Traditional Knowledge Systems and Methods of Disaster Risk Reduction among the Communities in Sikkim Himalaya

A Thesis Submitted

To

Sikkim University

In Partial Fulfilment of the Requirement for the

Degree of Doctor of Philosophy

By

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Date: 30/07/2019

DECLARATION

I, **Pribat Rai**, hereby declare that the research work embodied in the thesis titled **"Traditional Knowledge Systems and Methods of Disaster Risk Reduction among the Communities in Sikkim Himalaya"** submitted to Sikkim University for the award of the **Degree of Doctor of Philosophy**, is my original work. The thesis has not been submitted for any other degree of this University or any other University.

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Certificate

This is to certify that the thesis titled **"Traditional Knowledge Systems and Methods of Disaster Risk Reduction among the Communities in Sikkim Himalaya"** submitted to Sikkim University for the partial fulfillment of the degree of **Doctor of Philosophy** in the Department of Geography, embodies the result of bonafide research work carried out by **Pribat Rai** under our guidance and supervision.

No part of the thesis has been submitted for any other degree, diploma, associateship and fellowship.

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

We recommend this thesis to be placed before the examiners for evaluation.

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Dedicated

To the

Disaster Victims of

Sikkim and Darjeeling Himalaya

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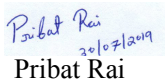

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Abbreviations

BMTPC-	Building Materials and Technology Promotion Council
Cartosat-	Cartography and Satellite
CBD-	Convention on Biological Diversity
CBRI-	Central Building Research Institute
CRED-	Centre for Research on the Epidemiology of Disaster
CSE-	Centre for Science and Environment
DEM-	Digital Elevation Model
DMMC-	Disaster Mitigation and Management Centre
DRR-	Disaster Risk Reduction
EM-DAT-	Emergency Events Database
FGD-	Focused Group Discussion
FIRMS-	Fire Information for Resource Management System
GI-	Galvanized Iron
GIS-	Geographical Information System
GSI-	Geological Survey of India
GoI	Government of India
GoS-	Government of Sikkim
HEC-RAS-	Hydrologic Engineering Center-River Analysis System
HFA-	Hyogo Framework for Action
ICIMOD-	International Centre for Integrated Mountain Development
ICSU-	International Council for Science
IEC-	Information Education and Communication
IMD-	Indian Meteorological Department
ISRO-	Indian Space Research Organisation
IST-	Indian Standard Time
LR&DMD-	Land Revenue and Disaster Management Department
MCT-	Main Central Thrust
NIDM-	National Institute of Disaster Management
NGO-	Non Governmental Organisation
NHPC-	National Hydroelectric Power Corporation
NRSC-	National Remote Sensing Centre

NSET- National Society for Earthquake Technology

NSSL- National Severe Storms Laboratory

RBC- Reinforced brick concrete

RC- *Reinforced concrete*

RCC- Reinforced Cement Concrete

SAPCC- Sikkim Action Plan on Climate Change

SSDMA- Sikkim State Disaster Management Authority

UNISDR- United Nations International Strategy for Disaster Reduction

UN- United Nations

UNEP: United Nation Environmental Programme

USGS- United States Geological Survey

WCDR- World Conference on Disaster Reduction

WCED- World Conference on Environment and Development

WDR- World Disaster Report

WHO- World Health Organization

WIPO- World Intellectual Property Organisation

WMS: Western modern science

WMS: White male science

Chapter I

Introduction

I.1 Introducing the Problem: An Outline

Similar appearing constructs of knowledge such as traditional knowledge, local knowledge, indigenous knowledge, folk knowledge, farmers knowledge and so on carries different meanings and implications; and as such , scholarship on knowledge is rife with discussion on which construct is the most appropriate (Berkes, Colding & Folke, 2000; Mazzocchi, 2006). For example, the word 'indigenous' generally highlights the autochthonous nature of this knowledge which may exclude the population who are not officially recognised as indigenous (Rai & Khawas, 2019), whereas the word 'local' may apply to a broader geographic context, although it may lack specificity (Berkes, Coding & Folke,2000; Mazzocchi, 2006). On the other hand the word 'traditional' emphasis on the diffusion of knowledge along a cultural continuity Berkes, Coding & Folke, 2000; Mazzocchi, 2006; Rai & Khawas, 2019), representing the relationship of living beings with one another and with their physical environment evolved by their adaptive processes (Berkes, Coding & Folke, 2000; Mazzocchi, 2006).

Though diverse term or constructs exist while defining the age old knowledge of local and indigenous community, still the nature and function of these knowledge system are similar to one another. These knowledge holds huge amount of information of the natural environment because of its centuries old experience and observation with the changing natural phenomena (Mercer, 2007; Rai & Khawas, 2019). History has

demonstrated how knowledge has been actively shared and exchanged among societies, and in this matter, holders of traditional knowledge are no different (Nakashima & Roue, 2002). Traditional knowledge acknowledges, accepts and adopts elements from other knowledge systems, just as other societies adopt elements of traditional knowledge (Nakashima & Roue, 2002). Thus, traditional knowledge is not static but dynamic in nature.

Table I.1: **Diversity of the term**

Terms	Meaning
Indigenous knowledge	Culturally integrated knowledge: knowledge of small, marginal/non-western groups.
Local knowledge	Knowledge rooted in local or regional culture and ecology.
Traditional knowledge	Handed down by whom, old, oral in nature (implying static, low level of change)

Source: Antweiler, 1998, p. 471

The role and value of traditional knowledge system for sustainable development and disaster risk reduction is becoming recognised by many scientists and policy-makers because of which currently, traditional knowledge has emerged as an evolving subject in national and international law (Anaya, 1996; Mauro & Hardison, 2000). Even the Convention on Biological Diversity (CBD)[1] have addressed the importance of traditional knowledge inventions and practices of indigenous and local communities and demands the approval of the holders of such knowledge for fair and equitable sharing of benefits arising from the use of such knowledge (Zedan, 2005).

Due to the nature and function of traditional knowledge as cost effectiveness and environmental friendly, its applicability in DRR and sustainable development is of

[1]The Convention on Biological Diversity was introduced at the Earth Summit on 5th June 1992 and legally came into force on 29 December 1993. The primary goal of CBD is to look into the sustainable use of biodiversity with fair and equitable share of benefits arising from the use of genetic resources.

much relevant (WCDR 2005). For example, the world's most biodiversity rich region are also the homelands of indigenous people (Nakashima & Roue, 2002). Although modernisation degraded the environment, the traditional culture or way of life and living was sustained and maintained across the local ecological system (Nakashima & Roue, 2002) in many other of the world.

However, modern scientific world usually ignores the traditional knowledge of indigenous as well as local communities, treating it as mystical or spiritual (Mercer, 2007; Rai & Khawas, 2019), primitive, emotional and un-intellectual what? (Warren, 1991; Briggs, 2005). The scientific world has largely focused on the technocratic paradigm[2] or solution while dealing with natural calamities. Therefore, denying the wider historical and social dimensions of natural hazards (Mercer, 2007; Rai & Khawas, 2019).

In contemporary era, we have witnessed various advanced technological innovation for disaster risk reduction (Rai & Khawas, 2019). For example, invention of high resolution satellite imagery, digital cartography, modern engineering building techniques to high yielding agricultural production (Rai & Khawas, 2019). However, when we observe the global disaster data base from 1900 to 2014 formulated by the Centre for Research on the Epidemiology of Disaster (Belgium), none of the above technological innovation have been highly effective in lessening the impact of disasters upon the people residing in both developed and developing nations.

Even World Disaster Report (2016) highlight that the estimated damage runs in the millions (US dollar) by natural disaster is highest in high human developed nations. Thus, this raises the question with regard to the capability and sustainability of the so

[2]Believes only in logical and scientific explanation

called modern civilization and their advanced technology in reducing disaster risk (Rai & Khawas, 2019) in coming future. As Deken (2007) rightly pointed out that focus on abundant scientific data and technology may not always be helpful in reducing the level of vulnerability and risk of natural hazards.

It has been just around 60 years that modern scientific societies (or institutions) have planned or created numerous formal disaster risk reduction frameworks for a safer world (Rai & Khawas, 2019). For example, even the United Nations-General Assembly formally began to recognise the need for emergency assistance in any disaster from 1960s onwards when they passed the resolution 2034 in 1965 (UNISDR n.d; Rai & Khawas, 2019). Since then, a number of disaster risk reduction (DRR) framework emerged in global circle (Rai & Khawas, 2019). Three such prominent ones are the Yokohama strategy in 1994, the Hyogo framework 2005-2015 and the recent Sendai framework 2015-2025 for DRR– all of which had different themes and areas of focus (UNISDR, n.d).

Even above three international framework for DRR slowly shifted towards the promotion of technological inputs for DRR in local level (Poterie & Baudoin, 2015). While the Yokohama strategy valued the local community partnership in disaster recovery and emergencies, the Sendai framework focused on 'aid recipients' (Poterie & Baudoin, 2015). Thus, reflecting the top down approach of new international DRR framework where, more investment in technological solution became the major criteria (Poterie & Baudoin, 2015).

In the context of the Indian State of Sikkim, disaster management rules and policies were formally introduced only after 2007 when the Government of India (GoI) introduced the Disaster Management Act on 25 December, 2005, mandating each

state to carry the State Disaster Management Authority along the framework or guidelines of the Disaster Management Act, 2005. However, it was only after 5 years after the enactment of the Disaster Management Act (2005) that the Government of Sikkim (GoS) worked towards its implementation. The GoS formed the Sikkim State Disaster Management Authority in 2010 under the Gazette notification dated 30th November 2010. However, mentions or inclusion of local traditional knowledge and its significance in DRR were absent in all the new policies and rules. In fact even the National Disaster Management Act of 2005 as well as the Sikkim State Disaster Management Policies and Rules has kept traditional knowledge of indigenous and local people out of the purview of DRR.

Before the introduction of Sikkim State Disaster Management Authority (SSDMA) 2010, mostly the post disaster management or relief work was the only significant management undertaken by the GoS. After the formation of SSDMA in the line of National Disaster Management Act 2005, mitigation and preparedness became the major disaster management strategy.

It was the 18th September 2011, with epicentre near North Sikkim earthquake that rocked Sikkim that revealed the lack of SSDMA in preparedness and mitigation strategy. Only the post disaster management was active but with little success as most of the relief workers were not trained in such Himalayan topography. The Mantam landslide in Dzongu, North Sikkim on the 13 August 2016 again highlighted the lack of pre-disaster management strategy of SSDMA. This shows the ignorance of SSDMA in understanding and exploring indigenous and local knowledge of the people who are more aware of their surrounding area.

In 2015 Sikkim State Disaster Management Plan Volume 1: DRR and Mitigation Plan identified the need to document the traditional wisdom of the indigenous community for disaster risk reduction. However, the report was not been able to highlight properly how this may be achieved and how indigenous knowledge could be integrated in main stream State Disaster Risk Reduction Framework.

Even the teachers handbook for class 4 to 8 student published by SSDMA describe natural hazards and disaster from the physical criteria and educate the student from the perspective of formal DRR stakeholders. Thus, totally ignoring the dissemination of basic traditional DRR knowledge of the place. Deken (2007) and Mercer (2010) rightly said that, though research institutes and formal development organisation are acknowledging the significance of traditional knowledge of indigenous and local community in DRR, in practice very little documentation has been made.

Thus, the study conceptualise traditional knowledge of both the indigenous and as well as other major local communities of Sikkim Himalaya. Their process of theorizing the man-environment relationship express the meaning of sustainable investment thus, providing the alternative for the dominant consumptive value of modern society (Hunn, 1999; Mauro & Hardison, 2000).

Documenting age old traditional knowledge from both the local and indigenous communities can provide not only vital opportunities for the planners and policy makers for reducing the vulnerability to natural hazards but also it can bring up the integration framework for DRR by bridging the gaps within the modern scientific DRR framework. Traditional knowledge has different sets of component which promotes the development of relational or holistic approach. It involves, interacts and interconnects the human, nonhumans (animals and plants) and nature together, thus

setting a perfect balance for sustainable development and DRR (Rai & Khawas, 2019).

I.2 Conceptual Framework

The word 'traditional' normally implies the static nature of knowledge by many academician and researchers (Rai & Khawas, 2019). For example, Warren in 1995 denotes the word 'traditional' as the 19th century attitude of "simple, savage and static" (Warren 1995 in Berkes et al., 2000; Rai & Khawas, 2019). For this reason, some scholars favour less value laden term i.e. 'indigenous knowledge' (Berkes, Coding & Folke, 2000; Rai & Khawas, 2019) which highlight the autochthonous nature of internal origin and culturally integrated knowledge (Antweiler, 1998; Rai & Khawas, 2019) of native people, thus making thing easier in denoting a particular group of people (Nakashima & Roue, 2002; Rai & Khawas, 2019). However, this way of conceptualisation also has a drawback as it ignores the knowledge from community who are not officially recognised as indigenous.

In most of the developing regions of Asia and Africa it is not wise enough to use the word 'indigenous' and any attempt to designate one group as indigenous but not another, provokes confusion (Nakashima & Roue, 2002; Rai & Khawas, 2019). For example, in central Tanzania, paddy was grown only since the 1930s, when it was introduced by Asian immigrants to the area (Shaka, Ngailo & Wickama, 1996; Rai & Khawas, 2019). Today it is widely grown by African farmers, all of whom consider rice cultivation (Rai & Khawas, 2019) as an indigenous activity (Shaka, Ngailo & Wickama, 1996). This example further raises the issue as to what actually constitutes 'indigenous', and how much the term has been term.

Distinction between indigenous knowledge and traditional knowledge do exist on the basis of academic discipline, context or language (Kelman, Mercer & Gaillard, 2012; Rai & Khawas, 2019, p. 3) and are not necessarily accepted as synonymous concepts. Both the concepts however have sufficient overlaps which allows them to be used interchangeably (Ryser, 2012; Rai & Khawas, 2019, p. 3). The term traditional knowledge would appear as a more encompassing one (Businge & Keim, 2009; Rai & Khawas, 2019, p. 3) and normally would refers to a more generalized expression of knowledge associating people with time-honoured ideas and practices (Ryser, 2012; Rai & Khawas, 2019, p. 3).

The concept of outdated or oldness is always mistaken while defining traditional knowledge (Rai & Khawas, 2019, p. 3). Traditional knowledge is based on existing knowledge (Haugen, 2005) tested by trial-and-error and transmitted to future generation orally or by shared practical experiences (Berkes, Coding & Folke, 2000; Rai & Khawas, 2019, p. 3). Dutfield (n.d) rightly states that 'traditional innovation' is the ability of traditional knowledge to change with the change in circumstances of the relevant people, groups, community or region (Le Gall, 2012, p. 68; Rai & Khawas, 2019, p. 3). It can be held by one person, many people or everyone belonging to a local people or an indigenous community (Haugen, 2005; Rai & Khawas, 2019, p. 3). Hence, the term traditional knowledge brings together the knowledge of indigenous and local people who may not be officially recognized as indigenous.

This research therefore focuses more on the conceptual framework of traditional knowledge highlighted by Dutfield[3], Berkes, Coding & Folke (2000), Connor (2003)

[3] Cited in Le Gall, S.B., 2012, 'Defining Traditional Knowledge: A Perspective from Caribbean', *Caribbean Quarterly 58*(4), 62-86.

and Haugen (2005). Traditional knowledge in the study has been defined as undocumented knowledge or oral knowledge which has been passed down from generation to generation to a particular cultural community, in the form of stories, songs, folklore, proverbs, cultural beliefs, rituals, community laws, local languages, culinary recipes and agricultural practices (Connor, 2003; Rai & Khawas, 2019).

The study therefore, documents the traditional knowledge of indigenous and local communities of Sikkim Himalaya in minimising vulnerability and disaster through a society by avoiding (prevention) or by limiting (mitigation and preparedness) the adverse impacts of hazards (Baumwoll, 2008), within the broad context of Disaster Risk Reduction framework highlighted by the United Nations International Strategy for Disaster Reduction.

I.3 Overview of Literature

Study in traditional knowledge started as early as 1960s when Gilbert White's Group[4] in Chicago initially focused on wheat farmers perception of and response to drought in Great Plain of North America (Deken, 2007). In 1975, David Vagdu even provided the first relevance literature on local environment knowledge in responding to natural hazards (Baumwoll, 2008) and Stevenson (1996) also highlighted the significance of indigenous knowledge in environment assessment before introducing any developmental project by the authority. Stevenson (1996) considered that indigenous people have in-depth knowledge of land, thus indigenous knowledge can play an important role in environment monitoring and project related changes.

[4] Gilbert Fowler White was the prominent American geographer in the University of Chicago. His keen interest was in natural hazard research and the group which he formed in 1960s was known as Gilbert White group.

In 1994, Yokohama Strategy and Plan of Action for Safer World recognised the significant role of indigenous knowledge in term of cost effectiveness and environmental friendliness (WCNDR, 1994). However, Yokohama strategy mostly gave preference to coping and recovery mechanism, where it highlighted the important role of indigenous people and their knowledge in facilitating easy and quick recovery at the local level (Poterie & Baudoin, 2015).

Since then, many research article and publication emerged around the world, which examined specific case studies on human response to different natural hazards. However, role and application of traditional knowledge still did not occupy even a minor place amidst the formal disaster planners and policy makers (Baumwoll, 2008) because before nineties, disaster was generally viewed as physical events (natural events) requiring technocratic solution.

Physical process was given more importance while implementing any disaster management policy where? (Deken, 2007) and technological solution with high tech warning system, surveillance and infrastructure was recognised as the significant tool for disaster management (Baumwoll, 2008). Thus, knowledge which originated within the local and indigenous community after long observation with natural phenomena was neglected and was more often than not regarded as unscientific (Baumwoll, 2008).

However, in spite of high investment in the area of disaster management, still the losses continued to increase every year. Development and lack of development both played a vital part in increasing the impact of disaster on human as well as on the environment (Deken, 2007). In other words, what has been increasing was not the

number of disasters but the impacts of these events on people and property (Twigg, 1998; Deken, 2007).

I.3.1 Disaster Risk Reduction – Evolution of Traditional Knowledge Paradigm

It was not until the beginning of the twenty first century that the value highlighted in the limited academic literature and reports on indigenous knowledge became to be reflected or incorporated in the policies of DRR organization (Baumwoll, 2008). Soon after 2004 Indian ocean tsunami, research in traditional knowledge in risk reduction gained pace. People of Simeulue island located just 40 km from the epicentre of 2004 earthquakeshocked the world by their traditional early warning system which helped them to survive the 2004 Indian Ocean Tsunami occurrence (Mercer, 2007; Baumwoll, 2008). The high survival rate was because of the local oral histories, which talked about the similar natural event happened in 1907 and advised the listener to run towards the hill top after observing the low tide soon after the prolonged shaking of earthquake (Mercer, 2007).

Though, modern scientific community totally failed to provide adequate warning of 2004 Indian Ocean tsunami, still many of them disregarded the indigenous knowledge of Simeulue island people and thus ignored incorporating the same in modern science (Mercer, 2007). However, various organizations namely International Centre for Integrated Mountain Development (ICIMOD) in South Asia, United Nations International Strategy for Disaster Reduction (UNISDR) and Kyoto University in Asia Pacific Region came forward with various publication of indigenous knowledge in DRR soon after the 2004 Indian Ocean tsunami.

In 2005 World Conference on Disaster Reduction, Kobe, Japan passed the new International Hyogo Framework for Action 2005-2015 focusing mainly on risk

preparedness and prevention strategies (WCDR, 2005a; Poterie & Baudoin, 2015). The framework highlighted the significance of community empowerment in DRR. However, external inputs, supports and external expertise became a major community empowerment criteria in understanding vulnerability and disaster rather than valuing the local community knowledge and expertise in DRR (Poterie & Baudoin, 2015)

In 2008, UNISDR came forward with the publication highlighting the need of proper policy formulation for recognising the potential of local community knowledge and practices in DRR. The report supported the significant of bottom-up approach in DRR and pointed out the urgent need to connect the traditional knowledge of local communities in coping capacities (UNISDR, 2008).Valuing and empowering local communities and their local knowledge in DRR can bring in reduction of loss of life, property and environment degradation (UNISDR, 2008).This gave a new dimension to the ongoing research and development, where human capability and behavior towards the environment emerged as the chief discussion globally in disaster management.

In 2015, new international DRR framework was formulated by United Nations office for DRR namely Sendai Framework for Disaster Risk Reduction: 2015-2030 (UNISDR, 2015). More emphases was given towards climate change issues and increased globalisation (Poterie & Baudoin, 2015). Though the framework highlighted the significance of local knowledge, focus was limited towards the technologically driven expertise for risk prediction and early warning systems (Poterie & Baudoin, 2015). Thus, indicating the top down approach for DRR (Poterie & Baudoin, 2015).

I.3.2 Application of Traditional Knowledge in Disaster Risk Reduction

Traditional knowledge is often defined as an expression of knowledge associating people with time-honoured ideas and practices associated with the other individual or family or community (Ryser, 2012). The following section highlights some of the practices and evidential measures of traditional knowledge in DRR.

According to World Disaster Report, 2014 (World Disaster Report, 2014) the estimated damaged in millions (US dollar) by natural disaster is highest in high human developed nation than the low human developed nations. This implies that abundant data and technology may not always help to reduce the level of vulnerability to hazards (Deken, 2007). Technological advancement is only a recent phenomenon and even before its evolution, numerous local communities around the world have prepared, operated and responded to different natural hazards simply using their indigenous knowledge (UNISDR, 2008).

According to Deken (2007), the understanding of local knowledge and practices can help identify what is needed and how people's participation in DRR can help to ensure a smooth and successful functioning of DRR project initiated by the external authority. It can contribute to cost-effectiveness in the long term, from both the financial and social point of view (Deken, 2007).

During the study of Eastern Terai region of Nepal and Chitral district of Pakistan, Deken (2007) reports that how the application of local knowledge by the respective locals has helped in reduction of flood disaster around their settlement. According to her, local environment and historical knowledge has played a great role in safe guarding the settlement in Chitral district of Pakistan. Local knowledge among the people in Chitral has allowed and enabled them to understand and interpret better

environmental warning signals (Deken, 2007). She also refers that a local knowledge within the Eastern Terai region of Nepal has helped the people to construct the flood resistance houses and at the same time non-technical local knowledge i.e. the spatial and social mobility within the community and neighbour helped them to construct a better recover strategy.

Weihua et al. (2008) have highlighted the traditional water management system developed by the local people of Xinjiang area of China during 17th century. The paper mentions how the local people living in dry area of the southern slope of mountain Tianshan in Eastern Xinjiang region known for its water scarcity have developed under ground canal by using their traditional tools. Therefore, the report described the effective traditional drought reduction technology in dry hilly topography of Xinjiang region and concluded that addition of scientific technology can further improve the method in future.

In 2008, United Nations Environmental Programme revealed that predictions and early warnings were mainly based on keen observation of the behaviour of birds, animals, insects, vegetation, trees, wind, air and water temperatures as well as clouds, earth movements and celestial bodies. Since different communities faced different environmental challenges around the world, they developed different ways of understanding and explaining the natural phenomena (UNEP, 2008).

In the context of prediction, Brian et al. (2008) has reported about how the indigenous early warning system developed by the indigenous people of Ghizo island greatly helped them to respond 2nd April, 2007, Solomon Islands tsunami. Soon after the earthquake, the village elders noticed the lagoon had been emptied. Indigenous people of Ghizo island immediately identified the upcoming disaster and responded promptly

in evacuating the settlement by moving to the higher grounds (Brian, Baumwoll & Moore, 2008). Therefore, the report concludes the effective indigenous mitigation technique when the right combination of education and physiography come together (Brian, Baumwoll & Moore, 2008).

Irfanullah and Motaleb (2011) have reported the traditional forecasting and preparedness knowledge of the local people of Bolipara village of south-eastern corner of Bangladesh. The report highlights the absence of modern technology for predicting any natural hazards. In addition, it describes how the people there developed their own knowledge for predicting and mitigating the arriving hazards by years of observation of the natural phenomenon. For example, when ants climb houses or cross the roads in line than heavy rainfall is predicted within 1 or 2 days. When wild boars and wild cocks come down the hills slope than flash floods are predicted by the local people (Irfanullah & Motaleb, 2011).

Similarly, Sethi et al. (2011) has provided an insight on the indigenous knowledge of the fishermen living in South Andaman Island. The report points out some of the early warning system and mitigation measures developed by the inhabitant of South Andaman island in predicting natural disaster. For example, local people predicts earthquake when the group of dog make unusual barking noise and when rainbows come in eastern side then they predict the chances of drought (Sethi et al., 2011). This helped the local people for generations to get alert and prepare themselves by storing dry food items like dry fish and paddy for drought and famine related disasters. Similarly, before the flood hazards, the people there also fence the dyke with bamboo poles to reduce soil erosion.

Traditional building technology as one of the unknown skill and practices of many people in today's modern society but during the earthquake disaster, the age old structure has played a significant role in mitigating the impact of earthquake disaster. For example, Langenlach (2010) has reported the resistance of traditional timber and masonry houses during Marmara and Duzee earthquake in Turkey which occurred on August and November 1999. He has mentioned that many traditionally build old timber and masonry houses remained standing next to the collapsed modern building. More than 25,000 people who died during Marmara earthquake, only few of those were trapped in traditionally build infill-structure (Langenlach, 2010). Thus, the paper points out the significance of traditionally build non engineering seismic resistance structure.

Similarly, Papadopoulos (2013) has also highlighted the effective resistance and significant resilience of traditionally build local structure during the Xanthi earthquake in Northern Greece. The structure not only performed well in terms of services but also showed an impressive resilience and strength capacity to earthquake load (Papadopoulos, 2013). He reports that, traditional structure rarely had a catastrophic collapse than the other modern concrete structure. Thus, the failure of modern concrete structure gave the sign of integration between the traditional and modern engineering design for building effective earthquake resistance structure.

Similar evidence of traditional seismic resistance structure was also highlighted by Khan in 2008. According to him, on 8th October 2005, a 7.6 magnitude of earthquake had a severe impact in the state of Jammu and Kashmir, India. About 90,000 household in Kashmir division and 8,000 household in Jammu division were greatly affected by the earthquake (Khan, 2008). However, regardless of the vast destruction, traditionally constructed building having the *'Taq'* and *'Dhajji-Dewari'* system

helped to save the lives of many individual in Jammu and Kashmir (Khan, 2008). Traditionally built structures sustained the major shock of the earthquake.

I.3.3 Himalayan context with special reference to Sikkim Himalaya

Mountain ecosystem is one of the fragile ecosystems of the world and it faces various hazards like earthquake, flash flood, forest fire, landslides, avalanches etc. however, this region also has rich biological resources and traditional knowledge base. Rao et al. (2003) highlights the inaccessibility and isolation of Himalayan region as the major cause of intact richness of traditional knowledge. People of mountain regions from centuries have preserved their traditional knowledge and it has provided them the bases of well being and livelihoods thus maintaining their health and also replenishing the environment (Rao et al., 2003).

In 2008, UNEP reported that ecological condition of any place not only changes the frequency and magnitude of natural hazard, but also works as natural barriers to reduce the impact of a disaster. For example, Gibji, Joshi and Dai (2011) highlights the conservational strategy of the Aka tribe of Arunachal Pradesh by their traditional methods and belief system. According to the report, Aka tribe in Arunachal Pradesh follow their age old belief of stories and proverbs before extracting any forest material/produce from specific area. The Mountain Vojo phu is very sacred for them. They believe that “one who plucks at mountain will lose the their way and soon suffer a death”. Such belief system helped them to protection their forest resources from over exploitation, which has directly helped them in mitigating and preventing various natural disasters like floods, drought and landslides.

Similarly, Negi (2010) have also reported the traditional belief culture of the villages in Uttarakhand for biodiversity conservation. He reported that local people fearing to

enter the sacred natural sites have helped the conservation of forest in some of the villages of Himalayan state of Uttarkhand. This has eventually protected the village situated below from impending avalanches during the winter months or sliding mountain debris throughout the year (Negi, 2010). In addition, conservation of forest resulted in safe guarding the spring water (Negi, 2010). Thus, the traditional belief itself reflects the experience which gathered the sustainable concept in different way to sustain the free and peaceful life.

Indigenous people normally belief that hydrological hazards are released by deities because of the human misbehaviour and uncleanness attitude towards the place where the deities reside (UNEP, 2008). To overcome such situation, indigenous people ask for forgiveness to the specific deities (UNEP, 2008). In Sikkim Himalaya similar traditional and cultural practices or belief have played a crucial role in protecting and conserving water sources. Local communities living around the rural areas in Sikkim Himalaya fear contaminating the spring-water sources and avoid pollution/defecation within the vicinity of the water sources (Sharma, 2012). These strong cultural beliefs has helped indirectly in the conservation of water resources in most of the villages of Sikkim Himalaya (Sharma, 2012).

Folklores are another cultural belief which has been transmitted to the community orally and most of it have originated due to the relationship existed between nature and human. Jha and Jha (2011) have highlighted one such folklore of Lepchas[5] community in Sikkim Himalaya. The story reflects the major landslide prevention methods by telling the listeners about which tree will be suitable to grow

[5] Among three ethnic communities in Sikkim Himalaya, Lepcha is one of them. Lepcha people are considered as the oldest and indigenous community of Sikkim Himalaya. The place name *Dzongu* in North Sikkim is home of Lepcha community where majority of Lepcha people resides. The place has given special status of protection from the government side to preserve the history and culture of Lepcha people i.e. no other community can buy or settle in Dzongu area.

in landslides prone areas. However, the paper identifies only one single method of traditional landslide mitigation techniques in Sikkim Himalaya.

Himalayan region is one of the most earthquake prone zone of the world. Though numerous earthquake occurred in this region, local people have survived its impact for centuries. Studies have found numerous earthquake resistant building structure developed by the indigenous people along the Himalayan belt. For example, Dixit (2004) has reported about the standing still of centuries old building structure in Nepal irrespective of number of earthquakes occurred. Even the National Society for Earthquake Technology-Nepal (NSET) has found the evidence of seismic-resistant elements in traditional building structure in Nepal (Dixit, 2004). He points out that, systematic exploration of those traditional wisdom and skill is needed in Nepal Himalaya which is fast disappearing due to change brought by the modern technocratic society.

South Sikkim Earthquake by Bhattacharya and Chourasia (2012)have also reported that out of 92,000 rural house, 54,000 traditional rural houses suffered various degrees of damage during September 2011 earthquake but the casualties rate was very less. Wooden framed houses with traditional *Ekra*[6] walling and light iron sheet roof was mostly intact. The traditional *Ekra* house performed significantly better than Reinforced Cement Concrete (RCC) frame (Bhattacharya & Chourasia, 2012).

During various natural disasters, different casualties like massive bleeding, loss of consciousness, shock and fracture are always reported along the high topographic area. As infrastructural development is often neglected here, the immediate medical attention by the governmental authority or NGOs is not readily available. In such

[6] Non-engineered traditional structure made up of bamboo beam-column, plastered normally by mud or cement. It is normally single or two storey house.

cases, traditional medicinal knowledge have worked as valuable recovery tool for the victim (Joshi et al., 2011) in the mountain regions.

Negi, Maikhuri and Vashishtha (2011) has reported the traditional healthcare practices among the village of Rawain valley in Uttarakhand, India. According to the report, local community's close affinity with the surrounding nature and inaccessibility of modern medical facilities became the chief cause in relying and developing rich ethno botanical knowledge for curing different diseases. The paper highlights that total of 63 plants species belonging to 43 families are used by local people here for treatment of more than 41 diseases (Negi, Maikhuri & Vashishtha, 2011).

In 2010, Panda and Misra came out with a work identifying and highlighting the function of traditional medicinal herbs of three ethnic community of Sikkim Himalaya namely, Lepcha, Bhutia and Nepali. Total of 44 local medicinal plant were recognised with their botanical name, distribution and uses (Panda & Misra, 2010). The study also highlighted the unwillingness of future generation to take up the traditional folk healing profession due to changing socio-economic condition in Sikkim Himalaya (Panda & Mirsa, 2010). Thus, to safe guard the traditional healing practices, the study purpose the identification of useful molecule for its integration in modern medicinal practices (Panda & Misra, 2010). However, the function of traditional herbs in DRR was not mentioned in the paper.

Similarly, Joshi et al. (2011) have also given the report of local medicine like *Banmara* (Eupatorium odoratum), *Bhui Champa* (Kaempferria rotunda), *Kukur Tarul* (Dioscorea deltoidea Wall) etc. which are used by the local community of Sikkim Himalaya. This traditional medicine are used for stopping bleeding, in reducing pain

and in regaining consciousness before the affected people are taken to the scientific/modern medical facilities (Joshi et al., 2011). Thus, the report have somehow highlighted the significance of traditional knowledge in post disaster medical response strategy. However, Sikkim being rich in biodiversity and ethnicity, more documentation of such traditional knowledge in DRR is needed. In addition, the use of traditional medicine is not very often acknowledged because of its association with 'witchcraft' and lack of safety assurance (Fletcher et al., 2013). Therefore, significant traditional medicinal strategies are not incorporated in national disaster response mechanism (Fletcher et al., 2013).

Role of traditional farming for sustainable agricultural practices is taking up a huge support base around the world. In Sikkim, changing land use study and the significance of traditional knowledge in conservation strategy within the *Mamlay* watershed, South Sikkim was first studied (Rai, Sharma & Sundriyal, 1994). The study highlights the changing nature of land use pattern in *Mamlay* watershed was due to rapid increase of population. The areas which used to be self-sustaining earlier were are no longer there (Rai, Sharma & Sundriyal, 1994). Therefore the paper describes the significant role that traditional knowledge can play in conservation strategy of *Mamlay* watershed. Some of the important traditional farming practices like mixed farming, crop rotation and agro-forestry adopted by the local people of *Mamlay* watershed earlier need to be applied (Rai, Sharma & Sundriyal, 1994).

Traditional food, both fermented and non fermented have a long history of it origination and local people have adapted such food for sustenance. In 1988, Tamang and Sarkar identified the method and preparation of six fermented traditional food of Sikkim and Darjeeling Himalayan communities. Whereas in 2010, 49 fermented food of Sikkim Himalayan communities was identified (Tamang, Okumiya & Kosaka,

2010). The paper explored the diversity of traditional food items with different elevation and individual ethnic community (Tamang, Okumiya & Kosaka, 2010). However, the paper also revealed the declining production and consumption of traditional food due to climate change and change in socio-economic life style of local people (Tamang, Okumiya & Kosaka, 2010).

In 2009, a study of taken upon the indigenous knowledge of Lepcha community for monitoring and identifying different birds species and its diversity at Dzongu, North Sikkim (Acharya, Chettri & Vijayan, 2009).The study was based upon theindigenous taxonomic knowledge of Lepcha community for biodiversity conservation rather then the socio-cultural adaptation or livelihood of Lepcha community in Sikkim.

Today, increasing commercialisation and urbanization and the subsequent erosion of traditional social networks has resulted in loss of traditional knowledge and its practices (Fletcher et al., 2013) in many Himalayan settlement zones especially in Sikkim Himalaya. Therefore in the context of Sikkim Himalaya, documentation of traditional knowledge and its various practices for DRR is a must. Simply highlighting its importance in DRR and sustainable development framework is not enough, until and unless the process, methods and its applicability is systematically documented, evaluated and integrated in DRR framework.

I.4 Rationale of the Study

Traditional knowledge and practices have been extremely significant for the livelihood of mountain communities (Sikkim Himalaya), who are often isolated from mainstream support. It has helped them to maintain their health and allowed them to use the environment in a sustainable way. Recently, there has been increasing recognition of the importance and usefulness of traditional knowledge in disaster risk

reduction in mountain areas. This vital knowledge-based-practices are however often ignored and due recognition have not been given yet. Therefore, they are being eroded with time due to implementation of western culture, economic development assistance, migration and mostly passing away of elders. It is high time to systematically document them and integrate them with the mainstream scientific knowledge for comprehensive disaster risk reduction. Holistic documentation of the role of various traditional knowledge bases in management of disaster shall enrich the ignored age old traditional wisdom of Sikkim Himalayan communities thus, avoiding the extinction of this knowledge system in coming future.

Timely preventative response to disaster risk requires technically sound, politically viable and communally acceptable early warning systems. This partly implies that disaster management planning and policy should be local people-centric one so that the local communities increase their resilient capability. Therefore, greater significance should be given on communities/ participation compared to other stakeholders in disaster risk reduction since they are the one who are directly affected by disasters. One feasible way of integrating local communities in disaster management processes is by putting local community resources, like their knowledge in use. Thus, encouraging participation of local community in DRR not only empowers the local people but also helps to propagate the needed information smoothly from grass root level towards the formal stakeholders. Therefore, the study havecritically appraisedthe role and extent of formal institutional disaster management framework of Sikkim State Disaster Management Authority. Exploring the significance of traditional knowledge in DRR would certainly help to fill up the gaps existed within the formal DRR framework and in addition it will also help to recognise the rights of ownership and the much needed acknowledgement of

traditional knowledge and its holders, thus safe guarding the ignored and vanishing traditional wisdom.

World today is shifting towards a modern thought and in many ways ignoring the age old traditional value and culture to generate fast and steady flow of economy. The rapid rise of modern technologies have made the human to ignore the environmental identity of the earth. For example, according to World Disaster Report (2016), from 2004 to 2014 people affected and people killed by natural disaster are highest among the developing nations. Though, this technological path paved the various ways for the human to tackle the emerging issues and hurdle, but it has also resulted in increasing the environmental disasters.

Ignorance of traditional knowledge by the modern society treating it as unscientific and irrational is the result why DRR institutional framework misses the significance of community participation and empowerment in planning and decision making. Scientific world forgets that this very 'unscientific' knowledge hold large amount of information of this natural world which can provide us with scientifically testable insights into some of the most pressing problems faced by mankind today. Our nature of adaptation is always built on traditional knowledge and adaptation is what we need in the period of changing climatic phenomenon and its unpredictable nature. The point is not to neglect or to talk about the negative impact of the modern or scientific knowledge in DRR. However, the study have focused on the existing dichotomies between the thoughts and the work of scientific and traditional knowledge, so that it helps to generate a proper systematic pathways for collaborative approach in DRR for the progress of both the community and the environment.

Disaster risk reduction is today a vital process to eliminate the future suffering but the cost incurred in disaster reduction process is too high and still the result in management of these efforts is not satisfactory. Developing nations and particularly the poor in those countries suffer most since most of them live on marginal lands and depend on high-risk, low return livelihoods. For example, the owners of buildings constructed with modern materials and technology normally belong to the socially and economically affluent classes. On the other hand, the financially weaker sections of the society are compelled to use cheaper and fragile materials because of its lower cost.

Thus, understanding of the working balance between traditional and scientific knowledge and techniques will help to bring a possible option during the phase of financial concerns for disaster reduction work. As most of the indigenous construction technologies have relatively low cost, the use of it can provides an opportunity for the economically weaker sections of society who are otherwise forced to live in weak constructions. However, unless and until integration of traditional knowledge with scientific knowledge is made, we cannot involve traditional knowledge into policy dimension or in any developmental initiatives. Thus, the study brings up the possibility of integration framework between traditional knowledge and scientific knowledge in DRR. Therefore, paving the path for valuing and legitimizing the practical and effective traditional knowledge in formal DRR framework.

Therefore, the primary research question of this study is '*what are the diverse traditional methods of the local communities in managing natural disasters and how can we integrate them with the formal scientific knowledge systems?'*

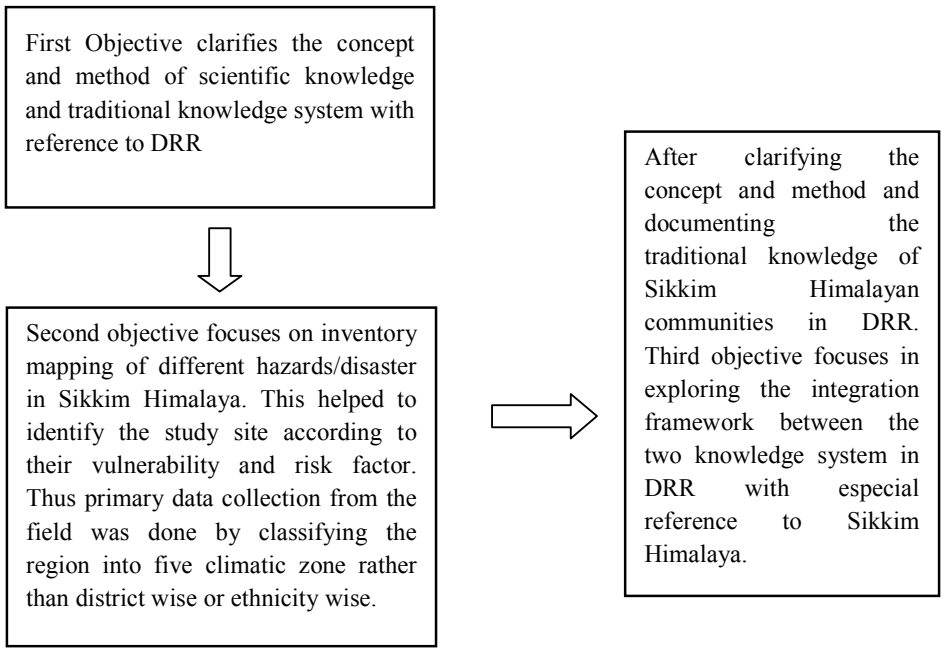
I.5 Objectives of the study

a. To evaluate the contesting bodies of traditional and western knowledge with reference to disaster risk reduction;

b. To prepare an inventory of natural hazards and map the response of local communities in Sikkim Himalaya;

c. To explore conceptual framework to integrate traditional knowledge with formal scientific knowledge in Disaster risk reduction.

Fig I.1: **Chronological link between the objectives**



I.6 Methodological framework for the study

Redman and Mory (1923) define research as a 'Systematized efforts to gain new knowledge'. Research consist of systematic method, initially introduces the problem, formulates the hypothesis or research question, collects the data and analyse the collected data to reach certain conclusion (Kothari, 2010). It is something that people

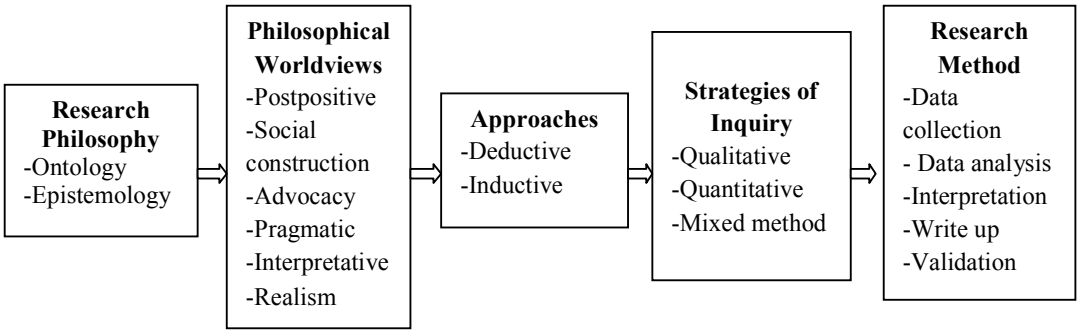
undertake in order to find out things in a systematic way, thereby increasing their knowledge (Saunders, Lewis & Thornhill, 2009).

Definition of research highlights the facts of doing research in a systematic way whereas the term methodology refers to the theory of how research should be undertaken (Saunders, Lewis & Thornhill, 2009). Before planning a research study, researchers need to understand the philosophical worldview to bring up the approaches needed in the study (Creswell, 2009). Then the strategy of inquiry that is related to the research approaches, and the specific methods of research that translate the approach into practice (Creswell, 2009) has to be built up and understood.

A number of models have been developed to illustrate the key element of research methodology. For example, research onion model developed by Saunders, Lewis & Thornhill (2009), has shown the important layers that needs to be considered before choosing data collection techniques and analysis. This layer consists of research philosophy at the outer layer whereas research approaches and strategies for data collection and analysis are at the inner layer.

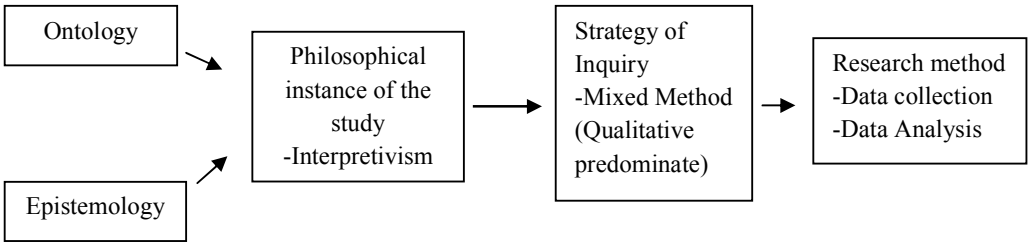
Another nested model developed by Kagioglou et al. (2000), consists of three elements: research philosophy, research approach and research techniques. This model highlights the fact that every research techniques are guided by the research approaches whereas research approaches are guided by the research philosophy. Both of the models show the importance of research philosophy in guiding any research work.

Fig I.2: **Conceptual Model of Research**



Source: Creswell, 2009; Saunders, Lewis & Thornhill, 2009.

Fig I.3: **Methodological Framework for the study**



Source: Creswell, 2009; Saunders, Lewis & Thornhill, 2009.

I.6.1 Research philosophy and its relation to the study

Research philosophy is a term that relates to development of knowledge and the nature of knowledge which contains assumptions of how we see the world (Saunders, Lewis & Thornhill, 2009). According to Deleuze[7], our research methods and projects do not begin in a vacuum, and neither do we as a subject. Instead, we find ourselves situated in the middle of a life in which ideas, opportunities and problems are thrown at us on a daily basis (Shaw et al., 2010, p. 10).Thus, we plan our research path with the world but never against it or above it (Shaw et al., 2010, p. 10). If the world is

[7] Cited in Shaw, I. G. R., Dixon, D. P. & Jones III, J. P., 2010. Theorizing Our World. In: B. Gomez & J. P. Jones III (Ed.) *Research Methods in Geography.* West Sussex: Wiley-Blackwell, 9-25

continuously presenting a problem to us, then the most better way to inquire it is to ask what exactly is the nature of the world? (Shaw et al., 2010, p. 10). This foundational starting point of inquiry help us to imagine those methods and toolkits that can be best suited for the research job (Shaw et al., 2010)

There are basically two ways of thinking about research philosophy- Ontology and Epistemology which will influence the research process. Ontology traditionally deals with question of existence, or what it mean *'to be'* or it is a set of assumption and theories that explore *'what the world is like'* (Shaw et al., 2010). The ontology spectrum is objectivism and subjectivism. Objectivism assumes that social entities exist in reality external to social actors whereas subjectivism believes that social phenomena are created from the perceptions and consequent actions of social actors (Saunders, Lewis & Thornhill, 2009; Shaw et al., 2010). The research study here have focused on communication and gathering of local knowledge which basically requires an interaction of people. Therefore, the ontology assumption for this research leans more towards the subjectivism.

Epistemology deals with our understanding of knowledge i.e. *how we come to know the world as a site for research and analysis* (Shaw et al., 2010). Saunders, Lewis & Thornhill (2009) defines the important distinctions of epistemology as positivism at one end and interpretivism at the other end. In the positivism philosophy, the researcher will work with an observable social reality and the end product of the research can be law-like generalization similar to those physical and natural scientist (Saunders, Lewis & Thornhill, 2009). Whereas, interpretivism is an epistemology which advocates that it is necessary for the researcher to understand the differences between the human roles as a social actors (Saunders, Lewis & Thornhill, 2009)

The research study required a data gathering from the expert and practitioners of age old traditional knowledge on disaster risk reduction. Therefore, the focus was more on the people's perception, the local practices and the awareness towards the disaster and risk reduction processes. For that the researcher needed to be part of what is being observed or interviewed in order to understand and explain the phenomena. Hence, the epistemology for this research leaned more towards interpretivism.

I.6.2 Selection of Philosophical World View/Paradigm/ Philosophical stances for the study- Interpretivism

According to Creswell (2009), choice of philosophical worldview for preparing research proposal helped explain why the researcher opt qualitative, quantitative or mixed methods approaches for the research. Therefore, the study followed the interpretivist approach because the main goal was to understand the meaning of the social situation from the point of view of those who live in it. Qualitative method pre dominated the methodology, although quantitative methods can also be utilized. Interpretivist approach had the flexibility to use mixed method strategy for the collection of data.

Table I.2: **Paradigms, method and tools (Interpretivism)**

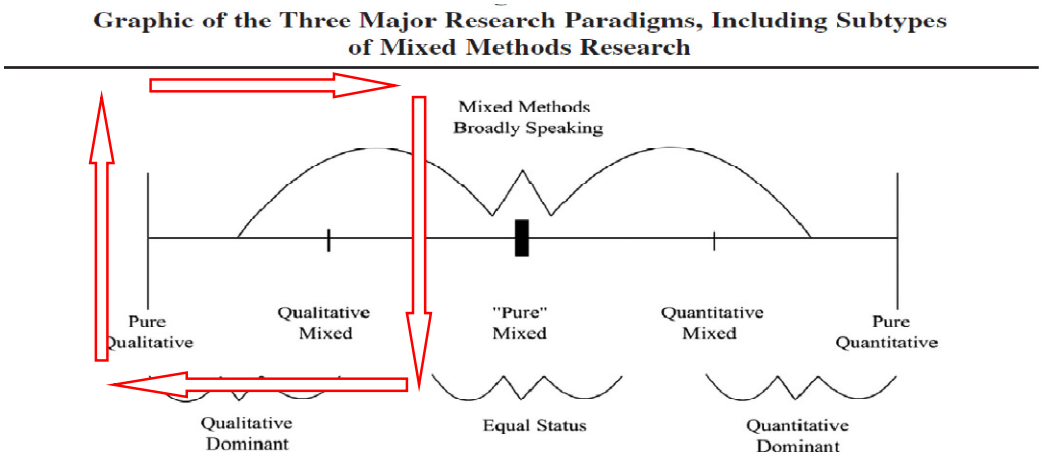
Paradigm	Methods (primarily)	Data collection tools (examples)
Interpretivist	Qualitative method predominate although quantitative methods may also be utilized	Interview, Observation, Document review, Visual data analysis

Source: Machenzie & Knipe, 2006.

I.6.3 Selection of strategy of inquiry for the study- Mixed method strategy

Strategies of inquiry are types of qualitative, quantitative and mixed methods designs or models which helps to provide a direction for a research deign (Creswell, 2009). For the said research study, mixed method approach has been followed as it helped to investigate the social world with more than one methodological tradition and techniques while gathering and analysing data (Johnson et al., 2007).

Fig I.4: **Mixed Method**



Source: Johnson, Onwuegbuzie & Turner, 2007.

In the above figure, the four arrows indicate the research strategies of data collection for the study. Here the qualitative data gathering is predominant as the study relies upon the interpretative approach while the addition of quantitative data will only play a supporting role for the study.

I.6.4 Research Methods- Data collection and analysis

Collection of secondary data- The source of secondary data includes the literature and reports from electronic database. The combinations of key words like 'traditional knowledge', 'indigenous knowledge', 'local knowledge', 'disaster', 'disaster preparedness', 'mitigation', 'disaster risk reduction' was used to extract the necessary

data. The electronic database consisted of: JSTOR website, UNISDR website, World Disaster Report website, ICIMOD website, Sikkim State Disaster Management Authority website.

For preparing inventory map of different hazards in Sikkim Himalaya, Digital Elevation Model and Satellite imagery was downloaded from the United State Geological Survey website. To include different natural hazards data inside the digital GIS map, various secondary data was also collected from Global and Regional Landslides Database, Geological Survey of India (GSI) database, Sikkim State Disaster Management Authority (SSDMA) database, Google Earth, Fire information for Resource Management System (FIRMS) and NRSC websites. Selection of the databases was done in such a way that it aimed at for making comprehensive covering issues to address the research problem and objectives (Rai & Khawas, 2019).

Table I.3: **List of major online secondary database sources**

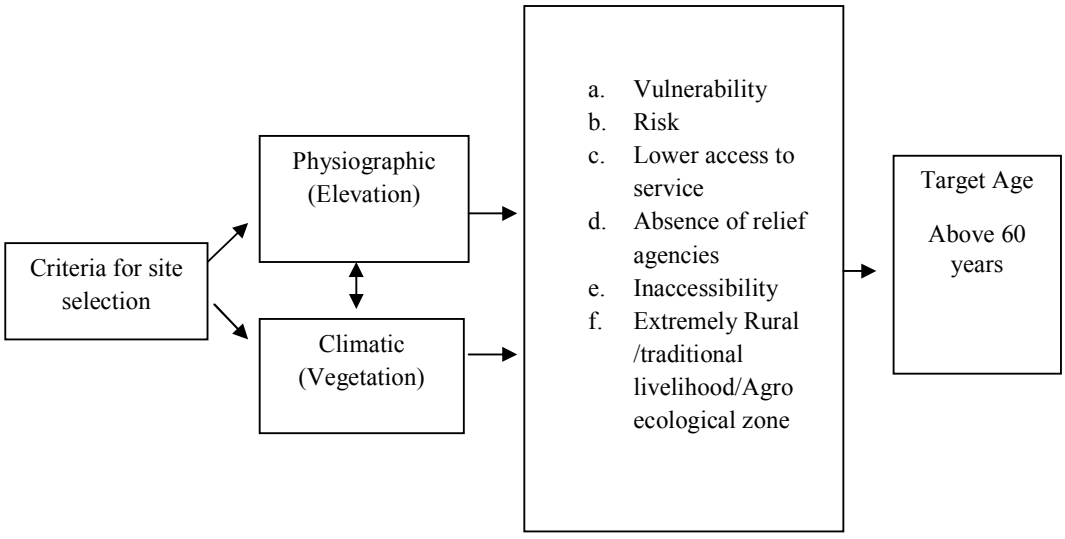
Digital Elevation Model and Satellite Imagery from United State Geological Survey.	EM-DAT International Disaster Database, from Centre for Research on the Epidemiology of Disaster.	Landslide data from Global and Regional Landslides Database, Geological Survey of India and SSDMA.	Earthquake data source from USGS, NRSC, Google Earth and SSDMA.
Forest Fire Data from Fire Information for Resource Management System.	Concept of disaster, vulnerability, risk and the International DRR framework from United Nations International Strategy of Disaster Reduction website.	Data on application of traditional knowledge in DRR was extracted from ICIMOD website, The Mountain Institute, Gangtok website.	Data on various disaster events in Sikkim from Sikkim State Disaster Management Authority.

Sampling- There is no homogenous or systematized knowledge base in the study area. Knowledge bases are scattered and at times may differ from one place to other.

Therefore, one of the major tasks for the study was to extract and collect as much relevant traditional knowledge information as possible and put them into right perspective.

The study site therefore has been selected according to the physical and climatic variation existing in Sikkim Himalaya. As geophysical and climatic variation not only influences different natural hazards but it also illustrates the livelihood dynamics in Sikkim Himalaya. Thus, selecting the area according on the basis of these factors have given the study the field location for documenting traditional knowledge system in DRR.Purposive sampling techniques have been used where the following chosen procedures or criteria has been mentioned below for selecting the sampling of population.

Fig I.5: **Purposive sampling for the study**



Interviews- The objective of interviews is to get detailed information, in the form of narratives or stories, of people's experiences, local histories, and shared knowledge to get verbal pictures of systematic behaviours. Unstructured interviews have been followed in the beginning to investigate the phenomena. However, semi-structured

interview was mainly carried out on individual basis for collecting the primary data. Semi-structured interview gave the room for corrective action in cases where questions were misunderstood. In semi-structure interview, rule of following a given order of question is not compulsory therefore it had a flexibility to add additional questions to get more information about the particular topic.

Thus, this method helped to provide a depth of information through the use of open-ended question, suggested by the researcher, and some that arose naturally during the interview process. Total of 45 semi-structured interviews were conducted along the four climatic zone namely Tropical, Sub-tropical, Temperate and Sub-alpine zone of Sikkim Himalaya and the target age group of respondents was above 60 years old.

Table I.4: **Total number of semi-structure interview in four climatic zone**

Tropical	Sub-Tropical	Temperate	Sub-Alpine
3	28	12	2

To understand the concept of disaster, its vulnerability and risk factors in various study sites from the local people perspective, a different set of 56 structured interviews with close ended question was also conducted. This structured questionnaire was prepared to rank the most common disaster and major intrinsic cause or factor of disaster from the local people's perception.

Table I.5: **Total number of structured interview in four district of Sikkim**

East District	West District	North District	South District
14	14	14	14

Focus Group Discussion- The main aim of FGD was to observe and examine the data gathered from the interview schedule. Total of four focus group discussion have been conducted along the four climatic zone of Sikkim Himalaya. Focus group subjects consisted of not more than 8 respondents. Among the 8 respondent, two were youth of age 30-40 years, while the rest of respondent was divided into three male and female of age above 60 years.

Table I.6: **Total number of focus group discussion in four climatic zone of Sikkim**

Tropical	Sub-Tropical	Temperate	Sub-Alpine
1	1	1	1

Fig I.6: **Questionnaire framework for identifying the role of traditional knowledge in reducing the vulnerability and risk factor in the Sikkim Himalaya**

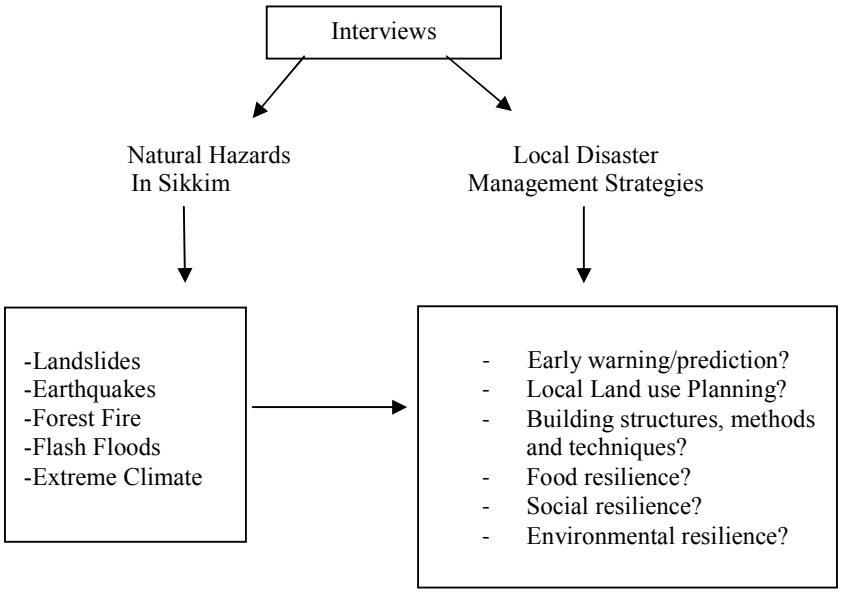


Table I.7: **Questionnaire framework for ranking of highly common Natural Hazards/Disasters**

Disaster	Earthquake (A)	Landslide (B)	Flood/Flash flood (C)	Forest Fire (D)	Drought/Water scarcity (E)	Famine (F)
Earthquake (A)	N/A					
Landslide (B)		N/A				
Flood (C)			N/A			
Forest Fire (D)				N/A		
Drought (E)					N/A	
Famine (F)						N/A
TOTAL						

Source: Adapted from the Mercer, 2007; Mercer et al. 2010

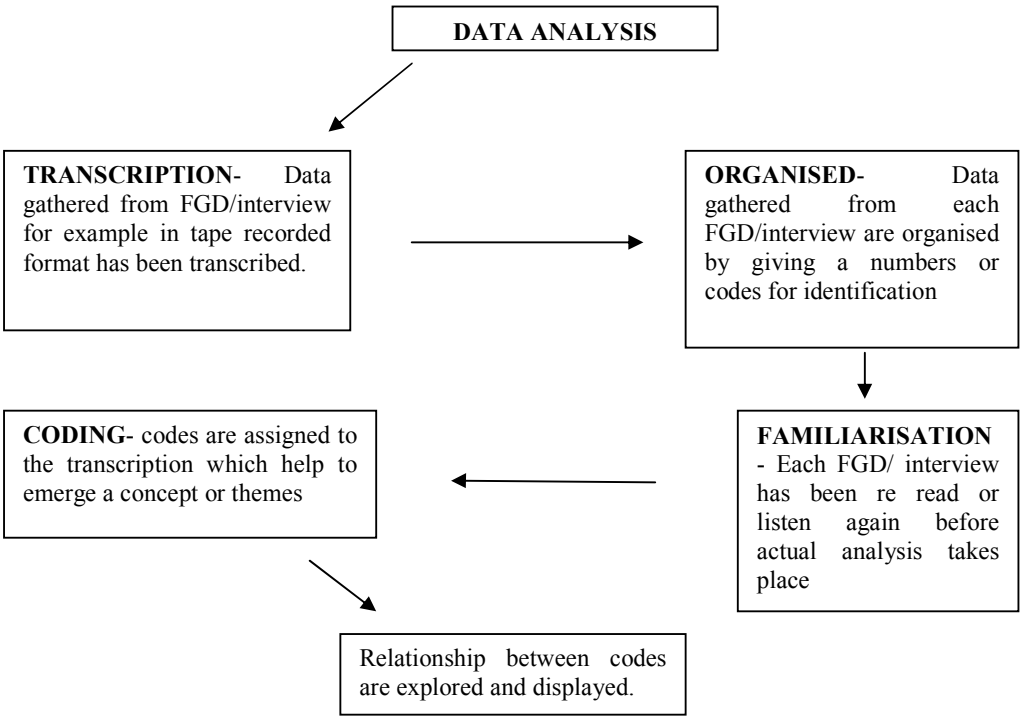
Table I.8: **Questionnaire framework for ranking the intrinsic cause of natural disaster**

Sign	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**
A	N/A													
B		N/A												
C			N/A											
D				N/A										
E					N/A									
F						N/A								
G							N/A							
H								N/A						
I									N/A					
J										N/A				
K											N/A			
L												N/A		
M													N/A	
N														N/A
Total														

Source: Adapted from the Mercer, 2007; Mercer et al. 2010

INDEX		
(A) Poor Building Material/High concrete house or buildings	(B) Traditional house	(C) Building structure in high risk zone
(D) Forest clearance	(E) Soil erosion	(F) Development of Hydro power dams
(G) Industrial development	(H) Loss of traditional farming practice	(I) Loss of fertile soil
(J) Changing in agricultural pattern/Scientific agriculture	(K) Absent of disaster planning/ lack of Govt initiative	(L) Lack of knowledge of disaster management among communities
(M) No community planning for disaster management	(N) Poor health care facilities	(O) None

Fig I.7: **Data Analysis**



Source: Lacey and Luff, 2007

I.7 Sikkim Himalaya- Study Area

Sikkim is the second smallest state of Indian union located on the western-most part of the Eastern Himalaya covering an area of 7,096 sq. km. This Himalayan state represents a diverse society or ethnic groups of people having various cultural and traditional beliefs. The three major groups of ethnic people inhabiting Sikkim are the Lepchas, the Bhutias and the Nepalis/Nepalese that together have enriched the cultural and socio-economic patterns of the state. The process of cultural interchange, cultural flow and marriage between intercommunity and other religion have made Sikkim totally multi-structured society. Therefore, the term 'traditional knowledge' of local and indigenous communities was very viable to use in Sikkim Himalaya as it included all the aged old communities for the purpose of study.

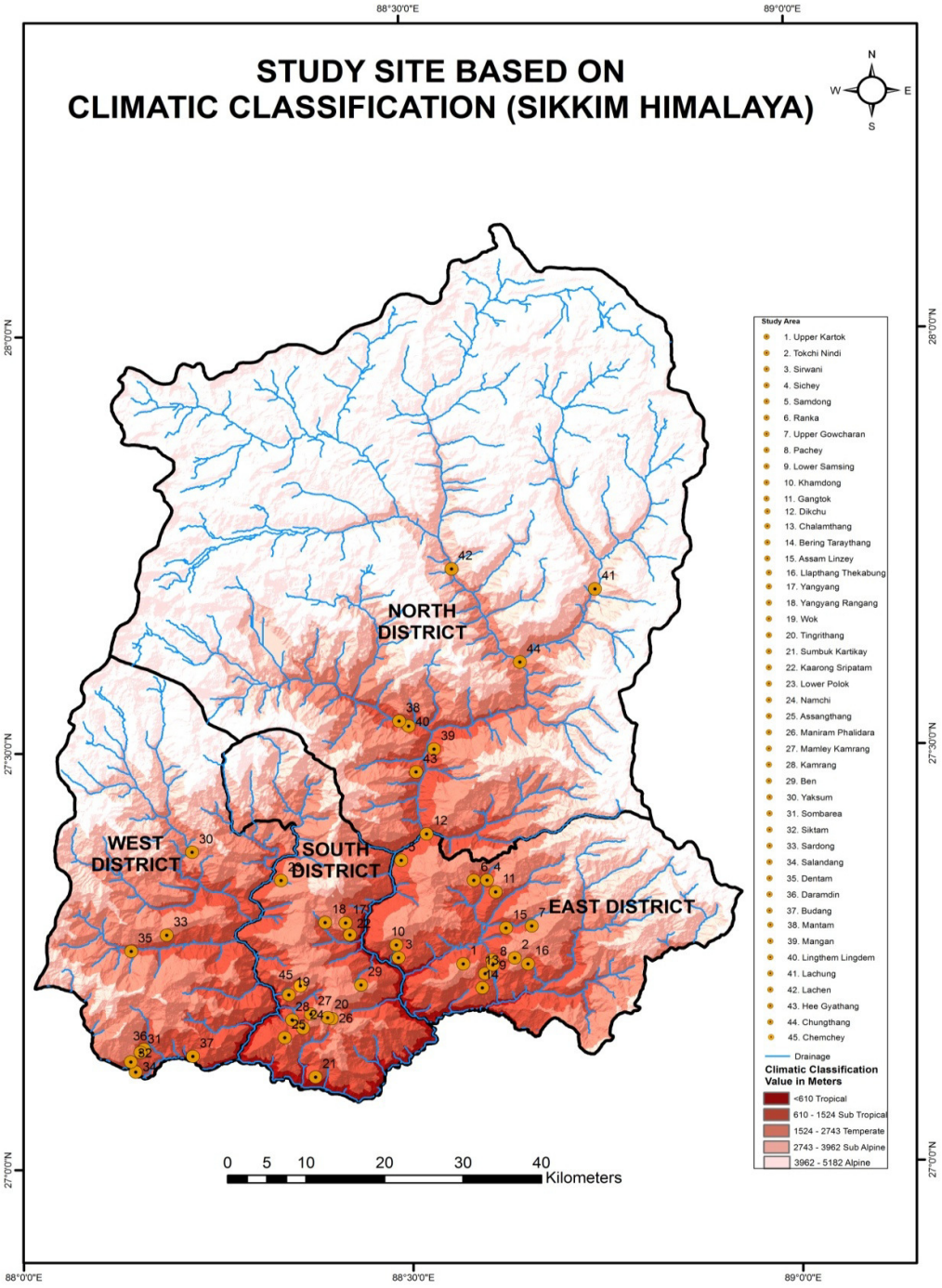
Sikkim Himalaya has an inherent nature and climatic condition which makes it prone to various types of natural hazards. The Himalayan state exhibits certain geographical characteristics where the region experiences the uninterrupted sweep of moisture laden southwest monsoon which have a direct impingement upon the Himalayan slope[8]. The state has 28 mountain peaks, more than 80 glaciers, 27 high altitude lakes, 5 major hot springs and more than 100 rivers and streams (LR & DMD, 2012).

Sikkim Himalaya receives heavy monsoon rainfall, due to which river banks are largely affected by flash floods and when debris of all kinds are added along the flow of water, than intensity of disaster increases rapidly. One natural calamity generally encourages another natural phenomenon. For example, when Teesta valley was flooded in 1968 due to heavy cloudburst it triggered thousands of landslides around

[8] Cited on Karn, Pradyumna P, Geographic Regions of the Himalaya, Retrieved November 21, 2013, from http://himalaya.socanth.cam.ac.uk/collections/journals/bot/pdf/bot_03_02_01.pdf

the Sikkim-Darjeeling Himalayan slope. Thus, the ecological prospect of the study area is such that it can easily trigger a natural disaster.

Map No: I.1



As this state is a part of huge and elongated Himalaya which is moving northward against the Eurasian plate, this region is ecologically sensitive and prone to earthquake. Therefore, it is obvious that earthquake has been a common natural phenomenon in the Sikkim Himalaya. Sikkim have experienced 18 earthquakes of magnitude 5 or greater over the past 35 years within the 100 km of epicentre of September 18 events (Kumar, Walia & Chaturvedi, 2012).

The region is also crisscrossed by narrow valleys and steep cliffs. Geologically it is weak comprising with sedimentary and low grade metamorphic rocks which are susceptible to weathering and erosion. This when combined with regions heavy rainfall causes extensive soil erosion and loss of nutrients through leaching. As a result, landslides are frequent. This disaster had a tremendous impact not only upon the safety of the people residing in Sikkim but also towards the state economy by destroying huge property.

Though, numerous disaster occurred in Sikkim Himalayan state, till now no effective early major warning system nor efficient grass root level disaster assessment and management centres has been established. Only the post disaster plans are followed by the government and the Sikkim State Disaster Management Authorities, which is not highly effective than the pre disaster plan.

Local people around this region are living with everyday risks from decades together. Their own traditional knowledge gained from the centuries old experience with nature has made them aware of arriving hazards and worked as the mitigation and recovery tools from time immemorial. However, traditional knowledge in this part of the Himalaya is not systematically distributed due to uneven topography or environmental condition. Therefore, the study has focussed on climatic and physiographic criteria to

collect every traditional knowledge data and those collected data are systematically analysed according to the framework or phases of disaster risk reduction adopted by UNISDR.

I.8 Limitation of the research study

While documenting traditional knowledge in different parts of the Sikkim Himalaya, certain obstacle or barrier was clearly observed for the study. Those obstacles certainly brought the limitation for the research study. For example, ignorance towards the traditional livelihood was one of the major obstacles for acquiring data from the field study.

Most of the local people (even elders) believe that, with increasing population and globalisation, it is difficult to rely in traditional methods alone for agricultural productivity or for sustenance of livelihood. Most of the rural farmers even advocated the importance of scientific agricultural techniques for profit maximisation. Thus, due to the rapid change in agricultural patterns, exploring traditional agricultural farming was very limited.

Not only the passing away of elders and ignorance of present generation created a major barrier for documenting traditional knowledge in Sikkim Himalaya but the limited funding for the study was another major issue. As Sikkim is one of the expensive Himalayan state to explore, the existing funding for research study was very limited for surveying and understanding in-depth Sikkimese socio cultural livelihood. Lastly, time factor also played a crucial role for research limitation as simply five years of research was very less to understand the traditional knowledge system of numerous local and indigenous communities of Sikkim Himalaya.

I.9 Brief Overview of the Chapters

Traditional knowledge system in DRR is highly acknowledged due to its environmental friendly methodological approach and cost effectiveness. However, its due recognition by scientific society is still far away due to its spiritual and cultural context. The oral tradition and strategy without experimentation and evaluation are not considered as knowledge by the modern scientific protagonist. Thus, to bring up the value and the significance of traditional knowledge system in formal disaster risk reduction framework, its integration with scientific knowledge system is outmost necessary by exploring and evaluating its necessary ingredient which are applicable and practicable in contemporary era. It is important to highlight that one form of knowledge is not enough to minimise the impact of disaster.

The first chapter of this thesis provides a general introductory with a statement of problem. Review of literature related to the traditional knowledge system paradigm in DRR and its application in disaster risk reduction from global to Himalayan context has been done, in order to find the gaps and to clarify the study perspectives with major objectives. Thus, it has created the path for rationalization of carrying the research study by raising the research questions. Methodological framework supporting interpretative approach has been followed here as this approach not only helped the study to understand the meaning of the social situation from the point of view of those who live in it but it also has the advantage for using both qualitative and quantitative strategy for data collection.

The second chapter focus on the existing philosophical context and discourses of traditional and western knowledge system with particular reference to its role and application in disaster risk reduction. The chapter has argued the diversity of the two

knowledge system in the context of temporal and spatial perspectives. The formal institutional framework of disaster management is also critically appraised here to draw attention regarding its productiveness in disaster risk reduction.

The third chapter highlights the importance of inventory maps of different natural hazards and disaster in Sikkim Himalaya and how those mapping would help to understand the vulnerability and risk factors in Sikkim Himalaya. After identifying the disaster vulnerability and risk by mapping the area with the available secondary disaster database, it helped to locate the study site of the local people to understand their adaptation and resilient nature in such a disaster prone area.

The fourth chapter explores the different traditional methods and measures taken up by the local communities in reducing disaster in Sikkim Himalaya. For identifying the research study area, inventory maps have been used by selecting the criteria of vulnerability and risk factors by analysing the land surfaces, slopes, vegetation, river banks and climatic factors. Since traditional knowledge system is not homogenously situated in one place, thus selecting the area according to above criteria was important.

The fifth chapter has focussed on the challenges of convergence for interconnecting the two knowledge system. The chapter emphasises in reducing disparities and finding the ethical space for resemblance and integration of two knowledge systems in DRR. Thus, the concluding part of this chapter is to explore the conceptual framework by incorporating both the knowledge system in disaster risk reduction method. Two divergent approaches i.e. traditional and scientific for sustainable development and DRR in mountain area would only provide the room for half possibility of success. Since, both the approaches lack in strong methodological

framework for DRR, therefore integration would allow the usage of the good method, practices and ingredients of both the knowledge system thus, creating the holistic approach for DRR.

The sixth chapter has summarised and concluded the major finding of the research by adding the recommendation needed for conserving and protecting the traditional wisdom as well as the necessary steps which can be taken by the formal Sikkim State Disaster Management Authority to involve the participation of local communities more in disaster planning and processes by understanding the actual requirement of the people during or before the disaster events.

Chapter II

Traditional and Western Knowledge on Disaster Risk Reduction

Knowledge can be simply defined as the information and skills which has been gained by experiences or education. It helps us to create a truth or belief about this universe. According to Smith (1895), the concepts, or categories or even the laws of science are not considered as knowledge because knowledge is imitation of reality and the concepts do not imitate reality. Therefore, in order to acquire and produce knowledge, the imitation must be perfect. He further assumes that the truth cannot be called as synonymous to knowledge (Smith, 1895). Truth is the ideal of knowledge as truth is just the agreement of thought with reality but knowledge consists in thoughts which agrees with reality (Smith, 1895, p. 489). Knowledge can be theoretical where the subject can be understood theoretically or pragmatically where the practical skills and expertise matters in its understanding.

From the time of Plato till today, the concept of knowledge is still on the path of debate. Many philosophers still argue about the nature of true knowledge and question about the incomplete knowledge. For example, Agassi 1972 tried to assume the difference between the ideal knowledge and the deficient knowledge. The discourse between these dichotomies of knowledge do bring out the concluding remark that any knowledge which has been testified is regarded as the ideal knowledge whereas imperfect knowledge makes allowance for acts of God (Agassi, 1972).

Actual knowledge is a lens that offers a particular picture of the world at a particular point of time; however, mostly uncertain, as observation lead towards interpretation

and different people has different lens of observation, the interpretation made by them generates numerous knowledge (Kerkhoff & Lebel, 2000). Therefore, it is very uncertain to define actual knowledge as it still lacks perfect reflection of the world which has been researched (Kerkhoff & Lebel, 2000).

According to western empirical tradition, the production of knowledge comes from pure objectivity where its principles are universal and its construction is without the influence of any personnel or cultural characteristic (Kaplan, 1964; Banks, 1993). However, the knowledge created by the individual or group is also highly influenced by their interpretation of their experiences and their positions within particular social, economic and political systems of the society even when objective knowledge is the ideal within a discipline (Banks, 1993, p. 5).

In 1991, Code who is regarded as the feminist epistemologist has stated that both the subjective and objective aspects are vital in the formation of knowledge therefore, both the aspects should be known and examine. The point of the questions is to discover how subjective and objective conditions together produce knowledge, values, and epistemology. Neither reject objectivity nor to glorify subjectivity because knowledge is neither value-free nor value-neutral; the processes that produce it are themselves value-laden; and these values are open to evaluation (Code, 1991, p. 70).

Today, different academic institutes hold different concept and nature of knowledge. From every specialised field of academia, differentiation varies. For humanities knowledge is communication and critical thinking skills, the social sciences would add methodology and sequence learning, and for the natural sciences facts, principles, and the scientific method remain the heart of the enterprise (Abbott, 2002; Marcum,

2006). Therefore, 'knowledge' gets lost in the musical chairs curriculum development process (Marcum, 2006, p. 22).

There are five categorization of knowledge- Practical (professional, business, workmen's, political, household), Intellectual (akin to a liberal education), Spiritual, Small-talk or past time and Unwanted knowledge (Machlup, 1962; Marcum, 2006). Whereas, contemporary and practical modern categorization distinguishes levels of knowledge beginning with the cognitive (know-what or book learning), competence (know-how or experience), systems understanding (know-why), and self-motivated creativity, which amounts to profound engagement with the subject (Quinn, Anderson & Finkelstein, 1996; Marcum, 2006). These categories simplify us about the existing typologies of knowledge according to the experiences of skills and information but cannot give the exact understanding of the concept.

Epistemology deals with our understanding of knowledge- that is, how we come to know the world as a site for research and analysis (Shaw, et al., 2010, p. 15). Therefore, in philosophical view, epistemology represents the study of knowledge. In 2009, Saunders, Lewis & Thornhill came up in defining the important distinctions of epistemology as positivism at one end and interpretivism at the other end. According to them, positivism philosophy deals with the visible social reality, where the concluding product of research can be law-like generalisation whereas, interpretivism is an epistemology which advocates the necessity for the researcher to understand the differences between the human in our roles as a social actor (Saunders, Lewis & Thornhill, 2009). Thus, interpretivism emphasises the difference between conducting research among people rather than objects.

Taking the two philosophical distinctions the present study has categorized the knowledge system into two types- a. Western or Scientific Knowledge and b. Traditional Knowledge. The former is generally understood to involve western technology or techniques where the experts of this knowledge comes from different scientific institutions and the knowledge is formally legitimate i.e. it has a specific, institutional certificate and is impersonal (Adamski & Gorlach, 2007). While the latter type of knowledge exhibits no concise definition but, however, has evolved by the local and indigenous communities based on their centuries of experiences and cultural tradition.

II.1 Traditional Knowledge System – clarification for the study

The age old traditional wisdom holds various definitions from different side of the academic societies. The term traditional knowledge or traditional ecological knowledge, local knowledge, indigenous knowledge, folk knowledge, farmers knowledge, fishers knowledge or tacit knowledge, all have evolved with their own descriptions and implications with ensuing discussion about which one is the most appropriate (Mazzocchi, 2006). Therefore, to clarify each knowledge system, it is better to understand them by exploring their historical background, defined attributes and present status.

The word ‘traditional', places emphasis on the transmission of knowledge along a cultural continuity (Mazzocchi, 2006, p. 463) derived from the historical experiences. It refers to a form of rational and reliable wisdom that has been developed from many generation by intimate contact within native peoples and which is passed down from generation to generation by experiential learning or by words of mouth, undocumented in written form. It includes, pre-existing underlying traditional culture

or folklore and literary and artistic works (WIPO, 2003). However, it might ignore the ability of traditional societies to adapt to changing circumstances (Mazzocchi, 2006, p. 463). In fact traditional knowledge is viewed as the static knowledge which is rarely changed according to the changing environmental phenomenon.

However, every society goes through changes during every phases of time because nature does not remain static thus, new skills and technologies are needed to adapt and survive in this ever changing natural environment (Berkes, 1993; Snively & Corsiglia, 2000). Thus, the word traditional remains in a disputed category while defining the age old knowledge. Knowledge never remains in a static position but rather get renewed or mixed to become better. Therefore, many researchers avoid using the word 'traditional' (Snively & Corsiglia, 2000) while referring to any native communities. This gave birth to 'indigenous' word in defining the native people as it totally avoided the disputable discourse regarding traditional and eventually began to put importance on indigenous people (Berkes, 1993; Snively & Corsiglia, 2000).

The word, 'indigenous', actually highlighted the autochthonous nature of knowledge (Mazzocchi, 2006, p. 463) of native people. However, it began to ignore knowledge from populations who are not officially recognised as indigenous (Mazzocchi, 2006, p. 463). Though, the word indigenous make things easier in denoting a particular group of people but in most of the developing regions it is not wise enough to use the word indigenous. Drawing on field evidence from Burkina Faso, Niemeijer and Muzzucato (2003) argues that, as much indigenous knowledge research has focused on taxonomies, rather than theories or processes, there has, consequently, developed a tendency to see indigenous knowledge as static too. A different focus on the processes of indigenous knowledge might, therefore, generate a deeper and more dynamic understanding of change (Nakashima & Roue , 2002).

Local knowledge is another term which has been frequently used by many scholars because it has the extra advantage of adding also the non-indigenous people in the list. For example, the people who have lived in a particular area for very long time and have developed their own local way of knowing the nature for their survival have created many age old practices but, however, they are not included in the list of indigenous people.

Therefore, the term 'local knowledge' has the advantage of including both the indigenous and as well as non indigenous people, whose extensive knowledge of the natural milieu is also a product of resource-based livelihoods extending across many generations (Nakashima & Roue, 2002). However, its major weakness is a lack of specificity (Nakashima & Roue, 2002; Mazzocchi, 2006), as most knowledge can be labelled local (Nakashima & Roue, 2002). Although local knowledge and practices certainly exist, they are inevitably mediated by external influences from immigrants, return migrants, extension workers, and visiting businessmen and so on (Shaka et al., 1996; Briggs, 2005).

At present, traditional ecological knowledge is interpreted and used by many scholars as a cumulative body of knowledge, practices and representations that describe the relationships of living beings with one another and with their physical environment, which evolved by adaptive processes and has been handed down through generations by cultural transmission (Berkes, Colding & Folk, 2000; Mazzocchi, 2006). However, when we separate the word traditional and define the term 'ecological knowledge' than its definition creates a problem in itself. As the word 'ecology' comes under the preview of biology, which is one of the domain of western science and traditional societies never were the western modern scientist (Snively & Corsiglia, 2000), therefore, it is not appropriate to consider the term traditional ecological science.

Unless ecological knowledge is defined broadly to refer to the "knowledge, however acquired, of relationships of living beings with one another and with the environment, then the term traditional ecological knowledge becomes tenable" (Berkes, 1993, p. 3)[9].

Therefore, a wide variety of terms has been used by scholars and educationists but no universal term is available in defining the age old knowledge of the people. The dispute between the concept and nature of age old knowledge remains still alive. However, in the context of Sikkim Himalaya the term traditional knowledge system remains more valid due to following reason. Firstly, there is no homogenous population in the study area and most of the local communities are not officially regarded or officially categorised as indigenous by the Government of Sikkim although they have a long history of settlement in Sikkim Himalaya. Therefore, to use indigenous word is not at all suitable for the study area. Secondly, the entire population of Sikkim Himalaya is scattered here and there with different cultural settings. Therefore, to use the term 'local' is also not appropriate in the context of Sikkim Himalaya.

Table II.1: **Diversity in local knowledge terminology**

Terms, synonyms	**Meaning; Salient aspects, implicit significance, antonym**
Indigenous knowledge	Culturally integrated knowledge; knowledge of small, marginal/non-western groups.
Endogenous knowledge	Of internal origin, as opposed to exogenous or external

[9] Cited in Berkes, F. (1993). Traditional Ecological Knowledge in Perspective. In J. T. Inglis (Ed.), *Traditional Ecological Knowledge- Concepts and Cases*. Ottawa: International Development Research Centre.

	knowledge
Native knowledge/expertise	Implies knowledge of a natural character, closeness to nature
Local knowledge	Knowledge rooted in local or regional culture and ecology
Sustainable knowledge	Sustainable within the natural and cultural environment
Traditional knowledge	Handed down, old, oral (implying static, low level of change)
Autochtonous knowledge	Of internal origin, culturally integrated
People's knowledge	Broadly disseminated knowledge, knowledge as potential for political resistance, as opposed to elite knowledge
Little tradition	Tends to denote oral knowledge, as opposed to great tradition
Community knowledge	Related to small social work
Cultural knowledge	Culturally integrated and practice-oriented
Ethnic knowledge	Related to an ethnic 'we'- group (ethnicity)
Culturally specific knowledge	Specificity, singularity, particularity
(cultural) belief system, (cultural) meaning system	Means the same as 'knowledge system' but implies a less scientific character
Everyday knowledge, practical knowledge, mundane cognition, vernacular, common sense, generalist	Informal, practical, applied, as opposed to academic, specialist, export knowledge or as opposed to ritual knowledge
Farmers' knowledge	Knowledge relating to farm as an economic unit
Peasant knowledge	As opposed to elite knowledge; implies experiences of dependency

Source: Antweiler, 1998, p. 471.

II.2 Western Knowledge/Scientific Knowledge- Exploring its Concepts and Nature

Scientific knowledge is acquired when certain belief or observation are systematically studied and tested by scientific methods and techniques rather than relying on subjective beliefs or unsupported speculation. Procedures of science plays a key role in gaining scientific explanation as science is considered as the branch of scientific knowledge. Scientific process requires the removal of the object of study from its context, literally or conceptually, and necessitates the elimination of variables that cannot be measured (Motz, 1998, p. 343).

Scientific knowledge must be justifiable (Kerkloff & Lebel, 2000) testable or falsifiable in some scientific or mathematical way (Lewis, n.d.)[10]. However, Clough (2000) came up with the thought that delusion in the concept of science and the nature of scientific knowledge is damaging the very general scientific literacy and in turn it has also affected the students approach towards understanding science and its very nature. It is very important not only to know the methods involved in scientific knowledge but also the historical, social and philosophical foundation of science to understand its scope and nature of doing work (Clough, 2000).

> The nature of science is a fertile hybrid arena including the history, sociology and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of what science is, how it works, how scientist operates as a social group and how society itself both directs and reacts to scientific endeavours (McComas, Clough & Almozroa, 1998, p. 4).

[10] Cited on Lewis, G. B. (n.d.). *The Nature of Science and the Scientific Method.* Retrieved June 26, 2019, from https://www.geosociety.org/documents/gsa/geoteachers/NatureScience.pdf

Two different concepts exist while defining science and its nature. One definition support science as characterized by objectivity, un-emotionality, rigor and control, while another recognise its characteristic with the quantitative method as applied in laboratory and experimental techniques (Benjamin, 1949). If this two differentiation of science and its nature is accepted than the former concept do not support philosophy, history, social studies, theology, and many authoritarian studies as science while the latter rejects even mathematics, astronomy, theoretical mechanics, biology and psychology which do not consist laboratory experiment or quantitative techniques as science (Benjamin, 1949). The very nature of science which formulated scientific way of doing and understanding the reality is in fact surrounded by many of these questions about its own concept, types and characteristics from both the philosophers and scientists in general.

Traditional concepts of science and its nature has to be changed because the traditional concept of distinguishing observation (description) and theories or values (normative statement) as an independent or separate from each other has become an important matter of question still today. Observations are not value free but values and theories influence what we see and how we are going to interpret it thus, it is wrong to consider scientific knowledge and its research as unbiased (Mitroff, 1980).

In fact scientific way of doing research is to be more aware of one's biasness and to understand the influencing factors of that biasness (Mitroff, 1980) because scientific knowledge is based upon the observation and information which can be measured or

assessed and later verified with a rational calculation without being influenced by any personal or social (Lewis, n.d.)[11].

II.2.1 Why the term 'Western' in the study?

There is a crucial debate regarding the western knowledge and scientific knowledge and which of these term hold the strong defending hand for the science and scientific community is another important discussion. When we assume the very nature of science than we normally notice its work as systematic and scientific. To support the evidence, data are collected systematically and tested or experimented with the valid rational calculation. Thus, explanations involving supernatural events and deities, which lacks in scientific measurement and experiment are discarded from the realm of science (Clough, 2000).

However, origination of scientific knowledge does not have a specific time of when and who did it the first because the very nature and methods for defining the concept was not formally documented and most of the knowledge in early historical period had the wide impact from the supernatural ideas and beliefs. During the period of renaissance[12] different scientific theories were developed and even the general law was created by the nobelist however, they were not been able to separate the religious belief within the realm of science. Thus, the distinction between the creation science and evolution science emerged later during the 1920's in western nation and these two sciences agreed to battle for supremacy not in the open field but taking the help of the court room constitutionally (Shermer, 1991).

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[11] Cited in Lewis, G. B. (n.d.). *The Nature of Science and the Scientific Method.* Retrieved June 26, 2019, from https://www.geosociety.org/documents/gsa/geoteachers/NatureScience.pdf

[12] The word 'Renaissance' which means 'rebirth' is considered as a period from 14th to 17th century in Europe. This period is marked as the bridge between the middle ages (Dark Age) and modern history. This was the period when the people began to acknowledge the importance of art, literature and science. Instead of relying on the will of God, people began to act according to capabilities.

Therefore, considering western knowledge as identical to scientific knowledge in the research study is because of the fact that, the very first official encounter for defending the science and its methods from the creation science or pseudo science[13] came from the western scientific academicians and researchers on August 18th, 1986 which is also known as 'The Louisiana Trial'[14]. During the 'Louisiana Trial' official evolution of concept, nature and scope of science was defined, defended and presented (Shermer, 1991). The supporter of creational science believed in divine power where as the supporter of evolutional science advocated the Darwin's theory of evolution. A supporter of the fundamentalist orator William Jennings Bryan, T. T. Martin, commented in 1923, "Ramming poison down the throats of our children is nothing compared with damning their soul with the teaching of evolution" (Shermer, 1991, p. 519). In fact, according to creationist, the theory of evolution was abolishing an ethical character of the American people because they claim that the evolution science do consider the acceptance of divine creator.

The battle for recognition started from 1920's when the theory of evolution was highlighted and supported by the scientific communities. Scopes trial (1925), trial in California (1979-1981), trial of Arkansas (1981) and the trial of Louisiana (1982-1987) were the four legal battle fought between the creational science supporter and the evolutional science supporter in United State of America (Bleckmann, 2006). However, due to the absent of concise definition and nature of science the evolutionist had to back down themselves in many court hearing (Shermer, 1991).

[13] Pseudoscience consists of statement or belief without any scientific experimentation or validation or it is a discipline that pretends to be a science.
[14] It was a legal battle fought constitutionally between the supporter of evolutionary science and the supporter of creational science.

However, on 18th August, 1986, around seventy-two nobel laureates from seventeen state academies of science agreed and submitted for an 'amicus curiae'[15]brief to the Supreme court in which nature and scope of science was defined and accepted (Shermer, 1991). Before Louisiana trial, scientists never came together against any outside force for defending the very concept of science but the case of Louisiana was different as the major opposition 'creationist' was implementing their stand all along the educational sectors without any valid justification or reason. Gell-Mann agrees, "It's not so much that we were being attacked from the outside, since outsiders can make worthwhile contributions, it's that these people were talking utter nonsense" (Shermer, 1991, p. 533). Therefore, the thoughts of creationist was totally impacting the very ideals of science, its methods and implementation and at the same time creationist was also trying to hold equal position in every educational institution by preaching the work of divine creator to the coming generation of students and scholars. Evolutionist believed that this would obviously defy the work of pure science and it was not at all good for the growth and development of the nation as well as the science itself (Shermer, 1991).

Therefore, this was the first legal battle in the history of science where the two contestant namely- pure science and the religious or creational science settled their dispute with the help of court rather than in the open market of ideas. Thus, it is very evident to say that, though the scientific thoughts or knowledge developed in various corner of the world but the very conflict of superiority between the science and non science started in western nation which was fought constitutionally and victor got the right lawfully.

[15] Amicus curiae means impartial advisor to a court who is not engaged directly to a legal case. However amicus curiae assist and give his/her expertise and information in regard to case issues to the court.

Thus, in the history of science the 'trail of Louisiana' is considered very important as it was the first legitimate constitutional battle between the creationist science (who believed divine creator and the word of holy text) and the evolutionist science (who discarded the religious belief). The trail was also important because it was the first time when all the scientific communities in the west came together for defending and in defining the science. Therefore, the study uses the western word instead of scientific word because of the very first legal battle won by the scientific communities of western nation in conserving the concept of pure science. However, the study does not differentiate the term scientific knowledge from the western knowledge, as the nature and function of both the knowledge are represented in similar fashion. However, the historical statement mentioned above only has the rationality of using 'western' in place of 'scientific' but will not differentiate the two terms in the study.

II.3 Traditional Knowledge Vs Western Knowledge

As many environmental problems are basically local in nature, the importance of cooperation and participation from the indigenous and local people in addressing the environmental issues is very important. As cost effectiveness and sustainable development is build within the traditional knowledge framework, different formal institutions around the world are taking a much interest in exploring indigenous and local communities knowledge practices for sustainable agriculture and biodiversity conservation. Though, traditional knowledge has many advantages in sustaining biodiversity in a sustainable ways due to its nature of connectedness with both the human and non human elements, still the legitimate recognition of this knowledge system has not been formulated officially.

Many delegates especially representing scientific communities around the world stated the contribution of traditional knowledge to modern science in the world conference of science, Budapest in 1999 (Nakashima & Roue, 2002). However, due to its connection with but human and un human element, legitimising traditional knowledge from the scientific community circle is somewhat difficult to accept the subject as the scientific or to integrate it into the scientific discipline because of the fear of involving spiritual, mythological and fictional element (Snively & Corsiglia, 2000). Therefore, though traditional knowledge is getting a huge support from various scientific communities but in true sense of its nature and characteristics, the very supportive groups of scientist does not want to implement it into science realm.

> Division of labour always exist between philosopher and scientist, however, we mostly turn towards scientist for knowledge. To have knowledge is one thing but to understand what knowledge is, is another and here the task of philosopher plays a vital role. Therefore, it is wrong to assume that all who know science can define why it is knowledge (Ramsperger, 1939, p. 390).

Thus, the following section of the chapter highlights some of the emerging disputes and explores a battle line between the two knowledge systems by comparing their disparity and similarity.

II.3.1 Construction of Binary Tension

The very epistemological foundation of two knowledge system expresses the distinct binary differentiation between the western and traditional knowledge system (Briggs, 2005). Though, some of the characteristics resemble the interconnection of the two knowledge system however, the inter-relation between the two knowledge systems rarely exists. For example, observation is not only the features of traditional knowledge but also considered as one of the initial phase in any scientific finding.

However, the systematic way of analysing the observed phenomenon is rarely done in traditional knowledge. Scientific knowledge is seen to be open, universally applied, systematically processed and very much dependent on rationality and intelligence, whereas traditional knowledge is seen to be closed, narrow minded, un intellectual, primitive and emotional (Warren, 1991; Briggs, 2005).

> Whenever the issue of indigenous knowledge is discussed, sooner or later the recurrent question of validity is raised. Is it scientific? Or, being composed of odds and ends, does it combine the best with the worst, juxtaposing without distinction empirical observations and obscure superstitions (Nakashima & Roue, 2002, p. 4).

Even the nature of identification differentiates between traditional knowledge and scientific knowledge. Local and indigenous people renowned in traditional wisdom do not differentiate too much within any subject matter. For them identification and structural examination of a particular plant and its fruits may not be much important then its uses and the process of preparation (Snively & Corsiglia, 2000). Thus, traditional knowledge is relational or holistic one where every element of the world is interconnected. Whereas, in scientific knowledge, influence of society and environment are normally viewed in confusing or in separate way. Modern science mostly considers its production of knowledge in laboratories or in legitimate institutes thus, framing the knowledge system from a reductionist tool box.

Modern science normally views traditional knowledge as uncivilized, backward, and emotional. The very concept of development too has exclusively relied on one knowledge system, namely, the modern scientific one (Escobar, 1995; Briggs, 2005). Therefore, the dominant role of western science has totally excluded the non scientific knowledge from the official recognition. Even the modern scientific community argues and questions the data collection method. According to modern science,

participatory method of collecting data is not too much accurate than the method involved from the traditional positivist approach. This distinct binaries differentiates and conceptualise the nature of science and non science for claiming the knowledge creation.

Scientific knowledge is characterised by its experimental, systematic and universal nature whereas indigenous knowledge is defined as practical, local and contextual (Nakashima & Roue, 2002). Therefore, the very nature between the two knowledge systems has different epistemological stance. Scientific knowledge is more objective in nature and relies in evidences and facts from the gathered data which have been justified by pure rational calculation. Whereas, traditional knowledge derives its data from the generation of observation made by the particular local and indigenous community. However, the observational data of traditional knowledge are not gathered systematically and lack scientific calculation though the vastness of data is much huge than the scientific one. The following table below highlights some of the major dichotomies between the scientific and traditional knowledge-

Table II.2: **Two different worldviews**

Scientific knowledge	**Traditional knowledge**
1. It favours analytical and reductionist methods	1. It favours intuitive and holistic view
2. Positivist and Materialist	2. Spiritual
3. It is objective and quantitative	3. Mainly subjective and qualitative
4. Based on an academic and literate transmission	4. Passed on orally from one generation to the next by the elders
5. It isolates its object of study from their vital context by putting them in simplified and	5. It depends on its context and particular local condition

controllable experimental environments	
6. Derived from interaction from non-aboriginal people and institutions, formal schooling, adoption of western scientific thinking, exposure to foreign values, attitudes and philosophies	6. Based on the shared experience, customs, values, tradition, subsistence lifestyles, social interaction, ideological orientation and spiritual beliefs unique to aboriginal communities
7. Assumed to be a best approximation	7. Assumed to be truth
8. Rapid acquisition	8. Lengthy acquisition
9. Short-term wisdom	9. Long-term wisdom
10. Powerful predictability in natural principles	10. Powerful prediction in local areas
11. Weak in local area of knowledge	11. Weak in predictive principles in distant areas
12. Explanation based on hypothesis, theories, laws	12. Explanation based on example, anecdotes, parables
13. Hierarchical differentiation	13. Non-hierarchical differentiation
14. Excludes the supernatural	13. Includes everything natural and supernatural

Source: Johnson, 1992; Brodnig & Schonberger, 2000.

Scientific knowledge is global in nature whereas traditional knowledge is considered local and place specific. Traditional knowledge has the limitation of space in itself as it only work in certain communities of people or place where they reside. However, Warren (1991) argues that traditional knowledge is not always static but also dynamic because it is continually influenced by cultural or internal creativity or when it comes in contact with the external system.

II.3.2 Development and Developmental Values

In the context of development, great deal of argument exists within the nature of traditional knowledge. Is it very useful universally or only worthwhile within the place/space in which it has been developed (Briggs, 2005). Due to its contextual

nature, traditional knowledge is mostly viewed as too place specific and thus question always arises in its function and applicability beyond the place of its origin (Briggs, 2005). Therefore traditional knowledge is frequently charged with being methodologically weak because it generates findings that are too complex to be of practical use to policy makers (Leach & Mearns, 1996; Briggs, 2005). These are some of the serious problem which traditional knowledge normally faces while promoting its uses in development.

In the context of agricultural development, modern scientific farming with mechanised instrument have tremendously increased the input and output ratio in terms of productivity. Now the question arises- Is it possible to use traditional agricultural farming for sustainable development to feed more than 7 billion people on the Earth? Do we take the risk of producing food grains by accepting the traditional methods and techniques where the output of production is low? Therefore, in the context of food security i.e. availability, access and utilization, modern scientific farming may sound more viable than the traditional farming practices.

However, it is also vital to understand the concept of long term sustainable development too. Modern practices of farming may raise the output level but without the use of chemical fertilizers, pesticides and other mechanised tools, the agricultural production will not rise. At the same time, the cost incurred in modern farming system is too high and the negative impact upon the local environment is well seen today.

Scientific worldview is mostly rooted within the economy of knowledge. For example, modern biotechnology has made possible of creating modern genetically modified seeds which has given a huge boost to the agricultural productivity. Though, the invention of new genetic seeds raised the food production, it totally symbolise the

'instrumentalist' view of nature that so many now criticise. Therefore, though input ratio is low in traditional farming practices, long term sustainable agriculture is assured and Brundtland report 1987 rightly defines sustainable development as "A development that meets the needs of the present without compromising the ability of future generation to meet their own needs" (UN, 1987, p. 24).

However, there are also some example of modern information technology and infrastructure which has helped the local people to increase the economic productivity. Development of efficient transport network and telecommunication within the rural area has gradually changed the way of economic progress recently. Today due to infrastructural facilities lots of local communities are frequently coming in contact with the other different cultural people thus, paving the path for cultural diffusion. These have provided opportunities for sharing the experiences, problems and solution. For example, in South Africa, a group of Rooibos tea-growing farmers visited another community to learn about marketing and following the exchange, the group formed a farmers association, improved its marketing system, and is now exporting the tea to Europe, multiplying its income (Aluma, 2004, p. 28).

II.3.3 Unitary Knowledge or Shared Knowledge

Conceptualizing the nature of traditional knowledge as the unitary knowledge or shared knowledge do generates some debate while categorising its function for the sustenance of livelihood. Fragmentation of knowledge sharing is mostly seen within the definite indigenous community. The most important factors are the age of the individual, experience, social and economic circumstances, political authority or power within the community and last but not the least is a gender differentiation (Briggs, 2005). These all factors have influenced the greater impact on the individual

access to knowledge and on that individual's ability to use such knowledge (Briggs, 2005, p. 14). Therefore, we can assume that traditional knowledge is a shared knowledge but not the unitary one because of its categorization or level within the local community.

Gender differentiation is the most important criteria in distribution and functioning of indigenous knowledge system is normally visible. For example, men and women in particular indigenous communities do not have the equal distribution of local knowledge system. In most of the indigenous and local communities it has normally been observed that men speak on the behalf of the community whereas women speak on the behalf of the women groups. Even the agricultural activities are divided between the men and the women. For example, male usually control cash crop farms whereas female controlled subsistence plots especially in livestock care (Briggs, 2005). Gender differentiation is not only between the male and female in controlling land management or resources but also seen within the women group too.

Whereas, modern knowledge systems do not have shared knowledge characteristics because it does not follow the level of oral tradition which is neither tested nor documented properly. However, to consider it as the unitary knowledge is also not at all possible because postcolonial and feminist critics of science have labelled the dominant paradigm of contemporary scientific research with the acronym 'WMS', which can mean both Western modern science and white male science (Kahn, 2010). In fact, the very nature of science is re-casted as the socio-cultural and political project that has however unconsciously securing the base of hegemonic power as one of its functions (Snively & Corsiglia, 2000; Briggs, 2005; Kahn, 2010).

II.3.4 Contextual, De contextual and Re contextual knowledge

It is normally observed that the key element of indigenous knowledge is embedded within the society in which it has been developed. Therefore, the nature of traditional knowledge is seen in its economic, political and cultural context (Bebbington, 1993; Adams, Potkanski & Sutten, 1994; Briggs, 2005). However, context is a personal construct because it is always strongly related to a personal (explicit or implicit) definition of a situation of action (Oers, 1998). This very nature of traditional knowledge makes difficult for the policy makers and planners for applying it in different geographical, political and economic setting. These in fact, makes a very distinct dichotomy between the traditional knowledge and the scientific knowledge as the former is deeply rooted within the society or context from where it has been developed whereas the later thrives on abstract formulation and separation from the lives of the investigated (Agrawal, 1995; Briggs, 2005).

Hence, the application of traditional knowledge in development discourses is questionable because of its contextual nature. The only possible path for the use of this knowledge beyond its place of origin is to fragment some of its useful parts and give a mix into the scientific knowledge paradigm so that it becomes de contextualised i.e. applicable irrespective of any geographical boundaries. However, still the problem doesn't solve here because as traditional knowledge is very locally embedded in its applicability and power there arises a real danger of losing its value or efficacy if it becomes depersonalized or de contextualized and used in some sort of top down approach (Briggs, 2005). Thus, it becomes difficult to apply the idea of traditional knowledge in the wider developmental arena. However, in terms of scientific knowledge its applicability is considered as universal.

History has the evidence of human migration during the different phases of environmental, social and economic changes around the world. Thus, in the context of human migration, knowledge system must have been de contextualised. However, the term de contextualisation does not fit well in such circumstances because when a particular group of people and its knowledge is transmitted and adapted from its native place to another region, re contextualisation takes place.

According to van Oers (1998), whenever de contextualization is said to occur, actually a process of re contextualization is going on. In fact the possibility of re contextualization may be possible if the geographic nature between the origin and migrated area has some similarity but the concept of de contextualization may not act possible because it does not satisfyingly provide an explanation for the phenomenon of transfer, as it focuses on the conditions of actions, whereas transfer is a feature of the activities themselves (Oers, 1998).

II.4 Traditional Knowledge Vs Scientific Knowledge in DRR

Since the time of human civilization, human had to face various natural calamities which even endangered their very existence on this planet (Rai & Khawas, 2019, p. 1). Though, the human learned to hunt, to domesticate animals and to grow crops but never became perfect to predict the nature's outcome or activities (Coppola, 2011). Unpredictability of nature's work showed the human, who is the actual boss or dominant player.There are various historical events and stories which depicts the near extinction of human race. Many theorists such as Jared Diamond (2005) and Dr Floyd McCoy (Cecil, 2011, Rai & Khawas, 2019, p. 1) have expressed about the great civilization of the world, such as the Mayan, the Minoan and the old Egyptian Empire, were ultimately brought to their knees not by their enemies but by the effects of

floods, drought, famine, earthquake, volcanic eruption, tsunamis and other widespread disasters (Fagan, 1999; Coppola, 2011; Rai & Khawas, 2019, p. 1). Similarly, the great Tang dynasty in China was believed to be extinct due to the change in monsoonal pattern, which caused in mass crop failure during the 8th and 9th centuries (Coppola, 2011; Rai & Khawas, 2019, p. 1).

Archaeological discovery has shown that our prehistoric ancestors faced many of the same risks that exist today like starvation, inhospitable elements, dangerous wildlife, famine, infection and violence at the hands of other humans and more (Coppola, 2011). However, these pre historic humans also learned to reduce the impact of natural risk and the most important mitigation of risk came when they learned to inhabit caves (Coppola, 2011). Though many historical events highlight the detail recording of many disastrous events, it has also mentioned various human responses during the said disastrous events (Rai & Khawas, 2019, p. 1). For example, the story of ancient floods in Bible, flood in Mesopotamia and Greek not only have mentioned about the causes of the disaster but also the response of the human during such natural calamities (Grandjean et al., 2008). The following statement from the bible highlights the prediction, preparedness and mitigation strategy:

> Make thee an ark of gopher wood. Thou shall make rooms in the ark, and shall pitch it inside and outside with pitch (Genesis 6:14). And this is how thou shall make it: The length of the ark three hundred cubits, the breadth of it fifty cubits, and the height of it thirty cubits (Genesis 6:15). And of every living thing of all flesh, two of every sort thou shall bring into the ark, to keep them alive with thee. They shall be male and female (Genesis 6:19)[16].

[16] Cited in Rai, P., & Khawas, V. (2019). Traditional knowledge system in disaster risk reduction: Exploration, acknowledgement and proposition. *Jamba: Journal of disaster risk studies, 11*(1), 1-7.

Protagonist in the above story of Noah's ark highlighted in the Bible attempts to prepare and mitigate the impact of huge flood upon the planets's biodiversity by simply collecting two of each species and placing them within the safety of the ark (Coppola 2011, Rai & Khawas, 2019, p. 2). The methods and materials for constructing Noah's ark is well portrayed in Bible. For example, reeds are considered as the most essential material to give cohesion to the wood and they were used in ancient shipbuilding for filling the gaps and crevices (Ullendorff, 1954).

According to Kempe (2003) during 17th century the above mentioned deluge i.e. great flood became the object of study by many empirical and mechanical scientists and the inundation recorded in bible gave the vital information regarding the history of the earth. In fact, the birth of modern geology came out of the Noah's flood story and this new science started with the paradigm of diluvialism[17] (Kempe, 2003, p. 156). Later the paradigm of uniformitarianism[18] of Charles Lyell was updated in geological studies.

Noah's flood gave the answer to the various confusing question especially to the Swiss naturalist scientist Johann Jakob Scheuchzer about the fossil shells and mussels found in the highest Swiss mountains (Kempe, 2003). However, the story of Noah's ark and the great flood today is considered as a myth because of the lack of scientfic evidence of global flood (Radford, 2014). What is left is a metaphorical use, especially in connection with questions about man's responsibility for natural or ecological disaster (Kempe, 2003).

Similarly, there are many archaeological evidence of flood control in ancient

[17] From the Latin word 'diluvium' for deluge.
[18] Theory which declines the concept of 'catastrophism' in landscape development and highlights that the landscape development process acts in the same manner and with essentially the same intensity in the past as they do in the present.

civilization. One of the interesting ancient flood mitigation strategy comes from the history of ancient Egypt civilization under the reign of king Amenemhet III, 1817-1722 BC (Coppola, 2011). The Pharaoh build more than 200 water wheels to divert the annual flood water of the Nile river into Lake Moeris (Coppola, 2011). This was the first river control project of the world which not only helped to mitigate flood but also it helped to reclaim over 1,53,000 acres of fertile land in Egypt (Coppola, 2011; Rai & Khawas, 2019, p. 2).

Evidence of risk management practices can also be found as early as 3200 BC. According to Covello and Mumpower (1985) in what is now modern-day Iraq lived a social group known as the Asipu[19]. When community members faced a difficult decision, especially one involving risk or danger, they could appeal to the Asipu for advice. The Asipu, using a process similar to modern-day hazards risk management, would first analyse the problem at hand, propose several alternatives, and finally give possible outcomes for each alternative. Today, this methodology is referred to as decision analysis, and it is a key to any comprehensive risk management endeavour (Coppola, 2011).

There are also various historical evidences regarding the organized emergency responses taken by the people during the various disaster events. According to Coppola (2011) one such example comes from the historical town of Pompeii which was burnt to ashes when volcano erupted from the Mount Vesuvius in 79 AD. When another town namely Herculaneum located just below the Mount Vesuvius was burnt to ashes without any survivors, the people living within the town of Pompeii survived in masses. This was because the citizens of Pompeii had several hours left before the

[19] Asipu were regarded as the traditional healers or experts in 'white magic'. They studied omen and was able to predict the future of the subject. To reduce the bad omen, they would also perform religious rituals.

volcano covered their city in ash, and evidence suggests that the city's leaders organized a mass evacuation (Coppola, 2011).

Similarly, modern fire department too has its root already developed back in 2000 years ago when the emperor Augustus established a formal fire fighting unit within the Roman army called Corps of Vigiles (Coppola, 2011). The structure of this fire fighting unit has a similarity with the modern fire fighting department. When the Rome felled down, the Corps of Vigiles disappeared, and this type of organised fire fighting unit or department did not appear anywhere in the world for another 1,000 years (Coppola, 2011, p. 3).

All those ancient stories, myths and folklore comes under the element of traditional knowledge system. These characteristics of traditional knowledge diversify itself from the realm of science and scientific knowledge. Scientific knowledge does not believe in subjective reality which ignores or lacks measurement, experimentation and verification. However, modern scientific society always forgets that, all those ancient stories, myths and folklores have evolved through generation of experiences with the natural environment. Difference is that, indigenous people orally interpret their finding in the form of metaphoric stories rather than writing it down formally (Snively & Corsiglia, 2000).

Today, risk assessment is simply done by gathering statistical instrument data of present as well as the past events and tries to quantify risk in terms of number of deaths attributable to particular hazards in a given period of time and the resultant damage to property (Bell, 1999). This gives the comparing option of total cost involved with the total costs for hazards mitigation. However, it is very difficult to

bring an accurate measurement and assessment of risk in terms of accurate financial concern (Bell, 1999).

Nature's role is supreme in governing any natural laws and a natural law governs the activities of different natural phenomena (Gad-el-Hak, 2008; Rai & Khawas, 2019, p. 3). Thus, though human today have developed high end scientific technology, they still lack the understanding of nature's activities or functions. For example, modern science does not have or developed a precise laws or theory in predicting earthquake hazards, thus making earthquake prediction more or less a black art (Gad-el-Hak, 2008; Rai & Khawas, 2019, p. 4). The following statement from United States Geological Survey (n.d.) states that:

> No. Neither the USGS [United States Geological Survey] nor any other scientists have ever predicted a major earthquake. We do not know how, and we do not expect to know how any time in the foreseeable future.[20]

Prevention, mitigation or the response to any disaster or entire disaster management framework are a recent comprehensive approach. Many of the today's management measures or practices have already been utilized in ancient or earlier human history. In fact, all those ideas of mitigation and responses have been taken out from the achievement of past civilization. While the management of disasters during the past few thousand years was limited to single acts or programs addressing individual hazards, many of these accomplishments were quite organized, comprehensive, and surprisingly effective at reducing both human suffering and damage to the built environment (Coppola, 2011).

[20] Cited in Rai, P., & Khawas, V. (2019). Traditional knowledge system in disaster risk reduction: Exploration, acknowledgement and proposition. *Jamba: Journal of disaster risk studies, 11*(1), 1-7.

Even the formal international DRR framework is roughly 50-60 years old (Rai & Khawas, 2019, p. 2). For example, United Nations General Assembly passed its first emergency assistance in case of any natural calamities in 1965 after passing the resolution 2034 (UNISDR n.d.; Rai & Khawas, 2019). Since then, three global DRR framework emerged namely, Yokohama Strategy in 1994, Hyogo Framework 2005–2015 and the recent Sendai Framework 2015–2030 for DRR (Rai & Khawas, 2019). Yet, the lack of understanding nature's outcomes and behaviors has failed to decrease the impact of disaster (Rai & Khawas, 2019, p. 2).

However, indigenous communities around the world have observed, experienced and survived the ruthless of nature's fury without the help of any scientific technology. As their knowledge has emerged from the bond of knowledge-practice-belief, appropriate environmental ethics always exist within it (Berkes, Coding & Folke, 2000) due to which today most of the biodiversity rich region is the home of indigenous community. The pervasive cosmology of traditional societies may be characterized as a 'community of being' worldview in which human are part of an interacting set of living things, a view that was also common in Europe up until medieval times (Callicott, 1994; Berkes, Coding & Folke, 2000). Even the conservationist approach who believes that nature and nonhuman must be protected from human interference does not know the true nature of indigenous belief system because in indigenous ethical system, nature exists in its own terms and nonhumans have their own reason for their existence (Pierotti & Wildcat, 2000) however, both are interconnected and interrelated with each other.

Science based society have always tended to over use the available resources and have always tried to simplify the complex ecological systems which has resulted in

the whole series of resource depletion and environmental degradation (Gadgil, Berkes & Folke, 1993). Modern scientific society normally used the pro-development extractive approach (Pierotti & Wildcat, 2000) where the natural resources were exploited for the comfort of humans and humans were considered as the controlling forces of the natural world. These have been today the chief reason for increasing the speed of climate change thus resulting different kind of environmental disaster.

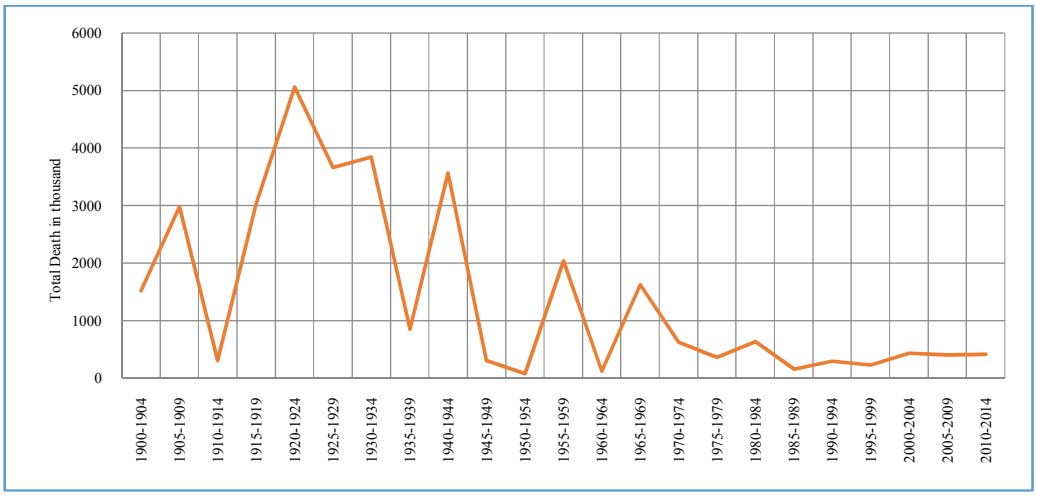
Though, every societies has their own worldview regarding their function and manipulation upon the natural world however, in indigenous worldview such models and prescription are much more closely integrated with moral and religious belief systems so that knowledge, practice and belief co-evolve with each other (Gadgil, Berkes & Folke, 1993). It is in this context that, the knowledge of indigenous and local community is important. As traditional knowledge views human as a part of the natural world with a belief system of having respect for the natural world, it can add the value for evolving sustainable relation with the natural resource base (Gadgil, Berkes & Folke, 1993). Therefore, traditional knowledge can be third alternative for, sharing elements with extractive and conservationist approach, yet remaining clearly distinct from both (Johannes, 1989; Pierotti & Wildcat, 2000).Traditional knowledge is expressed in the ability to experience a sense of place while casting off the modern western view that 'space' exists to be conquered (Pierotti & Wildcat, 2000).

II.5 Traditional Knowledge in Disaster Risk Reduction- Exploration, Acknowledgement and Proposition

Before exploring the role of traditional knowledge system in disaster risk reduction, it is vital to observe and analyse the some statistical data of natural disaster and its impact formulated by the Centre for Research on the Epidemiology of Disaster.

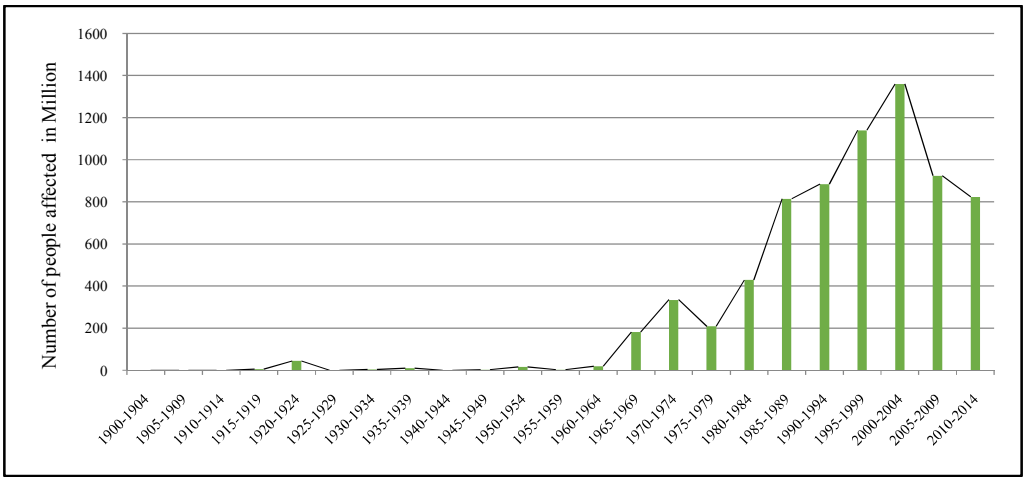
Analysing disaster database have helped to understand the frequency, rate and impact of disaster since 1900 to 2014 and to support the argument in the favour of traditional practices and methods in DRR, analysis of these data is out most important.

Fig II.1: **People killed by natural disaster: Global database from 1900-2014**



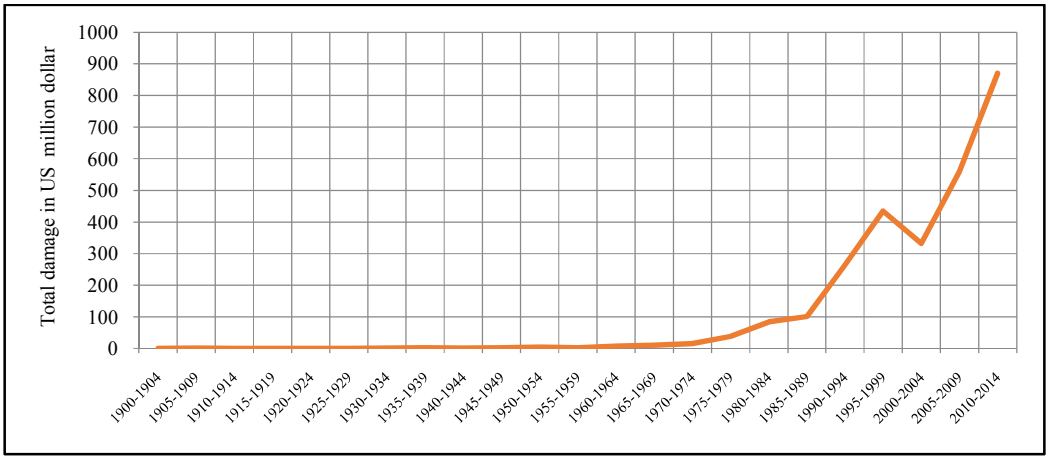
Source: Computed from EM-DAT International Disaster Database, Centre for Research on the Epidemiology of Disaster

Fig II.2: **People affected by natural disaster: Global database from 1900-2014**



Source: Computed from EM-DAT International Disaster Database, Centre for Research on the Epidemiology of Disaster

Fig II.3: **Damage by natural disaster; Global database from 1900-2014**



Source: Computed from EM-DAT International Disaster Database, Centre for Research on the Epidemiology of Disaster

The above two statistical bar diagram which shows the total number of people killed and total number of people affected by the natural disaster in five years interval time from 1900-2014. It further shows that the nature of lethalness of natural disaster towards human lives has been reduced, impact upon the physical, social and economic condition has rapidly increased. The impact upon the financial economy is increasing every year on both developed and developing nations. What may be the most disturbing of this trend is that the poor countries of the world and their citizens are assuming a much greater proportion of the impacts of disasters (Coppola, 2011).

Though, death rate has tremendously fallen down, still it is in a fluctuating manner. We can clearly observe that the decrease death rate happened in 1910-1914, 1945-1949, 1950-1954 and 1960 to 1969. However, from 1995-2014 death rate slowly began to increase. Thus, with the advancement of scientific methods and techniques, and after the introduction of international DRR framework, the death rate should have

decreased rather than fluctuate. However, the graphical result above shows a different analysis.

Similarly, if we see other two statistics namely, people affected by disaster and total damaged caused by disaster from 1900 to 2014, the graphical line shows the rapid uplift in every five years of interval. The most interesting picture comes from the year 2000 to 2014 where the total damage by disaster is in high peak. Therefore, the question arises towards the capability and sustainability of the so called modern civilization and their advanced technology in preparing and mitigating disaster risk in coming future. The above three statistical graphs clearly highlights the question: why modern civilization with sophisticated technology and huge investment are suffering to pave the way for the safer world?

There was a time when humans accepted natural hazards risk as a 'part of life' which has the possibility of management (Coppola, 2011). Evidence of such behaviour is apparent in almost any example of previous human settlement where communities along rivers build levees, those located along the sea coasts construct sea walls and jetties and farmers placed their houses and sowed their crops upon the fertile slopes of active volcanoes (Coppola, 2011). Today it has been reversed from 'part of life' to 'created in our life'. Huge population explosion, modern urbanization, exploitation of natural resources and unending human wants are responsible for the creation of disaster. In fact natural disasters are merely the result of human placing themselves directly into the path of natural hazards (Coppola, 2011).

Below tables explore, highlight and acknowledge some of the good practices and achievements of traditional knowledge in disaster risk reduction.

Table II.3: **Traditional knowledge in disaster risk reduction: Examples of good practices from the world around**

Good practices from the world around	DRR strategy	Description of the strategy
Early Minoan civilization of ancient Mediterranean region (Driessen, 1987)	Anti-seismic architecture	The building facades of the Minoan civilization had a different orientation of wall elements which helped to resist the shock from any direction. The absence or near absence of windows in the ground floor of the building helped to sustain the lower floor wall by not weakening it by any opening. The dimension of the room in Minoan houses was much smaller to increase lateral resistance and also to reduce the structural weight of the construction. Lastly, the large houses had a very low number of storeys as houses which are too slender and too high bend more easily during an earthquake.
From the 17th-century Xinjiang area of China (Fang et al., 2008)	*Karez*, a traditional irrigation technology to reduce drought disaster.	The basic structure of the *Karez* irrigation was composed of a vertical wall which was dug along the distance of 60 m–100 m in upper reaches, 30 m–60 m in the middle reaches and 10 m–30 m in the lower reaches. A passage was developed to build underground canals by linking numerous vertical wells. To prevent the underground canal from collapsing, wooden pillars were reinforced. When the underground linked canal reached the lower surface, it discharged the water into the small reservoir built on the lower altitudinal surface for the purpose of irrigation. No cost for water uplifting was observed because the topography itself played a vital role in diverting deep water flow, thereby functioning as gravity irrigation. The underground canal also had a minimum impact from evaporation, thus resulting in minimum impact from climate change and thus sustaining the population for thousands of years.
From the southern coast of Jamaica in St. Elizabeth (Beckford & Barker, 2007).	Drought mitigation strategy	The local people developed a local soil management practice to solve the water scarcity issue. They covered the agricultural field with dried Guinea grass to lessen the soil moisture and to reduce soil erosion on sloping land. Without any involvement of scientific technology, they successfully changed the rainfall deficiency area into a lucrative agro-activity area.
From the Lepcha community of Sikkim Himalaya, India (Jha & Jha,, 2011).	Folklore and its mitigation strategy	Folklore of the Lepcha community of the Sikkim Himalaya, India, has proved that folklore have developed from the experience and understanding of stories about the natural world around them. According to one folklore tale of the Lepcha community, *Uthis* (Himalayan Alder) jumped from the high cliff when *Guras* (Rhododendron) did not accept her marriage proposal. Thus, Lepcha people believe that in any steep sloping land or landslide prone area the Himalayan Alder grows. This story teaches the listener that in a fresh landslide so wood trees like Himalayan Alder are normally grown and when those trees hold the topsoil then hardwood trees can be grown to convert the landslide prone area into a forested area.

Source: Rai & Khawas 2019, p. 4

Table II.4: **Traditional knowledge in disaster risk reduction: Examples of achievements from the world around**

Disaster events	Traditional DRR strategy	Description of the event
26 December 2004, Indian Ocean Tsunami (Syafwina, 2014).	Prediction and mitigation	On the island of Simeulue which was just 40 km from the earthquake epicenter which caused the 2004 Indian Ocean tsunami, only seven people were reported killed out of 78 000. The oral tradition consisting of stories and songs carrying the messages of early experience of tsunamis made the local people of Simeulue Island conscious regarding the prediction of tsunamic waves. The oral stories and songs taught people that when an earthquake occurs then they should go to the coast and watch the movement of the des. If the low tide or retreat of the tide occurs soon after the earthquake, then run towards the higher ground as the low de will follow up with giant waves.
July 2005. Glacial Lake Outburst Flood in Brep village of the Chitral district, Pakistan (Dekens, 2008).	Early warning and preparedness	The Chitral district barely has 3.5% of suitable agricultural land and consists of steep mountain slopes mostly unsuitable for settlement with a high risk of flash flooding. Because of historical knowledge of flash flooding local people here have gathered the flood adaptation measures by reading the landscape and thus making the interpretation on where to build and not to build their houses. Their historical flood experience has made them understand and interpret early signs of potentially destructive floods too. In the 2005 Glacial Lake Outburst Flood in Brep village of Chitral district, not a single life was lost because the interpretation of stream behavior acted as the early warning and the village was evacuated in me
29 December 2009, Tsunami in American Samoa (Rumbach & Foley, 2014).	Response strategy	The *Aumaga* (often young and unmarried men who work under the direction of a village chief called Matai) is considered as the 'hands and feet' of the village in American Samoa. Being indigenous to the local area they were very fast and familiar with the local environment and were able to respond and rescue victims of the 2009 tsunami before the centralised government or non-governmental institutions arrived.
18 September, 2011 Sikkim Earthquake, India (Khawas & Rai, 2017)	An -seismic architecture	The Sikkimese traditional structure called *Ekra* house is built of a stone foundation and bamboo wall normally plastered with mud or cement. In spite of being a non-engineered structure, these houses have effectively worked as anti-seismic structures during the 2011 earthquake in Sikkim. Around 40 000 houses were reportedly damaged either fully or par ally. Among the fully damaged buildings, about 20% were composed of a Reinforced Cement Concrete (RCC) frame whereas only 4% consisted of traditional construction. According to Arun Rai, a resident of Assamlengy village, East District, Sikkim, India, '*Ekra* house shakes but never falls'.

Source: Rai & Khawas, 2019, p. 4

Nature is always changing and to survive with the changing natural phenomena, humans have to develop their adaptability. However, for some less common natural events like earthquakes, humans have very lower levels of success (Coppola 2011, p.

19-20) even today. Yet, in early Minoan civilization[21] earthquake mitigation strategies was quite advanced while the level of modern scientific technology during that period was almost absent.

Though traditional building structure are non-engineered structure, it has been developed as a result of ancient tradition which emerged in relation to changing environmental conditions; and thus improved over period of time as a response to the requirement of social and physical environment. As a result, traditional construction has been praised today by many architects, engineers and cultural anthropologists as being extremely effective solution to the needs of dwellers and to the physical requirements posed by their environment (Gutierry, 2004).

Traditional communities have also developed different methods of disseminating the information on prevalent likely natural disasters. For example, in western Kenya, the drums and horns were used to alert people to come together at known meeting points where the specific warning, instructions or advice was communicated and appropriate actions decided upon (UNEP, 2008).

When we bring up and try to conceptualize the two knowledge systems in DRR, than we normally find differences in the worldview of indigenous people and that of western dominant culture. For example, latter look backward and forward in time to get a sense of their place in history, while native people look around them to get a sense of their place in history. This difference has been described as thinking temporally in the case of western scientific culture and thinking spatially in the case of the native peoples culture (Deloria, 1992; Pierotti & Wildcat, 2000).

[21] The Minoan civilization flourished during middle Bronze Age on the island of Crete located in the Eastern Mediterranean from 2000 B.C. to 1500 B.C.

Viewing the world with spatial perspective have fosters the development of relational approach by including, interacting and interconnecting humans, non-humans and surrounding nature together (Rai & Khawas, 2019). Thus, the knowledge having connection criteria with the natural world can have a huge conservational ethic on the part of those who follows its principles. However, to consider all the traditional knowledge and practices as the wise ecosystem management tool is also not always right. There are various examples coming from the ancient or old traditional society about the indigenous people committing environmental wrongs through over grazing, over hunting or over cultivation of land (UNEP, 2008) which resulted in ecological imbalance around their settlement and later some even got extinct by different natural disasters. Exaggerated claims on behalf of any traditional ecological wisdom needs or requires a reality check (Berkes, Coding & Folke, 2000). Therefore, it is misleading to think of indigenous knowledge or traditional knowledge as always being 'good' 'right' or 'sustainable' (UNEP, 2008).

To identify and to generalise traditional knowledge which has a good function for ecosystem management is always a difficult task. Even researchers who do not possess specialized field of ecology may fail to identify or understand traditional practices having an ecological function for management of natural resources or sometime just misinterpret. For example, while identifying traditional practices we make no claims about their existing use nor do we make any claims that people who practiced them would necessarily interpret or explain them as we do (Berkes, Coding & Folke, 2000). In addition, if the place of the native people goes through rapid environmental degradation than the knowledge which was effective in securing livelihood may not be suitable at all (UNEP, 2008).

Therefore, all traditional knowledge cannot be treated as disaster risk reduction tool unless and until the local community recognizes them and practices for their daily sustenance of life. For example, there were lots of other ethnic tribe settlement near the Simeulue island during 2004 Indian ocean tsunami however, they were not been able to understand the prediction of 2004 Indian ocean tsunami. This was because there oral literature was given importance during some cultural event only and due to the advancement of modernisation, many youth didn't care much about the age old message of tsunami mixed in oral songs and stories. Therefore, without the recognition and utilization of indigenous knowledge, it stands as merely a part of common things in a community (Syafwina, 2014). Thus, solely defending the role of traditional knowledge for disaster risk reduction is not at all appropriate but recognizing its applicability can bring a major positive change in DRR cycle.

Today lots of traditional knowledge is on the path of extinction and various community has already forgotten about their past experiences too. Whatever knowledge exists had to be documented, to recognise its practical uses and sustainable characteristic. For example, the smong (Tidal wave or tsunami) story can be animated or rewritten in pictures so that the children can understand, remember and conserve it from being extinction (Syafwina, 2014). Traditional knowledge has a very long history of observation with natural phenomenon therefore such 'diachronic' observation can also be of great value if merged with the 'synchronic' observation on which western science is based (Gadgil, Berkes & Folke, 1993, p. 151).

Therefore, we need today is a Comprehensive Disaster Risk Reduction approach, where the amalgamation of appropriate ingredient of traditional knowledge and scientific knowledge are required to develop the holistic disaster risk reduction planning and policy. Modern scientific knowledge alone has tremendously failed to

safe guard the humans from the natural disasters and the concept of sustainable development cannot go much further with the guide of scientific knowledge alone where the physical space and the humans are isolated from each other. There is a need of a relational approach rather than the reductionist approach while dealing with a natural calamities and traditional knowledge has the whole set of relational approach involving humans, nonhumans (animals and plants) and natural setting keeping together a perfect balance for sustainable development.

Traditional knowledge holds a cost effective nature while keeping the environment in sustainable form. Cost effective nature presents a viable concern during the face of financial crisis for marginalised section of the people. For example, most of the developing nations lack the financial resources necessary to take and adopt high advanced technologies for disaster risk reduction (preparedness and mitigation). At the same time, most of the funds for nation's development normally get diverted towards the relief or recovery assistance (Coppola, 2011). Therefore, sophisticated modern technology has only its applicability in some high human development countries leaving rest of the low developed nation's empty hand and vulnerable during disaster. To sustain an equal balance of distribution of DRR tools, traditional methods must be integrated with core scientific techniques to lower the financial aspects so that every level of society can afford to use it.

Traditional agricultural practices are normally considered as the most sustainable in nature, but modern scientist argues that it still lacks analytical discourse (Nakashima & Roue, 2002) because traditional methods are embedded in the culture/traditions, ideology, language and religion of a particular community, and is therefore not universal and difficult to globalise (Maferetlhane, 2012). According to scientist, knowledge which lacks universality in its application cannot be considered as

knowledge but merely a skill (Nakashima & Roue, 2002). A skill here normally refers to the contextual knowledge applicable to and fit for only one local environment (Rai & Khawas, 2019, p. 4). Therefore, the question of broader acceptance or legitimisation always circles the body of traditional knowledge while advocating its useful nature in scientific research and management (Rai & Khawas, 2019, p. 4).

Documentation of practical traditional knowledge is important to highlights its significance in scientific research and disaster management. Since this knowledge at present, stands to be at verge of extinction not only due to lack of recognition from scientific community but also because of the increase in commercialisation, urbanisation and subsequent erosion in traditional social networking (Fletcher et al., 2013, p. 3; Rai & Khawas, 2019, p. 4).Thus, documentation would help to preserve it and safe guard it from extinction. However, it is also important to note that negligence of traditional knowledge and its practices in past and present formal DRR policies are not only because of predominance of technocratic thinking alone but also because of the lack of correlation between the indigenous people and the external DRR stakeholders (Hilhorst et al., 2015; Rai & Khawas, 2019).

Thus, documentation of effective traditional knowledge, its methods and practices for DRR becomes very important if the value of traditional wisdom has to integrate within the scientific research and disaster management (Rai & Khawas, 2019). Nonetheless, integration of traditional knowledge into the scientific circle for developing comprehensive DRR framework is not an easy task. Before merging traditional knowledge with scientific knowledge in DRR certain conscious steps need to be taken (Rai & Khawas, 2019, p. 5). The following section highlights some of those gaps which needs to be overcome first before developing an integrated framework between the two knowledge systems in DRR:

Firstly, inertia and inflexibility between the two knowledge systems must be overwhelmed. Inertia highlights general resistance to change (Huntington, 2000; Nakashima, 1993; Rai & Khawas, 2019, p. 5) and inflexibility highlights unwillingness to work together (Huntington, 2000; Nakashima, 1993; Rai & Khawas, 2019, p. 5). It is normally unacceptable for the traditional knowledge owners to accept and adapt to the new scientific paradigm by leaving their already existing traditional and cultural paradigm (Huntington, 2000; Nakashima, 1993; Rai & Khawas, 2019, p. 5) and at the same time inflexibility of modern scientific society in working together with the non-scientist or indigenous (Huntington, 2000; Nakashima, 1993; Rai & Khawas, 2019, p. 5) or local communities has created a huge gaps of isolation between the holder of both the knowledge system. To minimise this gap, it is necessary to first document the effective traditional knowledge and its methods in DRR as it would help to bring up the evidential proof of utility and effective practises of traditional knowledge in DRR (Rai & Khawas, 2019, p. 5). Thus paving the way of its integration in scientific methods and practices and slowly it will also help to overcome the inertia and inflexibility between the two knowledge systems (Rai & Khawas, 2019, p. 5).

Secondly, each knowledge holder must respect each other rather than substituting each other. However, the effort must come from both the sides (Rai & Khawas, 2019, p. 5). Imposing external knowledge or modern technology of DRR to the indigenous and local people would rather make the road tough for the emergency managers and the planners in formulating and implementing DRR project (Rai & Khawas, 2019, p. 5). It is because native population basically consider their knowledge to be a part of their own cultural identity (Businge & Keim, 2009, Rai & Khawas, 2019, p. 5). At the same time relying too much on modern technology alone would make the local

people too dependent on external forces (Takeuchi & Shaw, 2008) for safeguarding themselves from any disaster (Rai & Khawas, 2019). This results in minimising the community's capacity and ability to help themselves (Takeuchi & Shaw, 2008; Rai & Khawas, 2019, p. 5) during natural calamities. Respecting and building up already build up knowledge of indigenous and local people will empower them to recognise what they can do and cannot do for themselves (Kelman, Mercer & Gaillard, 2012). By bringing external contributors together with indigenous and local people in collaborative exercise, mutual trust can be fostered through personal connections and thus valuing the strength of different knowledge forms equally (Kelman, Mercer & Gaillard, 2012; Rai & Khawas, 2019) as no single knowledge system, either traditional or modern, can be an answer for any sustainability or development activity (Kelman, Mercer & Gaillard, 2012; Rai & Khawas, 2019, p. 5).

Thirdly, two knowledge experts must work together during DRR exercise or planning. Local people who have a poor understanding of scientific concept for DRR can discuss with scientists who, in turn, may have a poor understanding of local context (Kelman, Mercer & Gaillard, 2012; Rai & Khawas, 2019, p. 5). For example, combining local expertise in scientific hazard mapping exercise and survey would give a clear verification of the information needed (Dekens, 2008; Rai & Khawas, 2019); thus, participatory approach in DRR exercise is significant. The ideal DRR measures should incorporate a balanced mix of modern technology and traditional technology (Takeuchi & Shaw, 2008) to make cost-effectiveness a reality (Rai & Khawas, 2019, p. 5).

However, to bring up the effective and practical traditional knowledge within scientific research and disaster management, the need of testing, evaluating and validating of traditional knowledge is necessary (Kelman, Mercer & Gaillard, 2012;

Rai & Khawas, 2019). Traditional knowledge that has been tested and evaluated with trial and error can provide smooth transition for its assimilation in scientific DRR framework (Rai & Khawas, 2019).

Therefore, to sum up the discussion, this chapter overviews and brings up the discourses between existing philosophical worldview between traditional knowledge and scientific knowledge system with particular reference to its role and application in disaster risk reduction. This chapter highlights various diversities between two knowledge systems in its characteristic, functions and methods to understand its concept and nature. The chapter also outlines some of the vital gap existing between the two knowledge systems and its holders in DRR and proposes the possibility of integration framework in future if necessary criteria are overcome to bridge the gaps between the two knowledge system.

It clarifies the existence of dichotomy between the two knowledge system by defining their concept and nature. For example, traditional knowledge is well defined as an undocumented knowledge of an individual or a community which has been passed down from generation, orally without any experiment or verification. Whereas scientific knowledge do not believe in subjective reality or in belief system of an individual or a community which do not have any measurement nor have been verified by the rational calculation. One major dichotomy which always exists between two knowledge system is that, traditional knowledge is a relational knowledge where human, non human and nature are interconnected and interrelated with each other whereas scientific knowledge believes in reductionist approach where theory and laws which has been tested and verified are applied for generation of universal knowledge. Thus, traditional knowledge is local in context whereas scientific knowledge is general.

Therefore, the very unscientific nature of traditional knowledge minimise its possibility to be recognised by the scientific community for its applicability in planning and policy framework. The chapter also outlines that though traditional knowledge system has a difficult path for its recognition as an individual subject matter however its effective and practical ingredient can be documented, tested and verified systematically before integrating it in scientific knowledge circle. This would help not only to recognise the effective traditional wisdom formally but also would help in conserving the knowledge system of indigenous and local people which is in verge of extinction today.

However, the chapter also reveals that scientific knowledge system alone has not been much effective in reducing disaster. For example, disaster database mentioned in the discussion earlier shows increasing trend of impact of disaster upon people and property. Even with the introduction of advanced scientific technology and techniques, the result still leaves a lot to be desired. This is because scientific community have frequently viewed the world from the technocratic perspective where human are simply considered as an active agent who has right to modify every natural possibility into opportunity. Thus, the 'scientific community' always tries to simplify complex natural system while extracting resources; ~~and~~ this has resulted today in rapid resource depletion, degradation ecosystems and disaster.

This section of the study purposes to identify the major gaps existed within the two knowledge system in DRR to make way for possible integrated framework. Since, both the knowledge system have a divergent approach on building safer world, integration of best ingredient from both the knowledge systems would bring up holistic approach for DRR in near future.

What is needed from scientific society is a broader willingness to consider traditional knowledge relevance, the information it offers, and to incorporate the expertise that is available (Huntington, 2000, p. 1273). Identifying valuable ingredient of traditional knowledge can help to process its application in scientific research and management. As Clarke (1990, p. 245) rightly said that, progressing with the past can help in avoiding destructive environmental pitfalls while encouraging local communities to maintain and respect traditional approaches to the use of their environment.

CHAPTER III

Inventory of Natural Hazards/Disaster in the Sikkim Himalaya

The Himalayan state of Sikkim lies under seismic zone IV[22] which is known as high risk zone. The steepness of the slopes, presence of rapid drainage flow, seismic activities and rapid human developmental activities has made the area very prone to natural hazards and disasters in the form of regular soil erosion, landslides, flash floods, forest fire, avalanches etc. One natural calamity always triggers another natural event in this part of the region. For example, 1968 flash flood disaster triggered numerous landslides due to continuous rainfall and 18th September, 2011 earthquake induced numerous landslides due to steep slope.

Thus, preparation of inventory maps of different natural hazards and disasters in Sikkim Himalaya is very important to understand the past distribution patterns of hazardous event, their types and even the causal factors with the help of GIS (Geographical Information System) tools. Earlier scholars and scientists used to follow the conventional methods[23] to prepare inventory maps which were time consuming but today due to technological innovations, new and emerging techniques based on satellite data, remote sensing and GIS have facilitated the production of maps, reducing the time and resources required for their compilation and systematic update (Guzzetti et al., 2012).

[22] There are four seismic zone namely, seismic zone II (low damage risk zone), seismic zone III (moderate damage risk zone), seismic zone IV (high damage risk zone) and seismic zone V (highest damage risk zone). Sikkim falls under seismic zone IV.

[23] Conventional Methods rely chiefly on the visual interpretation of stereoscopic aerial photography, aided by field surveys

Descriptive map helps to analyse the natural phenomena, and analysis of disastrous event gives the clue for preparedness and mitigation measures. Question of vulnerability and risk factors associated with the human settlement can easily be answered by GIS mapping tools because of its advantage of representing the data in both spatial and temporal format. Therefore, GIS map can demonstrate the answer for the question, who all are vulnerable and why they are vulnerable?

This chapter is an attempt to create inventory maps of various natural hazards and disasters occurred in Sikkim Himalaya with the help of different GIS software like Arc GIS and Hydrologic Engineering Center-River Analysis System (HEC-RAS 5.0)[24]. The main objective of creating inventory maps is not only to analysing the past natural event in Sikkim Himalaya but also to identify the major research site for collecting and documenting the traditional knowledge system. Therefore, inventory map was not only helpful to create and understand a landscape modelling, its susceptibility and hazard assessment (Guzzetti et al., 2012), it also was very important to identify the exact study site for collecting the necessary data.

III.1 Landslide

A 'Landslides' is the movement of a mass of rock, debris, or earth down a slope, under the influence of gravity (Cruden & Varnes, 1996; Guzzetti et al., 2012) and can be sub-aerial and subaqueous (Guzzetti et al., 2012). Different phenomena causing landslide include, intense or prolonged rainfall, earthquakes, rapid snow melting, volcanic activity, and multiple human actions (Guzzetti et al., 2012).

[24] Hydrologic Engineering Center-River Analysis System software helps to prepare one and two dimensional unsteady flow of a river with calculation. It also helps to highlight the sediment transport and water quality modelling of a river.

Sikkim as a Himalayan state is very susceptible to landslide due to its fragile slope and weak geological characteristics (SSDMA, n.d)[25]. The Himalayan state is build up of pre-cambrian gneissic and Daling group of rocks consisting of mainly phyllites and schist (SSDMA, n.d.); this group of rocks are very prone to weathering and erosion. When weak geological make up of Sikkim Himalaya comes in contact with heavy monsoon rainfall, landslide becomes inevitable.

Rainfall is considered as the major triggering agent for landslide in the Sikkim Himalaya. Most of the landslide occurs during or after the heavy downpour or after the prolonged monsoon season (SDMA, n.d.) in Sikkim Himalaya. For example, on 5th of September 1995 rainfall induced landslide near the capital city of Gangtok killed 32 persons and similarly in Gyalshing on third week of August 2000, 11 persons were killed by landslide (SDMA, n.d.).

Though rainfall and weak geological structure of Sikkim Himalaya is considered as a main triggering agent for landslide, however, the other physical and human factors cannot be ignored. For example, steep unstable slope, presence of fold and fault, shaking by seismic waves, undercutting by the swift flow of Himalayan rivers along the banks and not the least degradation and exploitation of natural resources by the human being in the name of development have played as a key role in speeding the impact of landslide disaster in Sikkim Himalaya.

[25]Cited from SSDMA, n.d. *Sikkim State Disaster Management Plan (2010-2011)*. Gangtok: Govt of Sikkim Sikkim State Disaster Management Authority.

Map No: III.1

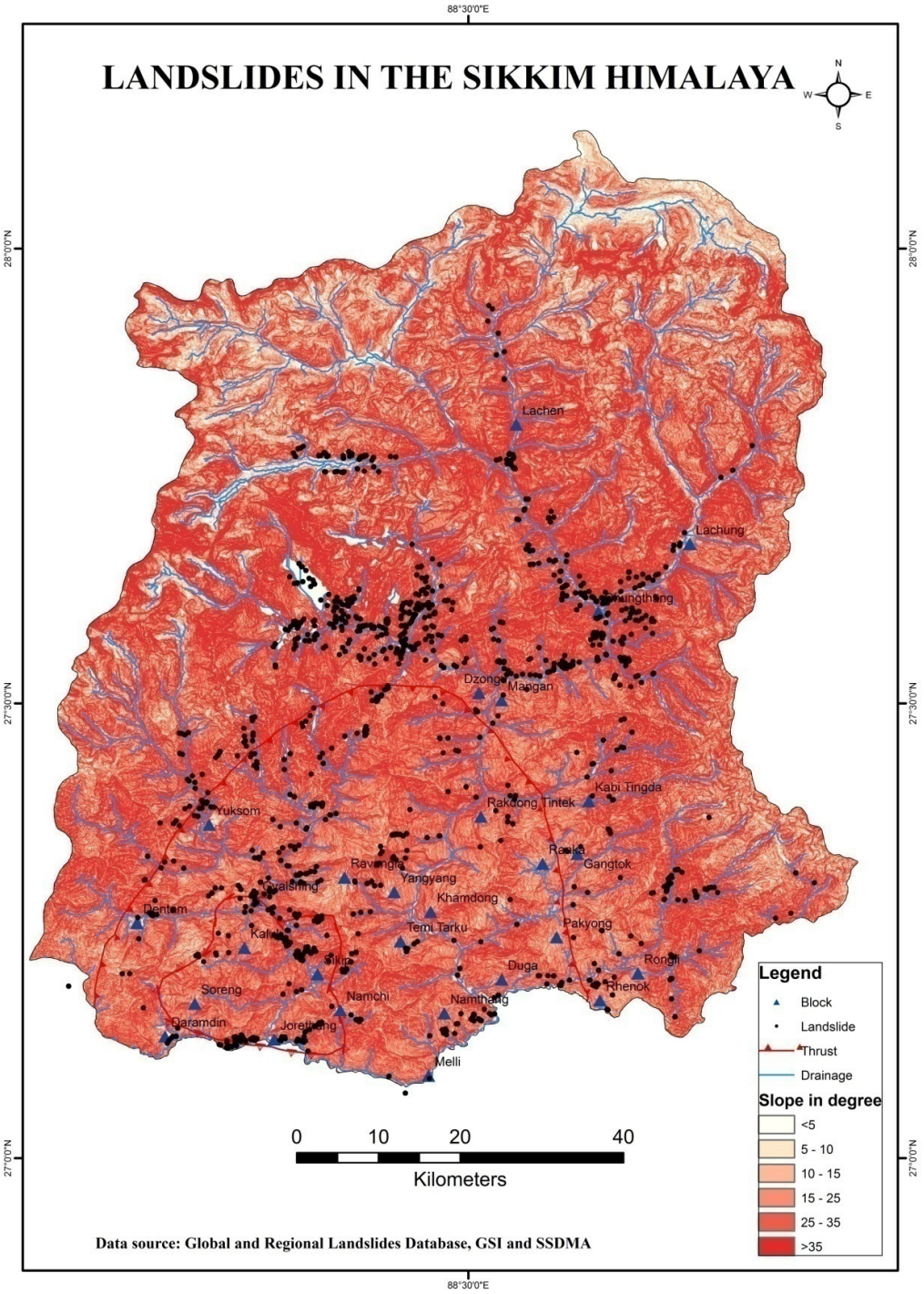
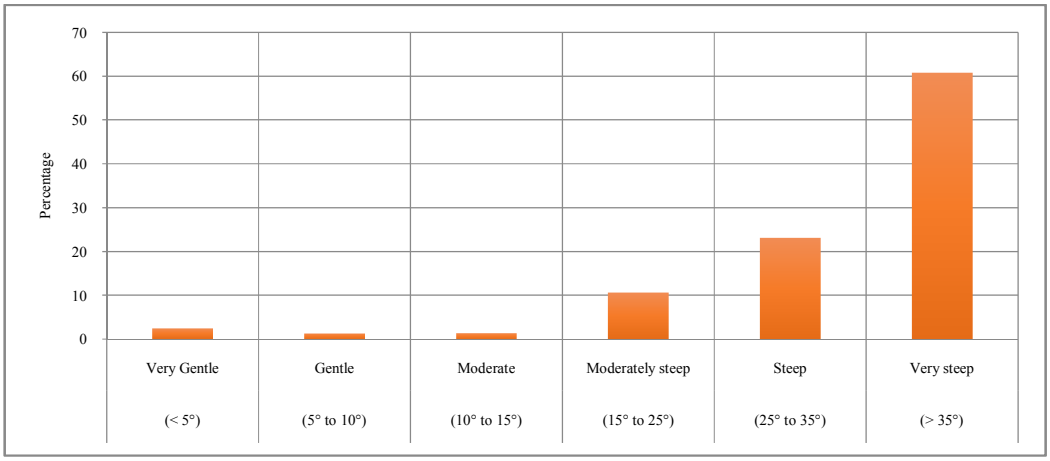

LANDSLIDES IN THE SIKKIM HIMALAYA
N
W
E
S
88°30'0"E
28°0'0"N
27°30'0"N
27°0'0"N
Lachen
Lachung
Dzongu
Mangan
Kabi Tingda
Yuksom
Rakdong Tintek
Rabha
Gangtok
Ravangla
Yangyang
Khamdong
Dentam
Temi Tarku
Pakyong
Duga
Rongli
Soreng
Namchi
Namthang
Jorethang
Melli
0 10 20 40
Kilometers
Legend
Block
Landslide
Thrust
Drainage
Slope in degree
<5
5 - 10
10 - 15
15 - 25
25 - 35
>35
Data source: Global and Regional Landslides Database, GSI and SSDMA

Fig III.1: **Slopewise frequency of landslide in the Sikkim Himalaya**



Source: Computed from Global and Regional Landslide database, GSI and SSDMA

Above landslide hazard map of Sikkim and statistical slope wise analysis graph demonstrates that the landslides in Sikkim Himalaya are mainly confined along the river channels and around the moderate to very steep slope. Most of the landslides are situated along the river banks area where slope of the land is more than 25 degree. The impact of undercutting of river banks by the rapid flowing Himalayan rivers and the presence of steep slope more than 25 degree around the same river bank areas can be considered as the major intrinsic physical factor for landslide hazards and disaster in Sikkim Himalaya. The slope analysis graph clearly represents the correlation between the landslide and the degree of slope in Sikkim Himalaya i.e. greater the steepness of slope higher the number of landslides.

Occurrence of seismic activities and the construction of mega hydro power project along the river Teesta have also acted as the supplementing agent in accelerating the rate of landslides in the Sikkim Himalaya. However, relatively lesser landslide prone area is found in the Southern and South-Eastern part of the Sikkim Himalayan due to

presence of comparatively lesser steep slope, low elevation and absence of mega hydro power dams.

III.1.1 18th September, 2011 Earthquake induced Landslides

According to Indian Meteorological Department, a strong earthquake of magnitude 6.8 shook Sikkim and Darjeeling areas and adjoining Nepal on 18:11 hours IST on 18 September 2011. The epicentre was near the Nepal-Sikkim Border which was about 68 km from Gangtok. Using visual change analysis technique through comparison of pre- and post-earthquake images with the help of different satellite images like Cartosat-1 and 2, Geo-Eye-1, QuickBird-2 and World View-2 data, Indian Space Research Organisation (ISRO) and National Remote Sensing Centre (NRSC) found out 1196 occurrence of new landslide occurred due to 2011 Earthquake (Martha, Govindharaj & Kumar, 2015). Geological assessment of the earthquake highlighted linear disposition of landslides along existing faults suggesting their reactivation (Martha, Govindharaj & Kumar, 2015).

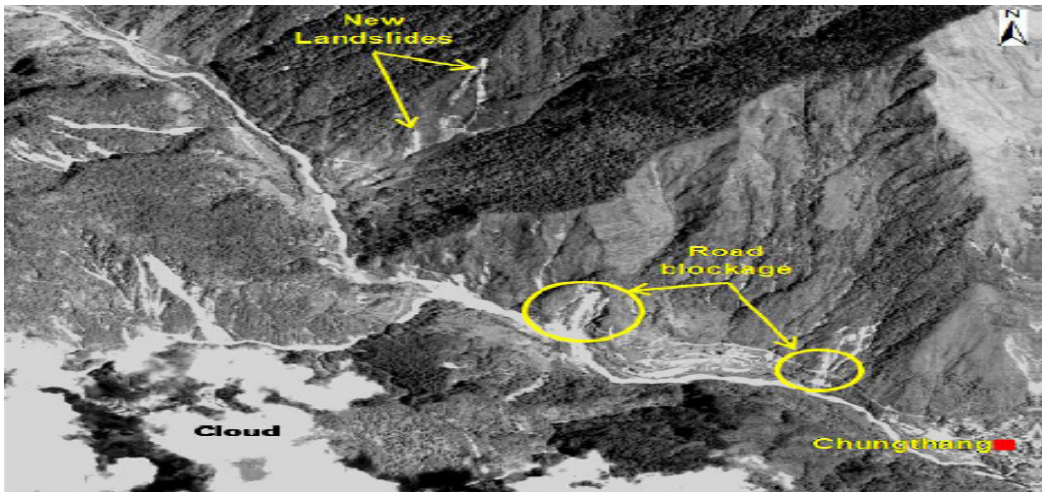
Normally earthquake induced landslide are considered as the most hazardous one than the landslide triggered by rainfall because earthquake induced landslide creates large deep-seated landslide which are capable of brutal disaster (Martha, Govindharaj & Kumar, 2015). Earthquake induced landslide has capability to block flow of rivers and snap connectivity in higher altitude.

Thus, it can hamper communication between the rural and urban area. It can also create a situation for flash floods when the river gets blocked by huge debris. The 18th September, 2011 earthquake induced landslide had a considerable impact upon the infrastructural connectivity in various places of North district of Sikkim like Lachung, Lachen, Mangan, Dzongu and Chungthang.

Map No: III.2 **Pre earthquake Cartosat-1 image near Chungthang block (North Sikkim)**

Source: Martha, Govindharaj & Kumar, 2015, p. 798.

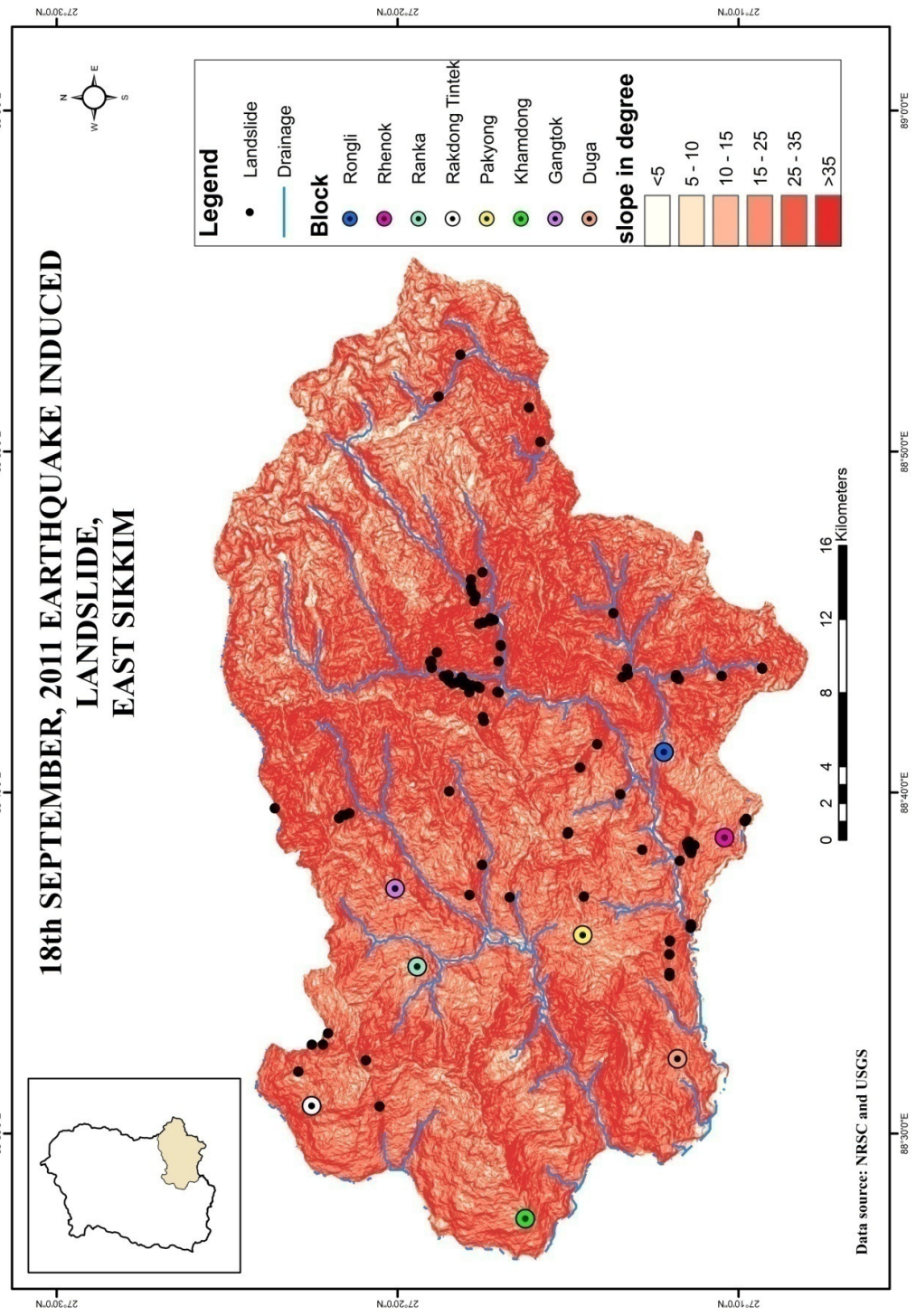
Map No: III.3 **Post earthquake Cartosat-1 image near Chungthang block (North Sikkim)**



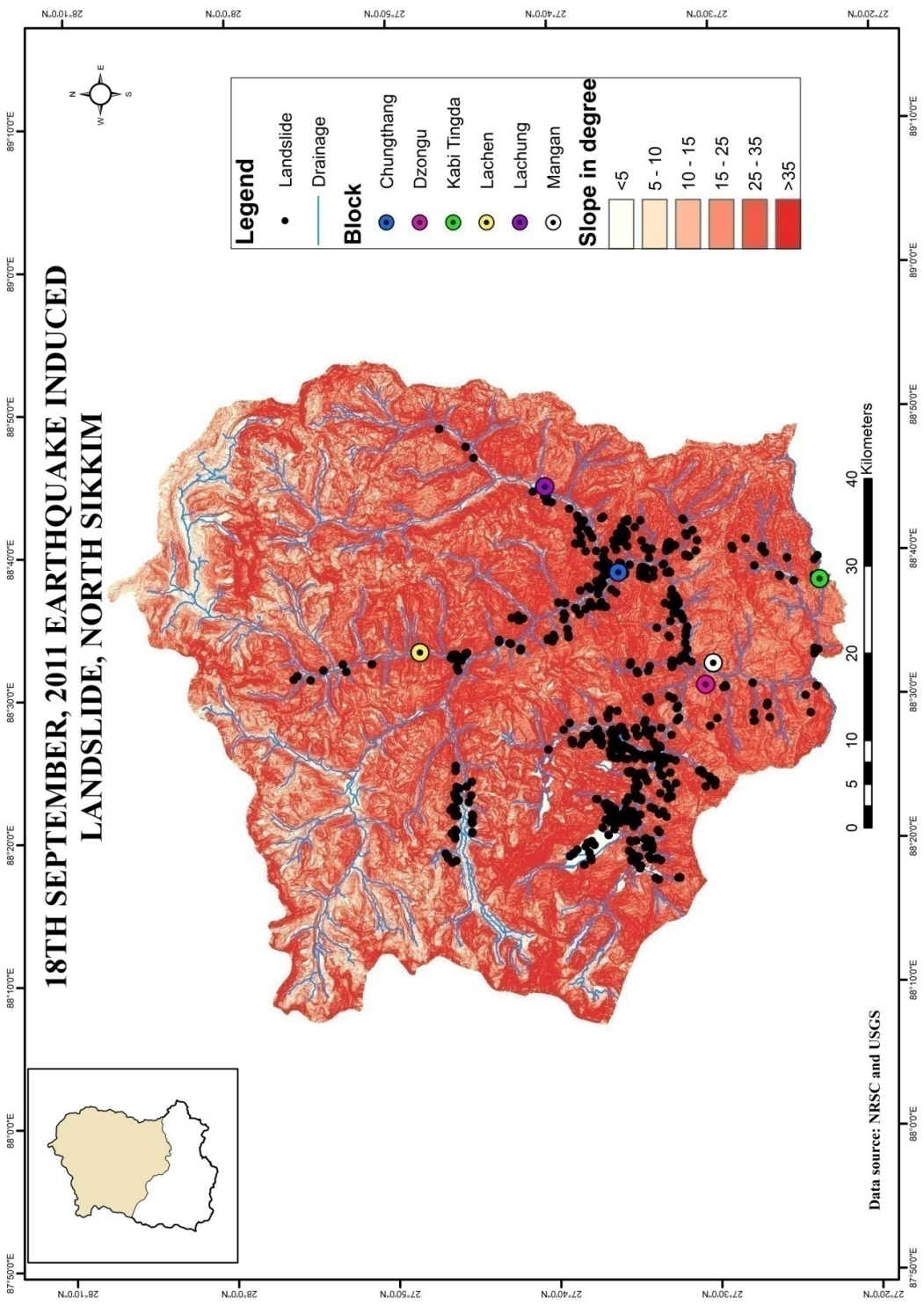
Source: Martha, Govindharaj & Kumar, 2015, p. 798.

Post earthquake Cartosat-1 image reveals the complete blockage and destruction of road connectivity due to earthquake induced landslide.

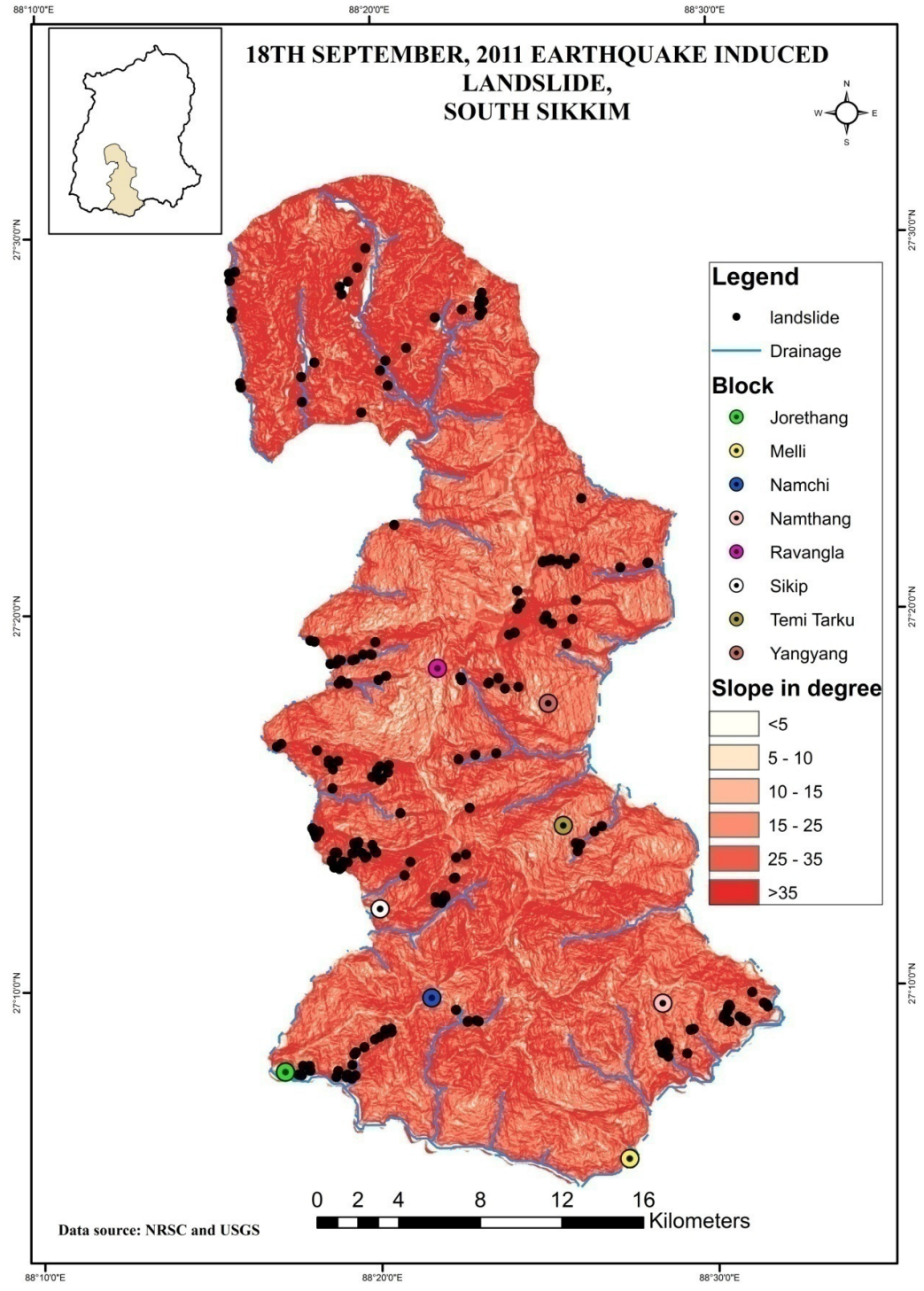
Map No: III.4


18th SEPTEMBER, 2011 EARTHQUAKE INDUCED
LANDSLIDE,
EAST SIKKIM
Legend
Landslide
Drainage
Block
Rongli
Rhenok
Ranka
Rakdong Tintek
Pakyong
Khamdong
Gangtok
Duga
slope in degree
<5
5 - 10
10 - 15
15 - 25
25 - 35
>35
0 2 4 8 12 16
Kilometers
Data source: NRSC and USGS
88°30'0"E
88°40'0"E
88°50'0"E
89°0'0"E
27°30'0"N
27°20'0"N
27°10'0"N
N
S
E
W

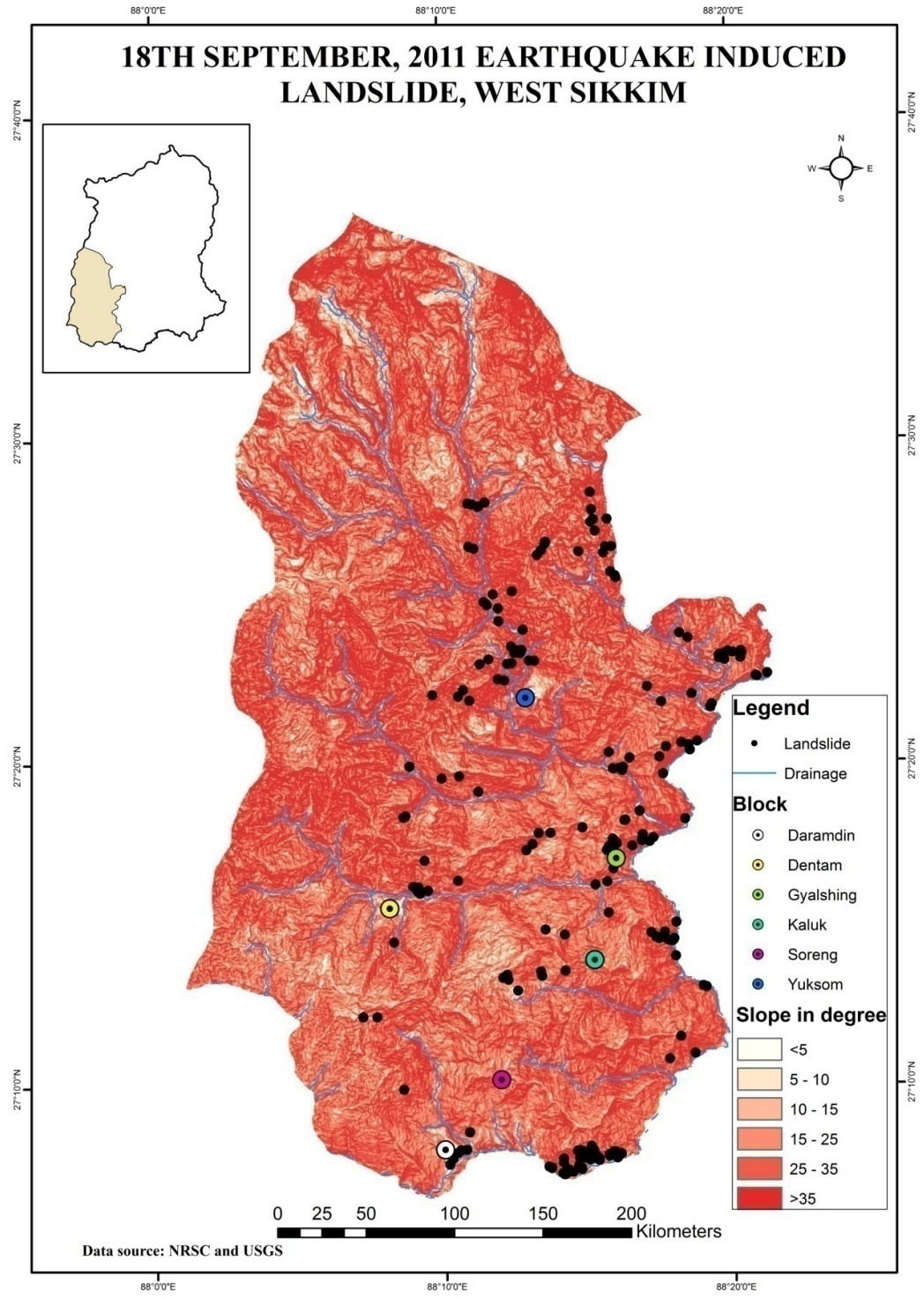
Map No: III.5


18TH SEPTEMBER, 2011 EARTHQUAKE INDUCED
LANDSLIDE, NORTH SIKKIM
Legend
Landslide
Drainage
Block
Chungthang
Dzongu
Kabi Tingda
Lachen
Lachung
Mangan
Slope in degree
<5
5 - 10
10 - 15
15 - 25
25 - 35
>35
0 5 10 20 30 40
Kilometers
Data source: NRSC and USGS

Map No: III.6


18TH SEPTEMBER, 2011 EARTHQUAKE INDUCED LANDSLIDE, SOUTH SIKKIM
N
W
E
S
88°10'0"E
88°20'0"E
88°30'0"E
27°30'0"N
27°20'0"N
27°10'0"N
Legend
landslide
Drainage
Block
Jorethang
Melli
Namchi
Namthang
Ravangla
Sikip
Temi Tarku
Yangyang
Slope in degree
<5
5 - 10
10 - 15
15 - 25
25 - 35
>35
0 2 4 8 12 16
Kilometers
Data source: NRSC and USGS

Map No: III.7


18TH SEPTEMBER, 2011 EARTHQUAKE INDUCED LANDSLIDE, WEST SIKKIM
88°0'0"E
88°10'0"E
88°20'0"E
27°40'0"N
27°30'0"N
27°20'0"N
27°10'0"N
N
W
E
S
Legend
Landslide
Drainage
Block
Daramdin
Dentam
Gyalshing
Kaluk
Soreng
Yuksom
Slope in degree
<5
5 - 10
10 - 15
15 - 25
25 - 35
>35
0 25 50 100 150 200
Kilometers
Data source: NRSC and USGS

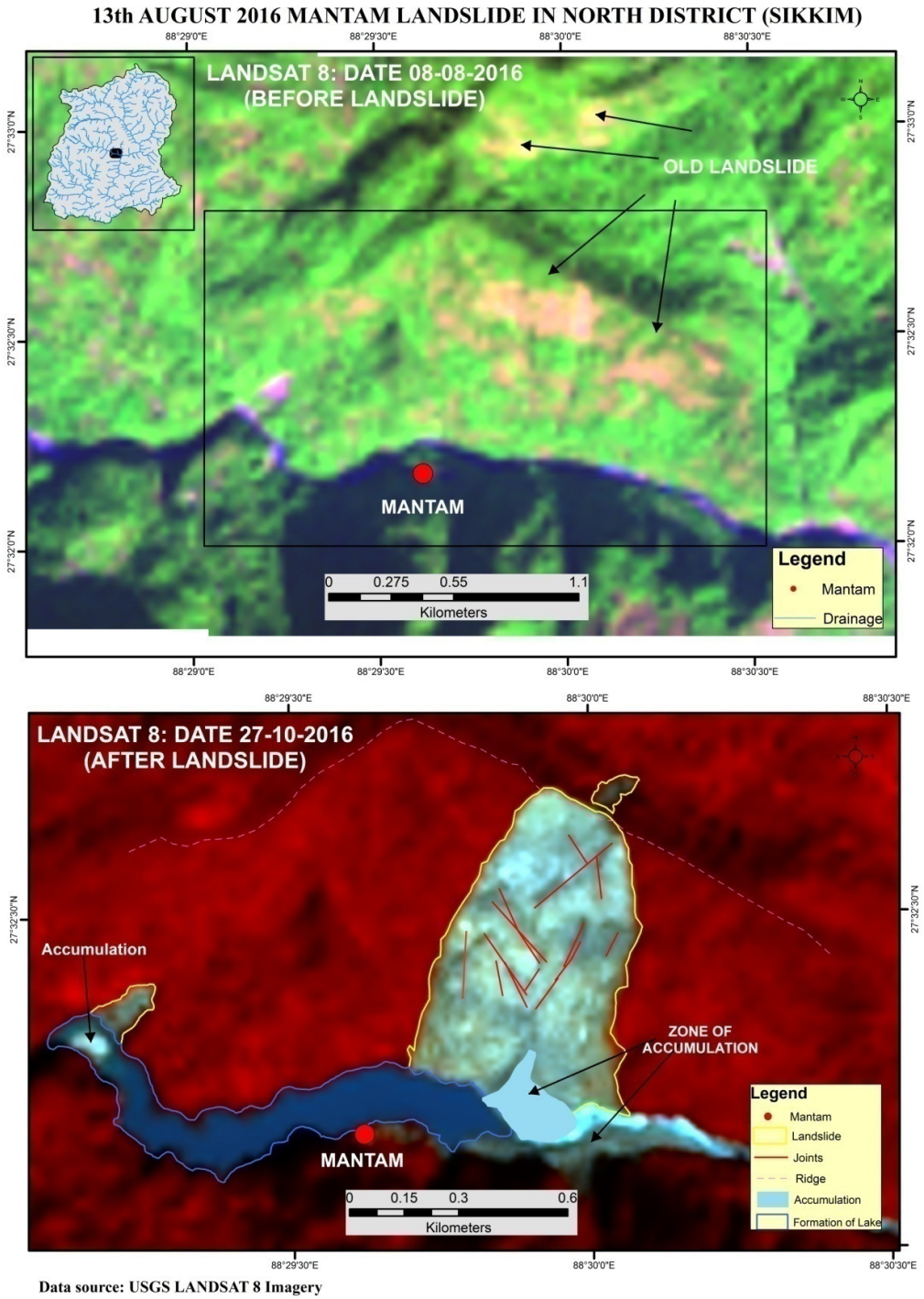
The above four 2011 earthquake induced landslide map demonstrates the steepness of slope along the river banks area, the same being vulnerable zone for landslide hazards in Sikkim Himalaya. For example, the river bank area where the angle of slope is more than 25 degree reveals the most landslide occurring zone during 2011 earthquake. The passage of 2011 seismic wave passing through the weak and steep geological structure gradually altered the load of the land surface and increased the rate of sub surface movement (SSDMA, 2015). This process is also called 'topographic amplification' (SSDMA, 2015). However, mega hydro power dams also did render already weak and steep geological structure to be more unstable and vulnerable. Thus, 2011 earthquake did not received any strong resistance in the Sikkim Himalaya.

III.1.2 Mantam Landslide, 2016

A massive landslide occurred near Mantam village in Dzongu, North Sikkim, India around 13:30 hr (IST) on 13 August 2016 (Martha, Roy & Kumar, 2017). The location of the landslide was 27° 32' 22.9" north latitude and 88° 30' 2.47" east longitude.

As landslide blocked the flow of river Kanaka, huge lake was formed and the formation of lake raised the water level due to which a connecting bridge between different villages was submerged and the about 300 m stretch of road was washed away (Martha, Roy & Kumar, 2017). Five houses in Mantam village were also submerged and the eight villages namely, Tingvong, Lingdem, Laven, Kayeem, Lingzya, Bay, Sakyong Pentong and Ruklu Kayeem were cut-off (Martha, Roy & Kumar, 2017). However, no human casualties were reported in the incident.

Map No: III.8



Data source: USGS LANDSAT 8 Imagery

Plate III.1 **Mantam Landslide**

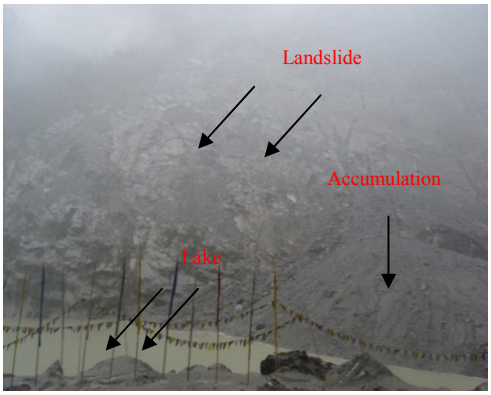


Plate III.2 **Formation of lake after 13th August 2016 Mantam Landslide**

Source: Field Survey, August 2016.

Debris deposits can be clearly observed on either side of the ridge line and the exposed joints after the landslide suggest a wedge type of failure near the crown followed by translational type of failure in the main body of the landslide (Martha, Roy & Kumar, 2017). Blockage of normal flow of river by the deposited debris formed an artificial lake of 2.2 km length and 209 m width (Martha, Roy & Kumar, 2017). Geologically, the area is in proximity with the Main Central Thrust (MCT) due to which, high-grade rocks of Proterozoic Central Crystalline Gneissic Complex (e.g. Quartzite, Schist and granite gneisses) are exposed in this area (Martha, Roy & Kumar, 2017).

Groundwater seepages from the exposed joint planes are also visible in the map and the image. Therefore, the aquifer-induced pore pressure and escarpment stress condition, as evident from the presence of an old landslide in the map (Map No: 3.8), could be the probable physical/geological causes of landslide occurrence on 13 August 2016 in Mantam (Martha, Roy & Kumar, 2017). However, development of mega hydro power dam in Chungthang block cannot be ignored too as it is likely that

it may have added to the physical stress during its development owing to huge underground blasting.

III.2 Earthquakes

Earthquake is the passage of seismic waves through the Earth surface which often causes violent shaking. The severest earthquake tends to occur at convergent plate boundaries where one plate descends beneath the other (Schneid & Collins, 2000). Sikkim Himalaya being a part of huge and elongated Himalaya is also moving northward against the Eurasian plate thus making it seismically active zone.

Therefore, it is obvious that earthquake has been a common natural hazard in Sikkim Himalaya. Earthquake in this region is usually interpolate in nature but preliminary data suggested that 18th September 2011 Sikkim Earthquake was triggered by shallow strike-slip faulting from an interplate sources within the over-riding Eurasian plate (LR & DMD, 2012).

The Sikkim Himalaya consists of young fold mountain range with weak geological structure which is often frequently vulnerable to weathering and erosion. Such fragile geological set up plated a crucial role in extending the impact of 2011 earthquake in the Sikkim Himalaya. Sikkim Himalaya has experienced 18 earthquakes of magnitude 5 or greater over the past 35 years within the 100 km of epicentre of 18th September, 2011 events (Kumar, Walia & Chaturvedi, 2012, p. 15). However, 18th September 2011 Earthquake was the most devastating one where almost 63 people lost their lives (LR & DMD, 2012, p. 12). Main shock followed by five aftershocks of magnitude 5.3 (moderate), 4.6 (light), 3.0 (minor), 3.4 (minor) and 3.8 (minor) induced more damage to already weakened buildings and road sides. Nearly 1,998 landslides occurred due to 2011 earthquake (NRSC, 2011). In addition, the continuous rainfall, road blockage

and numerous small flash flood added more difficulty to the rescue operation. List of aftershocks of magnitude 3.0 and above that was recorded till 9:30 hours IST of 19th September 2011 is given below.

Table III.1: **List of aftershocks**

Sl. No	Date	Time of aftershocks (IST)	Magnitude
1.	18-09-2011	18:42	5.3
2.	18-09-2011	19:24	4.6
3.	18-09-2011	20:35	3.0
4.	19-09-2011	00:57	3.4
5.	19-09-2011	03:21	3.8

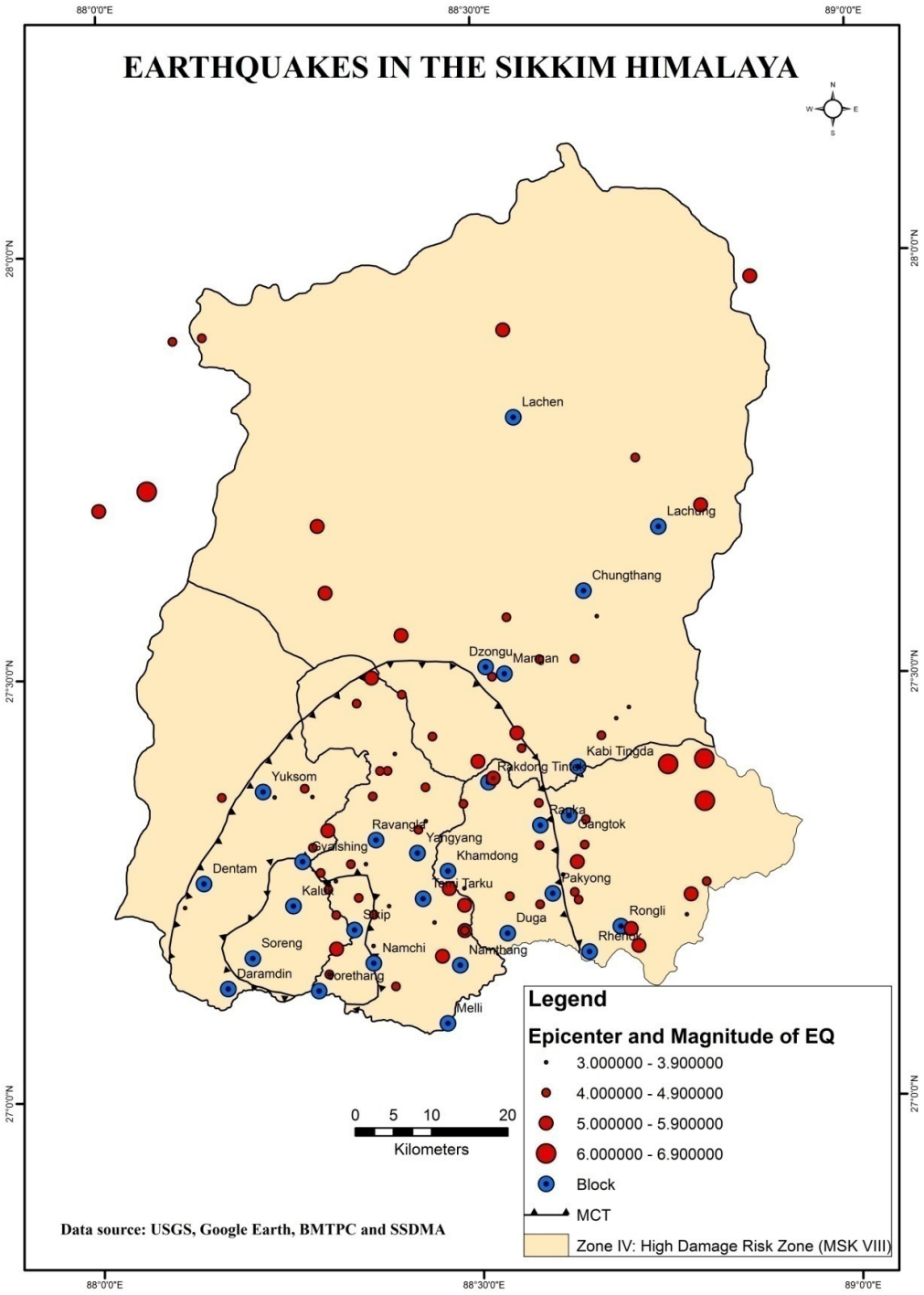
Source: Land Revenue and Disaster Management Department, 2012, p. 10.

Table III.2: **Impact of 18th September, 2011 Earthquake in Sikkim**

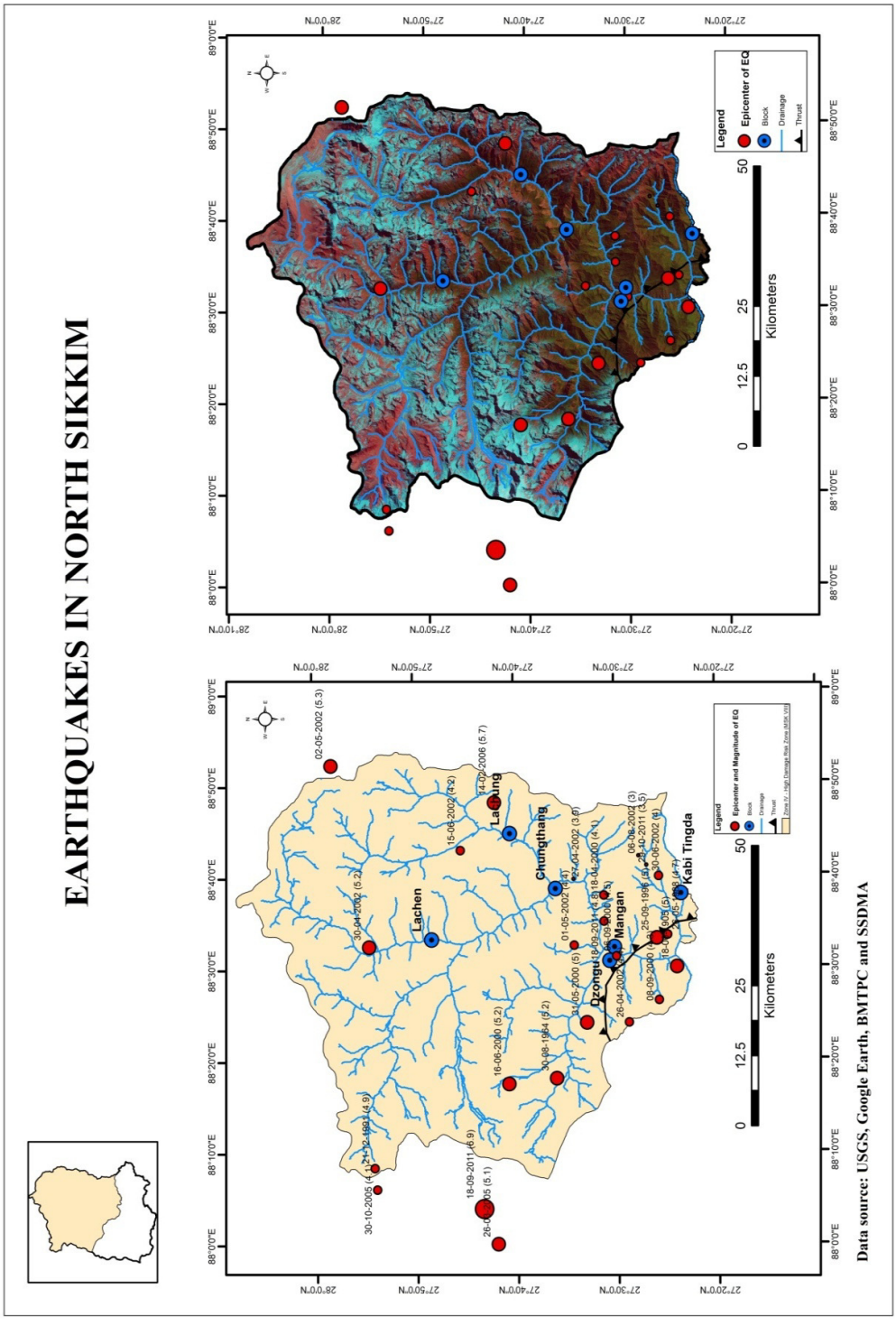
District	Death	Estimated homeless	Houses/building			
			Destroyed	Severely destroyed	partially	Slightly
North Sikkim	59	20160	6000	unknown	unknown	Unknown
South Sikkim	1	2755	820	-	446	1582
East Sikkim	13	20160	6000	-	9000	-
West Sikkim	4	1817	1679	5327	8342	-

Source: Vervaeck & Daniell 2011, http://earthquake-report.com/2011/09/18very-strong-earthquake-in-sikkim-india/, accessed on 15-10-13.

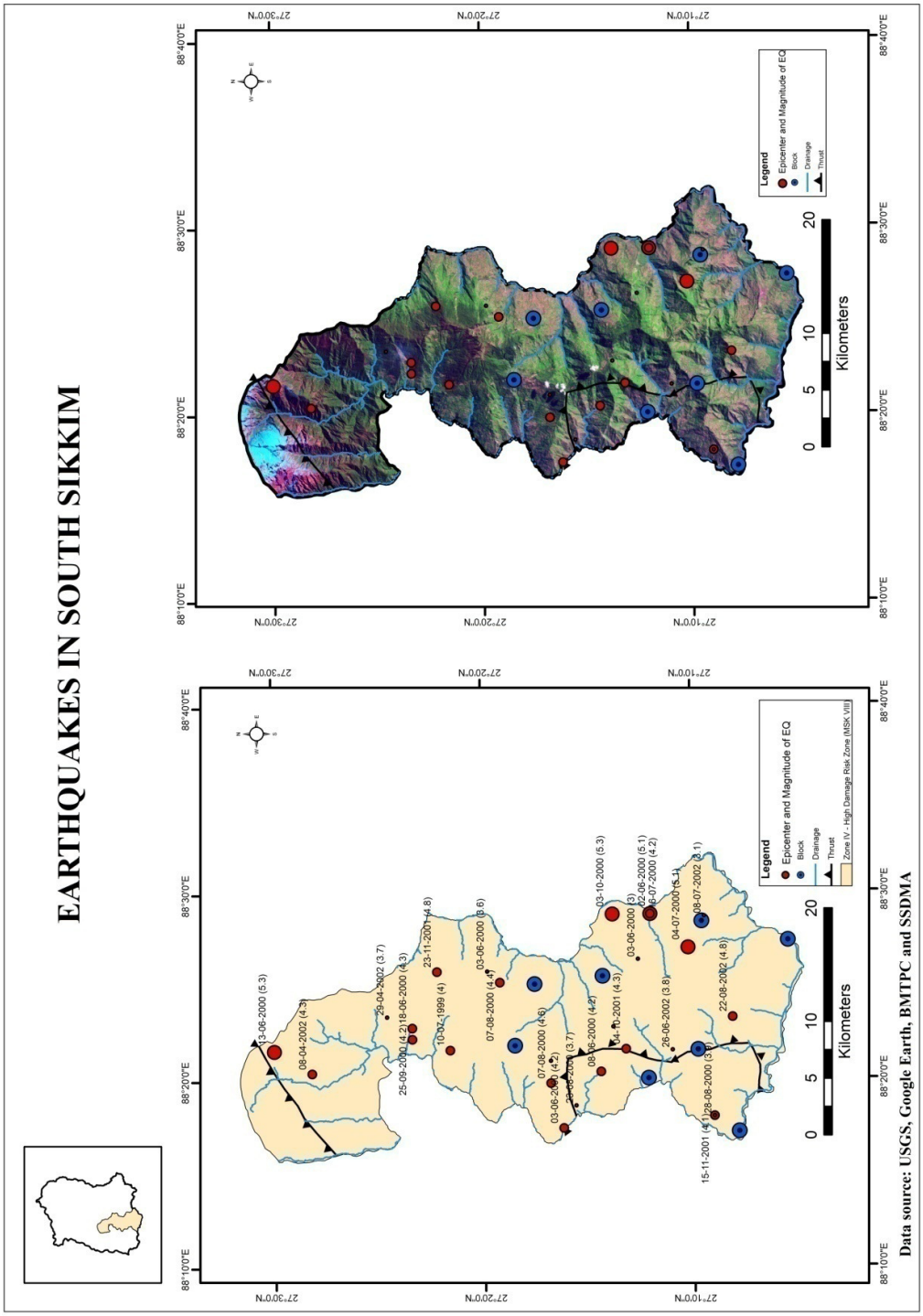
Map No: III.9


EARTHQUAKES IN THE SIKKIM HIMALAYA
88°0'0"E
88°30'0"E
89°0'0"E
28°0'0"N
27°30'0"N
27°0'0"N
N
W
E
S
Lachen
Lachung
Chungthang
Dzongu
Mangan
Kabi Tingda
Rakdong Tingbe
Yuksom
Ravangla
Rabka
Gangtok
Yangyang
Khamdong
Dentam
Pakyong
Kaluk
Tarku
Rongli
Duga
Soreng
Namchi
Rhenock
Namthang
Daramdin
Melli
0 5 10 20
Kilometers
Legend
Epicenter and Magnitude of EQ
3.000000 - 3.900000
4.000000 - 4.900000
5.000000 - 5.900000
6.000000 - 6.900000
Block
MCT
Zone IV: High Damage Risk Zone (MSK VIII)
Data source: USGS, Google Earth, BMTPC and SSDMA

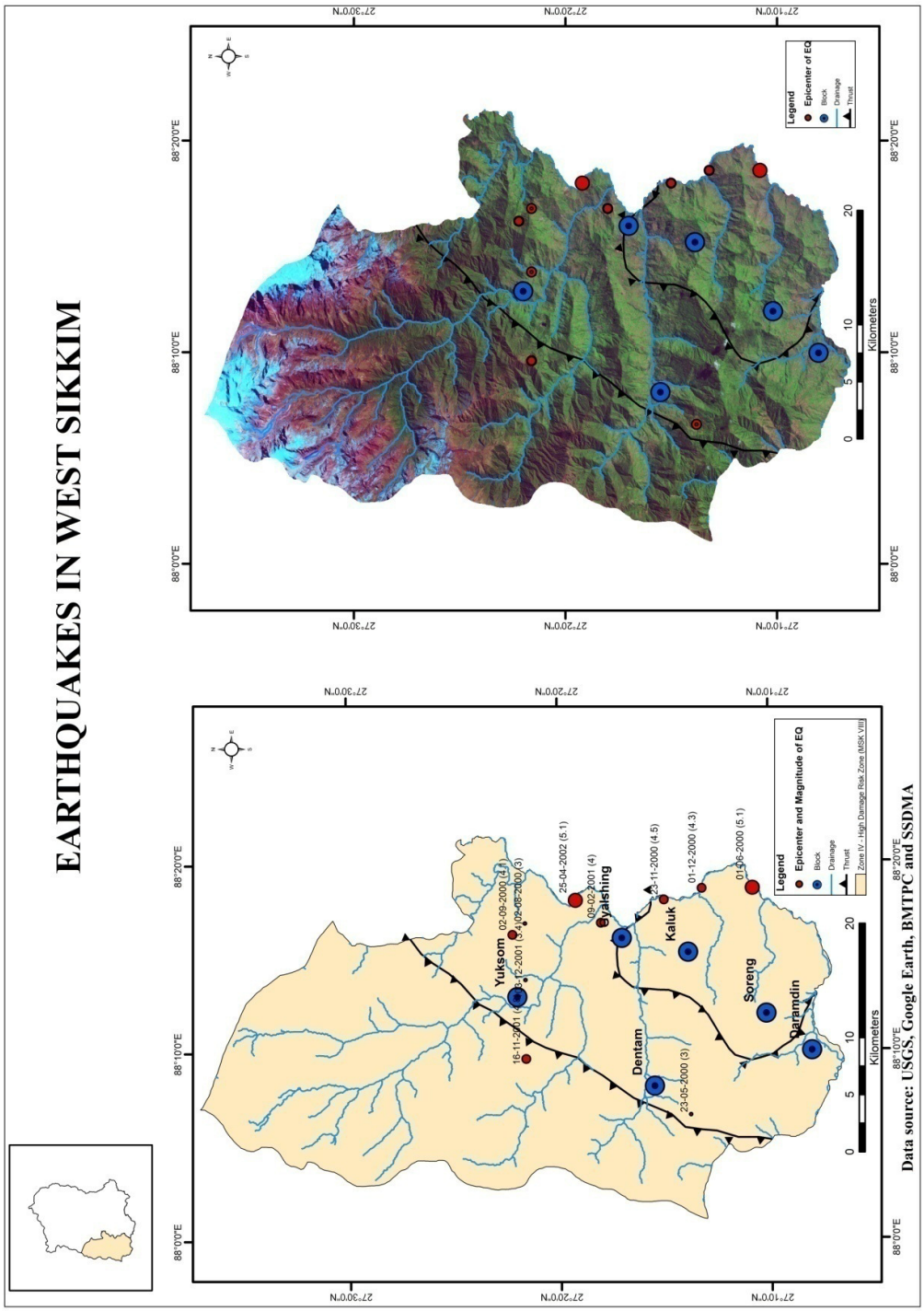
Map No: III.10


EARTHQUAKES IN NORTH SIKKIM
Legend
Epicenter of EQ
Block
Drainage
Thrust
Kilometers
Legend
Epicenter and Magnitude of EQ
Block
Drainage
Thrust
Kilometers
Lachung
Chungthang
Lachen
Mangan
Dzongu
Kabi Tingda
Data source: USGS, Google Earth, BMTPC and SSDMA

Map No: III.11


EARTHQUAKES IN SOUTH SIKKIM
Legend
Epicenter and Magnitude of EQ
Block
Drainage
Thrust
Zone IV - High Damage Risk Zone (MSK VIII)
Kilometers
0
5
10
20
88°10'0"E
88°20'0"E
88°30'0"E
88°40'0"E
27°30'0"N
27°20'0"N
27°10'0"N
03-06-2000 (5.3)
08-04-2002 (4.3)
29-04-2002 (3.7)
25-09-2000 (4.2)
18-06-2000 (4.3)
10-07-1999 (4)
23-11-2001 (4.8)
03-06-2000 (3.6)
07-08-2000 (4.4)
07-08-2000 (4.6)
03-06-2000 (4.5)
03-06-2000 (3.7)
08-06-2000 (4.2)
04-11-2001 (4.3)
03-10-2000 (5.3)
03-06-2000 (3)
22-06-2000 (5.1)
06-07-2000 (4.2)
04-07-2000 (5.1)
08-07-2002 (3.1)
26-06-2002 (3.8)
22-08-2002 (4.8)
15-11-2001 (4.1)
28-08-2000 (3.1)
Data source: USGS, Google Earth, BMTPC and SSDMA

Map No: III.12


EARTHQUAKES IN WEST SIKKIM
Legend
Epicenter of EQ
Block
Drainage
Thrust
Legend
Epicenter and Magnitude of EQ
Block
Drainage
Thrust
Zone IV - High Damage Risk Zone (MSK VIII)
Yuksom
Dentam
Kaluk
Soreng
Daramdin
Gyalshing
02-09-2000 (4)
09-08-2000 (3)
16-11-2001 (4)
25-04-2002 (5.1)
09-02-2001 (4)
23-11-2000 (4.5)
01-12-2000 (4.3)
01-08-2000 (5.1)
23-05-2000 (3)
Kilometers
0
5
10
20
88°0'0"E
88°10'0"E
88°20'0"E
27°30'0"N
27°20'0"N
27°10'0"N
Data source: USGS, Google Earth, BMTPC and SSDMA

Map No: III.13

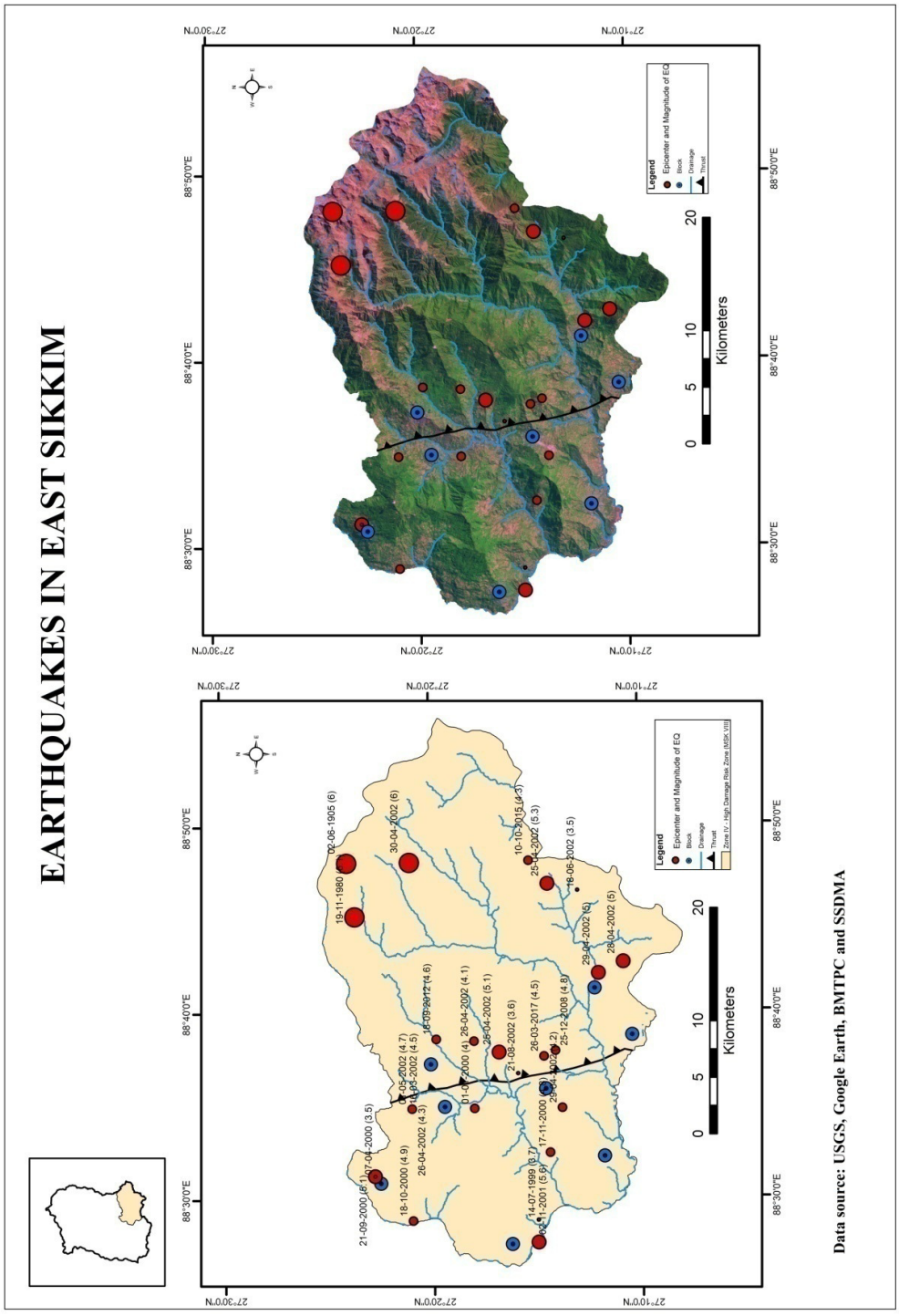
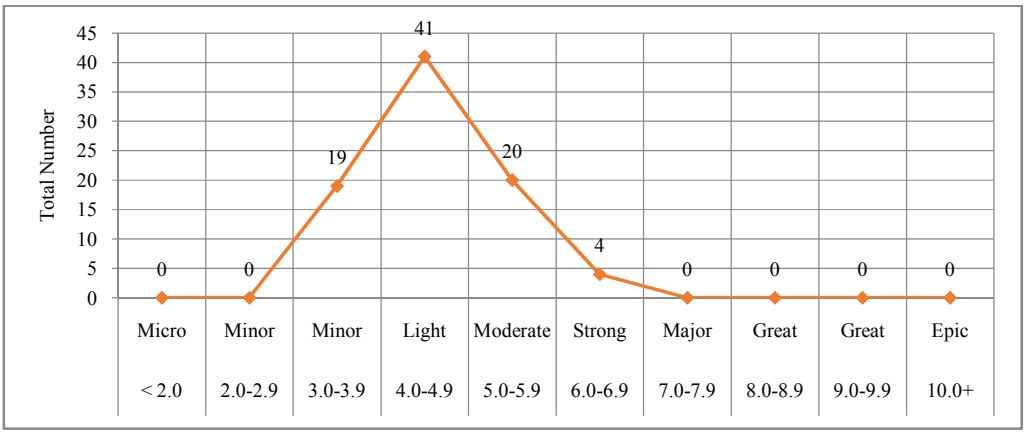

EARTHQUAKES IN EAST SIKKIM
Legend
Epicenter and Magnitude of EQ
Block
Drainage
Thrust
Zone IV - High Damage Risk Zone (MSK VIII)
Kilometers
0
5
10
20
88°30'0"E
88°40'0"E
88°50'0"E
27°10'0"N
27°20'0"N
27°30'0"N
02-06-1905 (6)
19-11-1980 (6)
30-04-2002 (6)
10-10-2015 (4.3)
25-04-2002 (5.3)
18-06-2002 (3.5)
29-04-2002 (5)
28-04-2002 (5)
28-03-2017 (4.5)
25-12-2008 (4.8)
21-09-2000 (4.1)
18-10-2000 (4.9)
26-04-2002 (4.5)
17-11-2000 (3.2)
14-07-1999 (5.7)
02-11-2001 (5.6)
Data source: USGS, Google Earth, BMTPC and SSDMA

Table III.3: **Richter Magnitude and Earthquake effects**

Richter Magnitudes	Description	Earthquake Effects
< 2.0	Micro	Micro earthquakes, not felt.
2.0-2.9	Minor	Generally not felt, but recorded
3.0-3.9	Minor	Often felt, but rarely causes damage.
4.0-4.9	Light	Noticeable shaking of indoor items, rattling noises. Significant damage unlikely
5.0-5.9	Moderate	Can cause major damage to poorly constructed buildings over small regions. At most slight damage to well-designed buildings
6.0-6.9	Strong	Can be destructive in areas up to about 160 kilometres (100 mi) across in populated areas.
7.0-7.9	Major	Can cause serious damage over larger areas
8.0-8.9	Great	Can cause serious damage in areas several hundred miles across.
9.0-9.9	Great	Devastating in areas several thousand miles across.
10.0+	Epic	Never recorded

Source: NIDM, https://nidm.gov.in/easindia2014/err/pdf/earthquake/earthquakes_measurement.pdf, accessed on 14-04-2019

Fig III.2: **Occurrence of Earthquake with magnitude in the Sikkim Himalaya from 1905 to 2018**



Source: Computed from USGS, Google Earth, BMTPC and SSDMA

Table III.4: **History of Earthquake above four magnitudes in Sikkim**

DATE	LATITUDE	LONGITUDE	MAGNITUDE
02/06/05	27.4	88.8	6
19/11/80	27.394	88.752	6.1
10/07/99	27.36	88.36	4
01/01/00	27.3	88.58	4
01/06/00	27.18	88.31	5.1
02/06/00	27.2	88.48	5.1
03/06/00	27.27	88.29	4.2
08/06/00	27.24	88.34	4.2
13/06/00	27.5	88.36	5.3
18/06/00	27.39	88.38	4.3
04/07/00	27.17	88.45	5.1
16/07/00	27.2	88.48	4.2
07/08/00	27.32	88.42	4.4
07/08/00	27.28	88.33	4.6
02/09/00	27.37	88.27	4.1
21/09/00	27.38	88.52	5.1
25/09/00	27.39	88.37	4.2
03/10/00	27.23	88.48	5.3
18/10/00	27.35	88.48	4.9
17/11/00	27.24	88.54	4.8
23/11/00	27.25	88.3	4.5
01/12/00	27.22	88.31	4.3
09/02/01	27.3	88.28	4
04/10/01	27.22	88.36	4.3
02/11/01	27.25	88.46	5.6
15/11/01	27.15	88.3	4.1

16/11/01	27.36	88.16	4.8
23/11/01	27.37	88.43	4.8
16/03/02	27.35	88.58	4.5
08/04/02	27.47	88.34	4.3
25/04/02	27.28	88.63	5.1
25/04/02	27.24	88.78	5.3
25/04/02	27.32	88.3	5.1
26/04/02	27.3	88.64	4.1
26/04/02	27.35	88.58	4.3
28/04/02	27.18	88.71	5
29/04/02	27.23	88.58	4.2
29/04/02	27.2	88.7	5
30/04/02	27.35	88.8	6
01/05/02	27.35	88.58	4.7
22/08/02	27.135	88.388	4.8
25/12/08	27.235	88.631	4.8
18/09/12	27.33	88.642	4.6
10/10/15	27.2548	88.8009	4.3
26/03/17	27.2442	88.6261	4.5

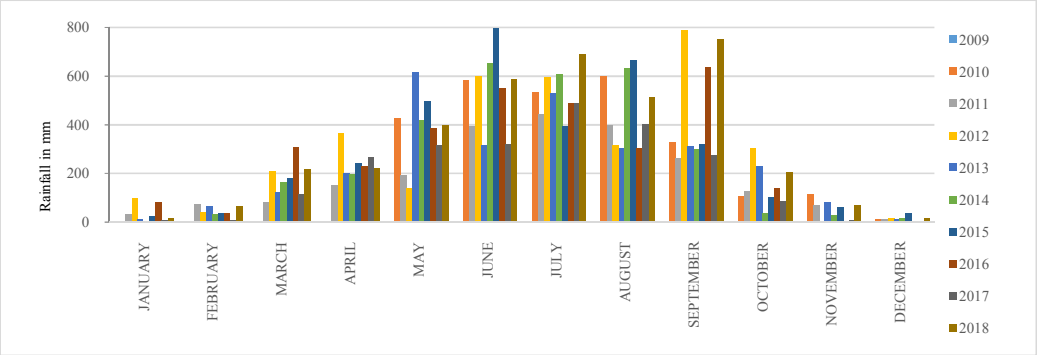
Source: USGS, Google Earth, BMPTC and SSDMA

III.3 Flood/Flash Flood

Flooding is simply an overflowing of water onto the land or the rise of water level in an area where there was normally little or none before. It happens due to following reason- when there is continous heavy rainfall, when snow melts too fast, when dams or levees break or when landslide block the flow of perennial river and creates a huge lake. In terms of the Sikkim Himalaya, cloudburst leading to high intensity of surface flow and the blockage of river by monsoonal rain induced landslide are considered as

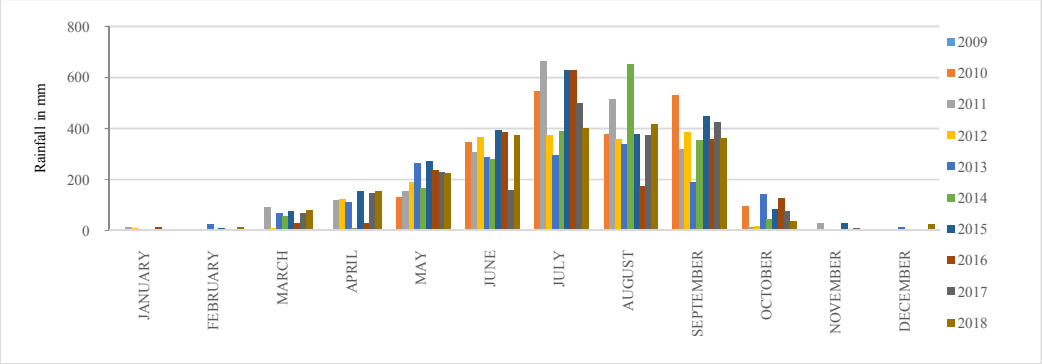
the chief reason of flooding. Thus, among floods, flash floods are common in Sikkim Himalaya. Flash floods are enormously hazardous because it usually combines the destruction power of a flood with incredible speed and unpredictability (NSSL, n.d.)[26]. It normally occurs when excessive water fills up river beds and over flows rapid rise of water in a short period of time with immense speed (NSSL, n.d.).

Fig III.3: **Ten years monthly rainfall statistics of North district, Sikkim**



Source: Computed from Hydrome Division, India Meteorological Department

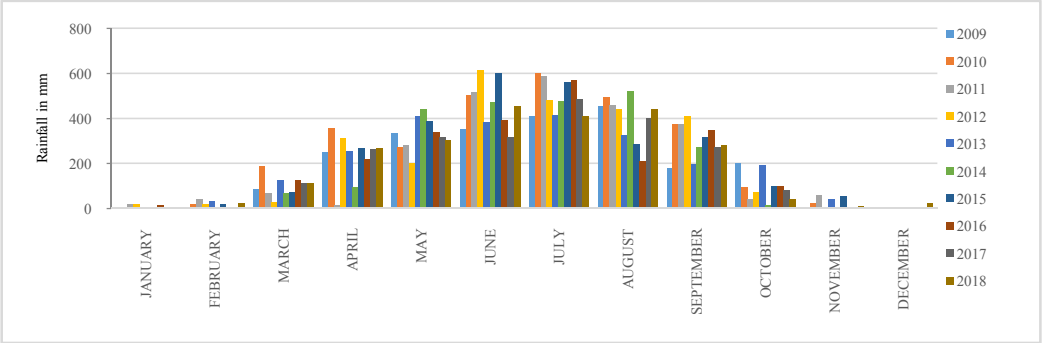
Fig III.4: **Ten years monthly rainfall statistics of South district, Sikkim**



Source: Computed from Hydrome Division, India Meteorological Department

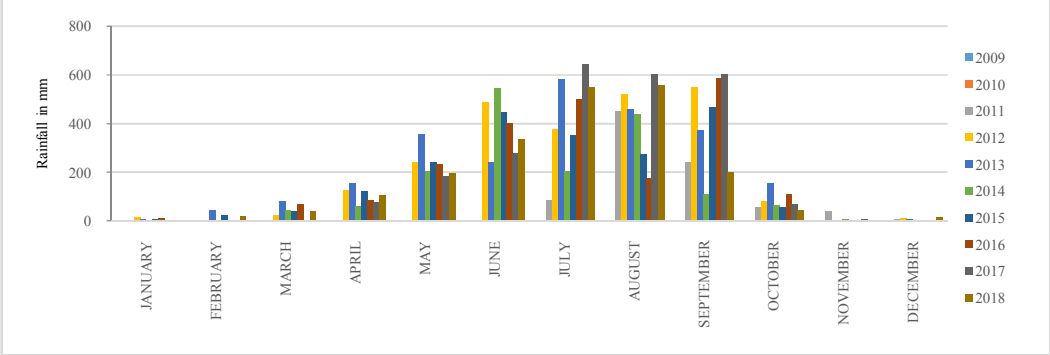
[26] Cited in NSSL. (n.d.). Severe Weather 101- Floods. *The National Serve Storms Laboratory*. Retrieved March 05, 2017, from https://www.nssl.noaa.gov/education/svrwx101/floods/

Fig III.5: **Ten years monthly rainfall statistics of East district, Sikkim**



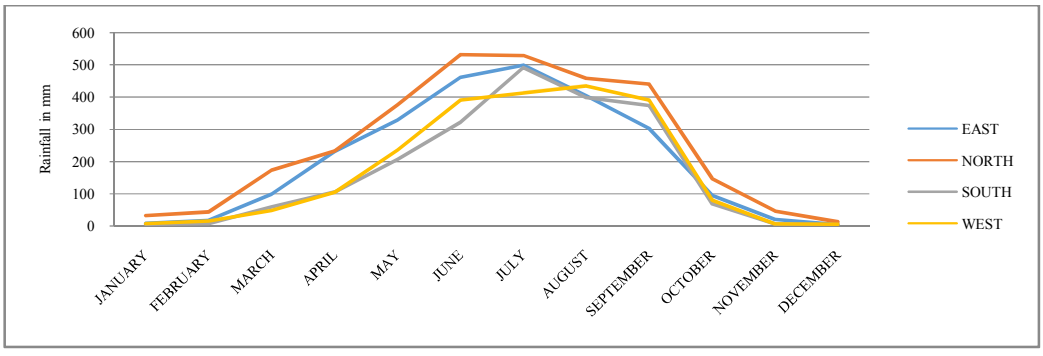
Source: Computed from Hydrome Division, India Meteorological Department

Fig III.6: **Ten years monthly rainfall statistics of West district, Sikkim**



Source: Computed from Hydrome Division, India Meteorological Department

Fig III.7: **Ten years monthly average rainfall statistics of Sikkim from 2009-2018**



Source: Computed from India Meteorological Department

III.3.1 Reconstructing 1968 Flash Flood

Teesta flowing through Sikkim and Darjeeling Himalaya is considered one of the wildest rivers of the Himalayan region. Teesta river valley in Sikkim Himalaya mostly consist of deep and dense gullies. The river valley is also prone to cloudburst, landslides and flash floods. Intense cloudbursts are more responsible than the earthquake in generating explosive characters of the Teesta valley in Sikkim Himalaya.

Due to the absence of high mountain range in lower catchment of Teesta valley, monsoon winds from Bay of Bengal causes huge amount of cloudbursts here (Agarwal, Labh & Nambi, 1991).The valley area experiences rainfall varying from 3,000 mm to 6,000 mm every year (Agarwal, Labh & Nambi, 1991).Thus, Teesta river has the highest sediment yield of all the Himalayan rivers, bringing down approximately 98 cum of silt per ha of its catchment per year giving an annual denudation rate of 9.8 mm per year, which is amongst the highest denudation rates estimated for any river valley in the world (Agarwal, Labh & Nambi, 1991).

Experts from Central Building Research Institute (CBRI)[27] argue that cloudbursts exceeding 1000mm in 24 hrs. will trigger landslides practically in any geological circumstances and in 1968 Sikkim Himalaya received huge rainfall for three continuous days (Agarwal, Labh & Nambi, 1991). This continuous rainfall caused numerous landslides all around the Sikkim Himalayan region and these landslides played a major role in exacerbating flash floods in Teesta valley of Sikkim and Darjeeling Himalaya. Therefore, an intense cloudburst was not only the major cause

[27]Central Building Research Institute, Roorke, India, is one of the constituent of Council of Scientific and Industrial Research which was established in 1947. Its main objective is to develop and promote science and technology for the service of nation.

of 1968 flash flood, the fragile geology of Sikkim Himalaya also played a vital role in exacerbating numerous landslides which in turn blocked the normal flow or river in many location.

According to local people who have witnessed the 1968 flash flood in Sikkim Himalaya, *it is one of the most disastrous event ever happened in this Himalayan region. Entire settlement along the lower catchment of river Teesta in Sikkim and Darjeeling Himalaya belt was destroyed completely.*

Table III.5: **Rainfall data of 02-05 October 1968 (Sikkim Himalaya)**

Date	Rainfall (mm)				
	0:00	6:00h	12:00h	18:00h	Total
02-Oct-1968	80	120	140	60	400
03-Oct-1968	70	90	140	120	420
04-Oct-1968	130	90	110	130	460
05-Oct-1968	110	190	150	49	499

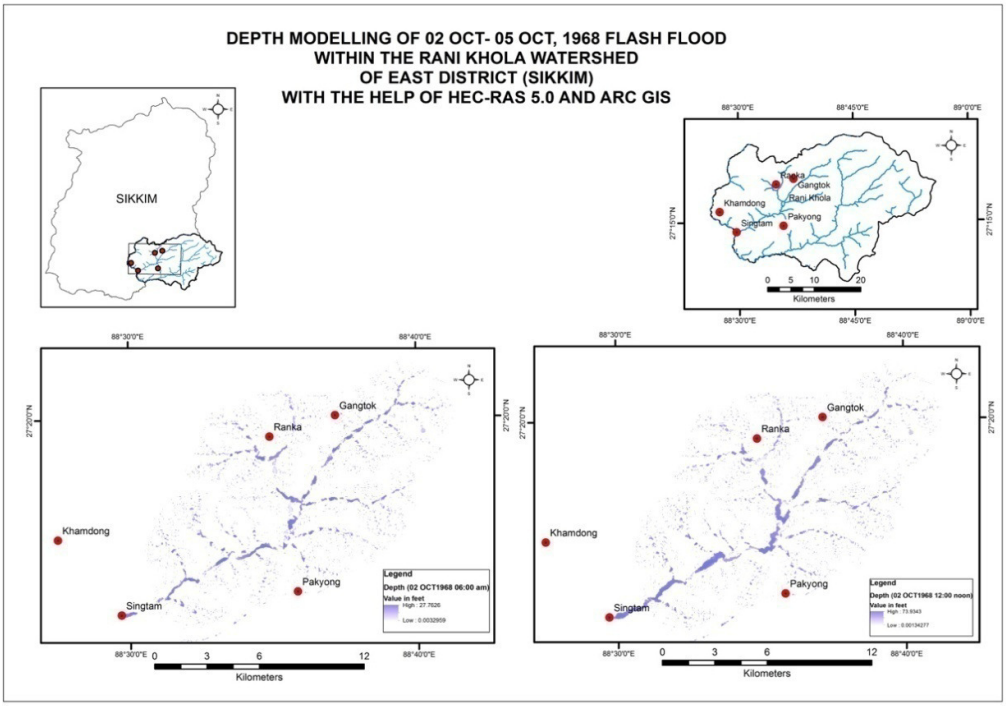
Source: Mandal & Chakrabarty, 2016

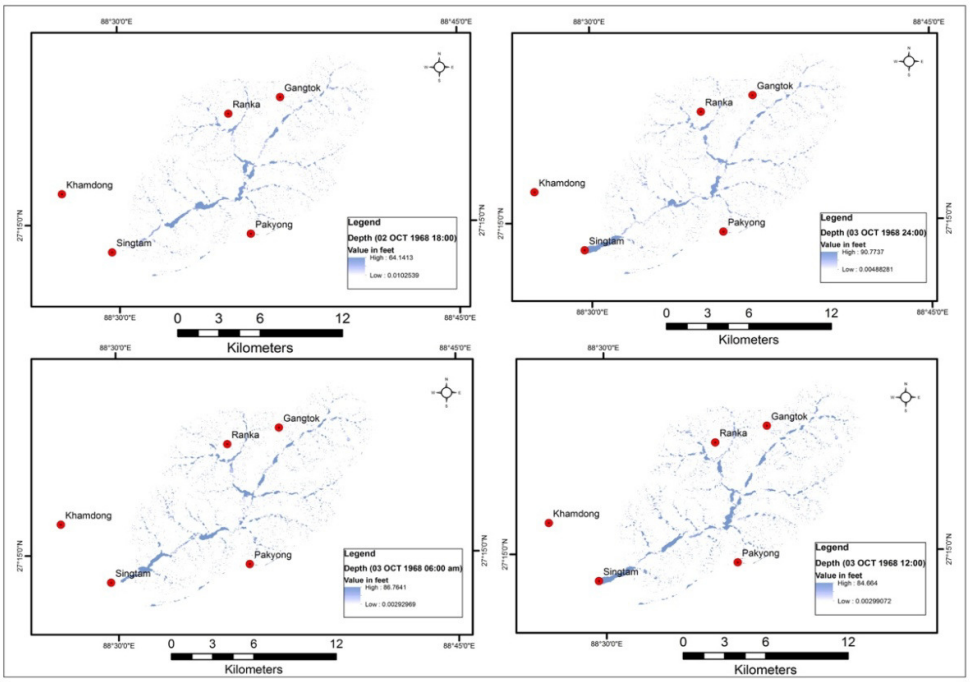
Mapping 1968 flood is difficult due to the lack of precise data. However, to rebuild the image of 1968 flash flood, the study tried to create a model by using Hydrologic Engineering Center-River Analysis System (HEC-RAS) software and the rainfall data extracted from the literature of Mandal & Chakrabarty, 2016. Only East district river basin has been taken for the study to create a model, as the modelling is just for the sake of rebuilding the event and to show a path for demonstrating channel flow analysis and flood area determination.

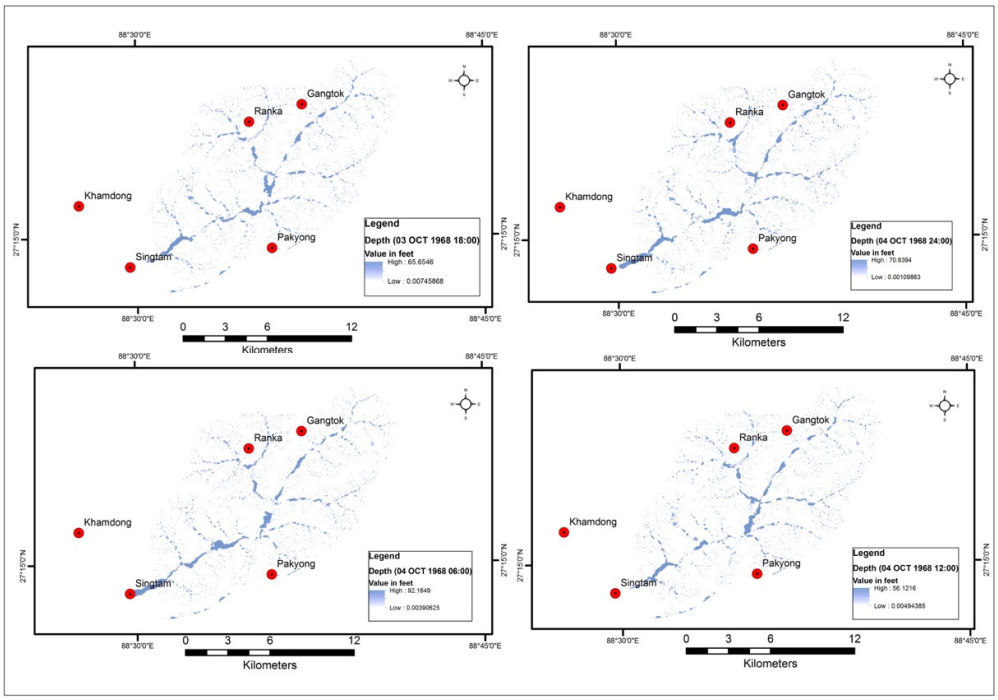
Digital Elevation Model of Sikkim Himalaya was extracted into the HEC-RAS software to gather geometric data of the study area including the riverbed, cross

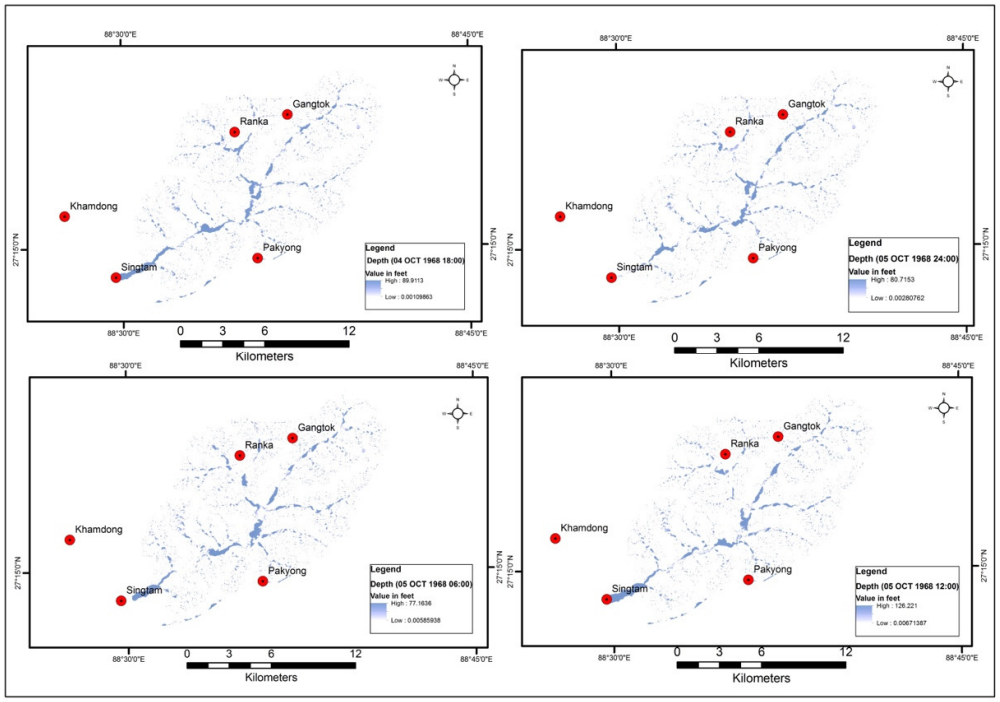
sections and water flow line. Rainfall data of 02nd October 1968 to 05th October 1968 was inserted in the interval of six hours gap. When the required data was inserted inside the HEC-RAS software and flow model was started, the velocity and depth of the river was generated in 3D image. Finally this result was exported and processed in Arc GIS software to create a 1968 flood risk map of East district of Sikkim. The map below clearly indicates Singtam block (East district) as the most high risk flood prone area during 1968. Thus, the flood risk map helps to identify the risky and vulnerable area during the time of excess rainfall. After identifying the risky and vulnerable area, early warning and mitigation strategy can take place smoothly.

Map No: III.14




88°30'0"E
88°45'0"E
27°15'0"N
Gangtok
Ranka
Khamdong
Singtam
Pakyong
Legend
Depth (02 OCT 1968 18:00)
Value in feet
High : 64.1413
Low : 0.0102539
Depth (03 OCT 1968 24:00)
High : 90.7737
Low : 0.00488281
Depth (03 OCT 1968 06:00 am)
High : 86.7641
Low : 0.00292969
Depth (03 OCT 1968 12:00)
High : 84.664
Low : 0.00299072
0 3 6 12
Kilometers


88°30'0"E
88°45'0"E
27°15'0"N
Gangtok
Ranka
Khamdong
Singtam
Pakyong
Legend
Depth (03 OCT 1968 18:00)
Value in feet
High : 65.6546
Low : 0.00745868
Depth (04 OCT 1968 24:00)
High : 70.9394
Low : 0.00109863
Depth (04 OCT 1968 06:00)
High : 92.1649
Low : 0.00390625
Depth (04 OCT 1968 12:00)
High : 56.1216
Low : 0.00494385
0 3 6 12
Kilometers


88°30'0"E
88°45'0"E
27°15'0"N
Gangtok
Ranka
Khamdong
Pakyong
Singtam
Legend
Depth (04 OCT 1968 18:00)
Value in feet
High : 89.9113
Low : 0.00109863
Depth (05 OCT 1968 24:00)
High : 80.7153
Low : 0.00280762
Depth (05 OCT 1968 06:00)
High : 77.1636
Low : 0.00585938
Depth (05 OCT 1968 12:00)
High : 126.221
Low : 0.00671387
0 3 6 12
Kilometers

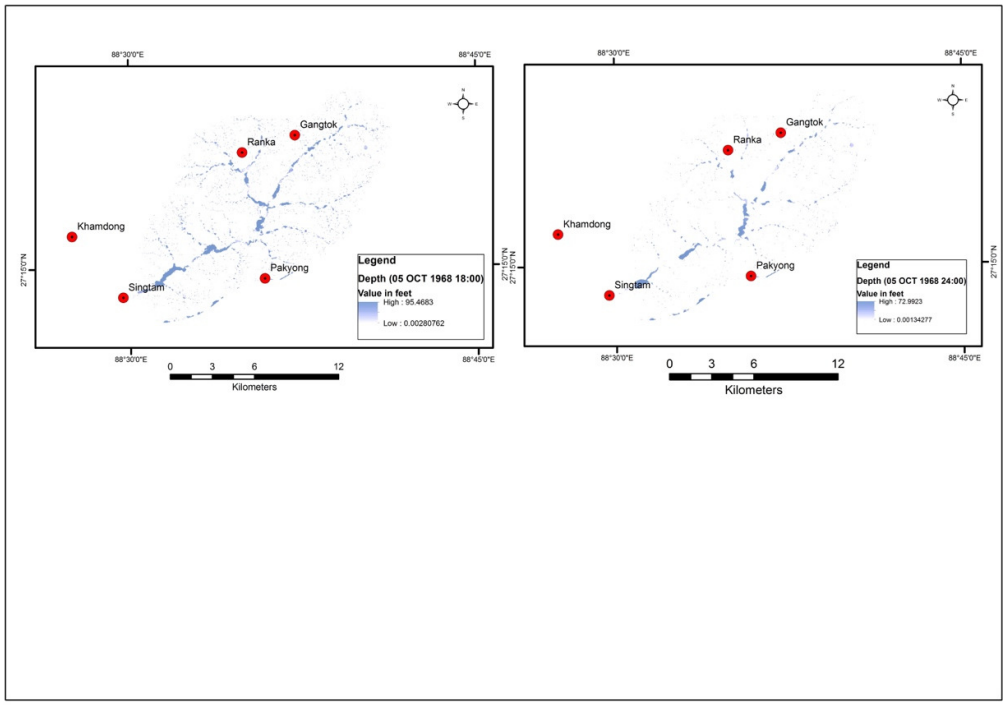
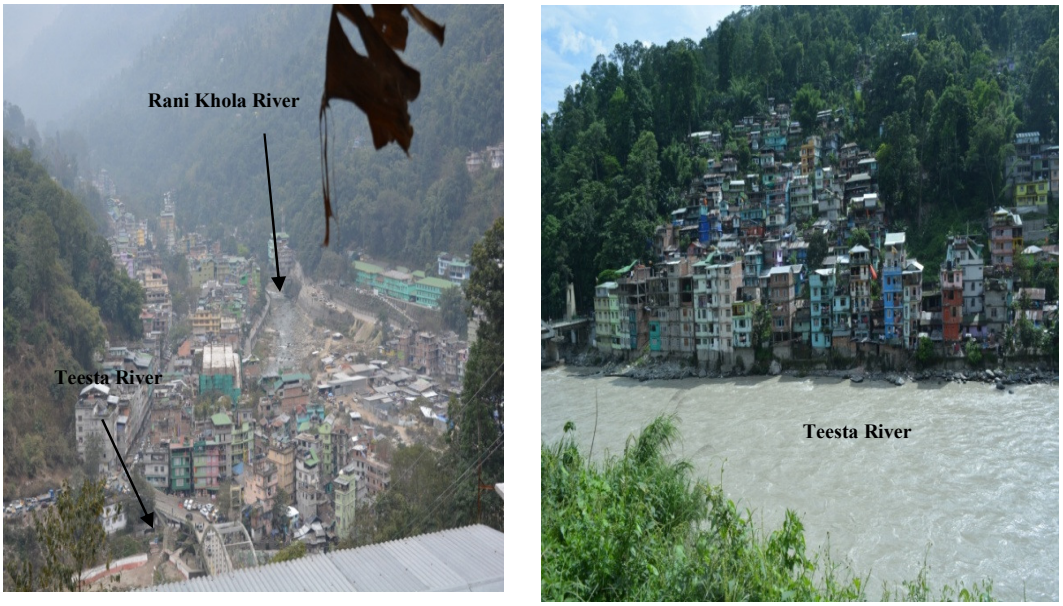

88°30'0"E
88°45'0"E
27°15'0"N
Gangtok
Ranka
Khamdong
Pakyong
Singtam
Legend
Depth (05 OCT 1968 18:00)
Value in feet
High : 95.4683
Low : 0.00280762
Depth (05 OCT 1968 24:00)
High : 72.9923
Low : 0.00134277
0 3 6 12
Kilometers

Plate III.3: **Location of Singtam Town, East district**



Source: Field Survey, 2014 and 2016

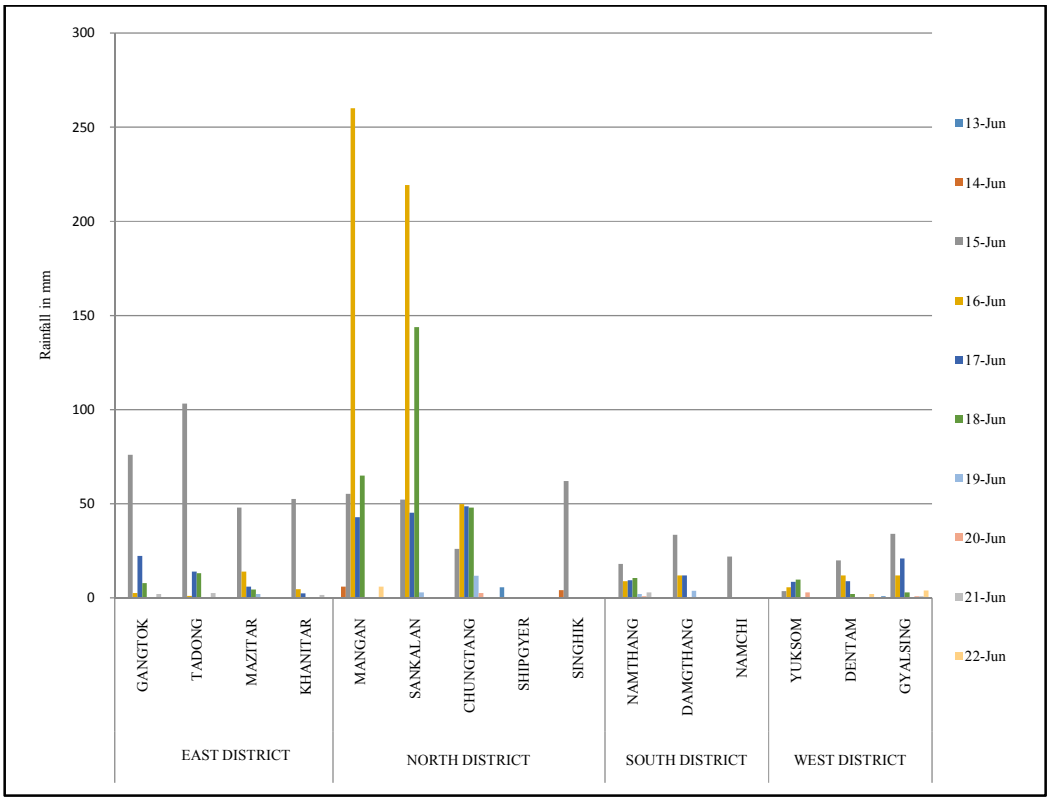
III.3.2 17th and 18thJune 2019 Flash Flood Event

Report of cloudburst was disseminated on 17th of June 2019 from North district of Sikkim by the authority. The alert was made especially for the local resident of Singtam (East district) and Rangpo (East district) area when the huge logs, debris and muddy water choked or jammed the flow of river water on Teesta Stage V hydro power dam at Dikchu (north-western part of East district of Sikkim). Within the hour of flash flood alert, the administration acted as quickly as possible to shift the local people to the safer place. No casualties were reported. However, about 427 tourists were reported to be stuck in Lachen (North district of Sikkim) because of occurrence of landslides in many vehicular roads.

Though flash flood alert from North Sikkim was disseminated by the administration on 17th of June 2019, however, the statistical rainfall data from 13th to 22nd June

especially from North Sikkim highlights the cloudburst event on 16th June rather than the 17th of June.

Fig III.8: **Station-wise rainfall (in mm) recorded in four district of Sikkim from 13th June to 22nd June, 2019**



Source: Computed from India Meteorological Department, Meteorological Centre, Gangtok

The above rainfall data from 13th June to 22nd June outlines the occurrence of actual cloudburst event (North district of Sikkim) on 16th of June 2019 rather than 17th of June 2019. However, the administration circulated the flash flood alert on 17th of June 2019 for the local people residing on Singtam (East district) and Rangpoo area (East district). This clearly demonstrates the said physical event i.e. cloudburst was not that much significant unless the human made factor played a major role on 17th of June. When tonnes of water with debris and other material began to store within the hydro

power dam, then the situation became more critical. To reduce the pressure on dam, the stored water has to be over flown thus, alerting the people about flash flood on 17th of June 2019. To support the argument regarding the significant factor that hydro power dam can play for flash flood hazards in Sikkim, following two picture have been presented below which was taken from Singtam town bridge (East Sikkim) on February, 2016 (During the dry Season).

Plate III.4: **Flow of Teesta river when water is obstructed by a dam, time 9:30 a.m., 1st Feb, 2016**

Plate III.5: **Flow of Teesta river in Singtam after the release of water from the dam, time 4:00 p.m., 4th Feb, 2016**

Source: Field Survey, 2016

Sikkim Himalaya is very prone to flash flood hazard due to its heavy downpour of heavy rainfall every monsoonal season, presence of numerous glacial lakes on the higher altitudes region, existence of deep river valley gorges and presence of geologically weak and steep unstable slopes along the river banks. Therefore, lower catchment area in Sikkim Himalaya with low elevation is normally in high risk of flash flood hazard.

However, still no precise GIS based flood risk mapping zone have been done by the administration to identify and to adopt the mitigation strategy in future. Though awareness programs have been conducted recently by NHPC and the administration, however, its outcome is not at all satisfactory. Still the local people in the lower catchment area of Sikkim especially in Singtam town and Rangpoo town resides near the river bank area. Due to lack of unplanned development and governmental initiative, numerous housing settlement is growing up around the bank of Teesta river.

III.4 Forest Fire

According to intensity, forest fire is basically classified into four types namely surface fire, underground fire, ground fire and crown fire (Satendra & Kausik, 2014). Prolonged dry season with high temperature with high frequency of wind are the major triggering physical factor for wild fire though today anthropogenic activities by unsocial human element have raised the intensity of forest fire. In India prolonged high temperature and dry season may be the cause of forest fire but in the context of Sikkim Himalaya prolonged dry winter is the major cause of forest fire. Thus, the dry month of December to March in Sikkim is considered as the major season for forest fire.

When dry prolonged winter season with high day temperature and the strong force of wind comes in contact with the available dry wood fuel of the forest, than the forest fire occurs in Sikkim Himalaya. Sal forest ecosystem extending below 2500m (Tropical and Sub-tropical vegetation zone) altitude is the most vulnerable zone for forest fire in Sikkim Himalaya (Sharma et al., 2012).

Map No: III.15

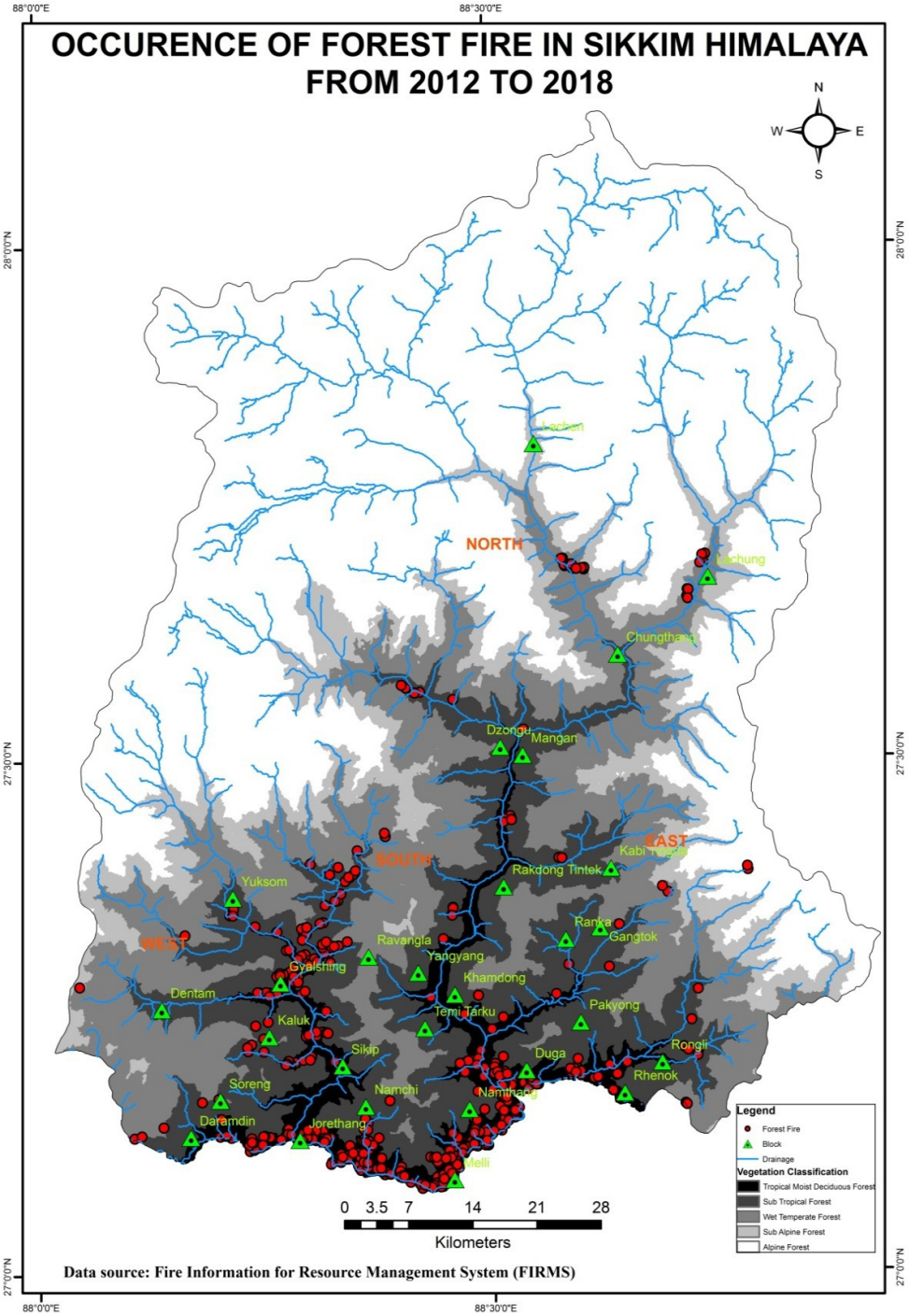
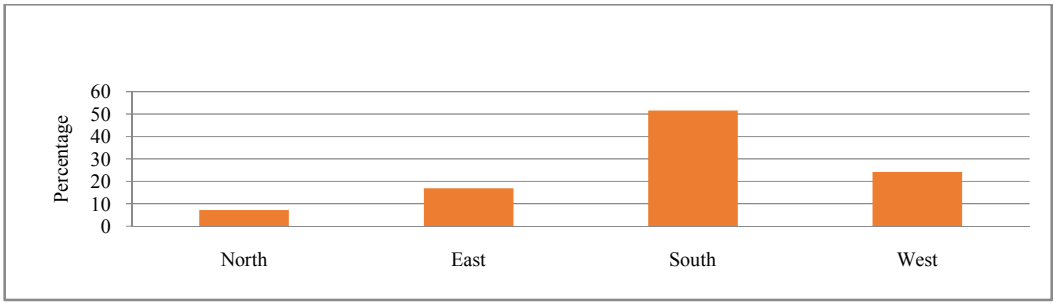

OCCURENCE OF FOREST FIRE IN SIKKIM HIMALAYA
FROM 2012 TO 2018
N
W
E
S
88°0'0"E
88°30'0"E
28°0'0"N
27°30'0"N
27°0'0"N
NORTH
EAST
SOUTH
WEST
Lachen
Lachung
Chungthang
Dzongu
Mangan
Rakdong Tintek
Yuksom
Ravangla
Yangyang
Khamdong
Ranka
Gangtok
Gyalshing
Dentam
Kaluk
Temi Tarku
Pakyong
Sikip
Duga
Rongli
Rhenok
Soreng
Namchi
Namthang
Daramdin
Jorethang
Melli
0 3.5 7 14 21 28
Kilometers
Legend
Forest Fire
Block
Drainage
Vegetation Classification
Tropical Moist Deciduous Forest
Sub Tropical Forest
Wet Temperate Forest
Sub Alpine Forest
Alpine Forest
Data source: Fire Information for Resource Management System (FIRMS)

Table III.6: **Forest Fire occurred from 2012 to 2018 in Sikkim Himalaya**

Sl No.	District	No. of Forest Fire	Sl No.	Vegetation Classification	No. of Forest Fire
1.	North	32	1.	Tropical Moist Deciduous Forest	298
2.	East	75	2.	Sub Tropical Forest	112
3.	South	229	3.	Wet Temperate Forest	26
4.	West	107	4.	Sub Alpine Forest	5
5.	Total	443	5.	Alpine Forest	2

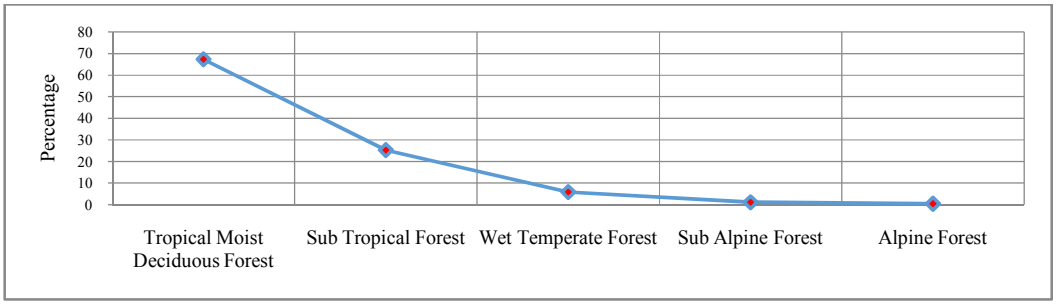
Source: Fire Information for Resource Management System (FIRMS), 2018.

Fig III.9: **District-wise occurrence of Forest Fire in percentage from 2012 to 2018 in the Sikkim Himalaya**



Source: Computed from Fire Information for Resource Management System (FIRMS) 2018

Fig III.10: **Forest Fire occurrence along the five Vegetational Zone of the Sikkim Himalaya from 2012 to 2018**



Source: Computed from Fire Information for Resource Management System (FIRMS) 2018

The frequency of forest fire decreases according to gain in altitude in the Sikkim Himalaya. For example, temperate and sub-alpine zone has very less forest fire incidence than the tropical and sub tropical zone. However, today due to climate change and associated unpredictability, incidence of forest fire is slowly increasing in the temperate zone too. Thus, climatic uncertainty or abnormality would make the forest ecosystem more susceptible to forest fire in future.

Elevation has been one of the important criteria in the Sikkim Himalaya in inducing forest fire. The temperature in the state varies according to altitude, rainfall and nearness to snowline. As noticed in the map and the figures above, altitude below 2500 meters has experienced a number of forest fires due to high temperature and the vegetational characteristics of the region. More intensity can be seen in Sal forest and to a lesser extent towards the temperate, sub-alpine and alpine region. Dry winter is more vulnerable to forest fire than the rainy summer in the Sikkim Himalaya. Long dry winter is mostly characterised by those vegetational zone in the Sikkim Himalaya where trees shed their leaves in winter season. Thus, when strong wind comes in contact with dry fuel foods during dry winter, forest fire occurs.

Though, winter precipitation acts as the mitigating factor for forest fire but due to the change in the climatic pattern, winter is becoming increasingly warmer and dry. Most affected area in the Sikkim Himalaya is the southern district and some part of western district because most of this area falls around the rain shadow zone due to which availability of precipitation is very less during the winter season.

III.5 Drought

Drought commonly occurs when there is a shortage of normal rainfall in a particular area. Though, rainfall criteria mostly define the existence of drought, the actual

concept of drought evolves when the surrounding environment in addition with humans and animals experiences the stress from the water deficiency. However, in board term drought is a deficiency of precipitation over a long period of time especially in a particular season when shortage of water impacts the agricultural activities and the surrounding environmental ecosystem (UNISDR, 2009). There are four types of drought namely, meteorological drought, agricultural drought, hydrological drought and socio-economic drought (UNISDR, 2009).

In the context of the Sikkim Himalaya drought disaster remains negative or zero however, drought hazards area have been identified recently in some portion of the Sikkim Himalayan state. Distribution of precipitation patterns has been a major criteria followed by the Department of Rural Management and Development, Government of Sikkim to identify the drought prone area of Sikkim Himalaya. For example according to the Sikkim State Disaster Management Plan, Volume 1, 2015, heavier rainfall area is located in central region consisting East district, central part of Southern district, central and south-western part of West district. These identified area receive more than 2400 mm of rainfall every year (SSDMA, 2015). Whereas the remaining area receiving 1200 mm to 2400 mm of rainfall annually (SSDMA, 2015) and has been focussed for drought mitigation planning and water security development measures.

To study and assess the drought prone area of Sikkim Himalaya, Tambe et al. (2012) and Sikkim State Action Plan on Climate Change identified 10 blocks out of 26 blocks in the state as the drought prone area. All the identified 10 blocks are located in the lower belt of the Sikkim Himalaya touching the three districts namely West, South and East district. The 10 identified blocks are Duga, Rhenock and Khamdong in East district, Namthang, Melli, Jorethang, Namchi and Sikip in South district,

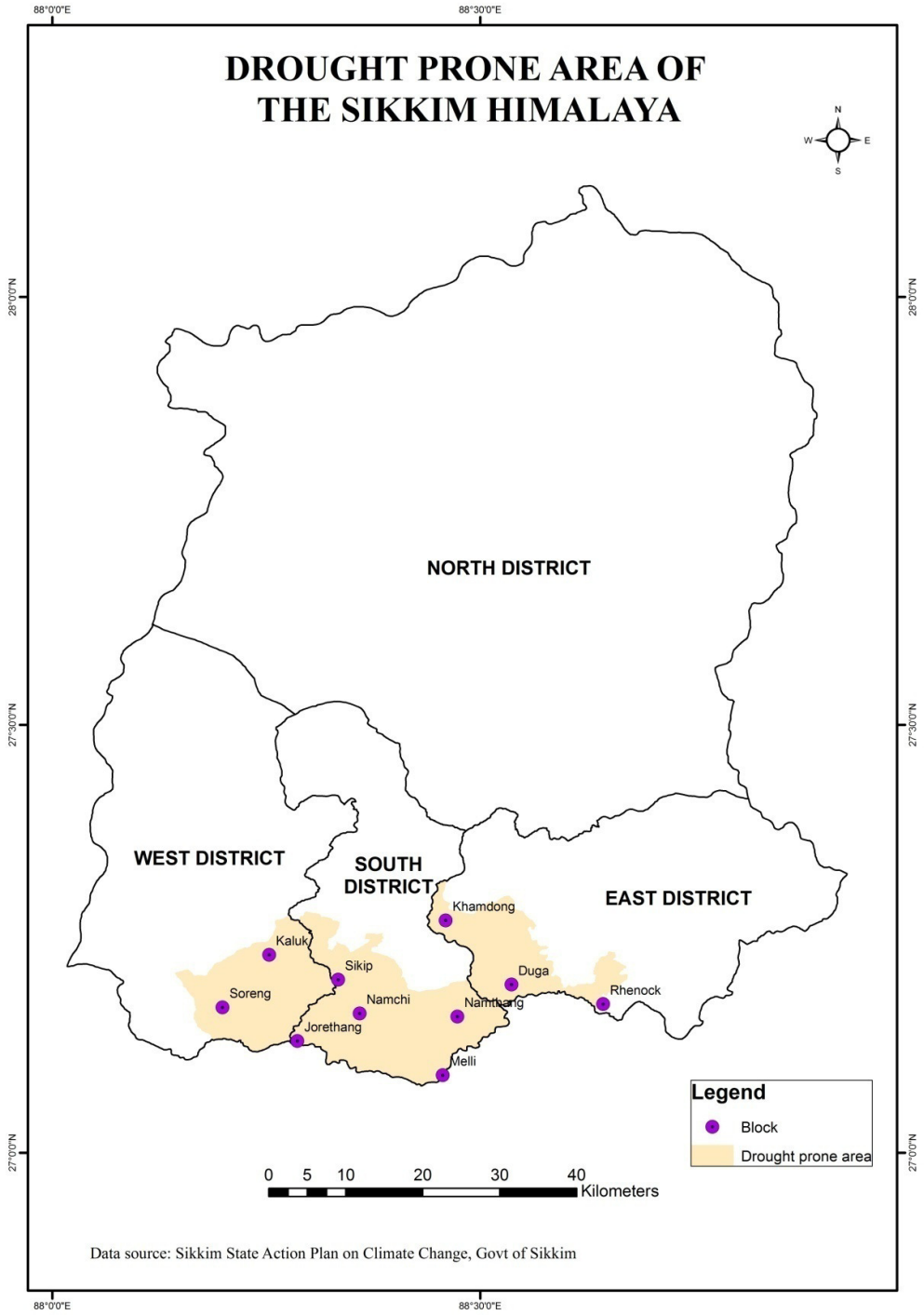
Soreng and Kaluk in West district (Tambe et al., 2012; Sikkim State Action Plan on Climate Change, n.d.).

The 10 blocks identified as the drought prone area of Sikkim Himalaya falls under the rain shadow zone of Darjeeling Himalaya where the annual rainfall is about 1500mm which is much less than the 2500mm received in other parts of the state (Tambe et al., 2012; Sikkim State Action Plan on Climate Change, n.d.). These area are also located in the gorge of river Teesta and Rangit where steep and rocky terrain characterise the landscape thus increasing surface run off but decreasing natural infiltration (Tambe et al., 2012). Most of the upper catchment of this identified block has less or no forest cover.

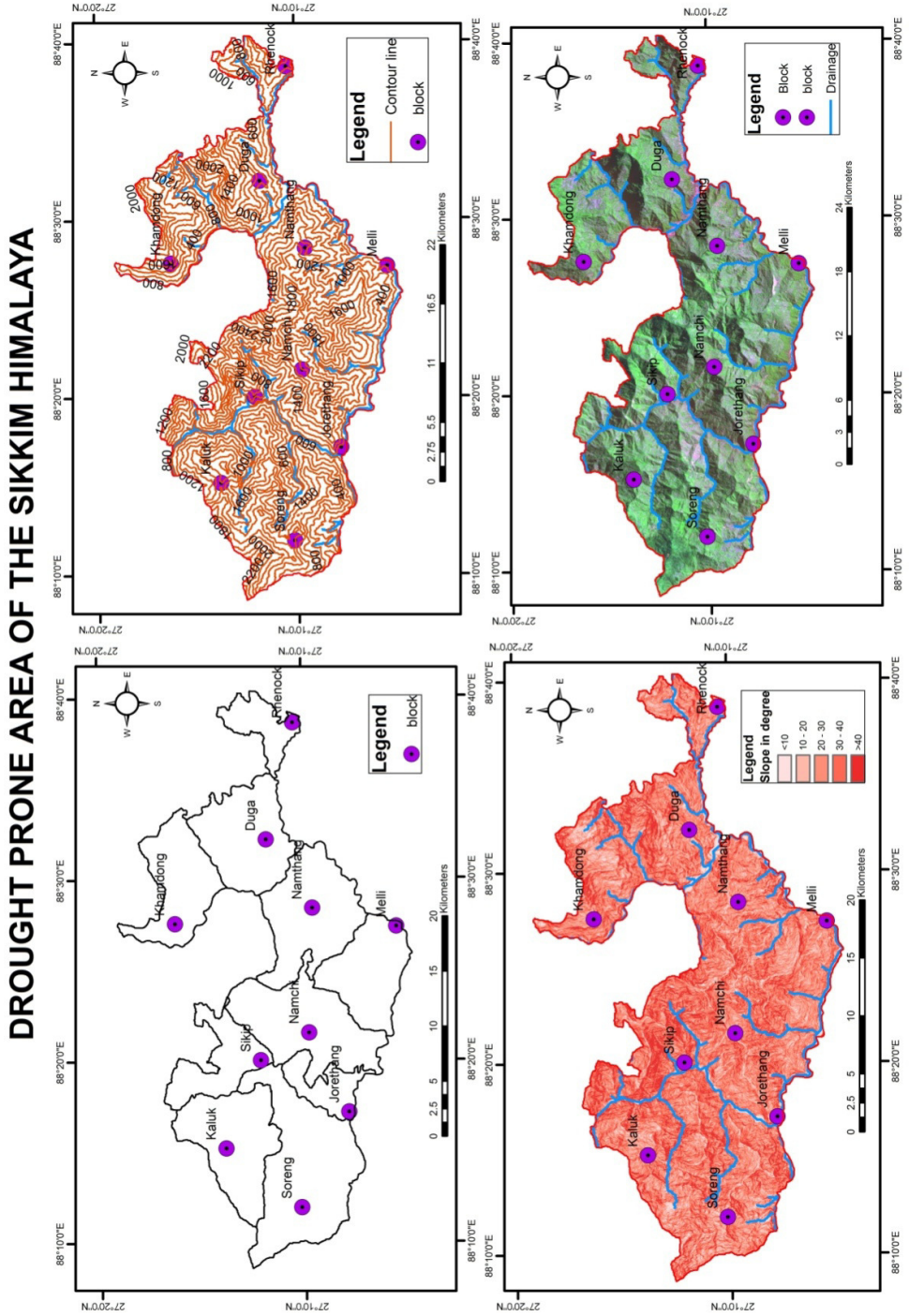
Though, many watersheds in South and West district have a forest but the location of reserve forest is along the river valley whereas most of the human settlements are located in the upper catchment. Thus, the ground water recharge is very low due to the absence of forest cover in the upper catchment. Therefore, the rain water harvesting by building artificial lake or small trenches in the upper catchment is necessary to recharge the ground water.

The 10 identified drought prone blocks of the Sikkim Himalaya have numerous perennial streams like Khani, Raphu, Rohtok, Rolu, Manpur, Barhi, Seti, Reshietc but the stream characterise of rapid flow through the deep gorges discourage the lift irrigation of water towards the settlement located in the upper catchment area (Tambe et al., 2012; Sikkim Action Plan on Climate Change, 2011). Thus, physiographic location of 10 identified block of Sikkim have played the major role in denoting the area as the drought prone area.

Map No: III.16a



Map No: III.16b



To sum up the discussion in this chapter, inventory maps of different natural hazards and disaster in the Sikkim Himalaya have been worked upon so as to have an overview of the situation. By exploring the techniques and process of mapping vulnerable disaster prone areas in the Sikkim Himalaya, the inventory map outlines the path for developing preparedness and mitigation strategy. The most significant outcome this section brings is that, after identifying the disaster vulnerability area through GIS tools and techniques, it helped to outline or select the location of the study site for collecting and documenting traditional knowledge of an indigenous and local communities

Inventory map of different hazards/disaster in Sikkim Himalaya not only helps to build up the sustainable thinking in developmental planning process but it also helps to identify the crucial area from where the information needed to capture the traditional knowledge system can be done. Thus, inventory mapping here in his chapter not only conceptualise the techniques for the rebuilding the risk and vulnerable zone but also pave the way to reach the most adaptive community to understand and document their survival measures. Mapping of every possible hazards/disaster event is necessary to highlight the past flaws in disaster management strategy. Thus, it will certainly allow the policy makers and planners to identify the disaster management gaps and to create a comprehensive possible path to reduce the future impact of the disaster. Therefore, helping to build up the developmental planning process in a right track and in a right time. Though, the chapter have used the secondary data from USGS, NRSC, Google Earth and SSDMA, however, the integration of local communities mapping techniques and process with the scientific mapping tools and techniques would certainly allow the planners and policy makers to understand the in-depth localised disaster issue more clearly.

CHAPTER IV

Traditional Knowledge Systems in Disaster Risk Reduction

(Human desire will be the worst upcoming disaster in Sikkim Himalaya)[28]

Sikkim, one of the part of Eastern Himalaya is surrounded by Nepal in the west, Bhutan in the east, China in the north and northeast, and Darjeeling one of the district of West Bengal in the south. Sikkim Himalayan state has 28 mountain peaks, more than 80 glaciers, 27 high altitude lakes, 5 major hot springs and more than 100 rivers and streams (LR & DMD, 2012, p. 7). Sikkim covering just about 0.2 percent of the India's total landscape have a very formidable physiography (Khawas, 2004, p. 1).Almost the entire state is hilly, with elevation ranging from 280 meters (920ft) to 8585 meters (28000ft) where the summit of Kanchenjunga is the highest point (Arha & Singh, 2008, p. 14)

Himalayan region is the home to the large number of tribal people and Sikkim Himalaya stands as one of the example in these regard. Diverse communities with different cultural background inhabits Sikkim Himalaya. Lepchas, Bhutias and different sub ethnic tribes of Nepali speaking communities have been living in this part of Himalayan region from centuries. The main reason behind the development of traditional knowledge in this part of the region was because of presence of indigenous early society, mountainous ecosystem, cultural belief system, tough mountainous topography and geographical isolation from the rest of the world.

[28] 86 years old Phedangma (A Limbu Ritual Specialist) on fate of disasters in Sikkim Himalaya.

Though, three major ethnic communities reside in Sikkim today, the cultural diffusion is always seen inside each community due to the long history of cultural harmony. Exchange of knowledge system within the different ethnic community have even produced the hybrid traditional agricultural knowledge. For example, Lepcha's (generally recognised as the aboriginal people of the region) in early times used to follow slash and burn cultivation. However, after the Nepali ethnic communities brought the new seeds and knowledge of settled cultivation, gradually over the years, with experimentation and usages, the aboriginal people and the Nepali ethnic communities together developed their own rich indigenous gene pool of rice suitable to different temperature, elevation, soil and moisture conditions (Pant, 2012, p. 3).

Thus, contemporary traditional knowledge of agricultural production in these regions is not a knowledge developed by one single communities but it is a skill and practices developed together by different communities in the region with decades of unity and socio-cultural harmony. Also due to the similarity of language spoken i.e. Nepali language (langue Franca of the state) although each individual community also have their own language, the cultural transmission has been intermingled within different communities. Therefore, traditional knowledge developed by one community has been easily accepted and used by other communities in Sikkim Himalaya if the physical and climatic factor of the region is homogenous and supportive.

Long observation, experiences, beliefs and rituals are some of the stock of traditional knowledge used by the communities of Sikkim Himalaya. The local people who are very close to the environment have always disseminated the environmental knowledge and coping strategy among the communities. Today, almost all the communities follows similar methods for the production of food grains, building of houses, for conservation of spring water, fermentation of foods for future food

security and cultural belief of folklore. These obviously state that every ethnic people of the region have respect and belief for the other ethnic communities and their socio-cultural patterns.

From food security to medicinal treatment, from agricultural production to settlement pattern, in conservation and sustainable use of forest, mitigation and response to natural calamities etc. all can be observed and followed by the local inhabitant simply applying their aged old traditional knowledge and skill. This traditional knowledge and practices today have provided the basis for different ethnic communities of Sikkim Himalaya for the well being and livelihoods of not only their individual community but Sikkimese as a whole.

Though, traditional knowledge is wide spread according to its prevalence and utility in Sikkim Himalaya, still not enough attention has been paid from an academic research or development policy perspective. The DRR policies adopted in the Himalayan region especially in Sikkim Himalaya demonstrate the ignorance or side lined towards the traditional knowledge system which forms a significant part of cultural life of indigenous and local people here. Therefore, it is very important to highlight this aged old knowledge in academic circle to safe guard the cultural patterns of the local communities which is in diminishing line due to globalization, modernisation and evolution of modern western thoughts.

The process of cultural interchange, cultural flow and marriage between intercommunity and religion has made the Sikkim totally multi structured society. Therefore, for the purpose of the research, community here have been defined as a group of local people or society sharing common landscape, ideals, resources, environment and aspirations (Mercer et al., 2010, p. 221) irrespective of individual

ethnicity. The study site therefore, has been selected according to the physical and climatic variation existing in Sikkim Himalaya. As geo-physical and climatic variation always influences the livelihood patterns, selecting the study site according to these factors would certainly helped to denote the area for documenting traditional knowledge system in DRR.

IV.1 Traditional Knowledge System and Disaster Risk Reduction

According to Mauro and Hardison (2000) indigenous societies ways of understanding and exploring natural resource is much opposite than the scientific modern world. They take it from the nature what is only needed for sustenance. Therefore, their role in conserving and sustaining the biodiversity is no doubt important. They know their surrounding very well and always act for their requirement according to the capacity of surrounded nature. Sustainability term though have not been known by them but the work in the field of sustainable development has been following by this people from early ages. Even before the introduction of modern technological knowledge for agricultural production, these people already were in the path of self sufficiency.

In context of the Sikkim Himalaya, such traditional society exists where nature and human relationships are interwoven together. Long observation of natural phenomena and dissemination of such observation and experiences has been passed down from one generation to another by word of mouth i.e. orally. The Sikkim Himalaya is one of the most fragile, vulnerable and risky region in terms of earthquakes, landslides, cloud burst, flash floods, forest fire, snow avalanches etc. However, from centuries local people in this part of the world have been living, adapting and responding to all those natural hazards. Without any advance technology, the local people here have survived every past fury of the nature. When the question arrives about how did the

earlier people or elders tackled the wrath of the nature? Then the answer lies upon their aged old experiences and observation which made them to predict and prepare for the arriving disaster.

Some of the examples of those numerous effective traditional disaster risk reduction measures followed by the indigenous communities of the Sikkim Himalaya have been highlighted below. It is necessary to document all those relevant traditional wisdom in DRR to extract the significant practical knowledge for its integration and acknowledgement in scientific research and management.

IV.1.1 Traditional Prediction System

Local people observing the nature and its behaviour from centuries have helped to develop their own traditional prediction system in the Sikkim Himalaya. Prediction of weather is an important aspect of traditional knowledge of local people here. The one who has the art of prediction is normally an elder or agricultural farmers. Local inhabitant especially the elder people and the people living around the rural agricultural economy can easily observe and interpret the extraordinary behaviour of some animals, birds and even insects. Though scientifically unproved, the connection between the animal and the humans from centuries have somehow developed a psychological disaster mitigation measures within the indigenous and local communities of Sikkim Himalaya. Following statement ~~given~~ by 72 years old man from Dzongu, North Sikkim highlights the psychological DRR measures during 18th September, 2011 Earthquake:

> *Before a minutes of 18th September 2011 earthquake, lots of dogs gathered together and began to cry loudly in my village. Though, I was not sure of*

the earthquake disaster but I and my family was sure that some disastrous event would arrive very soon.

In Lachung and Lachen (North district of Sikkim) transhumance was largely use to practice by the local people. However, due to prohibition of grazing by the government, it has been stopped though not fully. According to the locals, during the grazing time they use to send all the yaks and bulls freely in the mountain forest. If the bulls return home early before the yaks then the local people use to predict snowfall. This early warning system given by the animal made the local people of Lachung valley to prepare for an upcoming natural event.

Similarly, local people who live around or along the river banks especially of Teesta and Rangit river normally observe marine animal like crabs, frogs and toad behaviour. When these animals come out from the wet land and move to dry places than the local people normally believes that the particular area left by the animal would be swept away by landslides. They assume that the marine animal have the very sensitive sense to any change in water level. Thus, below table highlights some of the traditional prediction strategy followed by the local and indigenous people of the Sikkim Himalaya:

Table IV.1: **Prediction strategies of the Sikkim Himalayan communities**

Sl.no	**Local name of animals/birds /insects/plants**	**English name**	**What and how the disaster is predicted**
1.	*Chebay*	Drongo	Unusual sound made by this bird means rain storm in the area.

2.	*Koile*	Cuckoo	Sudden appearance of this bird with chirp sound is associated with health issue in the family of the listeners. This bird also gives the sign of planting maize. When the bird makes the sound like *"Gotmako cha"* then people plant Millets "*kodo"* crops.
3.	*Mirga*	Wild Deer	When loud grunting sound of this animal is heard, forest fire is predicted.
4.	*Gai*	Cow	Early warning of tremor or earthquake is linked with unusual sound of cow. Local people think that the animal has very sensitive sense to observe a minute tremor. Local farmers believe that crying sound of cow gives the sign of dry day *(Kharilo Parnu)*. When cows show the unexpected dancing move then rain is predicted. The sign of wind storm is also predicted from cow and goat behaviour. While making noise if they make their tail straight upward then it is a sign of huge wind storm.
5.	*Kukkur*	Dog	The unusual barking of dogs in a group gives the prediction of earthquake. For example before 18th September, 2011 earthquake a local people of Sichey area (East Sikkim) and local people of lower Dzongu (North Sikkim) did observed the unusual behaviour of dogs in their locality.
6.	*Baas Fulnu*	Flowering of Bamboo	Farmers in Sikkim Himalaya normally observe the flowering of Bamboo as a prediction of arriving food scarcity. Farmers normally cut down the flowering bamboo plants and burn it down. It is said that the flowering of bamboo attracts the rats and other grain eating animals. This in result makes the agricultural field very vulnerable to the rat attack or to the grain eating animals.

7.	*Chichimira*	Flying Termite	Appearance of *Chichimira* gives the arrival sign of heavy rain. According to the locals, this flying insect is always seen in groups before the arrival of rainfall. This flying termite is basically seen during the month of March to July.
8.	*Kamila*	Ant	Shifting of nest and eggs by ants normally gives the sign of heavy rainfall or landslide in that particular area from where the ant have shift their nest or colony.
9.	*Chowri Ghai*	Yak	During the grazing season all the yaks and bulls are set free. When the bull returns home early before all the yaks then the local people predict that it is going to be snowfall.
10.	*Kaak*	Crow	When the large group of crows makes an unusual sounds and fly without any direction here and there than it gives the sign of strong wind storm with heavy rainfall.
11.	*Bhaguta*	Frog	Local people living near the river bank normally observe the sound of frogs. When number of frogs scream or croak at same time than the people predict of upcoming heavy rainfall. The croaking of frogs normally starts with the arrival of monsoon season in Sikkim.
12.	*Utis*	Himalayan Alder	*Utis tree* (Himalayan Alder) on the slope gives the knowledge of landslide prone area to the local people. Himalayan Alder grow well in river banks area and the steep slope area (Rai & Rai, 1994). Local people also believes that Himalayan Alder always grows in that area where landslide has occurred.
13.	*Badel*	Wild Boar	Appearance of Badel (wild Boar) around the village area gives the sign of drought or food scarcity inside the forest.
14.	*Barshewla*	Earthworm	When a local earthworm named *'barshewla'* is seen on the surface in plenty of number then the

			cyclonic weather with heavy rainfall is predicted.
15.	*Gauthali*	Swift	If this bird is seen flying in a large group around the village than the local people predict of food scarcity in the forest area. Also the bird gives the sign of heavy rainfall.
16.	*Heu Chari*	Snow bird	If seen flying around the village then the local people predict of snowfall. However, today these birds are seldom seen.
17.	*Fista*	Tailor bird	When this bird arrives and begins to sing beautifully then sunny day is expected.
19.	*Kayanyang Chara*	English name not found	When this bird arrives then the local people of Dzongu (North Sikkim) area believes that the area will soon receive huge water or the place will get cover with water.
20.	*Bhalu*	Bear	When seen near the human settlement area, then the local people predict of food scarcity and depletion of forest resources. For example in Dzongu (North Sikkim) local people mostly have to experience the wild bear invasion to their crops.
21.	*Karnok*	Black headed crane	Migration routine of this bird is followed to cultivate different crops. Local people plants seeds and cucumber, pumpkin, beans etc. during the appearance of this bird around their village.

Source: Field Survey, 2016 and 2017

Contemporary scientific world has been gathering data and analysing it to measure the climate change patterns and issues from the scientific point of view. However, before the scientific evidence of climate change in formal literature and reports, the indigenous people already was aware of climatic nature due to centuries of observation and experiences. From the context of Sikkim Himalayan communities too such indigenous knowledge about climate change can be observed. For example, a 62

years old woman from Pachey village, East district of Sikkim beautifully highlights the following statement in regard to nature and human relationship in past and present climatic period:

> *Our grandfather use to tell us that Mother Earth always gives a sign in the form of animals, birds and plants. Therefore, we should respect every creature as it brings different messages from our mother Earth. Our grandfather use to tell us that when human will forget to worship the earth and begins to think themselves as a creator or god then everything will be change. The flow of wind and rain will not be in time and everything will go opposite. Insects, flowers and plants which we use to see in summer will slowly begin to be seen in winter. Harvesting of crop will change its season. During such situation nature will push and punish human to make them realise their mistake. Every nature's fury has a sign so that the pure and innocent people who worship and respect the earth and believes in those messengers (animal and birds) may know the coming event and protect themselves. Today our grandfather's prediction is coming true.*

IV.1.2 Traditional Belief and Prevention Strategy

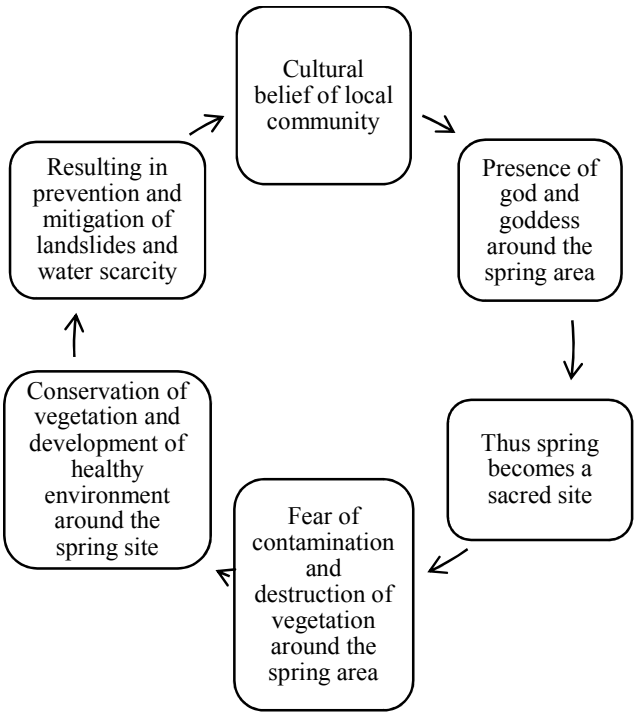
Traditional belief has its origin in oral tradition of a community in the form of myths, legend or folklores which has been passed on from generation to generation (Ramya, 2012) to preserve the cultural features of a local or indigenous community (Graburn, 2001). Traditional belief is a process expressed in tradition and culture (Motz, 1998) of a community which has rarely been changed and mostly reflected in religious practices and behaviour of a local community (Ramya, 2012).It acts as a moral code for a community to ensure the continuation of the ancestral tradition (Hadnes &

Schumacher, 2012) with honesty and respect.

Thus, it is always local and specific (Motz, 1998) in context. Western scientific paradigm discards its importance due to its lack of scientific verification or measurement (Motz, 1998). Therefore, ignorance of modern science towards the recognition of traditional knowledge is because of the presence of these spiritual base in traditional knowledge system which scientific community believes to be superstitious and fatalistic (Snively & Corsiglia, 2000). However, modern science fails to understand that spiritual belief and its explanation often contain significant ecological conservation and sustainable development strategy (Johnson, 1992; Snively & Corsiglia, 2000). It expand beyond the scientific assessment of truth to integrate efficiency, justice and happiness (Motz, 1998) within the local and indigenous community.

In the context of Sikkim Himalaya, there is a widespread traditional belief among the Sikkimese local communities that hydrological hazards like water scarcity or drought are released by specific deities and god in response to human misbehaviour. This traditional belief system has played a crucial role in protection and conservation of water resources in Sikkim Himalaya. Springs and their surrounding sacred forest which are called *"Devithan"* or *"Deurali"* (Abode of God and Goddess) are socially fenced with strong belief systems by the local people in Sikkim Himalaya. Thus, the local communities living around the rural areas fear contaminating the spring-water sources and avoid pollution in and around the water sources. These strong cultural beliefs have helped indirectly in the conservation of water resources in most of the villages of Sikkim which have fortunately helped to prevent water crisis in many rural area.

Fig IV.1: **Cultural belief and spring management**



Source: Field Survey, 2016.

Below statement from 86 years old woman from Namchi (South Sikkim) highlights the spiritual belief system and the contemporary cause of disaster in Sikkim Himalaya:

> *When "Devi Deurali" (scared area where deities resides) is polluted and exploited by human greed and action, then the human have to bear the consequences from the Earth in the form of different disaster. When nature delivers resources then human also have to acknowledge it with respect. However, today human is just taking away from nature without any acknowledgement. We need to worship them and ask for forgiveness for any unclean behaviour because nature is all powerful and we cannot stop her. Only nature can stop her fury. She always walks in her path and when*

she travels or come across an unclean or unholy path then she does all those bad things. So I blame human as the chief cause of disaster.

Plate IV.1: **Temple associated with the sliding zone; Tarey Bhir landslide (2017) near Sombarea, West Sikkim**

A.  **B.** 

C.  **D.** 

Source: Field Survey, November 2017

A. Tarey Bhir Landslide (2017) near Sombarea village, West Sikkim.

B. Presence of temple just beside the landslide area. Age of temple is unknown as local believe that their elders also use to worship there.

C. Picture showing the image of the local deities. The area is considered holy by the local people.

D. Construction of toilets and car parking zone near the holy place as the area was promoted for tourism by the authority. According to local people tourism activity around this holy place is the reason why the place became unclean and unholy, thus making the deities angry and resulting in landslide. However, according to the locals this is only the warning as no human casualty occurred.

Spiritual belief system in regard to natural hazards and disaster may sound too superstitious and without any logical explanation for the scientific community however, one traditional spiritual belief system of Lepcha community of Dzongu area,

North Sikkim do highlight the impact of human extractive developmental activities in influencing natural disaster. The following statement given by 63 years old man from Dzongu area highlights the belief of spiritual being in inducing landslide if not worshipped:

> *Lepcha Bongthing[29] believes that there is a ghost which actually cause landslide on Earth surface. Therefore, to prevent landslide, Lepcha Bongthing normally does puja (worship) to the deities and shift one of the small stone from the landslide pone area to another place to stop the future landslide. However, Lepcha Bongthing also believes that the place where the stone has been shifted will definitely receive landslide.*

Now, these above spiritual belief system of Lepcha community of North Sikkim actually highlights the beautiful example of human induced landslide disaster. The ghost here is actually us 'human' who has the power to change the landscape by technological innovation for economic development. When the Lepcha shift the stone to another place then it means that the local people is trying to influence the authority to stop the extractive developmental activities in such a fragile zone and requesting the authority to shift the developmental project to some other places. Again when Lepcha Bongthing says that the place where the stone has been shifted will receive landslide then it clearly defines that wherever the extractive developmental project would be shifted that place will definitely receive the nature's wrath in the form of landslide. Today in North Sikkim, local people believes that the major cause of landslide disaster is because of digging up tunnels for mega hydro power project and unplanned infrastructural development.

[29] Bongthing is a traditional priest of Lepcha's community.

Evolution of traditional belief system has a close link with the nature and its governing role. It evolved from the observation and experiences with natural phenomena. Thus, encouraging the relational approach with the surrounding environment to adapt and survive in changing environmental system. Their stories and folklores contain all those experiences of natural calamities, adaptation measures and endurance strategy which seldom have been examined by the scientific world. For example, one folklore of Lepcha's community highlights the landslide prevention strategy by involving the story of plants rather than human. The folklore goes as follow:

> *Once male Guras (Rhododendron) fell in love with the tall and slim female Utis (Himalayan Alder). He made a proposal for marriage to Utis but Utis requested him to visit her father for the permission. It was a cold dry winter month so all the flower of Guras tree had vanished. Guras visited Utis father and requested him to marry his daughter. Seeing bare and short Guras, Utis father humiliated him of his appearance and made Guras to promise him of not coming here again for such marriage proposal. When Utis heard about this she went to visit Guras. As the spring month arrived Guras looked very beautiful and Utis felt more in love with Guras. Female Utis requested Guras to marry her but due to the promise given to her father Guras declined the marriage proposal. After hearing the decline marriage proposal Utis went to the top of the hill and jumped from there. Since then, Lepcha people believes that Utis (Himalayan Alder) grows on the steep slope area often on the landslide or landslide prone area.*

This story reflects the major prevention methods by telling the listeners about which tree will be suitable to grow in landslides prone areas to control landslides. *Utis* (Himalayan Alder) tree prefer those area where the land has been exposed due to landslide or mudflow (Rai & Rai, 1994, p. 27). Thus, by planting the right herbaceous plants rather than the hardwood trees over the fresh landslides area, the future landslide disaster can be prevented. When these soft wood plants (Himalayan Alder) hold the top soil then gradually hardwood plants can be grown to convert the landslides prone area into stable forested area.

Above folklore also clearly explains the experience of indigenous Lepcha people with the natural calamities since time immemorial. They have developed those experiences into stories to help explain the nature and causes of disaster to upcoming generation. Their belief in folklore actually helps to guide the coming generation to take right action during the natural calamities. Therefore, though their stories appear as folkloristic, still it contains a sound principle of scientific philosophies for guiding the young generation in deciding the right decision for reducing disaster risk.

Lepchas of Sikkim Himalaya are among one such tribe who are mostly known for their understanding with the nature. They have many folklore which have some distinct element relating to pre-disaster preparedness and mitigation. One of the folklore is a short story related to a flash flood event in Sikkim Himalaya. The folklore goes as follow:

> *Once two river, Rangeet and Teesta, who are considered as husband and wife had a big quarrel which resulted in huge flash floods in Sikkim. All the animals panicked and ran towards the crest of the mountain to save themselves from the flood. As the fight between Rangit and Teesta not stop,*

animals prayed to Goddess Na-zong-nyo for their safety. After hearing their prayers, Goddess send blood Pheasant to help the victims. Blood Pheasant then began to drink the water from Teesta and Rangit rivers and soon water level began to recede.

The story here have outlined a vital mitigation strategy during the flash flood event. It enlightens the listeners that, during the major flood event, it is better to run towards the high ground to ensure the reduction of risk generated by the flood disaster.

IV.1.3 Traditional Preparedness and Mitigation

Traditional preparedness and mitigation usually comes from the knowledge and capacities developed by the local people to effectively anticipate, respond and to recover from impacts of natural events. It is important to point out that village elders are the chief person who actually guide and teach the upcoming young individuals in matter of preparedness and mitigation strategy. In the Sikkim Himalaya following types of traditional preparedness and mitigation strategies are been followed.

IV.1.3a Traditional food

There are two types of traditional food in Sikkim Himalaya, fermented and non fermented. Non fermented foods are simply those food items which has been extracted from the natural forest ecosystem and consumed freshly. Whereas fermented food items are those where one or more of its constituents have been acted upon by micro organisms to produce different or altered final product as fermented food for human consumption (Tamang, Sarkar & Hesseltine, 1988, p. 375). The fermentation and non fermentation techniques of traditional food preparation process are generally passed on from the elders, a practice protected and preserved by

tradition (Tamang, Sarkar & Hesseltine, 1988) and Sikkim Himalayan communities have numerous such traditional food preparation techniques.

Local communities of Sikkim Himalaya have vast knowledge of agro-ecological condition. The elders mostly guided the young ones on what crops to plant, where to plant, when to plant and how to plant. The elders also taught how to preserve and store food products to ensure food security during dry season. They also have vast knowledge of different forest plant species which can be consumed. This knowledge of identifying edible forest plant species have been handed down from generations.

According to usage and consumption, traditional food items in the Sikkim Himalaya can be divided into two types. First one can be termed as the commonly prepared and consumed traditional food items which are mostly eaten on a regular basis. For example, there are lots of commonly recognised local vegetables and fruits which are sold in the local market in a daily basis. Almost all people knows its preparation process but very few local people knows and understand its significance of origin.

Second one can be termed as occasionally used or almost vanishing traditional food items. These traditional food identification and preparation techniques is today in verge of extinction due to coming up of rapid fast food globalisation market, modernisation era and change in socio-economic pattern among the newer generation in the Sikkim Himalaya. Only very few elders in the Sikkim Himalaya have the knowledge to identify and to prepare those traditional food items. The interesting fact is that, these vanishing traditional foods actually was originated and developed during those harsh climatic condition when local people did not have a good agricultural production for their sustenance and survival. They entirely depended upon these traditional food during the time of drought and famine. Thus, the table 4.2 and table

4.3 highlights two type of traditional food of the Sikkim Himalayan communities with reference to disaster preparedness and mitigation.

Table IV.2: **Popularly consumed traditional foods of Sikkim Himalayan communities.**

Sl No.	Local Name	Process	Uses
1.	*Gundruk*	December-February is the most favourable month for preparing *Gundruk* due to less humid weather. Usually *'Rayo Saag'* (Brassica campestris L varcumifoliaRoxb) leaves is used to prepare *Gundruk.* (Tamang, Sarkar & Hesseltine, 1988, p. 378). Firstly, the leaves are dried in the sun for 1-2 days. After that it is smoothly crushed and soaked in hot water. By using hands or a huge stone, leaves are then pressed to drains the water within it. A small hole is dug where banana or bamboo leaves are placed. Then, dried leaves are put inside and covered by banana or bamboo leaves. Heavy stone is added to compress the substrate. The leaves are allowed to ferment in situ (15-22 days) until a fermentation odours develop (Tamang, Sarkar & Hesseltine, 1988) Lastly, *Gundruk* is taken out and dried in the sun for 2-4 days before consumption.	*Gundruk* has a self life of almost one year. Thus, it can perform as a significant diet during the food scarcity season.
2.	*Sinki*	Tap roots of Radish (Raphanus sativus L) is used to make Sinki. The method of preparation is similar to that of *Gundruk.* However, fermentation takes little longer than *Gundruk* i.e. 30 to 40 days (Tamang, Sarkar & Hesseltine,	Mode of consumption is similar to *Gundruk* and it also have a self life of almost one year. Thus, this traditional food too plays a significant role during the dry season.

		1988, p. 379).	
3.	*Gaba ko chana*	*Gabako Chana* (Dried stem of Colocasia esculenta) is prepared by slicing the stem in small parts and the sun drying it for about 3 days. After sun dried, it is put inside the hot water to make it smooth and soft. It can be eaten as a curry.	After sun dried, it has the life span of almost a month. Local people prepare it and use it especially during the shortage of food supply.
4.	*Tama*	From *Choya Baas* (Dendrocalamus hamiltonii) young bamboo shoots are collected during June to September. The collected young bamboo shoots are than boiled for at least 15-20 minutes in water. Boiling of shoot would help to remove bitterness ingredient from the bamboo shoots. After boiling, bamboo shoots are ready for consumption.	Since *Choya Baas* (Dendrocalamus hamiltonii) is abundant in the Sikkim Himalaya, its availability as a traditional food during the agricultural deficiency period is common.
5.	*Dhero*	It is a traditional food item of ethnic group of Nepali community in Sikkim Himalaya. Buckwheat or millet is the common crops which are used to make *Dhero*. Firstly, the local people grind Buckwheat or Millet into fine flour. After that, they boil the water and add the flour inside the boiling water. They stir the mixture till 5 to 10 minutes with a cooking spoon until the flour get mixed with the water and create a sticky substance. To get more flavour a small amount of ghee is also mixed in *Dhero*.	*Dhero* is basically consumed with the soup made up of *Gundruk* or from the dried fish locally called as *Sitra*. Normally. During a dry season when paddy cultivation was low, local people around the rural area normally used to prefer *Dhero,* since buckwheat and millets were available during the dry season.
6.	*Suka ko Masu*	*Suka ko Masu* (Smoked/dried meat) can be seen as common food items of tribal and some non tribal community in Sikkim Himalaya. Pork, beef and buff are the major meat used by the	This meat can last for a week or two before preparing for consumption. This process of meat preparation can sustain the family for a week during the

		community to smoke and dry it. For beef and buff, the local tribal people cut the meat in rope like shape and hang it above the traditional *chula* (kitchen). The smoke coming from the traditional *chula* dries the meat which can be later be eaten in a small quantity with potatoes or squish.	shortage of agricultural crops due to dry season.
7.	*Sitra*	Local fish like *Aasala* (Schizothorax richardsonii) are caught by the local people especially who are living near the river bank of Teesta and Rangeet river. They draw out all the inner abdominal part of the fish and stitch the remaining body of fish on the bamboo stick to let it dry by a sun for 4 to 5 days. This sun dried fish is known as *Sitra.*	Use of *Sitra* is also similar to smoked/dried meat.
8.	*Gurbo*	The young shoot of *Gurbo* (Arisaema Griffithii) is normally used for consumption. Spring is the perfect season to find the young shoot of this plant. Outer cover of the shoot is peeled out and the remaining shoot is cut into small pieces. The small pieces then are boiled in the water for half an hour. Boiled *Gurbo* than can be consumed as a local *sabji* (vegetable).	According to the local people, during famine like situation or during decline of agricultural production, the rural people of Sikkim Himalaya use to search *Gurbo* for consumption from the natural forest ecology.
9.	*Iskus ko chana*	*Iskus ko chana* (Sun Dried Sechium edule) is prepared firstly by peeling out the outer skin of the fruit and secondly, slicing the inner parts of the fruit into smaller parts. The sliced small parts are sun dried for almost two days. The dried parts can be taken as a curry.	After sun dried it has the life span of almost two month. This traditional food is prepared during the winter season to avoid the food availability problem.

Source: Source: Field survey 2015-2017

Table IV.3: **Occasionally consumed/vanishing traditional foods in the Sikkim Himalaya**

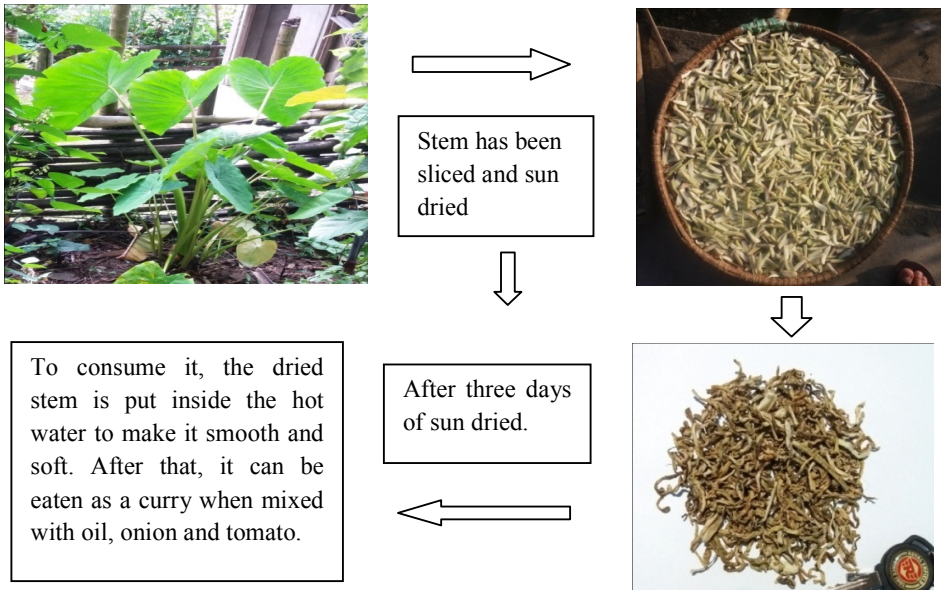
Sl No.	Local Name	Process	Uses
1.	*Gittha*	Tuber of *Gittha* plant (Dioscorea bulbifera) is cut into small pieces and boiled in water for about 20 minutes. During boiling process small amount of ashes are also put inside the water. Local people believe that adding of ashes would lessen the sourness, as tuber of *Gittha* is very bitter to eat. This plant is mostly found in tropical and subtropical climate.	During early days especially during the reign of last *Chogyal* (King) in Sikkim, many places in Sikkim had to face famine or food scarcity. During that time, local people use to visit forest in search of *Gittha* plant. This was one of the plants which made them to survive in famine situation. Today the uses of this plant as a food items is almost nil or zero.
2	*Bhegur*	*Bhegur* (Dioscorea deltoidea) is also another local plant whose tuber can be eaten same as the *Gittha* plant. Process is also same as *Gittha*. This plant is also found in tropical and subtropical climate.	This plant was also very important during the famine situation. *Bhegur* and *Gittha* both were available in forest during the food scarcity period. Today, this plant is also not used as food items by the local people of Sikkim Himalaya.
3	*Sisnu*	Root of *Sisnu* (Urtica dioica) was also another important food items during the famine period. The tuber of *Sisnu* plant is is also boiled in hot water for amost 20 to 30 minutes. Small amount of ashes are put inside the boiling water to lessen the sourness.	According to the local people of South Sikkim, boiled roots of *Sisnu* plant helped them to survive 1970s famine disaster. Most of the old aged people of Sikkim Himalaya knows its uses during the food scarcity as they had experienced the disaster and have survived by eating the boiled root of this plant.
4	*Phul Tarul*	Rhizome of *Phul Tarul* (Canna edulis) are normally boiled in the	The taste of the boiled rhizome is sweet. Earlier local people

		water for 15-20 minutes and later the boiled rhizome skin is peeled out and the inner part is consumed.	also use to make local beverage from the boiled rhizome by simply fermenting it.
5	*Makkai ko Kholay*	*Makkai* (maize) is grinded with the help of *Jhato* (A circular stone grinding instrument, see Appendix A) to convert the maize into small pieces like rice. The converted maize rice is later boiled with *sisnu* leaves (Urtica dioica) and consumed as *kholay* (liquid paste) during dry season.	During dry or famine like situation, this traditional food has been consumed especially by the elders in Sikkim Himalaya. *Sisnu* (Urtica dioica) is normally found everywhere and the local people always keep the harvested stock of maize for next year. Therefore, before any famine like situation arrives, they already have the last year maize stock in reserve and lots of *Sisnu* around their locality to make *Makkai ko Kholay* (Maize curd).
6	*Bhugray Roti*	Maize is grinded by a *Jato* (A local circular stone grinding instrument) to produce flour. The produced flour is used to make chapatti. Traditionally, local people use to wrap the uncooked chapatti with the banana or *Phul tarul* (Canna edulis) leaves and the wrapped chapatti is placed inside the hot ashes for about 10-15 minutes.	During the food scarcity the left over stock of maize are utilised by the local people to make chapatti in Sikkim Himalaya. *Bhugray roti* has a more thickness than the normal chapatti. Therefore, consuming one *Bhugray roti* would have been enough to fill the stomach.
7	*Makkai ko soup*	After harvesting maize, some of it is boiled in hot water for almost 10-15 minutes. After boiling it, maize seeds are kept for sundry above the tin roof for almost 2 days. Sun dried maize than will be stored or kept for future use if any food scarcity situation arrives. If the food scarcity situation arrives than the dried maize are again boiled in a water with some garlic,	Mostly this food items are used during the dry season when the food scarcity arrives around the locality due to drought. This dried maize can last for at least a one particular season.

		ginger, onion, tomatoes to make a *Makkai ko soup* (maize soup).	
8	*Ban tarul*	Rhizome of *Ban tarul* (Dioscorea alata) is boiled for 20-25 minutes. The boiled rhizome outer skin is peeled off before consuming it. This plant is found especially around the tropical and subtropical forest area.	Local people normally consume it by boiling and later peeling the outer skin of the rhizome. It can last for 2 to 3 days even after the preparation.

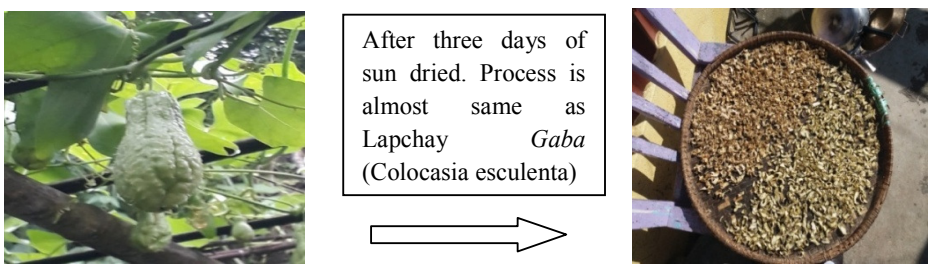
Source: Field survey 2015-2017

Plate IV.2: **Process for preparing *Lapchay Gaba* (Colocasia esculenta)**



Source: Field Survey, 2016

Plate IV.3: ***Iskus ko chana* (Sun Dried Sechium edule)**



Source: Field Survey, 2016

Plate IV.4: **Making of *Gurbo* plant (Arisaema griffithi) into curry**



Source: Field Survey, July 2018

Plate IV.5: **Pictures of traditional foods of Sikkim Himalayan communities**

Gundruk **(**Brassica campeetris L varcumifolia Rox B leaves are used to prepare *Gundruk)*

Kenima **(**Soya beans are used to prepare *Kenima*)

Sinki (Roots of Raphanus sativus L is used to prepare *Sink*)



Tama (Young shoots of Dendrocalamus hamiltonii is used to prepare *Tama*)

Churpi (Cow or Yak milk is used to prepare *Churpi*)

SukakoMasu (Dried/smoked meat)



Phaapar (Flour of Buckwheat "Fagopyrum esculentum")

Ban Tarul (Rhizome of Dioscoreaalata)

Lanka Pindalu (Root of Colocasia esculenta)

Ful Tarul (Canna edulis)

Source: Field Survey, 2016 to 2017

The above traditional food items of Sikkim Himalayan communities has normally been documented and scientifically analysed by various academician and food scientist to understand the process and ingredient needed for its preparation. Testing and validating traditional foods of Sikkim Himalayan communities are done by food scientist to identify its health benefit. However, none of the scientific communities came forward to understand its historical evolution, the reason for its birth as cultural recipes of Sikkim Himalayan communities. Indigenous and local communities of Sikkim Himalaya rarely had microbiological understanding of any traditional food. Thus, the evolution and preparation of such food must have developed due to the

changing natural phenomena. Experience of disaster like drought and famine must have a strong link for the creation of traditional food in Sikkim Himalaya.

IV.1.3b Traditional Houses

Most of the traditional houses in the Sikkim Himalaya are built with bamboo, local timber, stone, mud and sometimes with even cement plaster. Most of the traditional non engineered structures are more than decades old in age and have strongly resisted many past earthquakes. Different types of traditional building structures that can be seen in the Sikkim Himalaya are as follow:

***Chaukat* House-** It is a traditional house found in most parts of the Sikkim Himalaya especially in East and South Sikkim. It is normally two storey house which is built from the locally available building material. Wooden logs, stones and soil material are generally used to construct *Chaukat*. A typical *Chaukat* stands 10 to 20 m high from the ground level (Joshi et al., 2011, p. 201). The foundation for the stability of such high structure is normally dug 2-3 m deep and filled with dressed stone. The buildings are raised above the ground level up to height of 2.30 m to form a rectangle platform (with the help of flat stone, clay and stone filling) which helps to rest the main structure (Joshi et al., 2011, p. 202). Wooden logs are normally used or placed from the floor to support the upper storey of the front structure, whereas well-dressed flat stones are raised as a wall from the left, right and backside of the house to support the upper storey.

Plate IV.6: **Over 50 years old *Chaukat* house in Assemlengey, East Sikkim**

Source: Field Survey, September 2016

***Ekra* House-** *Ekra* house are traditional building structures made up of stone foundation where bamboo walls are normally plastered with mud or cement. These are single or two storey houses built with a wooden frame as main structural features. Light metal sheets are used as roofing material supported by the wooden frame. *Ekra* houses normally have one or two storeys because the material used for its construction is not much strong to support multi-storey construction. Such houses are much stable during the event of Earthquake and even if such houses collapse they do the result in loss of lives. Therefore, in spite of being non-engineered structure, these houses have a proper system of bamboo/wooden beam-column and fulfil the most of the earthquake safety requirements of having a proper connection between different elements (Tambe et al., 2012, p. 1394).

Plate IV.7: ***Ekra* house in Chungthang (North Sikkim).**

Source: Field Survey, October 2015

These above *Ekra* house in Chungthang (North Sikkim) resisted the impact of 18th September, 2011 Earthquake.

Plate IV.8: ***Ekra* house in Sirwani, South Sikkim**


Source: Field work, 2016

***Chitra* House-** *Chitra* is a traditional name given to a house made up of bamboo mat. Wall of this house are firstly made by cutting bamboo into thinner parts i.e. bamboo is fabricated into sheets which are later raised along the wood beams and fixed with the help of nails. No mud thatching is used on the wall like *Ekra* house. To keep roof light weighted and sustained by wood beams the house is covered by light weight tin sheets or tarpaulin. Even if these house collapse no major causalities will happen.

Plate IV.9: ***Chitra* house in Sombarea (West Sikkim) and Chungthang (North Sikkim)**


Source: Field Survey September 2016 and 2017

Plate IV.10: **More than 60 years old *Magar*[30] house in Chemchey, South Sikkim**

Source: Field survey, 2018

Manger house- A traditional house made up of stone foundation and local wood material especially extracted from local tree called *Katus* (Castanopsistribuloides) also known as chestnut. The local chestnut wood is moderately hard and are extensively available in temperate climatic region.

Lepcha House- Lepcha house is made completely of woods and based on the principal of gravity. The house is constructed square in shape and the size cannot be tampered with additional or subtraction of rooms after the completion. According to the Lepchas, the elevated pillar prevents the house from sliding when hit by natural calamities such as floods and landslide. This nine gigantic pillars of the whole tree size and length erected on nine big flat boulders shows the most marvellous and devious art form of building a Lepcha house. Due to modernization and passing by of elders this architectural structure is in the line of extinction.

[30]Sub-ethnic community of larger Nepali community.

Plate IV.11: **More than 100 years old traditional house of Lepcha community in HyeeGyathang village, North Sikkim -In the verge of Extinction**

A.  **B.**  **C.** 

D.  **E.**  **F.** 

Source: Field Survey, November 2017

A- More than 80 years old Lepcha House in Dzongu. According to Lepcha word it is known as *"KAA DEN-MO-LEE"* when translated literally '*KAA'* means *WE 'DEN'* means Where We Spend our Childhood learning the Basic *'MO'* Centre or main and '*LEE'* means Home (Lepcha, 2011)

B- The base of the house is made up of 9 huge tree pillars.The centre pillar is known as "*KAAOO DAMPHU"* (Lepcha, 2011) and it goes much higher than the rest of them.

C- Bark of the tree is peeled off to make a pillar. Entire tree is used to make a single pillar.

D- All the pillars are rest upon the top of the stone called *"KAADEN LONG"* (Lepcha, 2011)

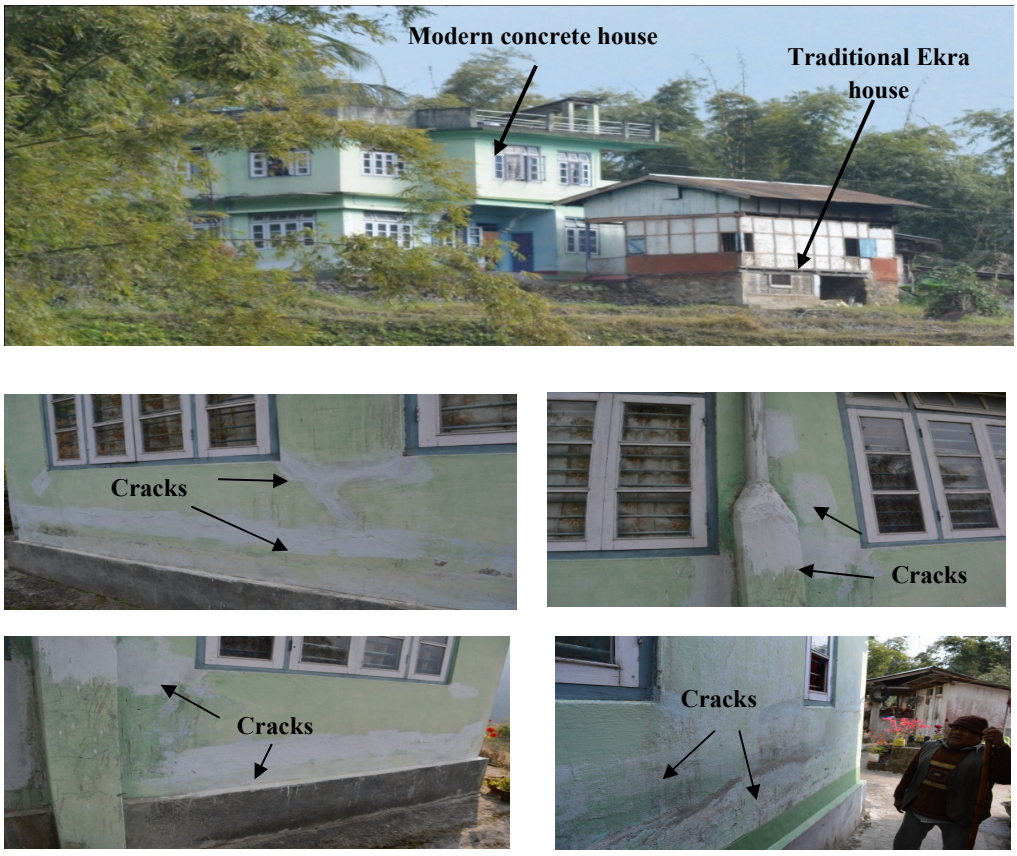
E- The stone upon which pillars stand act as the foundation to hold for pillar. Correct gravitation force is applied to make the pillar stand as stone and pillars are not artificially jointed by any material.

F- Notches are made on all four sides of nine huge tree size pillars. Long cross beams, called '*Doong'*, (Lepcha, 2011) which is also made from one entire tree length pillar are inserted through those notches. Thus, holding the pillars together and preventing them from falling down Not a single iron nails are used. The ground floor is partially enclosed where domestic animals and cattle are kept.

Plate IV.12: **Above 100 years old traditional *Bhotay Ghar*[31] in Namchi, South Sikkim standing still**

Source: Field survey, April 2017.

Plate IV.13: **Impact of 18th September, 2011 Earthquake on modern building structure in Sirwani village, East Sikkim**



Source: Field Survey, 2016

[31] It means the house was built by Bhutia community thus *"Bhotay Ghar"* means Bhutia's house

Plate IV.14: **Above 40 years old traditional *Kirat Khim*[32] in Namchi, South Sikkim**

Source: Field Survey, 2016

Table IV.4: **List of traditional anti seismic house in different climatic zone**

Sl No.	Traditional House	Climatic Zone	Material Used
1.	*Chaukat* House	Sub Tropical	Wooden logs, stones and local soil material. The roof is thatched with reed, straw and bamboo.
2.	*Ekra*House	Sub Tropical and Temperate	Bamboo splits, Stone foundation, mud or cement plaster. Recent times have seen corrugated tin roofs replacing the erstwhile thatched roofs as a more popular option.
3.	*Chitra* House	Sub Tropical and Temperate	Made up of bamboo mat.
4.	*Magar* House	Sub-tropical and Temperate	Wood planks from Castanopsistribuloides tree and local stone foundation.
5.	*Lepcha* House	Sub Tropical and Temperate	Wood from Castanopsistribuloides tree and local stone.
6.	*Bhotay Ghar*	Sub Tropical	Bamboo, mud and the roof is thatched with reed straw and bamboo
7.	*Kirat Khim*	Sub Tropical	Local mud, bamboo and stone are used. The roof is thatched with reed, straw or thin metal sheet.

Source: Field Survey, 2015 to 2018

[32] Rai ethnic community term themselves as *Kirat* tribe who believes in ancestral worship. *Khim* here means house.

Voices from the Field

I have two house, one is made up of cement concrete and the other is bamboo made Ekra house. I have constructed cement concert house in 1990 whereas my Ekra house was built on 1980. 2011 earthquake damaged 60 % of my concrete house however my Ekra house did not show any sign of damaged or neither it collapsed. It just shakes but never falls (Arun Rai, Assamlengy, East Sikkim).

During 2011 Earthquake I observed lower storey rectangular beam moving in north-south direction. wooden beam shaking in north-south direction. Then I realized that why we build our door in east direction. So when it shakes the house does not have large damage (Choden Lepcha, Dzongu, North Sikkim).

I believe concrete house is much more strong in the context of the material used. But strong doesn't mean that it always have the indigenity to adapt to the land. Concrete house is strong for 10-20 years but for long term durability traditional wooden house is much better in this land. Renovation is much easier and cheaper for traditional house than the cement concrete one. and it is also easy to renovate it in every year. (Norzing Lepcha, Dzongu North Sikkim)

Our old house is made of up bamboo and mud plaster. It was build in 1993. To cover the roof, paddy straw was used. This house acts automatically like a cooler during summer time and as a heater during the winter time. We never feared earthquake disaster because we knew that

even if the house collapse than no big causality would occur. Lightness of the house was the advantageous factors for earthquake mitigation (Dilip Gurung, Llapthang Thekabung, East Sikkim)

You know normally streets and roads are generally meant for beggars but 18th September 2011 earthquake made street as a safe zone for everyone. Ministers, Officers, Scientist everyone was there. My question is that why they left the building made up of marble floor and golden floor because everyone loves their life. On that day it taught the urban people that life is expensive. However we didn't slept on the street. We slept in our own houses. (Tshering Lepcha, Dzongu, North Sikkim)

IV.1.3c Traditional Mountain Farming

In Sikkim Himalaya mixed cropping or intercropping maize with pumpkins, maize with potatoes, maize with beans etc. are followed by most of the local rural people. These traditional agricultural practices not only have acted as the conservation measure by conserving soil fertility but it also has minimised the risk of total crop failure through drought hazards as it reduce the risk by having more than one crop variety in the field. Similarly, the local people also follow the rotational method in traditional farming. For example, sowing of pulses, such as soya bean, French bean, rice bean, black gram, green gram, yellow gram etc. are done in timely rotations period in all the fields which in turns have resulted in sustaining the fertility level of soil.

Plate IV.15: **Mixed Farming in Lachung Valley, North Sikkim**

Source: Field Survey, February 2016

Sikkim Himalaya is highly susceptible to soil erosion due to steep slope and heavy monsoonal rainfall. In the higher altitude of Lachung, North Sikkim, local people generally use available local material to reduce the soil erosion process. They generally place numerous stone all around their agricultural fields in a line format from higher slope to lower slope. This method has effectively managed to keep the soil intact all around the field thus lessening the soil erosion process.

Plate IV.16: **Stone line terracing to mitigate soil erosion- Lachung, North Sikkim**

Source: Field Survey, February 2016

Local people in Sikkim Himalaya also built a dry wall fencing commonly known as '*Dewal'* made by placing the huge stone in an orderly manner below their agricultural field or sometimes in terracing pattern. These traditional stone wall or fencing have played a very effective role in preventing landslides and soil erosion.

Plate IV.17: ***'Dewal'* a traditional stone fencing (a) In Sirwani village (East Sikkim) and (b) in Namchi (South Sikkim)**

a.  b. 

Source: Field Survey, 2016

Plate IV.18: **Use of *Amliso* (Thysanolaena maxima) plant for preventing soil erosion and landslides in (a.) Chalamthang, East Sikkim and in (b.) Sombarea, West Sikkim**

a.  b. 

Source: Field Survey, 2014 and 2018

Amliso (Thysanolaena maxima) plant is mostly grown in hilly areas to conserve soil from erosion during heavy rainfall. This plant has the fibrous root system (Alam et al., 2017) which helps to protect nutrient rich top soil from erosion. In most landslide prone area and in agricultural field, plantation of this plants can help to reduce soil loss upto 88% compared with bare area (Alam et al. 2017, p. 21).

One of the most common methods observed in Sikkim Himalaya is to see the sloppy field covered with the dried grass after planting crops like ginger. Dried grass is a local material available in the field. Before covering the crops, the grasses are burnt. The burnt grasses are then use to cover the crops. These methods have a very scientific explanation. The covering of grass actually works as a local soil management practices because steep and sloppy area in Sikkim is vulnerable to soil erosion when huge rainfall occurs. In addition this method also help to conserve the soil moisture which can be easily be decreased by warm weather. Thus the local soil management measure has played a vital role in sustaining the agricultural productivity without any external tools.

Plate IV.19: **Local soil management practice in Dzongu, North Sikkim**

Source: Field Survey, 2017

Terrace farming is another major traditional agricultural methods followed in Sikkim Himalaya. Most of these farming system is practiced in lower elevation of East, South and North district of Sikkim. However this agricultural method have also been observed in many areas of higher altitude of North Sikkim where the steep slope have been cut down for terrace farming. Due to its advantageous nature in agricultural productivity and soil erosion mitigation, most of the community is adapting it in large scale. Terrace farming is very sustainable and suitable farming technique in Sikkim Himalaya. It has the advantage of reducing the amount and velocity of surface water flow thus reducing soil erosion which is very common in Sikkim Himalaya. Terrace farming also have the advantage of trapping and holding water inside the field. As the water holding capacity of terrace farming is large therefore cultivation of some of the crops like paddy will be ease and in addition it can also help to recharge ground water for the spring.

Plate IV.20: **Terrace Farming in (a) East District and (b) West district of Sikkim**

a.  **b.** 

Source: Field Survey, 2017 and 2018

Plate IV.21: **Soil management practice in (a) Chemchey village and (b) Singtam (East Sikkim) by planting local trees *Gogoon* (Saurauia nepalensis) around the slope**

a.  **b.** 

Source: Field survey, April 2016, March 2018

Gogoon (Saurauia nepalensis) not only holds the top soil from erosion during rainy season but this plant is also one of the best known fodder plants (Rai & Rai, 1994, p. 96) and local fuel provider for the local people.

Agricultural methods and productivity are very much related in influencing the sustainable livelihood and risk reduction for local people of Sikkim Himalaya. Less agricultural productivity simply affects the resilience power of the local people by making them vulnerable to drought or famine disaster. Therefore, from time to time local people have tried to develop different traditional skills in Sikkim Himalaya to increase the agricultural productivity without disturbing the local ecosystem. Thus, the early traditional farming system incorporated numerous local methods for cultivating land for the sustenance of their livelihood.

The very first farming system introduced here was traditional slash and burn cultivation. The land was huge and the population was small therefore the local

people of Sikkim Himalaya adopted this farming system by following a minimum of 14 to 15 years rotational period. Small patches of forest were burnt and left for two to three days before planting crops. The burnt grasses and plants were naturally used as manure for the soil. Than by using their fingers or bamboo stick they use to dig small hole to plant the seeds. No external inputs were required and mostly mixed cropping was done. Following statement given by a local farmer in Dzongu, North Sikkim highlights the past and present agricultural scenario:

> *Earlier land used to be fertile and the population was very less. When one land was left vacant for 14 to 15 years then another land was used for slash and burned. We didn't used chemical fertilizer therefore mother earth was always happy during those days. Whatever we planted it grew. Now we don't have traditional fertile soil because the use of chemical fertilizer and pesticides have burnt the mud from inside thus the Earth's power to produce has been lessened.*

Methods of traditional farming were not same in every part of the Sikkim Himalaya. In South and West Sikkim, local people preferred terrace farming. However, the method and material used for increasing the productivity was much different than the terrace farming system which is followed today. They believed the land as their owner rather than the human as the owner of the land. Therefore, keeping and increasing the land fertility was their first priority and to do so they even use to visit long distance places in search of natural manure. Following statement of a female farmer of South Sikkim highlights those earlier and traditional farming practices and methods followed by her elders:

Our elders were so connected with the land that they use to visit terai area (plain area) to get elephant dung to raise the fertility of the land. After every Bhomi puja (land worship) our elders use to teach us to spread "kharani" (ashes) on the agricultural land to make the soil fertile. The process was so natural that we use to feel the beautiful smell of the land. We still want to spread those knowledge but now no one is much interested since it is laborious and old fashion. Earlier formal education was very low therefore people were very curious to know agricultural knowledge from the elders.

One of the most interesting thing of traditional farming system before the introduction of modern farming techniques was that the cattle was allowed to graze freely as the elders believed that grazing cattle manure are very strong and effective for the fertility of soil and for the productivity of the crops. However, today grazing cattle is totally banned by the government of Sikkim.

Voices from the Field

(Statement made by the local resident of Bering village, East Sikkim)

Before modern technology arrived we use to have a different land use pattern. We use to grow traditional varieties of different crops in our agricultural field and we also use to get other essential food items from the forest area itself. Springs was always located near or above our agricultural field and upper catchment of spring area was always surrounded by forest as a recharge zone. All the immediate requirement use to come from our traditional farming system and all the necessary

items required for agriculture production was also used to come from our surrounding area.

Therefore, resource recycling use to happen within the area without any external inputs. Paddy, Kodo (Millet), Fapar (Buck wheat) and even Bhan Tarul (Dioscorea alata) everything was there for consumption. Food security was there and cashless system use to function during those days. For example, we use to have 'Parayli' and 'Parma' system which means shared labour. When I helped you then you too would help me and this is how we use to do payment during early days.

Now the system has been altered. Production land has been bifurcated. Now we have abandoned all those kind of traditional agriculture system. In fact the question "Who Wants to be a Farmer" is arising within the educated and younger generation folk today. Trade able product based approach has been born. So now we are in cash based agricultural system. Today we need everything more so that we can sell it in the market. Now we prefer to grow such crops which would fetch large cash and this has led to the introduction of external inputs in our land. Today due to cash based approach we grow seeds given by external organization. Due to that we have lost traditional seeds and now we have become fully dependable in new modern seeds. Today local farmers are not been able to predict their agricultural production because they don't have vast knowledge about modern external seeds. The distribution of modern seeds and functioning of cash based system have made the whole indigenous network system collapse. We are now in run for money. What major mistake we are

doing today is that we are imposing the modern agriculture system inside the traditional agriculture system.

All the above narratives from the local people highlight their years of experience with the land. They know better of their land, its productivity and methods suitable for the eco friendly production. Thus, in the context of agricultural system in Sikkim Himalayan landscape, local farmers are the actual scientist whereas the modern scientist are just the learners.

IV.1.4 Traditional Emergency Response Strategies

Disaster response involves the public assistance given immediately after the disaster. It helps in reducing the impact of disaster by ensuring quick medical care and public safety and is sometimes also called disaster relief. Sikkim Himalaya consists of rugged topography and the good infrastructural development still lacks in major rural areas. In addition due to fragile ecosystem, one natural disaster always induces another disaster in this particular region and this makes the relief operation more difficult.

Therefore, in times of natural disaster the people living around the rural areas seldom believes in government or non government organization for immediate response system. Now the question arises how they have managed themselves during the occurrence of natural disaster since centuries. Answer lies on their aged old traditional knowledge which has been enriched by their decades of medicinal research. The age old traditional medicinal knowledge helped them to recover the affected victims before sending them to the good medical aided centre.

IV.1.4a Traditional Medicine of Sikkim Himalaya

The World Health Organization (WHO) defines traditional medicine as 'the sum total of the knowledge, skills and practices based on the theories, beliefs and experiences indigenous to different cultures, whether explicable or not, used in the maintenance of health, as well as in the prevention, diagnosis, improvement or treatment of physical and mental illness'(Abbott et al., 2014, p. 3).

Traditional medicine is not just a thing which has been followed by different indigenous and local community in the Sikkim Himalaya but it has a strong cultural identity too within it. It has helped to establish the relationship and ownership over the land where they have settled. It adds the substantial part to the history of a particular community about their land and illustrates the cultural and social way of life within the community.

The rugged topography with very little infrastructural development made the earlier individual community living around the Sikkim Himalaya to take up the measure to create medicinal cure from the local forest or land which they have. In course of time experimentation of different medicinal herbs made the community to develop the quick medicinal response in times of any disaster. Table 4.4 below highlights some of those common and mostly used traditional medicine by the local communities of Sikkim Himalaya during medical emergencies.

Table IV.5: **Traditional Medicine of the Sikkim Himalaya**

Sl No.	Local Name	Scientific Name	Distribution	Uses
1.	*Pailo Tabarkay*	Stephania glabra	Tropical and Subtropical Climate	Its powder is normally consumed for treating diabetes, tuberculosis, asthma and fever.
2.	*Sil Timbur*	Litsae cubeba	Subtropical and Temperate Climate	The seeds of this plant are normally chewed when the person suffers from cold, stomach pain and dizziness.
3.	*Chimphing*	Heracleu wallichii	Temperate and Sub Alpine Climate	The seeds of this plant is also chewed when the person suffer from stomach pain, cold and dizziness.
4.	*Khanakpa, Sil Timbur and Chimphing* (See Appendix B)	(Evodia fraxinifolia, Litsae cubeba and Heracleum wallichii)	Tropical, Subtropical and Temperate Climate	These three plant is crushed together to make a mixture of paste. The paste is later applied around the shifting muscle (cramp) of the injured person leg.
5.	*Parijaat*	Nyctanthus arbotristis	Tropical and Subtropical Climate	Leaves are boiled in water and served to the patient suffering from malaria. The bark paste is also applied to treat dislocated joints.
6.	*Titaypati* (See Appendix C)	Artemisia vulgaris	Tropical and Subtropical Climate	The leaves are used to stop nose bleeding. When the leaves are squeezed, the green liquid which comes from it are normally used for cleansing propose.
7.	*Pakkhanbed* (See Appendix D)	Berginia ciliate	Subtropical, Temperate and Sub Alpine Climate	Rhizome of *Pakkhanbed, Bhuichampa* (Kaempferia rotunda) and *Harchur* (Viscum articulation) are crushed together

				to form a paste. These pastes are applied over the fractured parts of the body with the help of bamboo leaf as a bandage. Its paste is also used to minimize body ache. During high fever the root and rhizome of this plant are boiled in the water and later served to the patient.
8.	*Ghiukumari* (See Appendix E)	Aloe barbadensis	Tropical and Subtropical Climate	The juice of this plant is normally given to the weak person. When the skin or hand is burned, the inner portion of the plant is robbed all over the affected parts to reduce the pain and to decrease the infection.
9.	*Banmara* (See Appendix F)	Eupatorium sp.	Tropical and Subtropical Climate	Local people normally use the leaf juice of the plant to stop the bleeding especially when ones hand or leg get a minor cut.
10.	*Betlauri* (See Appendix G)	Costus speciosus	Tropical, Subtropical and Temperate Climate	During urine infection the juice of *Betlauri* plant is normally taken. The paste of this plant is also use to cure ear infection.
11.	*Tulasi*	Ocimum sanctum	Tropical and Subtropical Climate	Leaves and roots are normally eaten by the local people during the fever or gastric.
12.	*Nageswari*	Mentha viridis (root)	Tropical and Subtropical Climate	The paste is normally consumed during pneumonia.
13.	*Abhijalo* (See Appendix H)	Drymaria cordata	Tropical and Subtropical Climate	Its juice is consumed to treat sinus. Local people also consider that the water which has been mixed with *Abhijalo* is consumed then it is good for brains.

14.	*Sisnu*	Urtica dioica	Tropical and Subtropical Climate	Paste of its root is applied in minor facture. The tender and the leaves are also taken as vegetable which is good to minimize high pressure. It is believed that if its root paste is consumed before one hour to delivery by the pregnant woman than the child birth will be smooth and easy.
15.	*Phapar*	Fagopyrum dibotrys	Subtropical, Temperate and Sub Alpine Climate	During tonsil the white flower of this plant is chewed and eaten by the local people.
16.	*Bhuichampa*	Kaempferia rotunda	Subtropical Climate	When bone is dislocated then the rhizome of *Bhuichampa* is crushed to make a paste and the paste is later applied in the swelling parts. Local people also call it as bone settlers. Local people also mix the paste of *Bhuichampa* with the red mud and the mixture is applied and tied around the facture parts.
17.	*Kaliningro*	Tectaria macrodonta	Subtropical and Temperate Climate	Root juice of this plant is normally taken to cure blood dysentery.
18.	*Nimpatti*	Azadirachta indica	Tropical, Subtropical and Temperate Climate	During the initial stage of cold and fever, local people boil the leaves of this plant and consume it. It is also consumed to treat gastric.
19.	*Cherowto*	Swertia chirayita	Temperate Climate	Some pieces of this plant is boiled in the water and later consumed to cure cold and fever.
20.	*Ambak* (See Appendix I)	Psidium guajava	Subtropical and Temperate	Bark and as well as its young shoot is normally chewed and

			Climate	eaten by the local people during the blood dysentery.
21.	*Rukamaru*	Spondias pinnata	Subtropical	The bark of this plant is normally chewed and eaten during diarrhoea and dysentery. Flower of this plant is also consumed in the form of pickle.
22.	*Ultekuro*	Achyranthesas pera	Tropical and Subtropical	Root paste of this plant is taken orally during pneumonia.
23.	*Phachang*	Zingiber zerumbet	Subtropical and Temperate	Rhizome of this plant is chewed and eaten during headache and stomach ache.
24.	*Bokay timur*	Zanthoxyluma latum	Tropical and Subtropical Climate	The seed of this plant is normally chewed and eaten during gastric problem. The seed is also used to make pickle.
25.	*Asuro*	Adathodavasic a	Tropical and Subtropical Climate	Leaves and roots are consumed to treat asthma and fever.
26.	*Totola*	Oroxylum indicum	Tropical and Subtropical Climate	Seed paste of this plant is taken to cure pneumonia and its bark juice is taken for treating jaundice.
27.	*Ghantiphul*	Hibiscus sp.	Subtropical and Temperate Climate	During dysentery the flower of this plant is consumed orally.
28.	*Budookhati*	Astilbe rivularis	Subtropical and Temperate Climate	Rhizomatic roots powder of this plant along with *Harchur* (Viscum ciliate) and *Pakhanbed* (Berginia ciliate) in a glass of milk with some honey, egg and 4-5 drops of mustard oil to cure body ache.
29.	*Kalohardi*	Curcuma zeodarica	Tropical and Subtropical Climate	Rhizome of this plant is chewed and eaten to treat jaundice.

30.	*Chuwa* (See Appendix J)	Phlogacanthus thyrsiflorus	Tropical and Subtropical	Flower of this plant is boiled and consumed as a bitter curry when cooked in edible oil by adding onion, tomatoes, garlic and some green chillies. It has a bitter taste and people suffering from diabetes and high pressure normally consume it with rice.
31.	*Golpatta*	Hydrocotyle japonica	Tropical, Subtropical and Temperate	Leaf juice of this plant is consumed to treat tonsillitis.
32.	*Bojho*	Acorus calamus	Subtropical and Temperate Climate	Rhizome of this plant is applied to treat skin diseases.
33.	*Bhakimlo*	Rhus chinensis	Tropical and Subtropical Climate	The seeds are crushed to make a powder and the person suffering from diarrhoea consumes the powder orally.
34.	*Bael*	Aegle marmelos	Tropical and Subtropical Climate	Dried peel of the fruits of this plant is made into paste to cure pneumonia.
35.	*Bikhma*	Aconitum ferox	Sub Alpine and Alpine Climate	Rhizome of its plant is normally eaten to cure from food poisoning.
36.	*Pinasey lahara*	Clematis sp.	Tropical and Subtropical Climate	Root and stem of this plant is burned a little and the smoke which comes out from it is inhaled by the person suffering from sinusitis.
37.	*Ankh*	Calotropis gigantea	Tropical and Subtropical Climate	Leaf along with mustard oil are used for treating the muscle cramp
38.	*Harchur*	Viscum articulatum	Tropical, Subtropical and Temperate	Use for treating muscular pain and bone fracture.

			Climate	
39.	*Akasey lahara*	Cuscuta reflexa	Tropical and Subtropical Climate	The stem of this plant is crushed to extract juice from it and the juice is taken orally or applied over the body in order to cure jaundice.
40.	*Avacoda bark (Fanshi).*	Persea americana	Tropical Climate	It is consumed to stop noise bleeding.
41.	*Monthung*	Sambucus adnata	Subtropical and Temperate Climate	*Monthung* is a plant which is used when a person leg gets cramp. The leaves are put inside the hot ash and later the hot leaves are applied and tied in the cramp parts.
42.	*Banana earthworm*	Unknown	Tropical, Sub-tropical and Temperate	Local people put banana earthworm inside the boiling water and later drink it to cure chicken pox.
43.	*Bhuiamala*	Phyllanthus amarus	Tropical and Sub-tropical	Juice is extracted from the tuber of this plant and taken orally to treat diabetes.
45.	*MaanPaa*	Nanorana liebigii	Sub Alpine and Alpine	Dried dust skin of this frog is applied on the cut part of the body to stop bleeding as well as to make the cut skin stick.

Source: Field Survey, 2015, 2016, 2017 and 2018.

Plate IV.22: **Traditional healer of South Sikkim showing the local medicinal plants**

Source: Field Survey, 2017

Traditional medicine plants and its uses are not a recent development however, it has a long history of its evolution and a strong connection with the surrounding natural set up of the place. Since, the Sikkim Himalaya is characterised by complex physiographic, climatic and ecological set up, natural hazards in the form of earthquakes, landslides, drought, famine, forest fire, flash flood are common in this part of the Himalayan region. Thus, in early days before the introduction of modern health care system, indigenous and local communities of Sikkim Himalaya not only have to bear different natural calamities but also various health hazards associated with the natural set up. Thus, the invention and discovery of numerous traditional medicinal plants was necessary for survival and adaptation measures. This traditional medicine thus carries a long history of experimentation and experiences with surrounding nature.

To sum up the discussion, this chapter thus explores different traditional methods, practices and measures taken up by the indigenous and local communities of Sikkim Himalaya in disaster risk reduction. For identifying the study area for data collection, inventory maps have been used by selecting the criteria of physiography, vulnerability, risk factors and importantly the past disaster events in Sikkim Himalaya. For example, by analysing past disaster events, land surfaces, slopes, vegetation, river banks and climatic factors certain area or GPU (Gram Panchayat Unit) was selected. Since traditional knowledge system is not homogenously distributed or situated in one place and in addition contemporary Sikkim represents multi-structured society, thus selecting the area according to above criteria was important. Keeping the different natural set up of the Sikkim Himalaya as the important criteria, documentation of the existing traditional knowledge has been done in this chapter.

Static and homogenous traditional knowledge system of one ethnic group is not truly available due to the difference of physiographic and climatic variation in Sikkim Himalaya which influences different livelihood patterns of the local communities. Thus, it clearly explains that though the variation in ethnicity occur within the local communities in Sikkim Himalaya however, the physiographic and climatic factors have made them to adopt and developed similar traditional knowledge system for their sustainable livelihood. For example, terrace farming which was introduced by Nepali community is also today largely practiced by other ethnic community like Lepchas and Bhutias in North and West Sikkim because of the similar physical and climatic factors. Similarly, documentation of traditional building structure though reveals the different architectural design however, the material used and the reason for its construction are similar to each other.

Most of the traditional knowledge especially the traditional food items and its process of preparation is slowly vanishing due to the rapid change in socio-economic livelihood among the present generation and also because of the lack of conservation and dissemination from the formal authority and the knowledge holders itself. Some of the traditional food have unique characteristic for mitigating drought and famine disaster. There identification and methods of preparation must be documented to safe guard it from extinction and later must be evaluated to consider its applicability in drought management framework.

In almost every corner of Sikkim Himalaya traditional farming system reveals the similarity of effective methods. For example, similar patterns for reducing soil erosion, similar methods for conserving and increasing soil fertility and similar practices of mixed farming to secure them against total crop failure. Thus, traditional farming system of Sikkim Himalayan communities is build up in such a manner that it totally outlines the major preparedness, mitigation and sustainable strategy.

Cultural belief system exists only when an individual or a group believes it. Though belief system cannot be measured or justified with a mathematical ~~calculation~~ precision, it still holds a community together in a unified manner and it gives the expression of distinctiveness between one community to another. Cultural or spiritual belief system of indigenous community of the Sikkim Himalaya is not a recently developed system. It has been followed from centuries and these belief system have helped to preserve the way of life of various local community in the Sikkim Himalaya. Most of those cultural belief system contains various folklore, stories and myths, which often highlights different disastrous events, its causes and mitigation strategies. Thus, cultural belief system though considered as unscientific and superstitious, contains vast knowledge of ecology and its conservational strategy.

Though the chapter explored and documented all those scattered traditional knowledge system of Sikkim Himalaya, however, it is important to understand that documentation alone simply does not give a logical meaning towards the applicability of traditional knowledge in DRR. However, it definitely paves the way to bridge the gaps existing within the formal institutional framework of Disaster Risk Reduction.

CHAPTER V

Framework for Integrating Traditional Knowledge and Scientific Knowledge Systems for Disaster Risk Reduction

Various debate and discussion still exists amongst the planners, policy makers and even academic community regarding the most efficacious knowledge system and its methods and applicability in DRR and sustainable development. The two knowledge systems i.e. the scientific and traditional both have their own ways of defining the activities of nature and the phenomenon that occur in it. However, scientific knowledge over takes the traditional knowledge system as it is tested and undergoes universal evaluative strategies. Whereas, traditional knowledge contrarily lies in the hidden ground due to its less scientific character. Lacks of quantification coupled with less scientific explanation have prevented traditional knowledge from occupying the place of significance within the various international DRR frameworks.

However, it is also not right to consider scientific knowledge alone for effective DRR and sustainable development as the World Disaster Report (2016) itself highlights the high human developed nations as the most disaster affected nations in terms of high loss to financial property in the world. In addition, International Disaster Database from Centre for Research on the Epidemiology of Disaster, Belgium, highlights the increasing property damage by natural disaster every year. For example, according to CRED (n.d.) report, from 1980 to 2014 the global damage of property by disaster increased rapidly from 100 million US dollars to 900 million US dollars approximately.

Similarly, in terms of the total number of people affected by natural disaster every year is additionally incrementing at a fast pace. The CRED (n.d.) had further reported that around 400, 1300 and 800 million people were affected by natural disasters in the year 1980 to 1984, 2000 to 2004, and 2010 to 2014 respectively. Therefore, development of modern science, its technological innovation and data were and are not always efficacious in determining and diminishing disaster peril. However, the point here is not to discard the role of modern scientific framework and technologies in DRR but to highlight its existing gaps, which can only be bridged by supplying and integrating the necessary ingredients of traditional knowledge within the DRR.

In the context of the Sikkim Himalayan state, two disaster management plan was introduced -first, the Sikkim State Disaster Management Plan (2010-2011) and the latest, the Sikkim State Disaster Management Plan Volume 1: 2015. Both the plans have mainly focussed on DRR from the lens of only one form of knowledge system i.e. the scientific or technocratic knowledge. However, the earthquake on the 18th September 2011 that rocked the entire State of Sikkim, the landslide on the 13th August 2016 in Mantam, North Sikkim and recent flash-flood from North Sikkim on 17-18 June 2019 visibly revealed the limitedness of DRR, and thereby, the failure of technocratic DRR framework of Sikkim State Disaster Management Authority.

Sikkim being one of the most fragile Himalayan region requires different comprehensive framework for DRR where the scientific techniques and local people's experience need to be evaluated together. The framework should be predicated upon the local people's requisite rather than what the authority thinks that can be delivered. Consequently, the following section of the chapter brings out the indispensable but flexible integration approach between the modern and traditional knowledge system and its holders in DRR. Ignorance and (or) dominance of one form of knowledge

system in DRR has only consummated half prosperity towards sustainable development and DRR due to certain gaps which both knowledge systems hold.

V.1 Challenges for integrating Traditional Knowledge with Scientific Knowledge- Exploring the Gaps

Power relationships are often sighted in both the knowledge systems (Wisner & Luce, 1995; Deken, 2007; Mercer et al., 2009). The scientific society inclines to consider traditional knowledge as methodologically week, subjective and localised (Brodnig & Schonberger, 2000). Due to its localised nature, the legitimate rights of its implementation have always been questioned. The very dichotomy between the two knowledge systems exists because of their concept and function while defining the nature, human and non-human element.

Traditional knowledge which is considered rich in oral history of an individual community embodies a wealth of wisdom of nature gained over millennia from direct observations, and which has been transmitted orally over generations (Mazzocchi, 2006). However, due to lack of documentation the age and time of its origin is arduous to highlight. Without the evidential proof of its subsistence it becomes difficult issue to acknowledge its legitimate right as the modern world accept the law according to the facts and evidence. On the other hand, scientific knowledge holds the evidential proof of data in the different stages of its applicability. It has the facts and data well tested and experimented of different time series with diverse paradigm. These nature of documentation in the form of written scripts have given advantage to stake its legitimate right upon knowledge creations.

Indigenous people believe nature as a provider as well as destroyer. They endeavour to enlarge the positive role of nature by offering prayers, guarding and acknowledging

the gift of the nature. Understanding both the good and bad role played by nature comes from generation of observations and experiences they gained from the nature. Therefore, the data amassed by them is sizeably voluminous and can be termed as diachronic data (Johnson, 1992) which designates a long time series of observation in one categorical location. However, the authentic facts with time are mostly misleading because of its oral nature.

Whereas, in scientific knowledge, no laws or theories are accepted until a verification of data is proved. Though, observation is very consequential method of data amassment in scientific knowledge, the time series of data collected are very less. In scientific knowledge, data can be accumulated for some short concrete period like field visits and can be termed as synchronic data (Johnson, 1992) - customarily collected over a short term series but over large areas (Johnson, 1992). The data are generally generated by specialist and experts (Johnson, 1992) however, for indigenous people gathering of data is simply taught from their forefathers or data are generally generated by resource users themselves (Johnson, 1992).

Words and numbers are two different strategies of data collection Traditional knowledge designates the oral history of experience and observation therefore; data extracted from the indigenous and local people are in the form of oral history which is seldom written or documented. The data is purely collected in a qualitative way where the words from the local people postulate the prime significance. All the data amassed from stories, folklores, rituals, notion, experiences etc. does not have any statistical quantification or factual verification. On the other hand scientific knowledge considers statistical quantification very significant because data accumulated from a field are tested to prove or confute the hypothesis. Quantitative analysis is the key to understand the object of study.

Indigenous and local people do not consider any of its surrounding environmental features as a separate entity. According to them, everything is inter-connected and cognate with each other thus bringing together environment as a component of social and spiritual relation (Johnson, 1992). Their relationship holds the key towards holistic approach where each and every element of nature are revered and accepted as the core member in their livelihood journey. However, the method and strategies applied from traditional knowledge is limited according to its geographic place of its origin. Consequently, the very contextual characteristic of this knowledge system brings the question of its applicability and role for larger environmental sustainability.

Scientific knowledge does not believe in subjective authenticity. Quantification, experimentation and verification are one of the prime steps of scientific knowledge (Rai & Khawas, 2019). Once a law and theory is created then its applicability disseminates all over the geographic region irrespective of the geographic variation. Consequently, scientific knowledge has universality and favours analytical and reductionist methods as opposed to the more intuitive and holistic view often found in traditional knowledge (Mazzocchi, 2006).From this brief outline of dissimilarities, we can gain an understanding of how hard it is to integrate two systems of knowledge that are so profoundly different. Endeavouring to analyse and validate traditional knowledge systems by utilising external (scientific) criteria sometimes even carries an immensely huge risk of distorting such systems in the process (Mazzocchi, 2006). Concurrently, we cannot extract just those components of traditional knowledge that seem to quantify up to scientific criteria and ignore the rest. This process of knowledge mining would atomize the overall system and can even threaten traditional knowledge with dispossession (Nakashima & Roué, 2002; Mazzocchi, 2006).

According to Feyerabend, any form of knowledge will make sense only within its own cultural context (Mazzocchi, 2006). Therefore, substitution would not be a great option rather than integration. However, integration would prosper only if the policy and planning for DRR involves all the stakeholders i.e. it should be like a round table conference between the formal stake holders and local stakeholder for whom the DRR policy and planning is made. As simply implementing policy without knowing the requisite of the marginalised or vulnerably susceptible communities does not distribute a positive result. As Mazzocchi (2006, p. 464) states that "just as different maps can give accounts of the same territory, so too can different forms of knowledge about the material world, its actual representation ultimately depends on the observer's view".

Thus, to reduce disaster risk and address increasing susceptibility to natural hazards, it is essential that incipient and sustainable relationships are built upon the strengths of both knowledge bases (Agrawal, 1995; Wisner & Luce, 1995; Larsen, 2006; Mercer et al., 2009). Identifying the categorical strengths of each knowledge base, and integrating those strengths, would further empower indigenous and local communities to prepare for and to mitigate natural hazards (Mercer et al., 2009).

V.2 Exploring the path for incorporating the two knowledge systems for Disaster Risk Reduction in Sikkim Himalaya

Dwindling of biological diversity is not only because of the loss of species living within it but also due to the erosion of indigenous wisdom which was governing it (Unsworth et al., 2012). Therefore, the loss of biodiversity is also correlated with the reduced capacity for the transmission of subsisting traditional wisdom among the coming generation (Unsworth et al., 2012). Thus, it is consequential to protect the

biological and cultural diversity which are linked with the traditional knowledge system, to enhance the future resilience and sustainability of the indigenous and local people (Unsworth et al., 2012) who are mostly ignored and marginalised.

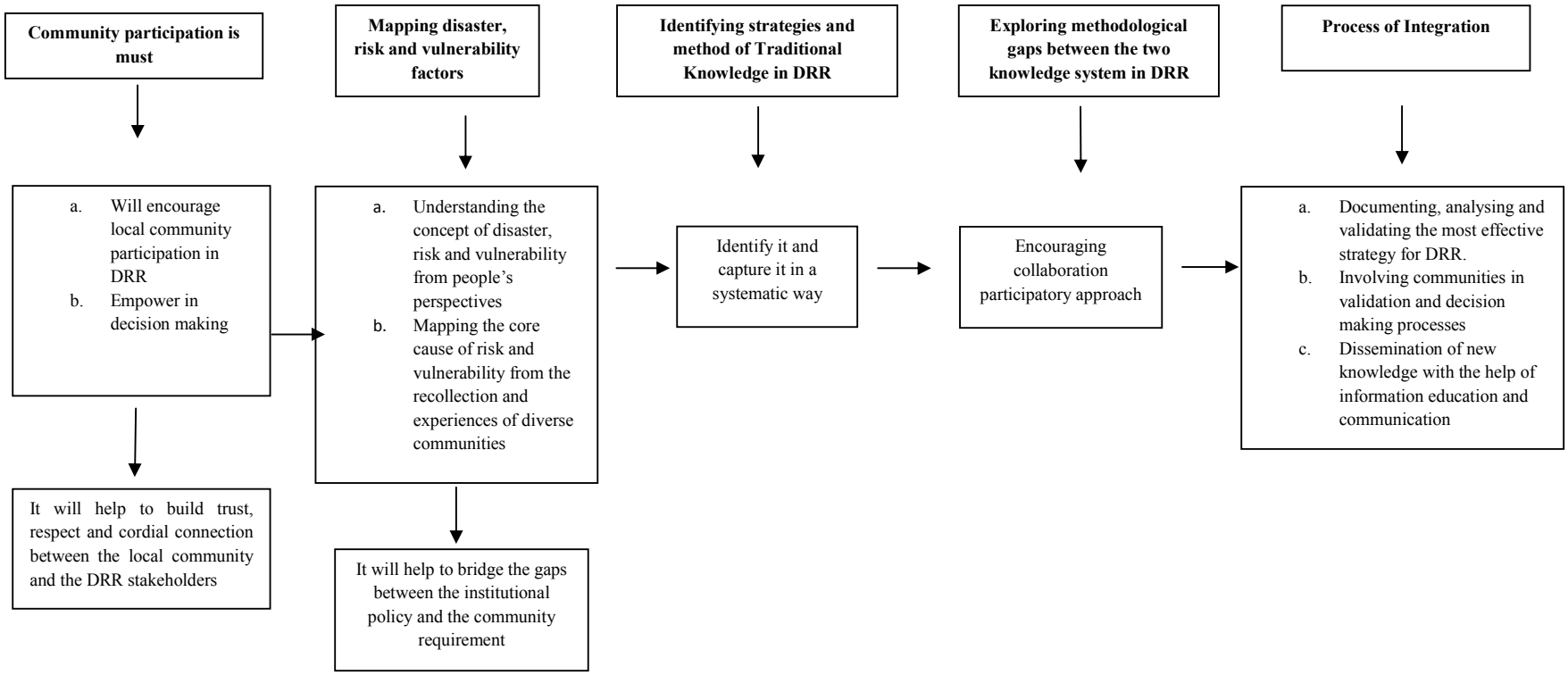
Even Article 8 of the Convention on Biological Diversity urges us to "respect, preserve and maintain knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity" (United Nations, 1992; Mazzocchi, 2006). Therefore, supremacy of scientific knowledgeand its practices alone cannot lead towards a sustainable goal. As nature and its role are always dynamic, the integration of relational approach within the modern scientific DRR approach would certainly avail the planners to understand the core issues from the local people perspective. The recognition of integrated DRR approach is necessary where both the knowledge system and its holders could collaborate rather than substituting each other (Unsworth et al., 2012).

Collaborative framework between the two knowledge systems will likely have far greater chances of success than frameworks embedded within a singular world view (Unsworth et al., 2012). For example, to overcome the issue of nature's complexity, modern science tries to develop different approaches to resolve the challenges but normally gets half success. However, it is equally useful to understand those challenges from the indigenous people perspective too (Mazzocchi, 2006). These would certainly give a way for modern science to discover those ingredients which was needed to answer the complex issue of the natural world. Thus, the created gaps can be bridged with the integration of the two knowledge systems and these would undoubtedly develop a holistic approach for comprehensive DRR framework.

Thus, the above arguments do not favour the dominance of one knowledge system for DRR, rather support the identification and integration of necessary wisdom of both the knowledge systems and its holders to build a holistic framework for DRR. The framework described below has been developed to identify the gaps and strength between the two knowledge working cultures in DRR. This framework explores some of the needed connection for bridging the two knowledge experts together to reinforce the socio-cultural resilience and adaptation measure for disaster risk reduction in the Sikkim Himalaya.

The institutional framework developed by Sikkim State Disaster Management Authority have been exhaustively analysed to identify the subsisting gaps between the formal stakeholders who implement the DRR policy and the local communities for whom the policy has been developed. However, the integration framework is not a complete static process but flexible as it encourages constant revision, modification and flexibility as indigenous and local knowledge of communities are always adapted according to the environmental and climatic change (Mercer et al., 2010).This framework have been developed with the help of extant literature reviews, focusing majorly towards delimiting the gaps between the traditional knowledge and scientific knowledge in DRR and the field survey within the study area which availed to outline some of the major DRR issues arising from the grassroots level.

Fig V.1: **Framework for Integrating Traditional and Scientific Knowledge Systems for DRR in the Sikkim Himalaya**



Source: Adapted from Mercer, 2007; Mercer et al., 2009; Mercer et al., 2010; Hiwasaki et al. 2014; Field Survey 2015-2018

V.2.1 STEP 1 – Participation of local communities

The concept of community, although quite complex, has been a primary pillar upon which the local and regional programmes are developed and conducted by the governmental and non-governmental organisation (NGOs) to promote sustainable development (Buckle, Marsh & Smale, 2003; Mercer et al., 2010). However, conventional top-down developmental strategies have not been much satisfactory to accomplish the required assistance to the indigenous and local communities, most of whom belong to the marginalised section of the society (Narayanan, 2003). The major reason of the failure of such DRR plan and programme is because the external agencies and authority who initiates those developmental programme mostly view the local people as an 'object' rather than the 'subject' and endeavours to distribute 'what they can' rather than focussing on *'what* people actually needs' (Narayanan, 2003).

Thus, the participation of local and indigenous community in any developmental planning and (or) in decision making is essential to ascertain the right track of development in a right place at the right time. For example, after the earthquake that hit Sikkim on the 18th September, 2011, the local people living in the rural area of Dzongu, North Sikkim faced extreme hardships due to lack of efficacious governmental initiative especially post disaster. The relief workers who were sent by the government authority and other non-governmental organizations consummately failed to rescue and support the earthquake affected local people of Dzongu. According to the local people there, the trained disaster relief force was not been able to adapt in the rugged and forested terrain of Dzongu. They were more confused and unprepared. The local people believed that if the mitigation forces would have consulted and interacted with the local people during the event of disaster than the

work load would have been reduced and relief work would have been effectively undertaken. According to 69 years old local resident of lower Dzongu:

> *I think when people from outside suddenly come in our place and show their help after the disaster than it seems quite fake. Mostly relief work during 18th September, 2011 earthquake seems like show off with unnecessary investment and clear greed.*

The above verbal expression clearly highlights the lack of involvement of local people in disaster risk reduction plan formulated by the formal authority in Sikkim. Though, Sikkim Disaster Management Plan 2015 highlights the importance of participatory approach in DRR, it still fails to conceptualise the approach from the local people's perspective. Significance of community based disaster management approach through a formal line department appointed by the authority is mentioned in both the Sikkim State Disaster Management Framework 2010-2011 and Sikkim State Disaster Management Plan 2015. However, both the institutional framework thoroughly ignores the local people's perception and decision upon the initiated DRR plan and policy

Thus, the two way flow of knowledge and information for DRR are absent and only one way top down approach is in operation in both the framework. For example, the following section from the Sikkim State Disaster Management Plan, Volume 1, 2015, p. 25, clearly explains the top down approach in DRR: "Local community groups and voluntary agencies including NGOs should actively assist in preparedness, relief and rescue and mitigation activities under the overall direction and supervision of the SSDMA, they should actively participate in all training activities as may be organised and should familiarise themselves with their role in disaster management". Here the

term “under the overall direction and supervision of the SSDMA ”clearly reveals the top down DRR approach of SSDMA.

The participatory approach initiated by the disaster planners must be reconstructed to encourage the local and indigenous people to express and share their opinion (Mercer et al., 2008) freely about the hazards, susceptibilities and the ground requisite with the external DRR experts. This in turn will enable the planners and disaster managers to understand issues of risk and vulnerability from the ground itself, which can be helpful to formulate mitigation plan according to the requirement of local or indigenous community, most affected by natural disaster.

Community participation in DRR should be such in manner so that local, indigenous and marginalised people can give their views and inputs openly regarding the natural phenomenon to the government and nongovernmental authorities.

Encouraging community participation in this way would certainly give an advantage to the state project coordinators in formulating the DRR project with ease and success. In addition, it will further help to bridge the gaps existing between the scientific manager, disaster planners and the local community. Increased participation of local community in DRR will certainly improve DRR plan by making it more context specific and ensuring ownership rather than partnership in DRR process and programme (Olowu, 2010; Poterie & Baudoin, 2015). Thus, it will bring the concept of empowerment in decision making.

DRR project or work in any particular region or area would not be considered as success unless and until the local inhabitant accepts the policy as their own. The core involvement of formal stakeholders alone upon the DRR policy and implementation program would certainly lead towards the uncertain and unpredictable DRR plan in

Sikkim Himalaya. Every DRR policy and its implementation must focus the local, indigenous and marginalised people (or communities) living within the affected and(or) vulnerably areas and should give them the access and powerin decision making processes because they know better what is right for them. Additionally, they are also very fond of their surrounding habitat, enabling them to give better inputs as to what works or not for them and their immediate surroundings.

Since the most affected and the most experienced people are the local people itself, therefore, encouraging their participation, and empowering them in decision making would help the disaster management planner or the formal stakeholder to pave a quick and sustainable way for disaster risk reduction. Therefore, local people who are always directly affected by the natural hazards should have the say while deciding and developing any disaster risk reduction policy and implementation program (Wisner et al., 2004; Mercer et al., 2008).

Participation approach also helps to build trust, respect and cordial connection between the local community and the DRR stake holders. However, the efforts must come from both the side. Imposing external knowledge and modern technology for DRR to the indigenous and local people would rather make the tough road for the emergency managers and the planners in formulating and implementing disaster risk reduction project. It is because native population basically consider their knowledge to be a component of their own cultural identity (Busingye & Keim, 2009; Takeuchi & Shaw, 2008)

At the same time, relying too much upon modern technology alone would make the indigenous and local people too dependent on external forces (Takeuchi & Shaw, 2008) for safeguarding themselves from any disaster. This results in minimising the

community's capacity to help themselves (Takeuchi & Shaw, 2008) during natural disasters. Respecting and building up on the already existing knowledge of indigenous and local people will empower them to recognise what they can do and cannot do or in other words, capability for themselves (Kelman, Mercer & Gaillard, 2012).

By bringing external contributors together with indigenous and local people in collaborative exercise, mutual trust can be fostered through personal connections and thus valuing the strength of different knowledge forms equally (Kelman, Mercer & Gaillard, 2012) as no single knowledge system, be it traditional or modern can be an answer for all sustainability or development activities (Kelman, Mercer & Gaillard, 2012).

V.2.2 STEP 2 - Mapping Disaster, Risk and Vulnerability Factors

Understanding the concept of disaster, risk and vulnerability factors from people's perspective is very essential as it will allow to capture the core cause of the disaster from the ground itself, which in fact always gets missed within the institutional framework formulated by the formal stakeholders. Local and indigenous peoples' view of disaster is very context specific; therefore, the concept, cause and its impact often come from the experienced they have gained in the past. For example, a 78 year old man Phedangma[33] from Sombarea village, West Sikkim defines disaster and its causes as follow:

> *Disaster happens due to the polluted ill behaviour of man towards the surrounding nature. Too much human exploitation and interference with nature are the major cause for the shaking of earth. The more we are educated, the more we begin to think or consider our self as equal to the*

[33]Local priest of Limbu community

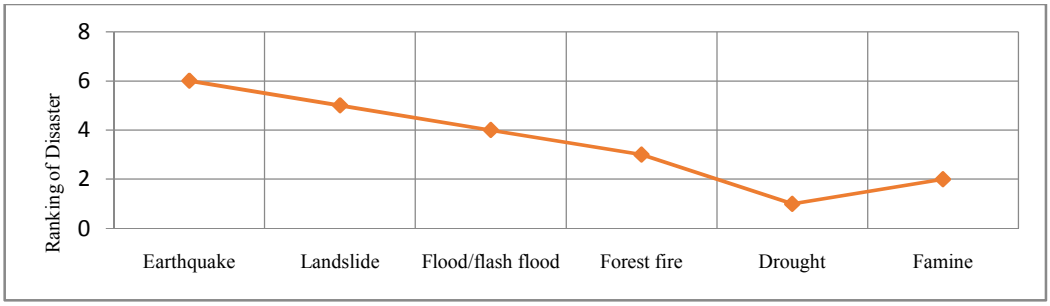
earth or even God. When we forget the truth and forget god and disrespect nature. It is then that disasters happens to balance the truth and lie. Therefore, to avoid disasters human have to be truthful towards mother earth.

Similarly 72 years old man from HyeeGyathang village, Dzongu, North Sikkim conceptualise disaster as follow:

If you love nature, nature will love you too. How are you going to respect species of nature, the nature too will respond according to it. You see 18th September 2011 Sikkim earthquake and 2016 Mantam landslide around Dzongu area have clearly shown how human greed has caused these disaster. Even after seeing and experiencing these two disasters if the people still close their eyes and ignore their unclean developmental activities than it is going to be much worse in future.

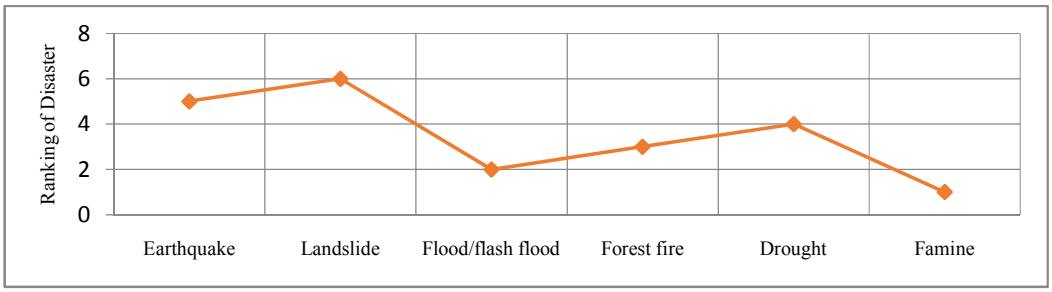
For in depth understanding of common natural disasters in Sikkim Himalaya from local people's perspective, a questionnaire was prepared and structured interview was conducted for ranking the common disaster in their locality. Six natural disasters were mentioned in the questionnaire and the interviewees or participants were asked to highlight the most common disaster according to their rank in four districts of Sikkim namely, North, South, East and West district. After collecting the data, four statistical graphs of each district were prepared to understand the occurrence of most common disaster according to local people's perspective. Higher ranking indicates the high occurrence of a particular disaster.

Fig V.2: **Ranking of Disaster in North district of Sikkim – From Local People's Perspective**



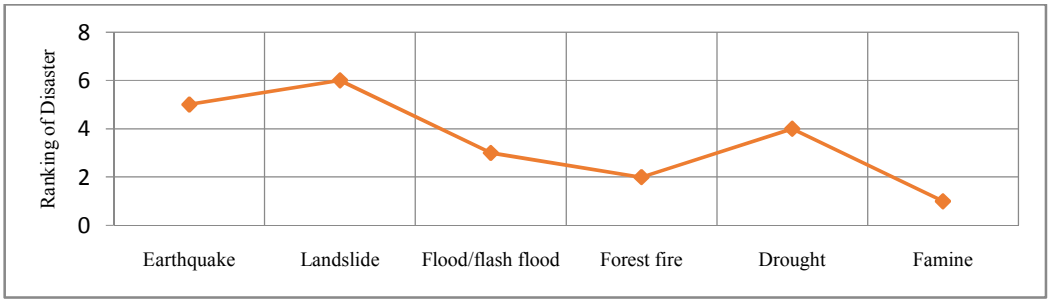
Source; Field Survey, 2016 to 2018.

Fig V.3: **Ranking of Disaster in South district of Sikkim – From Local People's Perspective**



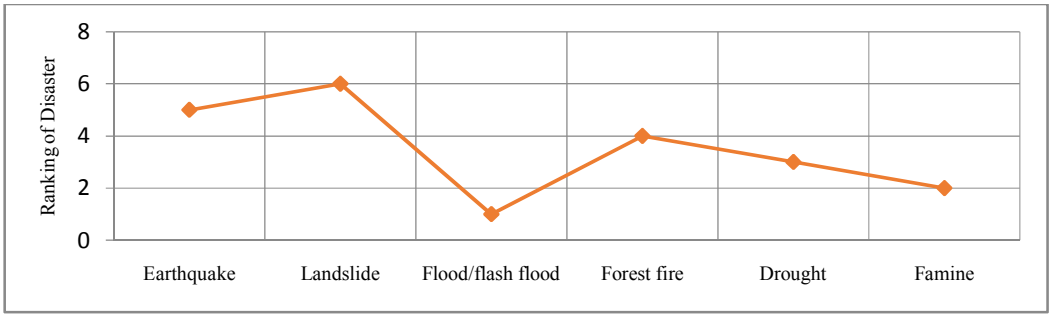
Source; Field Survey, 2016 to 2018

Fig V.4: **Ranking of Disaster in East district of Sikkim – From Local People's Perspective**



Source: Field Survey, 2016 to 2018.

Fig V.5: **Ranking of Disaster in West district of Sikkim – From Local People's Perspective**



Source: Field Survey, 2016 to 2018.

According to people's perception, North district is vulnerably susceptible to disaster in this following manner earthquake<landslide[34]<flash flood, in the South district by landslide<earthquake<drought<forest fire, in East district by landslide<earthquake<drought<flash flood occupied the high ranking whereas in West district by landslide<earthquake<forest fire<drought occupied the higher ranking. Thus, a local person knows very well about their surrounding and the environmental phenomena occurring and affecting their surroundings. Their perception though unscientific, is originated through the experiences of the affected people who have been residing in there for decades. These experienced perceptions though scientifically unexplained must be given significance before implementing any formal DRR policy.

Formal institutional gaps can only be bridged if the planners and the policy makers commence to think outside the reductionist tool box. The total hierarchical system or the top down approach has to be deconstructed to reconstruct the two way flow of information. Localised understanding and acclimatization is indispensable for the

[34]< less than sign

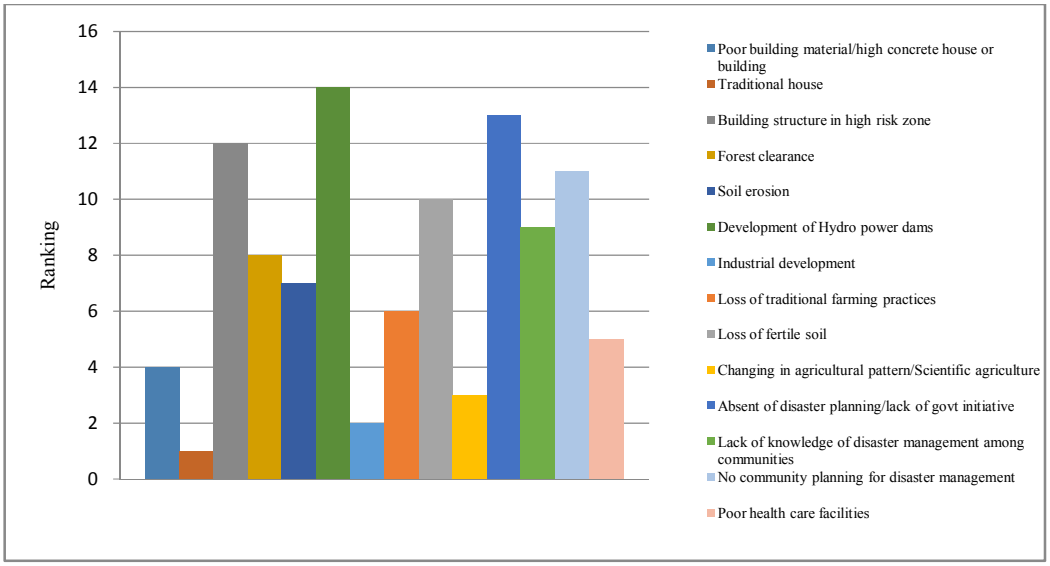
DRR stakeholders to understand the site for implementation of policy and to identify the exact requisite of the local community.

Formal stake holders in Sikkim State Disaster Management Ascendancy should also understand that DRR framework is a recent development after Government of India took a defining step by enacting the Disaster Management Act on 23rd December, 2005. In continuation of the National Act, Sikkim State Disaster Management Act was passed on 2007 to develop a Comprehensive Disaster Management Plan. Thus, it clearly questions the maturity of the SSDMA in conceptualising and dealing with disaster.

From centuries, local and indigenous people in Sikkim Himalaya have experienced numerous disastrous events. They have in depth experiences and knowledge of changing natural phenomena passed down from their elders. They have survived and have even adapted according to the climatic variation. Their survival and adaptation made them resilient to numerous natural hazards. From agricultural activities to building of houses and from understanding the natures sign from birds and animals to inventing and experimenting the food security, all have made them resilient to unpredictable and uncertain climatic condition in Sikkim Himalaya.

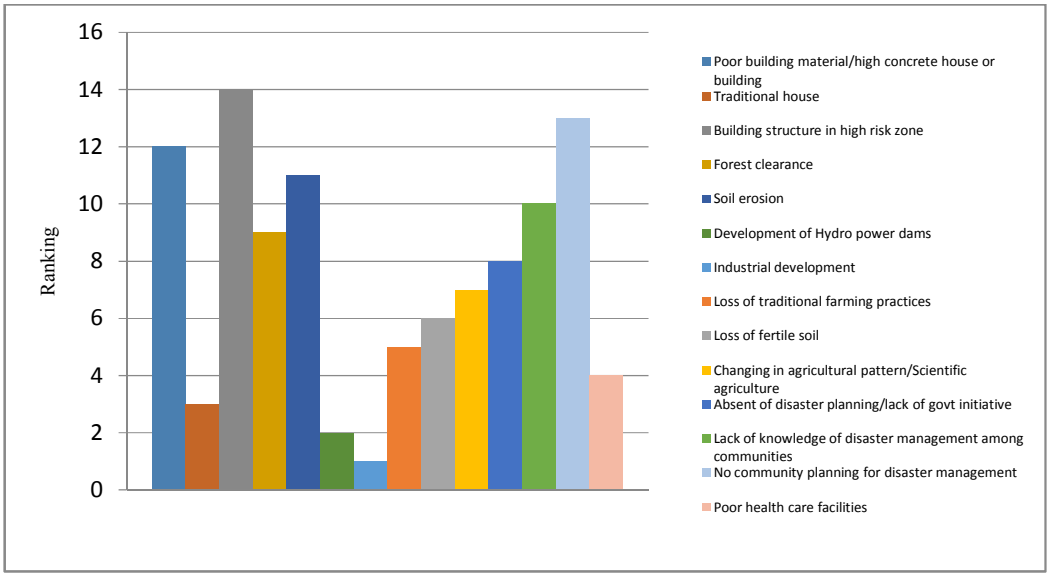
Thus, mapping disaster from the local community's perspective would certainly help the planner and policy makers to understand the core ground issues and requisite. Since any disaster planning is for safe guarding the local people, understanding and analysing their local view point would certainly facilitate the planning process to go in more precise way. Below four statistical graphs have been presented to show the local people's perception regarding the major intrinsic causes of disaster in four district of Sikkim state. Higher the ranking, higher are the causes of disaster.

Fig V.6: **Causes of Disaster in North district of Sikkim – From Local People's Perspective**



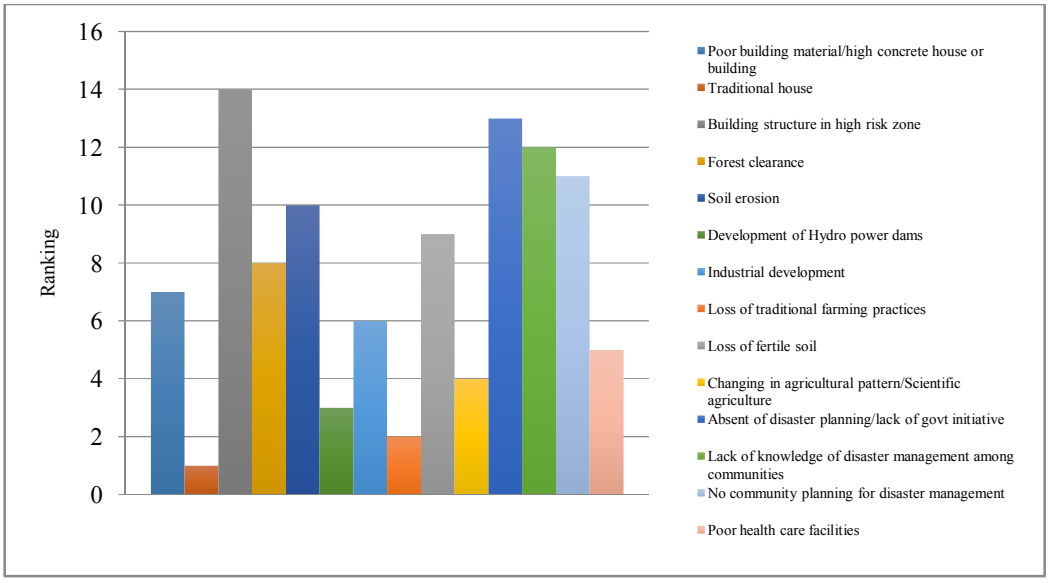
Source: Field Survey, 2016 to 2018.

Fig V.7: **Causes of Disaster in South district of Sikkim – From Local People's Perspective**



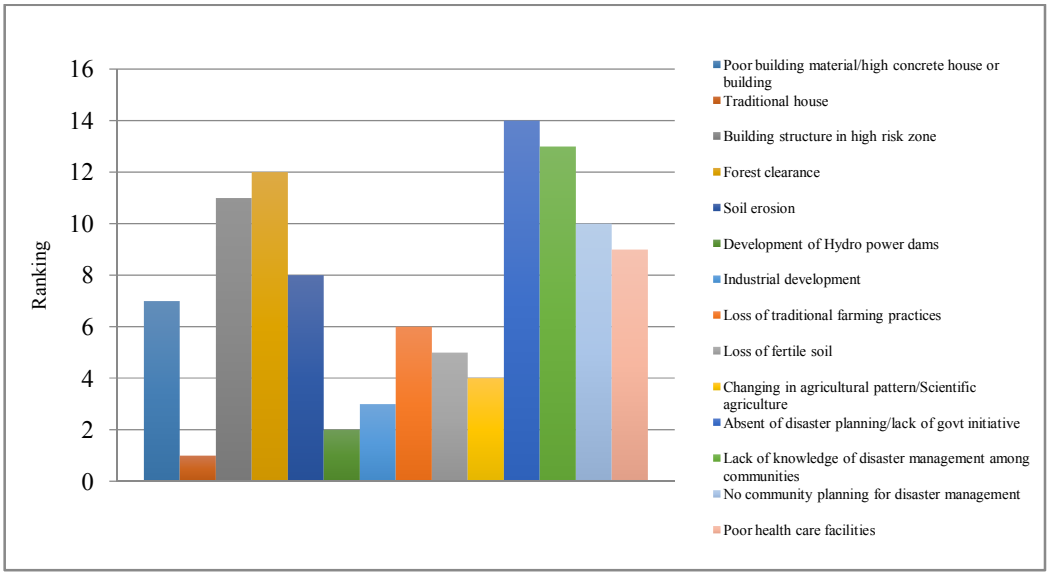
Source: Field Survey, 2016 to 2018.

Fig V.8: **Causes of Disaster in East district of Sikkim – From Local People's Perspective**



Source: Field Survey, 2016 to 2018.

Fig V.9: **Causes of Disaster in West district of Sikkim – From Local People's Perspective**



Source: Field Survey, 2016 to 2019.

The above four statistical graph outlines ranking of intrinsic cause of disaster from the local people's perspective. Statistical graph of North district highlights the development of hydropower dams and absence of disaster planning/lack of government initiative as the two major intrinsic causes of disaster. The following statements below from the local resident of Dzongu, North district do connect the above graphical representation of the causes of disaster in North Sikkim.

> *We were involved to safe Teesta campaign only from 2007. After that, manyevents happened in Dzongu. There is a spiritual and physical element for the cause of landslide in Dzongu. Stage III dam have been constructed near Chungthang (North Sikkim) and its power house distance is not more than 3-4 km from the Mantam (Dzongu). Therefore, the use of tonnes of dynamite before the construction of tunnel obviously had done many cracks and loosened the slope material. We objected to the authority but no one cared. When Mantam landslide occurred in 2016 and blocked the river, the sleeping authority and the people along the lower catchment suddenly woke up. Now we have some positive aspects for the cause we are fighting for because now we feel that not only we are fighting for the protection of the nature but also the nature is responding and showing her support to us (Statement from a 38 years old man from North Sikkim).*

Another statement made by a 34 years old youth of Mangan, North Sikkim highlights the insignificant response activities of the trained Disaster Relief Force during 2011 earthquake:

> *When they come, we the local people also support them. During 2011 earthquake, numerous landslides occurred in North Sikkim and many local*

people, NGOs, and relief agency came for help. However, that was the time when the government authorities really realised the magnitude of the problem because National Disaster Relief Force which came here for rescue was not been able to work properly. We are not blaming them but the authorities should have known that they are entirely trained in some other areas and that coming to the mountainous area for relief work was quite not the same. They were not at all familiar with the physical terrain here. They were carrying huge equipment and were confused which path to follow. Many a times they failed because I myself was there to guide them. They had no idea what they were supposed to do. I just carried a few light local equipments which could be used for relief and rescue. Disaster Relief Force was carrying huge equipment but there was a little path to move it on.

When the question of community participation initiated by Sikkim State Disaster Management Authority was asked than the following statement was made by 64 years old man from Llapthang Thekabung village, East Sikkim.

During landslide disaster, relief agencies do visit our place to conduct relief work but surprisingly they never share with us their knowledge and techniques of mitigation and response strategy. They work and we just observe them.

Now, if we observe the above four statistical graph of the entire four districts of Sikkim then we could find that traditional house has been ranked almost low for the cause of disaster according to the local people. To support the lower ranking of traditional house, the very answer again comes from the following statement.

Replied a 64 years old man from East Sikkim when asked about the advantage of the traditional house.

> *I constructed my traditional bamboo house in1993 and it still stand still. Though today we have concrete house but still I prefer traditional house. This house is very useful to adjust the extreme temperature during different season. In winter we get warmness inside this house and during summer it is cool inside the house. Even if any major earthquake does cause this house to collapse, then we need not to be fear because the material used for its construction is very light.*

Similarly, one of the local resident of Dzongu, North Sikkim highlights a brief contestation between traditional house and concrete house in urban area of Sikkim:

> *Firstly building of traditional house depends upon the individual community also. What material is used and how they are used depends upon the individual community culture. However when you make mud plastered bamboo house in the commercial or urban area like Gangtok then the people would definitely laugh at you because modernization is here. So they will laugh but one day they will cry and you will laugh.*

The above statement outlined a significant factor when 38 year old environmental activist of North Sikkim gave his experienced view in regard to failure of modern technocratic knowledge and society living in the urban area of Gangtok city during 18th September 2011 earthquake. According to him:

> *You know normally streets and roads are generally meant for beggars but 18th September 2011 earthquake made street as a safe zone for everyone.*

Ministers, officers, scientists everyone was there. My question is that why they left the building made up of marble and golden floor because everyone loves their life. On that day it taught the modern urban people that life is expensive. However we didn't sleep on the street. We slept in our own traditional houses.

Thus, understanding the concept of disaster from the marginalized section of the society or defining the cause from the eyes of the experienced one would avail to focus the core causal issue which customarily gets deleted in most of the institutional framework. All the formal stake holders should understand that every institutional framework created by international, national or regional authority genuinely have a prevalent goal, which is to minimise the impact of disaster in the coming future. Without the involution of local and marginalised society, the goal cannot be achieved because whenever disasters strike, most of the affected people belongs to this category.

Consequently, focusing on the core issue within and from the local people perspectives would avail the scientific society or the formal DRR stakeholders to identify the gaps subsisting within the institutional framework. It will avail to deconstruct the conventional hierarchy and promote the two way flow of information both ways - from top to bottom and from bottom to top. Even the financial burden can be minimised when the precise connection is made between the formal stakeholders and the local/indigenous community as it helps to identify the exact requisite of the affected or vulnerably susceptible community.

The policy adopted by SSDMA thoroughly visualise the top down approach and mapping post disaster or relief system from those top down perspective would

certainly create confusion and unfamiliarity rather than smooth efficacious mitigation. This has happened during 18th September 2011 earthquake event and additionally during the 2016 Mantam landslide event in North Sikkim. The trained disaster management personnel were not at all efficacious when they have to rush towards the unknown steep forested terrain for rescue and relief operation.

Below verbal expression from a 71 years old woman from Namchi, South Sikkim clearly highlights the dissatisfaction of disaster management work done by formal stakeholders and mitigation agency. According to her:

> *Local people's idea must be taken into account before any mitigation strategy is formulated by the authority because we know our land much better than the external experts. However, local people views are mostly ignored by them. Most of the external experts who come here do not have much field practicality. Their job during and after disaster events is mostly to take picture and go away. No cordial communication is seen between us and them because they are much educated and are in high post so we feel that it might hurt their ego when uneducated local people like me question their work. And yes, mostly they feel low and annoyed when local people ask any question. But, they must understand that even though they are educated, they do not have much local knowledge. They may be educated but we are experienced. We need to share each other knowledge and expertise. People in chair have to understand it.*

Institutional framework of Sikkim State Disaster Management Authority (SDMA) often have worked in understanding the geophysical and climatic structure of Sikkim Himalaya as the major criteria for understanding or defining disaster and its causes.

Although, it is important to have basic understanding of geo-physical structures of the unstable Eastern Himalaya, the mapping of the Sikkim Himalaya solely from the technocratic perspective alone would not be enough to safe guard the local and vulnerable people here. It is important to grab the idea and wisdom from the rich culture of the people who are living and adapting with the hazards from centuries. Localised and scientific understanding of hazards both should collide together to identify the exact ground reality of a vulnerable and risky area.

V.2.3 STEP 3 - Identification of strategies and methods of Traditional Knowledge System in DRR

When all the above two steps of community participation and mapping disaster from the local/indigenous people's perspective is fulfilled then the cordial relation between the formal stakeholders and the local people begin to develop. This would result in smooth sharing of two way measure of disaster risk reduction tools and ingredient from both the knowledge holders.

Development of trust and respect is very important in order to get into the heart of the indigenous and local people. This would certainly help the policy planner and other DRR stakeholders to study and analyse the practicality of the traditional knowledge system of the local community of Sikkim Himalaya and also its draw backs. After that, the expert can utilise their expertise method to collect the effective data from the indigenous and local community. For example, the oral history of experiences and survival can be documented properly with the help of videos and voice recordings. By involving local expertise and local people in collecting data, the methods would make the process more viable and authentic.

Capturing effective traditional wisdom in systematic manner is crucial and necessary as it would help to conserve the most practical knowledge from extinction. The oral stories or even folklore can be very useful for the disaster planners to deal with the changing environment as most of the stories and folklore originate due to human-nature relationship. It will also help the modern planners to understand the relationship between the local communities and their environment. In conclusion, the disaster planning initiatives becomes very soft and easy to conduct and implement within the communities when the traditional culture of that particular community is well known (or familiar) for the disaster planners.

To bring the successive collaboration/collaborative approaches and (or) methods between the two knowledge systems in DRR, traditional knowledge of indigenous and local communities must require a further development in testing, evaluation and refinement (Kelman, Mercer & Gaillard, 2012; Rai & Khawas, 2019) in a systematic way. Six steps have been proposed by Syafwina (2014) for the recognition process of effective traditional knowledge in DRR.

First step gives the importance to the assessment process of different traditional knowledge followed by indigenous and local communities (Syafwina, 2014). Assessment here refers to the evaluation process of identifying whether the traditional wisdom is useful, valuable and transferable (Syafwina, 2014).

In second step, identification process of its useful function can be measured. For example, is the knowledge still in use by particular communities or has it been just a past knowledge which has not been utilised today (Syafwina, 2014; Rai & Khawas, 2019). The third step is that if the approval of the identified traditional knowledge within the community. Does the community approve and have adopted the knowledge

which has been identified? If the knowledge has been approved and adopted by the community than the fourth step comes in where the question or inquiry of its practicality can be raised because indigenous knowledge becomes meaningless without its practical use within the communities (Syafwina, 2014).

Practicality of knowledge system is very important as practical knowledge have the ingredient of suitability and workable function which can be applied and integrated. In fifth step, the effective practical knowledge in DRR can be transferred from the community or individual to the formal stakeholders by creating methodology for collecting the required data base (Syafwina, 2014).

Finally, in sixth step the transferred knowledge can be recorded and (or) documented with the help of modern tools and techniques (Syafwina, 2014; Rai & Khawas, 2019). To conserve the knowledge system of different communities, traditional knowledge archives can also be developed by the Sikkim State Disaster Management Authority. The effective and practical traditional knowledge tested systematically with trial and error would certainly give a smooth path for its integration in scientific methodology for disaster risk reduction thus giving birth to a holistic approach.

V.2.4 STEP 4 - Encouraging Collaborative Approach

The two knowledge systems demonstrate numerous methodological dichotomies which makes the integration process difficult (Bryant, 1998; Unsworth, et al., 2012). However, co-producing knowledge through science and indigenous knowledge partnership is possible if the indigenous knowledge is focused as a process rather than the content (Berkes, 2009; Unsworth et al., 2012). As process would represent the workable nature and the function of the indigenous knowledge therefore, attempt to integrate two knowledge systems can be tested and validated. However, merging of

useful and effective traditional knowledge into the scientific circle for disaster risk reduction is not an easy task.

Certain measure has to be overcome first before the two knowledge systems are integrated and collaborated into the DRR work. First it has to overcome inertia and inflexibility. Inertia highlights the general resistance to change (Nakashima, 1993; Huntington, 2000) and inflexibility highlights the unwillingness to work together (Nakashima, 1993; Huntington, 2000). It is normally unacceptable for the traditional knowledge owners to accept and adapt to the new scientific paradigm by leaving their already existing traditional and cultural paradigm (Nakashima, 1993; Huntington, 2000) and at the same time inflexibility of modern scientific society in working together with the non-scientist or indigenous (Nakashima, 1993; Huntington, 2000) or local communities has created a huge gap between the holder of both the knowledge system.

To minimise the gap and to bring together the collaborative approach, it is necessary to first document the effective traditional wisdom and its methods in disaster risk reduction (Rai & Khawas, 2019). This would help to bring up the evidential proof of its utility and effective practises in DRR thus paving the way of its integration in scientific methods and practices which slowly would help to overcome the inertia and inflexibility between the two knowledge systems (Nakashima, 1993; Huntington, 2000; Rai & Khawas, 2019).

After that, collaborative approach between the two knowledge systems holders in DRR will give a way for bridging the existing methodological gaps. Like indigenous and local people who have a poor understanding of scientific concept for disaster risk reduction can discuss with scientist who in turn may have a poor understanding of

local context (Kelman, Mercer & Gaillard, 2012). Combining with the local expertise for scientific hazard mapping exercise and survey would help to give a clear verification of the information needed (Deken, 2008; Rai & Khawas, 2019). Thus, collaborative participatory approach in DRR exercise is significant because the ideal DRR measures incorporate a balanced mix of modern technology and traditional technology (Takeuchi & Shaw, 2008; Rai & Khawas, 2019) to make the cost effectiveness and environmental friendliness a reality.

While conducting research on indigenous knowledge or local community it is very important to address community concerns also (Unsworth et al., 2012) and collaborative participatory research approach would certainly address those problems by involving both knowledge experts to work in one field to set the method of collecting field data. For example, community leaders and groups (both men and women), traditional and religious leaders, local Panchayat, state government and national government, local and national NGOs and local academics and experts can be involved in DRR research and conduct field observations, focus group discussion, workshops, semi-structured interviews, participatory mapping and transect walks (Hiwasaki et al., 2014).

Therefore, formal DRR stakeholders can identify the local people within the local community to become researchers by training them in methodology and in understanding scientific terms (Hiwasaki et al., 2014). When local people are involved and taught to collect the primary data, the process of data collection would be easy and smooth and with minimum error. The partnership between the local and the formal stakeholder thus would generate the trust and respect between the two knowledge holders and the ownership of the DRR project would develop within the local people. Thus, the collaborative approach would certainly help to bridge the gaps

existing between reductionism and spirituality by integrating them together for investigating the wider complex structure of our natural world.

V.2.5 Techniques of Integration- Requirement of Analysis and Validation

The resilience of communities facing disasters can increase, when new and old techniques and knowledge are combined (Hiwasaki et al., 2014). However, external organisation or the formal stake holders can play a major role for integrating two knowledge system in DRR. As they are the one who can initiate the program to bring up the local community together and can organize the orientation and training to identify, document, assess and validate the local knowledge (Hiwasaki et al., 2014).This process would help the formal stakeholders to identify and access the most practical local knowledge which can be integrated with science. According to Hiwasaki et al. (2014), each documented local and indigenous knowledge has to go through six step of analysis and validation phase before its integration in scientific framework:

Data analysis: All the observation have to be tabulated and analysed by comparing the outcome and also need to provide the explanation about the outcome (Hiwasaki et al., 2014).

Community validation: Community validation is outmost important as it will help to identify the practicality or the effectiveness of documented knowledge from the community itself (Hiwasaki et al., 2014). This can be done by involving community in focus group discussion or interviews. For example, the authority should be given to local community to identify whether those knowledge is widely practiced in the study area or it is still being used locally in preventing, mitigating and helping community to prepare from disaster.

Natural and Social Science validation: After gathering the outcome of local community's validation process, scientist and experts can also analyse the outcome from their perspective (Hiwasaki et al., 2014). Combining both natural and social scientist to validate the outcome is necessary. Natural scientist can analyse and explain the local community's practical knowledge from their scientific evidences and can also separate the traditional knowledge which is not been able to explain from the scientific circle (Hiwasaki et al., 2014). To fill up the gaps of unscientific explanation of local knowledge, social scientist can be brought up to highlight the social relevance of that knowledge which had not been able to gain prominence in the scientific circle (Hiwasaki et al., 2014). Local or indigenous knowledge with little scientific basis can be assessed by the social scientist in understanding how those knowledge still act as the resilience tool against disaster. Thus, both the experts can bring up the light for integration of traditional knowledge in scientific domain by providing insights from their own perspective.

Re-evaluation of scientific validation from the local perspective: Later returning the scientific validation of the local knowledge system to the local community itself through workshop and seminar would certainly facilitate the community to obtain better understanding of their traditional practices from the scientific point of view (Hiwasaki et al., 2014). The knowledge which was not been able to validate scientifically can also be discussed with the community. This interaction would help the local community to compare the outcome brought by the scientific community and also help to safeguard the local knowledge which is scared to the community (Hiwasaki et al., 2014).

Labelling the traditional knowledge system: Last step is to label the scientifically approved and socio-culturally connected traditional knowledge system relevant to

disaster risk reduction (Hiwasaki et al., 2014). The local knowledge which is still difficult to validate by the scientific society, though, it have worked as the DRR tools in the past would require more in-depth study (Hiwasaki et al., 2014).

Dissemination through Information, Education and Communication (IEC): When the integration of two knowledge system in DRR is done, the mass dissemination of such knowledge is required. Formal dissemination of such new knowledge system can be promoted through information, education and communication material (Hiwasaki et al., 2014). Workshop, seminars and educational institute would be the best place for the dissemination process of such new knowledge system. This will help to articulate the importance of traditional knowledge in DRR, thus regenerating and building up its practicality (Hiwasaki et al., 2014). The dissemination process would also encourage scientific community to go for further research and investigation in understanding traditional knowledge system in DRR, strengthening and increasing its recognition in the coming future.

Therefore, for the successful development of integration framework for DRR in the Sikkim Himalaya certain significant criterion needs to be addressed. Like encouraging local communities participation and giving empowerment in decision making process would help to build the trust and respect between the two knowledge holders. After developing cordial relation, documentation can be an easy process. A systematic assessment and validation from the scientific circle can help to bring about the most needed and practical ingredient of traditional knowledge system in DRR– what is it?. Then without much difficulty, this scientifically tested and validated traditional knowledge can be integrated in formal DRR framework. After integration, the new knowledge for DRR can be disseminated through proper informational and communicational methods.

Therefore, to sum up the discussion, the chapter have overviewed the challenges of convergence for interconnecting the two knowledge system in the DRR. This chapter also outlined the emphasis in reducing disparities and finding the ethical space for resemblance and integration of two knowledge systems in DRR. The major part of this chapter has explored the conceptual framework by incorporating both the knowledge system in disaster risk reduction method. Two divergent approaches i.e. traditional and scientific for sustainable development and DRR in mountain areas have only provided the room for half possibility of success due to numerous gaps existing within the nature and function of both the knowledge system. Since both the approaches lack strong methodological framework for DRR, integration would certainly allow to extract and use the good practices and ingredients from both the knowledge system for DRR.

One way technocratic approach followed by Sikkim State Disaster Management Authority has been a failure in this part of the Himalayan region. Controlling and implementing disaster policy without the involvement, participation and empowerment of local community have failed to reduce disaster risk in the Sikkim Himalaya. Local people know the actual requirement needed for reduce disaster risk because they are the ones who suffer from disasters. Without the involvement of local people, the SSDMA policy is much articulated in reductionist and top down manner. The one way top down approach would not create a two way interaction and information flow which is mostly required for early warning and response activities.

Sikkim State Disaster Management Authority has not developed such a framework where information and communication flow can be reached from the grassroots level. It is because the institutional framework has just ignored the value and importance of traditional knowledge system existing within the communities. Just highlighting the

importance of documentation of traditional knowledge without mentioning its process and validation is not enough for creating trust, respect and partnership with the local community for any DRR project.

Therefore, the chapter reveals the significance of integration framework for DRR and encourage the formal DRR stakeholders to consider and come forward in identifying the age old knowledge system and its practical ingredients. Integration is possible if the external stake holders take the initiative of reconstructing the DRR framework. These can be done by collaborating the two knowledge system experts by encouraging participatory approach for collecting data and analysing and validating those documented knowledge with the help of trans-disciplinary approach to create a new hybrid knowledge system for DRR.

The chapter also signified that a complete working balance between traditional technology and scientific technology can present a viable option in the face of financial concerns for disaster risk reduction work because traditional knowledge offers a very cost effective approach with environmentally friendly method. Lastly, integration process between traditional knowledge and scientific knowledge would pave the way for legitimisation of ignored but scientifically practical traditional knowledge system.

CHAPTER VI

Conclusion

The overall findings of the research brings up some of the crucial issues which, had remained largely ignored by modern scientific society while framing the institutional framework for Disaster Risk Reduction in Sikkim Himalaya. These issues and gaps have been explored by reviewing the nature and function of both the knowledge systems in DRR, with the availability of evidential literatures and the field survey. The need for the development of a holistic DRR framework in Sikkim Himalaya by integrating good practices and ingredient of traditional and scientific knowledge system has been supported as the consequential alternative in the study. Consequently, this chapter has complied and summarised the significance of integrating efficacious traditional knowledge system in formal DRR framework by providing the evidence of its sustainable role in various disaster events which occurred in Sikkim Himalaya.

According to the literature, the study brings up the concept of traditional knowledge as a shared knowledge between the culturally homogenous communities, passed down from one generation to another orally but lacked well documented literature. However, in the context of Sikkim Himalaya today, interfaith and inter-caste marriages have made the appearance of traditional knowledge system more homogeneous in many different ethnic communities. Due to multi-structured society and cultural harmony, traditional knowledge of one community have been accepted and utilized by another community if the climatic factors and the physiographic character of the place are homogeneous. The diverse ethnic groups residing within the same physiographic location in Sikkim Himalaya identified common species of plant,

animal, rivers and other natural setups by the common local indigenous name. However, not much difference was found while exploring the function and utilization of traditional knowledge in similar climatic and physiographic location in Sikkim Himalaya.

Centuries of observation of natural phenomena have made traditional knowledge system affluent in diachronic database. However, lacks of scientific analysis and experimentation have made this knowledge non-legitimate before the scientific world. This is the reason why traditional knowledge and its practices stood invisible during the early 1990s when the scientific society commenced to view disaster as a physical event requiring mostly scientific solutions. However, while exploring literatures in traditional knowledge and disaster risk reduction, it was found that research in traditional knowledge for DRR genuinely commenced as early as 1975 when David Vagdu came up with his publication highlighting the consequentiality of local environment knowledge in DRR.

Since then, numerous academicians came forward to highlight the nature and function of traditional knowledge for the conservation of biodiversity and sustainable development. For example, Clarke (1990), Berkes (1993), Gadgil et al., (1993), Adams et al., (1994), Antweiler (1998), Huntington (2000), Berkes et al., (2000) and even the Yokohama Strategy (1999) forwarded by United Nations World Conference on Disaster Risk Reduction outlined the pertinence of traditional knowledge as environmental cordial and cost efficacious. However, traditional knowledge still failed to occupy its legitimate place for exploration and recognition within the scientific society, until the event of 2004 Indian Ocean tsunami.

The study found that it was only after the event of 2004 Indian Ocean tsunami, significance of traditional knowledge in DRR commenced to highlight within the scientific world. Scientific world was shocked after knowing the traditional early warning system of the local resident of Simeulue island, the island which was just 40 km from the epicentre of the earthquake. There traditional early warning system saved almost whole of the indigenous population of Simeulue island during 2014 Indian Ocean tsunami. This finding brought an incipient discussion globally on the topic of human capability and behaviour towards the environment and soon the concept of disaster as the physical event requiring scientific solution commenced to change.

After the 2004 Indian Ocean tsunami, research in traditional knowledge in DRR gained pace. Scientific society was surprised when they failed to predict and mitigate the 2004 Indian Ocean tsunami even with high investment in innovative technological instruments. Thus, raising the question for scientific technology and its data collecting methods to understand natural phenomenon and its impacts. Therefore, the broader understanding developed from the overview of literature was that the technocratic solution alone was not enough for DRR because the risk and susceptibility factors are additionally connected with the socio-economic and cultural patterns of the society too.

Similarly, while analysing the Sikkim State Disaster Management Plan (2010-2011) and Sikkim State Disaster Management Plan 2015, it was revealed that top-down and the technocratic solution was given more focussed and consequential within the DRR institutional framework. For example, framework clearly stated that that during cloudburst and flash flood events, physical structural measure like the construction of dams, flood protection walls and flood diverting channels should be created to prevent cloudburst and the flash flood hazards. Similarly, for flood proofing measures (non-

structural measures), the significance of creating specific building by laws around the flood prone areas and establishing of flood forecasting system for early warning system have additionally been outlined. However, both structural and non-structural measures totally ignored and isolated the local and indigenous people's say in decision making, resulting in the development of a one way top-down DRR approach.

Relying too heavily upon technology and a top-down approach are critical components of the fragile ecosystem of Sikkim Himalaya. While Sikkim's State DRR framework 2015 had denoted dam construction as the major objective for the prevention of flash flood, field surveys conducted at the flash flood prone and affected areas found contrary ground realities. There was total objection and contestation from the local people who believed that major environmental issues in Sikkim Himalaya today was because of the establishment of mega hydropower dams. Even the regulations created by the authority to avert major socio-environmental damages and also to vigilant the people living around the flood prone area have not been practiced with efficacy or authentically. One example can be clearly observed from the Singtam urban area where maximum settlement is near the flood prone banks of the river Teesta and river Rani Khola but still, no efficacious and efficient measure have been undertaken by the authority. This clearly explicates the lack and ignorance of local people's participation and involvement in DRR planning and policy from the formal stakeholders and the DRR institute of Sikkim Himalayan state.

An exorbitant amount of reliance upon technocratic solution highlights the priority towards economic development rather than sustainable development, as sustainable development always enclose four pillars of development together i.e. economic, political, socio-cultural and environmental development. The blind belief in technocratic solution to control natural process or phenomenon is totally misleading.

The examples are numerous in the context of Sikkim Himalaya. Short term vision is the major reason why this technocratic approach of formal DRR stakeholders has failed to safeguard the life and property of the local and indigenous communities living here since the implementation of this DRR approach.

Long term sustainable approach has been ignored while framing the DRR framework in Sikkim Himalaya. The focus towards the local and indigenous inhabitant, their local perspective towards disaster mitigation and the importance of their knowledge to understand the natural phenomena are totally absent. Technology and local observation should both have gone hand-in-hand as it would sanction the technical and local stakeholders to identify the core susceptibility of the place as well as the people more precisely. However, the concept of integration and collaborative approach between the formal stakeholder and the local and indigenous community in DRR activities is completely absent in Sikkim State DRR framework.

Thus, to understand the gaps within the formal DRR framework of SSDMA, it was indispensable to explore and analyse the problem from the initial stages of evolution. Therefore, three major objectives were formulated and focussed for the study to understand the background of the problem and to bring to front the needed necessary solutions and recommendations for the said problem. The first objective was *"to evaluate the contesting bodies of traditional and western knowledge with reference to disaster risk reduction"* to understand their concept and dichotomy in DRR, globally as well as locally. This objective revealed and helped to develop the direction to outline the methodological gap between the two knowledge systems in DRR.

The second objective reflected the significance of "*preparing an inventory of natural hazards and to map the response of local communities in Sikkim".* Mapping different hazards/disaster events in Sikkim not only helped to understand the background of those hazards/disasters but also developed a method for identifying the study site for documenting traditional knowledge in DRR. Documentation of traditional knowledge in DRR revealed the practical (still being followed by the local people) and non-practical (still subsist in their cultural system but not utilized in daily activities) knowledge system within the local communities of Sikkim Himalaya. After the reflection of both the two above objectives, the third objective was *"to explore conceptual framework to integrate traditional knowledge with formal scientific knowledge in Disaster risk reduction"* with especial reference to Sikkim Himalaya. The overview of literatures, analysis of two DRR framework of Sikkim State Disaster Management Authority and the gathered field data supplemented the necessary ingredient for developing integration framework between two knowledge system in DRR. The paragraphs below have chronologically summarised the study finding and conclusion vis-a-vis the three core research objectives mentioned above.

Overview of literatures assisted to understand the concepts and the existing dichotomy between the two knowledge systems for the study. It clarified the concept of scientific knowledge which was based upon systematic observations – one that can be tested, quantified, validated - mostly built on the positivist approach following reductionist method to collect specifically quantitative data. On the other hand, the study revealed that traditional knowledge is intuitive and holistic in nature, where information can be accumulated through qualitative methods. The systematic way of analysing the observed phenomenon is infrequently done in traditional knowledge,

whereas in scientific knowledge the centre of rationality is developed by observing, testing and quantifying the hypothesis.

The interconnections were found in the study between both the knowledge systems because of the feature of observation present in the two knowledge system in its initial phase. However, the inter-relation rarely exist because of the vast methodological diversity. Weakness in scientific methods and analysis was the major reason why traditional knowledge was non-legitimised by the scientific community. Although the study also found that science was a social construction of our own society however, it disunites spiritual from material, religion from knowledge, and culture from nature. Such a dissected worldview was not shared by indigenous cultures whose philosophy is better characterized as relational or holistic. Therefore, the study found that traditional knowledge of local and indigenous communities do not qualify as science or scientific because traditional knowledge are not knowledge which has been originated from the reductionist tool box.

The study additionally unveils that scientific societies normally focus upon the micro element of the earth to formulate the general theory and laws, thus discarding the subjective element from their study. Whereas, indigenous society focuses upon each and every element which surrounds their respective domain. Somehow, the major gap which modern scientific society have developed while formulating theories and even policies was that they were mostly unaware about the dynamics of the fragile ecosystem which is interwoven with physical, socio-economic and cultural element together.

While examining academic literature and numerous other reports, it unfolded that the work of the scientific society in disaster risk reduction strategy was roughly 60 years

old. For example, the need of emergency assistance or support was formally recognised and introduced by the United Nations General Assembly only from 1960s when the resolution of 2034 in the year 1965 was passed. Similarly, after that, three international DRR framework was introduced by United Nations office for Disaster Risk Reduction namely, the Yokohama Strategy (1994), Hyogo Framework for Action (2005-2015) and recent Sendai Framework (2015-2030).

On the contrary, the study found the adaptation and resilient measure of indigenous and local communities worldwide have been developed even before the invention of high technology-predicated early warning system or scientific standard operating procedures. They have prepared, operated, responded and survived to different natural calamities simply utilising their indigenous methods and practices which were passed down from one generation to the next. However, the review of literature and field survey also found some of the flaws within the indigenous and local communities while dealing with natural disaster. For example, archaeological evidences highlighted the extinction of the world's great civilization like Mayan, old Egyptian empire and the Tang dynasty of China by the impact of floods, earthquake, drought and famine. Similarly, the primary field data from the Sikkim Himalaya additionally revealed some of the disadvantage of static characteristics of traditional knowledge system in the field of agricultural production. For example, an extravagant amount of dependence upon the traditional knowledge of forest ecology highly impacted the agricultural activities in West Sikkim during 1970's. Most of the elder were so much knowledgeable and adaptable in forest ecology that they infrequently had time to develop the cultural technology for the up-gradation of the agricultural activities. Though terrace farming subsisted in West Sikkim during those days, still elders

mostly depended on forest ecology for aliment and livelihood because of the effortless availability of food within the forest ecology.

Thus, the study reveals that although traditional knowledge had many positive aspect of natures' understanding, an inordinate amount of dependency upon nature actually made the local people static and immobile in cultural up-gradation. When most of the resources were easily extracted from the nature for the sustenance of life then somehow it made the traditional framing practices insignificant. Thus, food scarcity during those periods in West Sikkim was not only natural but human induced additionally.

Consequently, exploring different literatures and the field data do bring the essentiality of examining traditional knowledge through thorough check and analysis before considering and recognising its practical value. Thus, after scanning the required literature and probing the field data, the study found that dominance of one system of knowledge either scientific or traditional in DRR is not enough for safer and sustainable development. Both the knowledge system and its holder need to integrate and collaborate for developing a holistic DRR framework. Thus, the study fortifies the consequentiality of a Comprehensive Disaster Risk Reduction approach by integrating the needed ingredient from both the knowledge system for developing an incipient holistic disaster risk reduction framework in Sikkim Himalaya. The concept of sustainable development cannot go much further with the guide from the scientific paradigm alone because of its method, which isolates physical space and the human.

This gaps created by the modern DRR society needs to be filled up for developing a comprehensive DRR planning and policy. Consequently, the study expresses the

importance of integrating good practices of traditional knowledge and its relational approach within the formal DRR framework. Good practices of traditional knowledge can play as a medium for advocating the relational approach by interconnecting and interrelating human, non-human (animal and plants) and nature together, setting an impeccable balance for sustainable development and DRR.

Traditional knowledge holds a substantial amount of information of the natural world because of its centuries-old experiences and observation of changing natural phenomena. Thus, it can complement current modern science which lacks data in understanding climate change issues. Merging the utilisable and practical traditional methods in formal DRR framework would not only avail to fill up the subsisting gaps for comprehensive DRR plan and policy but additionally avail to pave the path for the legitimisation process of traditional knowledge system. Thus, the study reflects the necessity of a flexible collaborative approach between the two knowledge systems and the two knowledge expert to come in one platform for developing the integrated framework for DRR.

To bring up traditional knowledge wisdom within the scientific domain for its integration, the study reveals the significance of documenting traditional knowledge in a systematic way. However, Sikkim Himalaya being a multi-structured society, it was consequential to identify the landscape first rather than the individual ethnic communities for collecting the traditional wisdom. As different physical landscape also encourages different adaptation measures, following the physiographic criteria for site selection became paramount for the study. Thus, the study examined the physiographic variation of Sikkim Himalaya with the help of Digital Elevation Model extracted from United State Geological Survey website and with the help of Arc GIS tools, five climatic classification of landscape was categorised.

Mapping the study area with the help of Geographical Information System (GIS) tool brought the idea to identify the location of study site for conducting field survey and also to understand the landscape susceptibility and risk factors of the study site. Therefore, five different climatic zones were identified were: Tropical, Sub-tropical, Temperate, Sub-alpine and Alpine. This climatic categorisation became the major criteria to identify the location for the accumulation of primary data.

More in-depth exploration of GIS tool in the context of hazards and disaster in Sikkim Himalaya outlined the creation of inventory maps of different hazards and disaster in different spatial and temporal aspects. As a conventional method of mapping hazards and disaster was too time consuming, hence to reduce the time and resource requirement for the compilation and systematic updates, high resolution time series satellite data was utilised. Therefore, analysing the map with the avail of various GIS tool brought the understanding of various past natural events which in turn availed to delineate the susceptibility and risk factors both spatially and temporally in Sikkim Himalayan landscape. Thus, after creating and analysing the hazards and disaster inventory map of Sikkim Himalaya, the major research site for accumulating primary data within the five climatic zone of Sikkim Himalaya became easy to demarcate. However, Alpine climatic zone was omitted due to unavailability of established settlement pattern.

The inventory maps of Sikkim Himalaya developed a conceptualised view of understanding a physical structure like slopes and drainage as the important factors in encouraging and modifying different natural hazards into disaster. For example, the landslide map outlined the connection between the steepness of the slopes more than 25 degree and the presence of rapid water flow as the major factor for landslide in Sikkim Himalaya. Similarly, reconstructing 1968 flash event with the help of GIS

tools availed the study to identify Singtam in East Sikkim as one of the flash flood vulnerably susceptible area. Inventory map of forest fire revealed the tropical and sub-tropical area of south and west district of Sikkim as the most risky and vulnerably susceptible area. Consequently, inventory map availed to disclose the identification of location or study site for primary data accumulation.

While examining and exploring the study site, it was found that traditional knowledge is widely spread according to its prevalence and utility across the Sikkim Himalaya. However, not enough attention has been paid of its applicability and role in DRR from the academic research or development policy perspective in Sikkim Himalaya. Such traditional practices which form paramount part of the cultural life of the Sikkim Himalayan communities were either ignored or side lined as an unscientific and irrational knowledge from the technocratic society without examining it.

To fortify its role, its applicability and highlight its consequentiality in DRR institutional framework of Sikkim Himalaya, the study visualise the importance of documenting traditional knowledge system in a systematic way. Exploration and documentation of traditional knowledge of Sikkim Himalayan communities is consequential as it would additionally avail to integrate the age-old community knowledge system within the conservation tool box because these knowledge systems are gradually diminishing due to globalisation and ascendance of western modern conceptions among the coming generation. For example, the study found the vanishing of different traditional food items and its process of preparation. These food items were authentically originated for consumption by the local people during hazardous changing environmental phenomena like drought and famine. However, due to modernisation and food globalisation, the coming young generation does not find it paramount for conserving such age old wisdom.

While investigating the role of traditional farming system for sustainable land management (preparedness) and aliment security (mitigation), the study found that the initial diminishing of traditional farming practices commenced when the government introduced modern farming system in Sikkim Himalaya after 1975. Commercialization on cash predicated approach was introduced in the agricultural sector for developing the economy of Sikkim state thus ignoring the environment and society, two fundamental pillars of sustainable development. This was the first technocratic step taken by the authority without consulting the local people or without understanding the indigenous landscape and the consequentiality of traditional farming practices.

Productivity in the initial phase was so astronomically immense that even local community commenced to overlook the traditional farming system. Consequently, prelude of modern agricultural system did work as the erasing instrument for century's old traditional agricultural system in Sikkim Himalaya. However, the study ascertained that after four decades, suddenly the government brought the new laws to veto all the non-organic production and initiated an immediate organic revolution. Virtually all the people genuinely favour the organic mission but the local farmers on one side of the corner were still in mystification because the land where they were ordered to produce organic was already addicted to the chemical fertilizer. While examining the grief of local farmers due to sudden introduction of organic mission, the study found that, once chemical fertilizer is utilized in agricultural field, the entire indigenous population of micro flora gets eradicated. Micro floras are those organism which avails to maintain the fertility of soil. After utilizing chemical fertilizer, even in 10 years it will not be assured that the original micro flora will be generated.

Thus, the organic mission was not very fruitful – both for the people as well as for the environment actually took place quite rapidly without the consent of the rural farmers. Therefore, the research study reveals that neither during the introduction of modern farming techniques in Sikkim nor in contemporary organic mission, the consent of local farmers or their local knowledge were taken seriously into consideration by the formal stakeholder or the authority. In fact, the consequentiality of organic farming gained pace in Sikkim only after the realisation of negative impact of chemical fertilizers upon the land and the environment surrounding the land.

However, the study has found some very fascinating characteristics of organic farming in the Sikkim Himalaya. Reviewing some literature and analysing some field data, it was revealed that there are certain guidelines and techniques for organic farming. Any crop grown with the help of cow manure is considered organic, which is consummately erroneous. This is because for organic farming, grazing area for cattle is paramount as grazing cattle provides diverse fodder and their manure have immensely colossal energy to keep the soil fertile. The study found that in the Sikkim Himalaya, grazing has been banned and the indigenous cattle breed is totally absent. In integration whatever bio fertilizer needed for organic farming is merely available in the Sikkim Himalaya.

Though the techniques of organic farming had some imperfection in the Sikkim Himalaya due to its erroneous implementation, its introduction in Sikkim Himalaya simply concludes and brings up the importance of the traditional farming system for long term sustainable development which was genuinely ignored by the technocratic society after 1975 in Sikkim. Today, process and system of organic farming in Sikkim Himalaya although differs from traditional farming, the inter connection do subsist between the two. In fact, the word 'Organic' has been conceptualised too much from

the scientific circle but still due credit of its evolution rest upon the traditional farming system. However, even to this day, the due acknowledgement is denied towards the knowledge holder of traditional farming system.

The reflection of field survey outlines various function of traditional agricultural system in Sikkim Himalaya. Co-mixed or simply mixed farming is one of the consequential characteristics of traditional farming system here. Different crops are planted in a single field to ascertain the minimum risk during total crop failure season. Intriguing thing in traditional farming system adopted by all the local and indigenous communities of Sikkim Himalaya was that, not only were the crops for human consumption given predilection but some plants like *Amliso* (Thysanolaena maxima), *Gogoon* (Saurauia nepalensis) and *Nivara (*Ficus hookeri) was also planted around the farming land. These plants are utilized as fodder crops for domestic animal, fuel wood for the house and significantly for minimising the risk of soil erosion and landslides. Therefore, traditional farming system had the inbuilt characteristic of prevention, preparedness and mitigation strategy.

The study additionally found that traditional agricultural activities in this component of Himalayan region is not a knowledge developed by one singular community but as an skill and practice, developed together by various communities with decades of experiment, unity and socio-cultural harmony. Additionally due to the homogeneous attribute of language spoken i.e. Nepali language as a langue franca of the State, (although individual communities also have their own local dialects) the cultural transmission became easy and have been intermingled within different communities. Thus, traditional knowledge developed by one community has been easily accepted and utilized by other communities if the physical and climatic factor of the region is homogeneous.

The local people here normally conceptualise nature as the true owner of the land. Worshiping the owner first before starting any agricultural activities or harvesting of crops has been observed in all the local and indigenous communities across Sikkim Himalaya. The cultural belief system of local people considering nature as the sole owner of the land makes the entire developmental process from the lens of nature primarily and human as secondary. Belief in spirituality in and around the rural settlement has set up the strict protocol of environmental conservation by the local and indigenous people. *"We belief in nature, we respect the nature and thus we worship the nature".* This statement itself highlights the importance of conserving and protecting the nature for the sustenance of good livelihood.

The study found that the system of believing nature as the provider directly have influenced the conservation of surrounding environment by providing the strict protocol to follow the nature's rule in any developmental activities. In Sikkim Himalaya, the right time is always observed by the local and indigenous people before starting any agricultural activities. Animals, birds, plants, winds and water gives sign to the local and indigenous people about what should be done and what should not be done. These observations have been developed from centuries of experiences with the natural phenomenon and have been passed on by their elders from one generation to the other. Thus, spiritual devotion within the local communities have directly influenced in safeguarding the surrounding environment due to fear of presence of local deities in and around their settlement. Believing, worshiping and respecting the surrounding nature avoided the uncleanness activities around it, consequently transforming spiritual devotion into practical devotion. *"Practice what you preach*" is a significant, day to day applicable term within the local and indigenous people of Sikkim Himalaya. These concept of *"Practice what you preach"* are somewhat absent

from the formal stakeholders who normally conducts DRR talks and seminars in some expensive hotels but lacks the implementation of DRR talks inside the field. Involvement of traditional belief system into practical reality is what makes the local and indigenous knowledge holder the true implementer of the theoretical policy.

The study also sketches out the existence of informal means of communication within the traditional knowledge holders while disseminating that knowledge within the community. Knowledge of forest, animals, birds, wild foods available inside the forest and prediction of natural phenomenon was not developed recently. However, it took indigenous community a long period to observe, analyse and adjust with the changing natural phenomenon. Therefore, the study found that the data which can be extracted from the traditional community have diachronic characteristic. This diachronic data which hasn't been documented and explored systematically by the scientific communities can help scientific synchronic data, absent more often in long temporal aspects. Therefore, unification of both the data would certainly give an advantage to the Sikkim State Disaster planners and policymakers to understand the natural as well as socio-cultural aspects of disaster in this part of the Himalayan region.

Sikkim Himalaya falls within seismic zone IV, and is considered as the very high seismic activity zone in the country. Within 100 year time, Sikkim Himalaya experienced around 41 earthquake of magnitude 4.0 - 4.9 (light), 20 earthquake of magnitude 5.0 - 5.9 (moderate) and 4 earthquake of magnitude 6.0- 6.9 (strong). Thus, in total 65 earthquake of magnitude above 4.0 occurred within the Sikkim Himalaya within the last 100 years. However, when the exploration of traditional knowledge began for the study, some of the interesting seismic resistance structure of local communities came forward. Examining the traditional housing structure revealed the

age of the house as more than 50 years old. Example, *Ekra* house, *Chaukat* house, *Chitra* house, *Magar* house, *Bhotay* house, *Taray* house, *Lepcha* house, *Kirat* house were some of the traditional seismic resistance houses which were made from the available local materials like bamboo, local timbers, mud and stone.

While analysing the earthquake database and its impact in the Sikkim Himalaya, the study found numerous anti-seismic evidences of traditional houses standing still with very less casualties. For example, 18th September, 2011 earthquake have beautiful evidence of reliability of traditional seismic resistance structure. The study found that among fully damaged building during 2011 earthquake, 20 percent comprised of RC *(reinforced concrete*) frame / masonry buildings frame while only 4 percent consist of traditional construction. The durability and resilient of traditional house during 2011 earthquake was because of its light weighted environmentally friendly material. Therefore, even if houses collapsed, no major injuries have occurred to the people living inside the house. However, scientific exploration, analysis and acknowledgement of traditional anti-seismic structure have been seldom done by the Sikkim State Disaster Management Authority nor by any technical institute in the Sikkim Himalaya.

The studies also found that traditional house not only have the perfect amalgamation of anti-seismic and eco-friendly materials but also had the cultural value of sacredness to the local community. Due to its cultural importance, a hygienic environment was always built around it. Local people believed that there is a supreme power in *'Silla Pathar'* (stone which makes the foundation of the house) so they normally worship *'Sila Pathar'* requesting the god to make the house stand still. Thus, the study uncovers not only the physical resistance of traditional house during seismic event but also the importance of psychological belief which makes the community strong and

resilient in any earthquake disaster. When physical structures have failed during earthquake disaster, then the cultural belief system psychologically worked to reduce the risk factor in Sikkim Himalaya. Therefore, it's a high time that formal DRR institute of Sikkim Himalaya should also explore the significance of those cultural belief systems to fill up the gaps existing within the earthquake resilient technique in Sikkim Himalaya. The exploration work should be done as early as possible because this traditional wisdom is on the verge of extinction as most of the traditional house building experts have either died or are very old.

Mapping hazards is very essential to explore and to formulate the future DRR policy and the word mappings have a strict concept of scientific survey from the technocratic point of view. Natural scientist like geologist, physicist and physical geographers have a strong background of exploring the underneath and above the surface process. They survey it, collect data, analyse it and brings the outcome in the form of digital maps. Thus, understanding natures sign from a scientific perspective builds up the basic concept of knowing natural phenomenon. However, there are also some cultural ways of understanding nature's sign and these techniques have evolved from over decades of observation of nature in that particular environment. Mostly these techniques are ignored or not recognised by the scientific community because it lacks analytical discourse. For example, in the West district of Sikkim a huge landslide occurred (*Tarey Bhir* Landslide) in 2018. Formal DRR community was busy in identifying the characteristics of soil, rock and vegetation to map and understand the core cause of the landslide. However, the local people had different cultural techniques in identifying the core cause of landslide there. According to the local people, the un-cleanliness around the sacred site due to high tourism activities was considered the core cause of landslide. After analysing the local people spiritual

viewpoint, the study found that the area was once highly populated by the tourist due to the presence of sacred temple around the area. This rapid economic development highly changed the area into a tourism hub rather than the sacred site thus, increasing the un-cleanliness activities around the area.

The above cultural techniques of identifying the core cause of landslide are very different from the scientific perspective but however have the logical explanation regarding the human induced disaster. For example, even scientifically it can be approved that too much plastic waste and technological interferences in a fragile ecosystem for economic development would definitely result into disaster and *Taray Bhir* landslide did exposed it. Thus, it is essential to go in-depth study of such cultural techniques, especially by the social scientist. The study of physical structure alone cannot guarantee the smooth work of DRR policy. Understanding people and their relationship with the surrounding environment is important. When both the scientific and cultural techniques are integrated then the DRR policy will certainly have best from both the physical and human element to implement the policy.

The close examination of Sikkim State Disaster Management Authority framework 2010-2011 and 2015 and the field study clearly points out the logic behind the negligence of traditional knowledge in past and present from the formal DRR planning and policymakers in Sikkim Himalaya. For example, the study found that, predominance of not only the technocratic thinking was the reason behind the ignorance of traditional knowledge but also due to the lack of connection between the local people and the external stakeholders increased the distance between the two knowledge experts. Though the significance of documenting traditional knowledge is well mentioned in SSDMA framework in one paragraph of one single page, however, process, analysis and validation of those documented traditional knowledge is absent.

Participatory research approach is considered as the most vital approach to collect data from the indigenous and local communities for DRR project as it allows people participation's in research as well as in decision making process. Participatory approach also empowers the communities to come forward to highlight the core issue in their respective area. It highlights and encourages building the partnership of two knowledge experts and thus resulting in the two way flow of information. However, the study found that in Sikkim State Disaster Management Authority Plan 2015, participatory approach have been defined as the participation of local community in DRR work under the supreme control of formal stakeholders appointed by the departmental authority. Therefore, it reveals that no two way flow of information existed in SSDMA Plan 2015 thus, ignoring the priority of local stakeholder knowledge andtheir issues and empowerment in decision making process. Top-down approach of SSDMA plan 2015 with one way information flow system would never understand the actual requirement of the local communities before or during or post natural or even human induced disasters.

Exploring, analysing and validating traditional wisdom in DRR is thus important to fill up those gaps which have been created by the formal DRR institution in Sikkim Himalaya. However, to bring up the wisdom of age old knowledge in formal institutional framework, recognising its process and acknowledging its owners should be the prime work of the formal stakeholders. The trust and belief systems between the two knowledge experts would simplify the process of integration of both the knowledge system for DRR. Therefore, the study articulates some policy recommendation for integrating both the knowledge system in DRR to bring up a holistic framework. Exploring the existing literature on the good practices of traditional knowledge in DRR and examining the field survey in Sikkim Himalaya

express the possibility of integrative framework in the context of Sikkim Himalaya if certain important criteria are not overlooked by the formal disaster planners and the policy makers:

Firstly, equal participation of local and indigenous communities in all the disaster management plans and policies would pave a smooth path for the developmental activities initiated by the governmental or non-governmental organisation. Such participation approach would focus more on the requirement of the local community rather than merely targeting the necessity from the formal stakeholder's perception. For example, failure of National Disaster Relief Force during 2011 earthquake highlights how top-down approach with one way information flow was totally ineffective in rescue mission.

Secondly, nature's path cannot be altered or modified permanently by any technological barrier. However, its risk can be reduced if the technical framework adopts a more sustainable solution for long term risk reduction attempts. Therefore, involving local people in decision making process would certainly promote those long term sustainable approach as it helps the planner and policymaker to understand disaster, risk and vulnerability from the perspective of the local and indigenous people. Thus, the study outlines the importance of community participation in decision making process in depicting and understanding the source of disaster from bottom up. Understanding local people's view-points and experience in regard to the cause of disaster would certainly help the planner to identify the core cause and requirement of the disaster affected community.

Thirdly, the study supports the deconstruction of top-down approach and encourages the two way flow of information to develop the precise disaster risk reduction plan.

Involving local community in the entire formal DRR workshop, encouraging local community to address their own perspective vis-à-vis planning and policy and respecting their tradition of understanding the land and its resources are some of the steps which formal DRR stakeholder should take to develop the two way information flow.

Fourthly, the study conceptualises the significance of a collaborative approach between the experts of two knowledge systems for building smooth integration framework for DRR in Sikkim Himalaya. Working together, rather than substituting each other for DRR, such approach can create a holistic methodology for risk reduction measure. To develop the collaborative approach, formal stakeholders must foremost develop trust and respect with local and indigenous people.

Fifthly, after documenting the traditional knowledge, it is important to explore the practicality of existing traditional knowledge system by testing and validating it in a systematic and scientific way because all the traditional knowledge which contains superstitious/super natural belief cannot be enclosed within the DRR institutional framework due to its irrational consideration. Integration of valid or practically proved traditional knowledge within the institutional framework would categorically develop the process of its legitimisation and conservation informal literature or in educational system too. Thus safe guarding it from extinction.

Lastly, the possibility of enactment of integration framework between traditional knowledge and scientific knowledge in DRR solely lays upon the external and formal stakeholders initiatives because they are the one who have the power and authority to implement the DRR plans and policy in the state.

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Appendix A

Jhato

Figure 1. This photograph illustrates the image of traditional grinding instrument of Sikkim Himalayan communities especially of Nepali ethnic communities. It consists of two round stones of which the bottom part is attached to the ground or the floor in the house and has a big nail or wood in the centre to keep the top stone in place while grinding. The top part however has two holes in it, one in the middle to insert grains and the other on the side to place a handle for grinding. The grains are ground using a circular motion with the help of the handle and the person has to be sitting down to do the task.

Appendix B

Khanakpa (Evodia fraxinifolia), *Sil Timbur* (Litsae cubeba) *and Chimphing* (Heracleum wallichii)

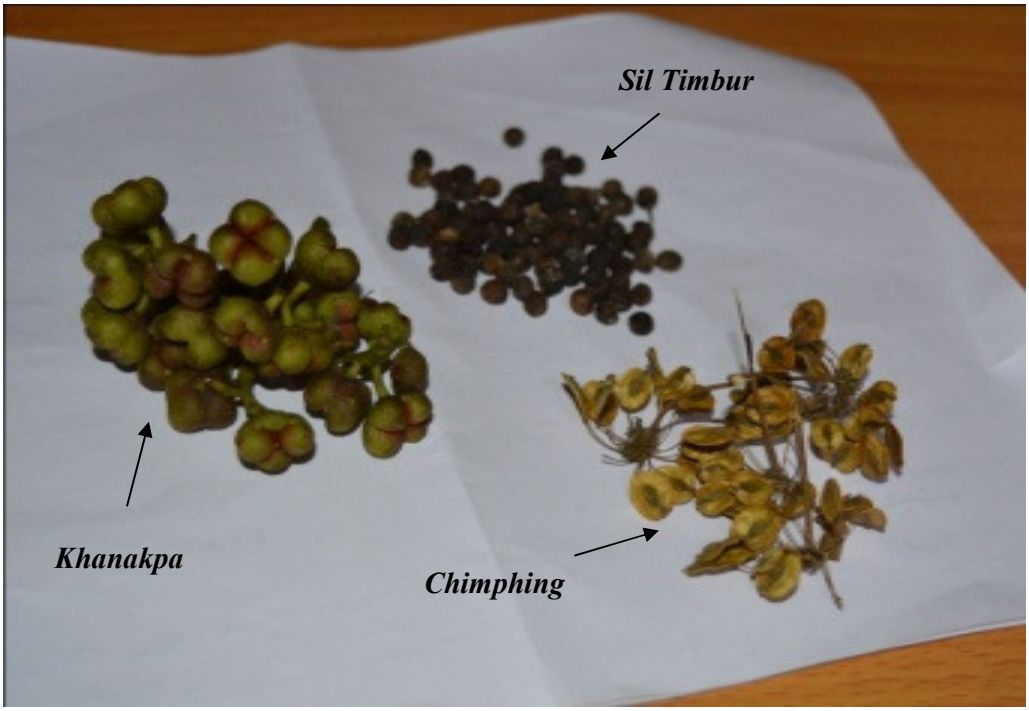

Figure 2. This photograph illustrates the image of three traditional medicinal plants found in Tropical, Subtropical and Temperate climatic region of Sikkim Himalaya. These three medicinal plant are crushed together to form a paste which is normally applied around the shifting muscle of the injured person leg.

Appendix C

Titaypati (Artemisia vulgaris)

Figure 3. This photograph illustrates the image of *Titaypati* (Artemisia vulgaris), a traditional medicinal plant found mostly in Tropical and Subtropical climate of Sikkim Himalaya.

Appendix D

Pakkhanbed (Berginia ciliate)

Figure 4. This photograph illustrates the image of Pakkhanbed (Berginia ciliate), traditional medicinal plants found in Subtropical, Temperate and Sub alpine climate of the Sikkim Himalaya. This plant is normally used for curing body ache and fracture.

Appendix E

Ghiukumari (Aleo barbadensis)

Figure 5. This photograph illustrates image of *Ghiukumari* (Aleo barbadensis), traditional medicinal plant mostly found in Tropical and Subtropical climate of Sikkim Himalaya. Juice of this plant is normally served to the weak person.

Appendix F

Banmara (Eupatorium sp.)

Figure 6. This photograph illustrates the image of *Banmara* (Eupatorium sp.), traditional medicinal plant mostly found in Tropical, Subtropical and Temperate climate of Sikkim Himalaya. Leaves of this plant is used to stop bleeding or to cure the minor cut.

Appendix G

Betlauri (Costus speciosus)

Figure 7. This photograph illustrates the image of *Betlauri* (Costus speciosus), traditional medicinal plant found mostly in Tropical, Subtropical and Temperate climate of Sikkim Himalaya. Juice of this plant is consumed to cure urine infection.

Appendix H

Abhijalo (Drymaria cordata)

Figure 8. This photograph illustrates the image of *Abhijalo* (Drymaria cordata), traditional medicinal plant found in Tropical and Subtropical climate of Sikkim Himalaya. This plant is used for treating sinus.

Appendix I

Ambak (Psidium guajava)

Figure 9. This photograph illustrates the image of *Ambak* (Psidium guajava), a local fruit plant found in Subtropical and Temperate climate of the Sikkim Himalaya. Young shoot and its bark is consumed to stop dysentery.

Appendix J

Chuwa (Phlogacanthus thyrsiflorus)

Figure 10. This photograph illustrates the image of *Chuwa* (Phlogacanthus thyrsiflorus), a local medicinal plant found mostly in Tropical and Subtropical climate of Sikkim Himalaya. This plant is consumed to reduce high blood pressure.