters. Basically, there were seasonal dry period, landslide and natural earthquake. In the post construction periods, the impacts have been enlarged. As per the villagers, during pre dam period they used to practice bamboo plantation to avoid landslides in extreme periods but this practice is not effective in recent times. The massive disaster ever they experienced prior the dam was in 1968 flood and landslide and after the dam (2011 and 2015 earthquake) which destroyed massively

Food Insecurity

Water availability in the dry season has become a serious problem in the region. One of the villagers from Lower Samdong Village responded during focus group discussion *“The vegetables are not grown efficiently as before because of water*

shortages and pests, now most of us are depending upon the vegetables coming from Siliguri (West Bengal)". It is further explored that this is primarily due to the high intra annual rainfall variability, with more than 70% of annual precipitation in much of the Himalayan region falling during the monsoon season (Vaidya 2015).

The region is exclusively depending on rainfall and natural springs for agriculture and livestock. The long stretch of tunnelling just below the villages and drying natural spring has badly impacted the productivity of traditional food crops, fruits and vegetables.

Plate 4: Paddy Cultivation in Lower Samdong

Photography: Navin Rai, 10 Aug, 2016

Dikchu, the land with good cardamom production has turned into scarce or no cardamom land due to water scarcity. Cardamom is water intensive crops and has severely been affected by tunnelling and water shortages, which negatively impacting the economy of the region (Lepcha 2013). Paddy is cultivated in rainy summer season has comparatively good production in the region but climatic variability or untimely rainfall has affected the production level.

Inadequate Development Program

The development programmes such as free electricity, water facility and houses repair promised by state government to facilitate the people of affected areas during pre-construction and construction period are yet to be fulfilled.

As part of their local area development program, hydropower companies however, undertake community development projects such as road, school repair and footpath construction, electrification and water supply for villages, and livelihood skill development in project affected areas (Chandy, et al. 2012). The community development programmes are also yet to be fulfilled.

Health Hazard

Most of the villagers experienced the increasing numbers of mosquitoes due to reservoir of river water. Similarly, the villagers also have a complaint of dirty and filthy smell coming out from the reservoir. The pests attack in the agricultural crops is seen in the villages. However, one of the proponents observed...*"because of unbalanced ecosystem and lack of water availability in the village area, the productivity of vegetables and crops getting decreased. Therefore, we are compelled to import most of the kitchen commodities from the market".*

3.4 Conflicting Issues around Hydropower Projects

The government and the company did relentless effort to settle down the social unrest in connection to hydropower dams and its impacts in their village. They persuaded the villager during pre-constructional and constructional period by promising certain kind of socio-economic facilities and opportunities for instances free electricity in the village, and compulsory job allocation. As soon as the government and the company

hold their grip over the village and villagers, they started constructional work with unsatisfactory wages.

The villagers were devoid of precise information regarding the government's plan of the dam construction. All the respondents claimed that-"*The stranger people came suddenly and conducted survey without any prior information"* it proves that maximum people were untold about the project in the village. Later on, people from the company approached the villages and placed developmental programs. They tried to convince the villagers to sell their land property to the government for the hydropower projects. It has been articulated by Huber and Joshi (2016:19) that discussions of hydropower projects were initially confined to landholders whose land was to be acquired, even though project implementation would affect the community members of periphery.

It is further argued that the Tista HEP-V was implemented without taking into consideration of any suggestion of the local people **(**Lepcha 2013). Therefore, it has been suggested that society at large has to be involved by providing correct information through the media (Molden, et al. 2014:70).

Most of the proponents centred their arguments against the dam construction which directly destroyed and devaluing the existing natural settings. As per the villagers, the locality had sufficient amount of water resources comprising perennial natural springs, the perennial springs used to existed throughout the year prior to the emergence of dam construction. The villagers replied it was due to underground tunnelling. As in corollary, the scarcity of water in the region has become a common issue in contemporary scenario.

The respondents made their strong arguments against the dam builder where the company provided employment to villagers as a labour or contract based job and entire top class jobs were given to the outsiders/non-locals. The labour received Rs 2500 per month which was comparatively very low amount as a wages. Furthermore, during construction phase the problems of open muck dumping created lots of social turmoil. The company used to dump the muck alongside the village road, as per the villager open muck disposal have more impacts on health of people and on agriculture.

Lots of problems gradually appeared such as drying of natural springs, cracks in houses and lands, unnatural landslides etc. Since, Sikkim is classified as geologically sensitive and is considered as part of seismic zone V prone to high magnitude earthquake. Therefore, some of the NGOs like Affected Citizens of Teesta (ACT) were full flagged repulsion against the constructions of dam which could lead socio-cultural and environmental problems.

The people have experienced uncertain rock fall and debris fall due to fragile landscape created by the massive underground tunnelling. As per the respondent's articulation, their lives were in danger situation where the quality and quantity of water has deteriorated. The natural springs are the only source of water for drinking, livestock and irrigation throughout the region are drying and converted into seasonal in recent times.

Furthermore, during winter season the water levels in the Tista River becomes extremely low and the ecology of the river getting impacted. The low water levels revealed the decrease in fish quantity and quality. During conversation, a respondent replied with lots of regret that *"The Tista River basin is nothing like it used to be, the*

fishes are not found abundantly as before". The hydropower is the prime vehicles for ensuring environmental sustainability as well as security are come under much criticism through ground level.

Due to dam construction the normal fish migration would be affected. The EIA report admits and acknowledges suitable passages in the form of fish ladders for fish migration. But so far, there is no fish ladder in the Tista III project, nor has any effort been made to protect the aquatic life (Lepcha 2013). The Tista-V has the similar case. The people's perceptions around the Hydropower dam and environmental changes have been summarised below.

Table 6: People's Perception around Dam Construction

Opportunities and problems	Pre-construction	During-construction	Post-construction
Dam as a service provider	-Promised 100% job opportunity. -Promised 100% electricity facility.	-Some people got contract based job. -Some people were provided with third grade job. -No one was provided with first and second grade job since many youths were educated**.**	-Became jobless after the construction of dam completed.
Morphology of land and resources	-Dam believed to be a good at the beginning. -Will not appear cracks in home and land. -Will not dry natural springs	-Appeared cracks in home and land -Gradually drying up of natural springs (around 25%).	-Almost 80% of the natural springs dried up. -Loss of farmland/reduction in farm production because of less water. -Excessive landslides/roadside slide.
Dam for Free electricity Facility to victims	-Promised 100% electricity will be free of cost.	-promised 100% electricity will be free of cost.	-The electricity is not free of cost, since the project (510MW) was commissioned in 2008.

Drinking Water Facility	-Perennial spring water sources within the village premises. -Had privately owned plastic piped or bamboo channel.	-Spring water dried up. -State government promised to get water from other sources.	-Irrigation Dept. Constructed the water storing tank. -But no water in the tank because there is no perennial water around. -No provisioning of water for household and irrigation from any perennial source.
Compensation	-Unsatisfactory compensation.	-No compensation.	-No compensation (still there are damages going on after the dam is commissioned).

Source: Based on FGDs

Table 7: People's Perception on Environmental Change

Changes	Pre-construction	During Construction	Post Construction
Spring	-lots of green vegetation -Enough natural springs (dhara) around the village -More fish quantity in the river Tista -Not much mosquitoes	-Road constructional work started -Blasting and tunnelling -Big trees and surrounding vegetation on the way get deforested -Natural springs getting drying up gradually	-Almost 80-85% natural springs dried. -lots of cracks in roads, ways, houses and lands appeared.
Water scarcity	-No water scarcity (even in dry winter season)	-experienced water shortages due to gradual drying up of natural springs in the village	-Extreme water scarcity during dry winter season
Rainfall pattern	-good rainfall patterns (before 15-20 years)	-Fluctuation in rainfall patterns	-some time erratic rainfall -sometime less rainfall in rainy season and vice versa
Agriculture	-Used to grow enough vegetables and crops.	-Production of the vegetables and crops get declined because of less	-Most of the vegetables are now imported from Siliguri (West Bengal)

	-Self sufficiency of the crops -Used to sell vegetables in the market	water -Most of the crops became vulnerable due to dam building (because of water shortages both from climate variability and dam building)	-Cardamom, ginger and orange production declined many fold in the region -Green leafy vegetables mostly grown in winter season get declined

Source: Based on FGDs

3.5 Conclusion

This chapter tried to explore the socio-environmental impacts of dam in Upper Tista Catchment. Wherein, the growing population, lifestyle and increasing resources needs in this 21st century somehow put natural resources into severe pressure. Meanwhile, shifting to non fossil fuel based energy such as hydropower dams have got greater attention throughout the world. Water scarcity is experienced in all sectors in dam affected villages of Tista-V in Sikkim Himalaya; it is believed to be due to hydropower dam. In fact, the construction of dam has resulted into drying up of natural springs in the villages.

The dams were built on the logic of development of local communities by starting predatory developmental agendas of the central and state governments who are equally blameworthy of visiting disaster on the region (Gohain 2008). Since, the mountain ecosystems and mountain people are exposed to multiple drivers of changes and one of them is climate change (Macchi, et al. 2011).

The field study tried to explore the grounded insights of people's perception about hydropower dam in pre-construction, during construction and post-construction of dam building in Upper Tista Catchment (Sikkim). During pre-construction period, the local people were attracted by the developmental agendas of the government such as job opportunities, 100% electrification or free electrification, and good compensation

to the victims. But the hydropower dam appeared devastating agents in the villages as soon as the constructional activities started.

The village people received comparatively less compensation to revive their fractured land and houses. The maximum houses get cracked and tilted but most importantly neither the NHPC nor the state government have listened the plea of local people. It is strongly arguable that the local people were misinterpreted and mislead by both state government and NHPC.

The politicians tried to convince the local people in the favour of dam during pre-construction period. During pre-construction and construction period, people did not know much about the hydropower dam. As per the villagers, there were some fears surrounded in the locality in case of not giving their consents to government such as the fear of police and fear of victimization.

Moreover, the socio-cultural and environmental security of Himalayan state of Sikkim is in danger zone due to aggressive hydropower projects. Social Impact Assessments (SIAs) are as important as Environmental Impact Assessment (EIAs) especially in a sensitive region like Sikkim Himalaya which is known for its socio-cultural and ethnic diversity. Since, the developmental agenda of the state was highly centralised and lacked stakeholder participations while the stakeholder participation is strongly needed. It is said that a participatory approach should be adopted by involving the stakeholders or the affected peoples (Gopalakrishnan 2012).

The government should be able to define its developmental agenda with the local people and use natural resources with people's participation. India as a nation also needs to rethink its high growth developmental pathway, which is putting enormous

stresses on natural resources (Joy 2013). It sounds right that hydropower dams should opened to public scrutiny with widespread debate on performance, benefits and negative impacts (Parasuraman and Sengupta 2001).

The water resources development in one side may cause scarcity and environmental degradation in other hand. Therefore, policy maker, decision maker and the project developer should understand the dynamics of free flowing river water and its transboundary nature.

Chapter 4

Adaptation Strategies of the People to the Changing Environment

4.1 Introduction

The previous chapter reflects on the various forms of environmental and social insecurity perpetuated by climate variability and hydro power projects and people's perception around them in Upper Tista Catchment. This chapter explores and examines various adaptation initiatives of the local people to the problems created by climate variability and hydropower projects.

Sikkim is a part of Eastern Himalayan region of India and is under impacts of growing climatic variability. The place has rich mountain ecosystem and biodiversity and is indeed sensitive and vulnerable to climatic variability. The region has been experiencing extreme weather events in the form of erratic rainfall or reduction in the temporal spread of rainfall and frequent winter drought.

Moreover, the climate variability has greater impacts in human livelihood; it is proved that the water and agricultural sectors are severely impacted by climate change (IPCC 2007). Additionally, the water resource has been severely impacted and it has well explored that future scenarios of water availability suggests that water storage may also become a key strategy for climate change adaptation (Vaidya 2013). Similarly, adaptation strategies should aim to increase the flexibility in management of vulnerable ecosystem, and enhance adaptability of species and reduce social-environmental pressure. Therefore, an adaptation strategy becomes an urgent need to tackle the changing environment in recent times.

Sikkim Himalaya is impacted by dual drivers i.e. hydropower projects and changing climate. The people of Samdong-Kambal and Rakdong-Tintek GPU (Sikkim) and adjoining villages are reported to be vulnerable to climatic variability which led to food and water insecurity and environmental insecurity in the region. Therefore, in order to understand the reality, the study took extensive Focus Group Discussions (FGDs) and tools of PRAs such as resource map, weather chart, crop calendar with the help of people in the villages. Altogether the study makes use of 5 FGDs and 4 PRAs.

4.2 Adaptation initiatives in the Sikkim Himalaya

The climate variability has its imprints in every sector and water resource is one of them. In the context of Himalayan region the lack of safe and enough water is directly linked to food insecurity, water borne diseases, and environmental degradation which can inflame local and regional level tension. An adaptation in the context of climate change refers to the actions taken by individuals, communities, or governments in response to climate change and reduces the adverse impacts being aggravated by climate change or to take advantage of opportunities offered by such changes.

Some of the adaptation initiatives have been implemented in the context of water in the state so far as spring shed development approach by which dying springs can be revived by using geo-hydrology techniques (Tambe, et al. 2012). Similarly, artificial recharging of dried springs through rain water harvesting specially in the recharge zone, to increase the percolation of rain water and recharge of ground water (Bhattacharya, et al. 2012).

In Sikkim Himalaya the problem of drying of springs is becoming a burning issues and concerns for the government and the villagers. The direct impacts of drying of natural springs are on human livelihood, socio-culture and environment. It has been broadly explained in the preceding chapters that the drying of natural springs are due to the impacts of climate change on precipitation patterns such as marked decline in winter rain, coupled with other anthropogenic causes such as construction of hydropower dams in mountains. It has been recorded that Sikkim has the highest dam density in India (Tambe, et al. 2012; Pandit and Grumbine 2012).

It has been observed that the impact of climate changes on retreat of east-Rathong glacier in Rangit Basin of west Sikkim is alarming (average retreat: 13.3m/year). Furthermore, there are potential glacial lakes in Sikkim that may take the form of GLOF with some of the glacial lakes already growing in size (Luitel, et al. 2012; Kumar and Prabhu 2012).

In Sikkim, the traditional rabi crops like mustard are being promoted to adapt to the warmer and drier winters (Bhattacharya et al, 2012). The adaptation strategies to meet the food insecurity include crop diversification through popularisation of indigenous varieties such as buckwheat, maize, paddy, soybean, rajma, rice bean and urd that are climate resilient (Tambe, et al. 2012).

The agricultural sectors are impacted by climatic variability in general Sikkim Himalaya. The extreme climatic conditions such as long dry spells lead to the emergence of viral diseases such as *Chirkey, Furkey* and fungal disease *Colletotrichum* which conspicuously reduced in productivity and plantation of large cardamom in Sikkim (Sharma and Rai 2012).

It has been recorded that a deficit rainfall or dryness was witness during 1986, 1988, 1989, 2006, and 2009 which have caused adverse effects on the economy of Sikkim such as in drinking water supply, irrigation to rabi crops, vegetable, orange etc. It is estimated that 60% of State's large cardamom production was lost during these dry spells (Rehman, et al. 2012). One of the extensive and comprehensive studies done by Sharma and Rai (2012) that in Sikkim Himalayan region the human observations over the last 30-40 years have revealed that there is shifting of species over the agro-climatic range from lower to higher altitudes.

Similarly, small-scale local water storage options offer a means of collecting monsoon precipitation to provide for agricultural and household needs over the entire year, and they help to build community resilience (Vaidya 2015). Further, it has been projected that the north-western part of the North East region Comprising of Sikkim show an overall reduction in precipitation by about 3 percent in 2030s (Arrawatia and Tambe 2012). Therefore, the water storage may also become a key strategy for climate change adaptation.

The threats and impacts of climatic variability have been experienced throughout the Himalayan region and some of them are mentioned above precisely. But in the same period it has been witnessed that the people are trying to adapt with the changing environments. Adaptation is the only option or pathway to counteract changing environment in Himalayan region.

4.3 Adaptation Strategies: Experiences from the Field

The villages under study area Samdong-Kambal and Rakdong-Tintek GPU are largely dependent on primary economic activities such as agriculture, dairy, livestock, poultry

and bee keeping. As per the respondents, the air temperature has shown a significant increasing trend in the villages. The people's perception of villages brought important information regarding the changes in climate over the long period of experiences which indicated that the weather patterns have become unreliable and adaptation became important initiative in the villages.

According to the respondents, they have implemented a technique of planting trees around the water emanating areas so that the dying springs can be revived. Furthermore, they believed that the maintenance of adequate forest covers in the upper portion of the spring emanating areas, for them it acts as recharge zones in order to rejuvenate the water level in the area.

The problem of crop failure according to time changes is not a new phenomenon in villages but during the last 10-15 years the region faces acute water problem leading low productivity of crops such as rice, maize, millet, buckwheat, large cardamom and green vegetables. Most of the respondents centralised the issues of highly commercial large cardamoms and ginger which are facing serious health diseases like Chirkey, and Furkey which reduced production level.

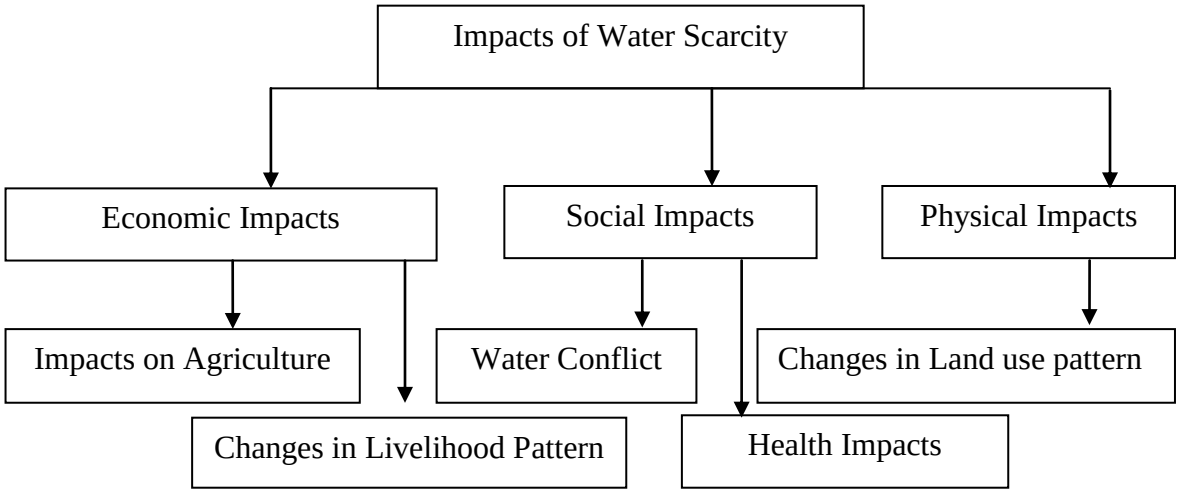
Since two years, some villagers have re-planted the new cardamom sapling (Saremna) brought from far place (west Sikkim) to village. And interestingly, the villagers are quite happy that the health of replanted sapling are in good condition and has not been attacked by any diseases. As far as Sikkim Himalaya as a whole is concerns, some of the initiatives have been taken as:

> *"Undertake large cardamom rejuvenation programme through control of disease and pests. Involve ICAR, Spices Board etc with a special focus on identification of emerging diseases, production of quality plant material including tissue culture. Building systems in horticulture department to provide advisory services for improved management practices including shade*

trees. Continue the ginger disease management programme, to control pests and diseases through biological and organic interventions. Intensify Sikkim mandarin orange rejuvenation programme by providing technological and input support which may include budded plants for early fruiting, drip irrigation, mulching etc" (Bhattacharya et al, 2012).

In recent years overall temperature in both day and night has shown increasing trend due to which water bodies (natural springs) have started drying up. In the villages the adaptation became very difficult because of water scarcity. Therefore, the water scarcity in the villages is the major cause of concern. As per the respondent the water scarcity has direct impacts in water intensive agriculture such as paddy and cardamom. The impacts of water scarcity in the villages are shown below:

Figure 2: Impacts of Water Scarcity



Source: Based on FGDs, Sept. 2016 (Samdong-Kambal and Rakdong-Tintek GPUs)

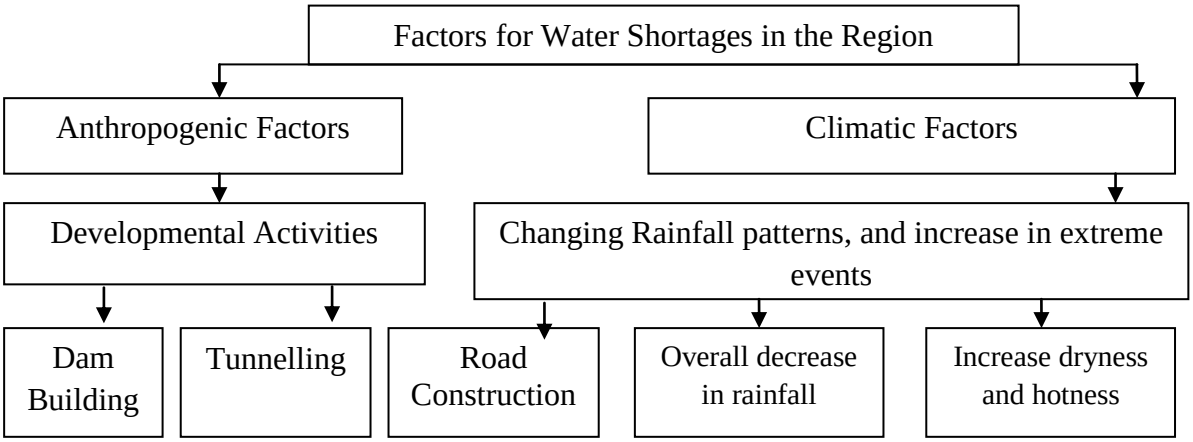
The impacts of water scarcity in study area are shown in above (Figure 2) with the help of PRAs and FGDs. It reveals that there are broadly three sectors such as economic, social and physical on which water scarcity has impacted immensely. According to villagers, the water scarcity has impacted on agricultural sector which led to changes in livelihood patterns. Similarly, due to water scarcity there arise

sometime water conflicts among the communities. It has been also reported that the occurrence of land use changes in the region due to dryness of land surface.

In water scarce condition, it has also been observed the diseases and a pest in citrus fruits in the villages. It was identified this disease has an adverse impacts on productivity as drying of twigs from the tip, root/foot rot, scab, sooty mould, red rust, nematodes, vascular-borne disease caused by Tristeza virus, colonization of ants in the citrus twigs etc.(Sharma and Rai 2012).

As per the information given by villagers, they are trying to cope with the changing environment in the region through different techniques but it is very difficult to maintain it because of water shortages. There are different factors that responsible for the water shortages in the villages as under:

Figure 3: Factors Responsible for Water Shortages in Study Area



Source: Based on FGDs, Sept. 2016

The figure 3 reveals that there are two factors responsible for water shortages i.e. climatic and anthropogenic factors. According to the respondents both the factors have actively deteriorating the region. The villagers discussed that the climatic factors such as changing rainfall patterns, hotness, coldness etc. are experiencing for the last

10-15 years but the anthropogenic factors (developmental activities) such as dam building, tunnelling and road construction immensely deteriorated the region.

Almost all the respondents from Rakdong-Tintek and Samdong-Kambal GPUs revealed that overall temperatures were slightly higher as compared to last one decade. And the rainfall has decreased during the winter season. More erratic rainfall sometimes and delay in the exact arrival of the rainfall. Extreme events will have greater impacts on sectors with closer links to climate, such as water, agriculture and food security, forestry, and health. Therefore, based on the evidences provided by the respondent that change in climate has the potential to seriously affect water management systems in the region.

There is general acknowledgement among the villagers that climate and weather conditions have impacted in many grounds noticeably in recent years by becoming hotter and drier than normal. According to the respondents the growing and production level of crops reduced due to extreme events. The observed climatic variability and its impacts are as under:

a) Almost 80% of natural springs dried up in the region.
b) There is no scope of growing vegetables because of acute water problem.
c) Reduced crops productivity due to increase in pests and disease.
d) Decreasing soil fertility.
e) Even if the vegetables are grown then productivity remains unsatisfactory.
f) Morning and night cold increased due to cold air blown from dam during winter time.
g) Production of fruits like oranges and banana has decreased.
h) Almost 80% of the kitchen commodities they are buying from the market which is imported from Siliguri (State of West Bengal)

In the other hand, frequency of landslides increased manifold during summer (rainy season), it is further accentuated by the tunnelling (dam) and road constructions in the region. During monsoon season of 2014 and 2015 experienced erratic rainfall and immense damaged done by landslides along roadside and river bank. The impacts done by hydropower dam in the villages are as under:

a) Cracks in the houses and lands
b) River bank erosion and sinking
c) Aggressive Landslides
d) Deforestation
e) More mosquitoes in summer season

So far, the people of the region have applied different adaptation strategies to tackle from such impacts as below:

4.3.1 Agricultural and Livestock related Adaptation

The agriculture and livestock are the main sources of income in the village. The agricultural productivity such as cardamom, ginger, orange, rice, and vegetables have reduced comparatively for the last 10-15 years. The native people of this region believed that the declining trends of agricultural productivity are caused by climate variability as well as the anthropogenic cause (hydropower dam and tunnelling).

According to the respondents there have remarkable changes in the cropping pattern in the region; most of the agricultural land became fellow or barren land for the last 4-5 years. The water intensive agriculture like rice has been reduced, and cardamom field left uncultivated because of disease as well as insufficient water. They have

changed the timing of sowing and harvesting period of rice and maize. Recently, some of them have started re-cultivating or replanting cardamom species.

For water intensive agriculture the people using long channel or (Kulo) to bring irrigation water from the water sources (natural spring or Kholsa) for rice cultivation but this became challenging task due to water shortages during the last one decade. Almost 80% of natural springs have dried up and remaining 20% become seasonal. The villagers used to have surplus of cardamom and vegetables but due to acute water problem the productivity has gone down; therefore people are now dependent from other sources.

Dairy Farming

The cardamom, ginger and oranges used to be main source of income before but since last 8-10 years the production level has gone down. Other than agriculture, the dairy farming is most important source of income generation in the region. There are varieties of fodder plants such as *amliso, neebara, sarkari ghass, gogun* etc. They added the fodder plants to promote dairy farming in the region are good adaptive initiatives.

Bee Keeping

According to the community people some of them have adopted bee keeping (Mawri Palan) as a means of income generation. Meanwhile, Sikkim is identified as one of the biodiversity hot-spots in the eastern Himalaya and development of bee keeping has greater scope in the region.

Terrace Farming

The practice of terrace farming is very common in study area. Terrace based agriculture in the region reduces the excessive land or the soil erosion during torrential rainfall. The people of the region have started re-planting of new species of cardamom i.e. Seremna in terrace land. The production or the outputs is yet to come from the field.

Moreover, the people are getting good opportunities from MGNREGA scheme to achieve suitable income generation as well as promotes the agricultural, livestock and village road (footpath) related work in the society. In Sikkim this scheme promotes agricultural activities to generate production level. Similarly, the scheme invests funds in building cow shed and pig shed to promote livestock related activities in the villages. The village footpath is also maintained through this scheme in village.

4.3.2 Disaster related Management

The study area is vulnerable to landslides along the roadsides, river bank slides, vigorous soil erosion and the problem of land sinking. According to the respondent, the land sinking is caused by the action of removing and storing process of river water reservoir which gradually pulling down the whole land lying above the reservoir. The houses and the land are in severe condition led by these sinking processes of landmass wherein, cleavages are randomly appeared in both houses and lands.

Similarly, if weather data of last 2 decades (1991-2000 to 2001-10) alone is taken into account, the number of rainy days as well as the annual rainfall in the mid hills of Sikkim has declined at the rate of 0.72 days/ year and 17.77 mm/year, respectively (Arrawatia and Tambe 2012). The extreme events have risen nowadays, drought like

situation during winter was rare in the past but it is occurring frequently in recent times. The repeatedly coming natural disasters in the region are landslides, rock fall, and debris fall which is increased manifold after the dam has been established. The dam site villages are so fragile that villager experienced land vibration (unnatural) and consequently led cracks in houses and lands.

Rim Treatment or protection wall

The villagers are more concerns of land sinking lying above the reservoir. The rim treatment or the protection wall is implemented by NHPC and this wall is meant for protection of river bank as well as the area outside the reservoir from land erosion and river bank slides. Such type of protection wall is constructed near the Dikchu town but is in a bad condition. The half portions of this wall get damaged and there is danger of being further river bank erosion or devastation of the region.

Plate 5: Rim Treatment or Protection Wall at near Dikchu (East Sikkim)

Photography: Navin Rai, 22nd November, 2016

Geo-synthetic cloths: The Company has used 'geo-synthetic cloths' to avoid river bank erosion, actually this cloths cover-up the sliding area from further slides or erosion. Generally, the logic behind using these cloths is it does not let water (rainwater) to percolate or penetrate inside the landslides portion. But according to the villagers, the cloths being used by the NHPC to protect land have not been successful, as the cloths itself gets washed away by the rain.

Disasters are either natural or manmade but Dikchu and adjoining area became hazardous zone due to anthropogenic drivers of disaster. Tunnelling threatened the people of the region leading unexpected landslides in unexpected places. The river bank erosion is very aggressive and there are chances of pulling down the inhabited land into river.

In 2014, the villagers were overshadowed when one of the family members of Lower Samdong village was unfortunately killed by rock fall inside the house due to land vibration. During conversation with villagers one respondent Mrs. Kopila Bhattarai of Lower Samdong replied that *"We are the real victims; here unnatural land vibration or shake has been experienced many times, one of the most vigorous unnatural earthquakes has recorded particularly in this village on 23 June 2016, but no property and physical harm recorded".*

Concrete roadside walling

The roadside walling is most common in Sikkim to protect road and land during rainy season from damages. The roadside walling is the only way to protect road and land from destructions. According to the community perception, nowadays the concrete roadside walling is not been able to bind or resist the landmass, it is because of erratic rainfall during monsoon period and it is further aggravated by the underground

tunnelling. It is further discussed that the land is not stable, it is in sinking condition and people are most susceptible and vulnerable in this area.

Plate 6: Landslide during torrential rainfall at lower Rakgong village

Plate 7: Concrete roadside walling to protect road at lower Rakdong village

Photography: Navin Rai, 10th August, 2016

4.3.3 Natural Resource Management

The government of Sikkim have already started springshed development programme or *Dhara Vikas* to revive springs in Sikkim. This strategy is being run by various department of government with support of private institution. The main objective of this programme is to promote climate change adaptation strategy for drought prone areas by reducing surface runoff of rainwater and allowing more water to percolate down to recharge underground aquifers which help in increased discharged from springs.

As far as the study area is concerned, the plantations have been done by the villagers in fragile landforms to protect land from degradation as well as to revive the streams in the aquifer. The suitable plants like *Terminalia myriocarpa* (Panisas), *Duabanga grandiflora* (Lampati) and banana species were planted in area.

The government have promised to fetch the water to every households but the promise is yet to be fulfilled. In order to store water, the government have facilitated cemented tanks but it remains empty throughout the year. However, the villagers have to go distant other sources in order to manage (mitigate) the acute water shortages during winter. The eighty percent of the natural springs already dried as per the information being given by the villagers. Furthermore, the water sources on which villagers are depending upon are most vulnerable and comparatively have less water volume than past.

4.3.4 Lifestyle Related Adaptation

As far as lifestyle related adaptation is concerned, they preferred private and government job rather than doing agriculture and livestock. The young people

preferred to go pharmaceutical company for income generation for their livelihood sustenance. The young people perceived that to work in the farm is scope less and economically less attractive. Since, the region has acute water problem and to maintain agriculture in the region is very difficult.

Table 8: People's Perception and Adaptation Initiatives to extreme events and Changing Climate

Climatic Parameter	Experienced Changes	Experienced impacts	Adaptive Initiatives of the Community People
Temperature	-Increased overall temperature (Increased warmer days). -Intensity of hot days increased. -Not so extreme cold at winter.	-Insects and pests (diseases) are appearing in crops. -Erratic landslide in rainy season. -Drought like condition in winter season. -Natural springs are drying. -Water Scarcity due to less rainfall. -Decreased in Agricultural production.	-Some of them have access machine like fan and fridge during extreme hot. -Changes agricultural pattern (skipping the timing of sowing and harvesting period of crops)
Precipitation	-Uneven rainfall (sometime erratic rainfall and sometime drought like condition). -Shortening rainfall season. -Less rainfall during winter. -Rainfall intensity during summer increased.	-Water scarcity -Drying up of natural springs from the original aquifers. -Reduced agricultural production.	-Managing the water for household and livestock through pipe water from the available source (farther sources). -Planting trees in and around the water's emanating point or source.
Coldness/Hot-ness	-Duration of overall coldness decreased. -Increased overall hotness	-Production in Fruits and vegetables decreased (Orange, cardamom and green vegetables).	-Changes in cropping patterns -Using organic materials (e.g. organic manure, pesticides and insecticides).
Landslides	-Facing aggressive landslides due to erratic rainfall.	-blockage of road and village footpaths.	-Traditional concrete walling -Bamboo and broom grass planting in fragile

			areas.
Water scarcity	-Almost 80% of natural springs dried up and became seasonal.	-Declined food productivity (Production level of rice, orange and Large Cardamom reduced). -Food scarcity or shortages.	-Importing vegetables from Siliguri (City of West Bengal). -Agricultural land remained uncultivated or (fellow land).
Drought	-longer dry period	-increased dry land	-Used dry land under fodder crops like broom grass (Amliso), Fig tree (Neebara), Khanew etc.

Source: Based on PRA and Focus Group Discussion

4.4 Conclusion

This chapter tried to sketch out the major climate change adaptation initiatives practiced by the local community of Samdong-Kambal and Rakdong-Tintek GPUs. An important grounded insight in respect of climatic variability and its impacts on community livelihood have been focuses in the chapter.

According to the villager's perceptions, it was discussed that Sikkim Himalaya is under severe impacts of climatic variability for instance, the extreme events in the form of erratic rainfall, frequent winter drought, storm, hailstorm etc. The climatic variability have greater socio-economic-environmental implication such as -uneven rainfall, increased warmer days, decreased rainy days, longer dry period, shorter winter days which leads to erratic landslide in rainy season, drought like condition in winter season, water scarcity due to less rainfall, drying up of natural springs and decreased in agricultural production.

While, the villagers have started adaptation strategy to counteract changing environment such as agricultural and livestock related adaptation, disaster related

adaptation, natural resources and lifestyle related adaptation. The climate is changing but in fact the villagers are further affected by the dam building.

The important insight of this chapter was to highlight the different adaptation initiatives and techniques adopted by the villagers. The people of the villages have changed the cropping patterns and changed the timing of sowing and harvesting period (at least ten days late in case of lately rainfall) of rice and maize. The villagers have commercially sound dairy farming but during winter season the available resources like grass, fodder and water becomes limited to feed their livestock. Therefore, the people of the region have argued and demanded water facilities for their livelihood. It is highly recommended that the water is everything and should be facilitated for the people of the villages.

Chapter 5
Conclusions

Globally accepted win-win energy through hydropower dam appears to be one of the most contesting developmental pathways in the face of climatic variability to attain sustainable, clean and green energy in Sikkim Himalaya. In this study the different grounded perspectives have been assimilated and analysed in order to understand the impacts being posed by hydropower dams and climatic variability.

The different construction stages of hydropower dam have been taking into account in order to understand the people's perception around hydropower dam like pre-construction (before 2000), during-construction (2001 to 2008) and post-construction (after 2008) of Tista-V. The observations in dam affected site and various conversations with the locale people brought good information. It has been identified that the hydropower project have affected the region socially and environmentally, wherein undesirable destructions like drying up of natural springs, landslides, riverbank slides, cracks in houses and land appeared distinctly. Similarly, it has also been identified that the people have experiences of climatic variability in the region.

It has been observed that the upper Tista catchment have experiencing climatic variability in the form of rising temperature, and decreasing rainfall patterns but the damming construction and water diversification adds up the severity of the condition. The issue further broadens when the loss of water quality and quantity was raised by the local people wherein the developments are in name of mere national interest. And it was claimed that in the face of climatic variability, the quality and quantity of the river water has gone down due to dam building. Furthermore, the developmental race

of hydropower dams in the Himalayan region has serious implications for the well-being of the mountains community. Hence, the people are critically voicing against the construction of cascading dams for the sake of environment (Arora 2008; 2009).

It is an arguing factor that the voices of the local people rooted from these problems were not listened by the government. Therefore, the community people have reframed the state-led hydro-mission as a destructive and devastating developmental pathway wherein the voices and claims made by the common people treated as irrational and delegitimized by the project developer and the state government. In fact, the environment has directly and indirectly linked with different aspects of societal, economic and political and has serious matter of debate at local, national and international security.

This study is guided by an overarching research question i.e. "*how do local people build their perceptions of climate variability and hydro power development in Sikkim Himalaya. And how do social groups adapt to the changing environment?"*

The study have tried to sketch out the different arguments and the discourses of hydropower dam and changing climate. In the face of climatic variability, the construction of hydropower dams reflecting the social antagonism, mostly in Himalayan region. Kyoto protocol (1998) declared that GHGs are major source of global warming from fossil fuel based energy and there should be an alternatives for this energy. Therefore, CDM have highly put forwarded their heinous strategy to construct mass numbers of hydropower dams in mostly developing countries to generate clean energy. But the local people made their arguments against the hydropower dams where they believed that the construction of hydropower dam would lead to environmental and cultural destruction.

Similarly, the study have tried to recognized hydropower dam building as the most heinous and lead to substantial human impact on Riverine ecosystems. The surrounding environments are transformed due to quarrying, blasting, muck disposals, tunnelling and road constructions processes in the projected site. For instance, the small natural springs were dried up in the villages.

The study looked at the people's perceptions of hydropower and climate variability and their adaptive strategies in upper Tista catchment. The respondents in the villages were experiencing changing climate and they have been trying to adapt with the changing environment.

Particularly, the third chapter intends to explore the various grounded insights of environmental and social insecurity aggravated by hydropower dam in the face of climatic variability in Upper Tista Catchment (Sikkim). With regard to wider research objectives, this research has illustrated the people's perception of hydropower dams and climate variability in Upper Tista Catchment. The farmers generally had good memories of the past and people's perception of the issues related to climate variability and hydropower dam have been based on these memories. However, perceptions were strongly shaped by their experiences in the most recent years (Macchi, et al. 2011).

Most of the people centred their arguments against the dam construction which directly destroyed and devalued the existing natural settings. As per the villager's perception, the locality had sufficient amounts of water resources from perennial natural springs; the perennial springs existed throughout the year prior to the emergence of dam in the locality. The dweller of the areas have witnessed that due to underground tunnelling, the existing natural spring get diverted from the original

ways. As in corollary, the scarcity of water in the region has become a common issue in contemporary scenario.

Meanwhile, the average dam density across the Himalaya was 1.6120 dams/1000 km^2 which is comparatively more than the other places. Sikkim is part of Eastern Himalaya and is having the highest dam density in India i.e. (4/1000 km^2) (Pandit and Grumbine 2012). In fact, dams may be built for many reasons in general such as flood control, improvement of navigation, provision of water for domestic, industrial or agricultural use and generation of electricity but dams in Sikkim are meant for mere Hydro power generation in particular. The major concerns of the people was environmental insecurity led by hydropower dams.

It reflects from the hydropower discourse that the people who are most severely affected by hydropower dam have had little say in planning, design and implementation of these projects (Arora 2009). In order to understand and implement the policy in a defined area, one has to understand the people's opinion and perceptions over a particular context. It has been witnessed that in Sikkim Himalaya the people's opinion and perception regarding the hydropower dam and development were discarded during pre-construction and construction period (In Tista-V**)** (Sharma, et al. 2014).

The Tista-V was taken as study site in upper catchment in order to understand the people's perceptions about hydropower dam. The people's perceptions are framed into three categories as a) pre-construction b) during-construction and c) post-construction perception. Pre-construction perceptions of people about hydropower dam were totally different than post-construction perception. Most of the people during pre-construction period were attracted by the developmental facilities of the

project that was addressed by the state government during public commencement. But the construction of Tista-V dam started in 2000, which brought many environmental issues such as drying up of natural springs, reduced river water volume and excessive landslides during monsoon season. As per the villagers, the environmental degradations are still active in the region.

The ecologically fragile and seismically vulnerable zone faced changes in land use pattern, involving mainly conversion of agricultural lands and forests to roads, tunnels, and barren land. People of the study area i.e. Samdong-Kambal and Rakdong-Tintek GPUs became real victims of environmental degradation such as fears of uncertain landslides, future water insecurity, future food insecurity, fear of health hazards and changes in local environment.

In Upper Tista Catchment, the environment and the people are impacted by two drivers i.e. hydropower and changing climate. Furthermore, the fourth chapter tried to bring out the adaptation strategies adopted by the local people of these villages.

The adaptation strategy measures to climate variability and hydropower dam were identified in the study area through deep study basis. The information was gathered from the villagers with the help of extensive FGDs and PRAs in the study area. Some of the adaptation strategies used in this region is as disaster related adaptation such as roadside walling, terrace farming and planting suitable trees. Meanwhile, it has been identified the agricultural and livestock related adaptation such as bee keeping and dairy farming plays an important role in gaining income for the local people. It was found that they have been trying to adapt different techniques at community and household levels to cope with the changing environment. But it is also necessary to

assess the appropriateness of different strategies in the context of hydropower project and climate change scenario in Upper Tista Catchment.

The important findings are generated from case studies and they are as below:

Hydro-project involves extensive tunnelling in a geologically fragile landscape, the environmental and social impacts of which are grossly underestimated. The study site is more controversial in terms of environmental problems such as soil erosion, drying up of natural springs, and water scarcity.[15]

In the face of climatic variability the hydropower dams has accentuated the region by damaging environment. There are significant pressures on water resources in Samdong-Kambal and Rakdong-Tintek GPUs wherein people are dependent on limited available springs. Moreover, the perennial natural springs getting drying up therefore, the region are facing acute water problems during winter season and there needs of urgent water facility for household, irrigation and livestock.

The environmentalists and social activists' perspective prove the fact that environment has been deteriorated alarmingly due to unsustainable way of water resource development. It has been experienced and identified that the major water intensive agriculture such as paddy has been reduced and cardamoms are in vulnerable condition. Therefore, the voice against hydropower dam construction arises from the local level in Upper Tista Catchment. Finally, hydropower development for the sake of national and the state interests may lead to local environmental and cultural destruction.

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